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(54) **TUMBLE DRYER WITH A HEAT PUMP SYSTEM**

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EP 3 717 689 B1

Description

Field of the invention

[0001] The present invention relates to a tumble dryer, especially to a tumble dryer comprising a heat pump system.

Background of the invention

[0002] In tumble dryers, the heat pump technology is an efficient way to save energy during drying of laundry. EP 3 118 365 shows an example of a tumble dryer with a heat pump system. The air that is used to dry the laundry is circulated in an air flow circuit. In the air flow circuit, hot dry air is blown by a fan into the drying drum for removal of moisture from wet laundry. The warm humidified air leaves the drum and is cooled and dehumidified in an evaporator. The cooled air is then heated in a condenser and blown into the drying drum again. A general problem with tumble dryers is how to improve their efficiency further.

[0003] There are more examples of tumble dryers in prior art, a few are listed below:

CN 106592182A discloses a drying system and a clothes drying device, and the system comprises a housing, a fan, an evaporator, a condenser, a compressor, and a throttling device. The evaporator and the condenser are oppositely fixed in the housing, and the housing forms an air channel. The evaporator is located between the fan and the condenser in an extending direction of the air channel. The evaporator is disposed in an inclined manner, and is provided with a high end and a low end, which are opposite to each other. The low end of the evaporator is relatively close to the fan, and the high end of the evaporator is relatively close to the condenser. Two side surfaces of the evaporator are respectively a windward side and a leeside, wherein the windward side faces the fan, and the leeside faces the condenser. The housing is provided with an air guide mechanism between the fan and the evaporator, wherein the air guide mechanism is bulged towards an inner cavity of the housing. According to the invention, the air guide mechanism is disposed between the fan and the evaporator, and changes the direction of the air flue on the surface of the evaporator, thereby enabling air which is liable to be centralized at the corners of the evaporator and the housing to flow to the surface of the evaporator, and improving the uniformity of the surface wind field of the evaporator

US4621438A discloses an energy efficient heat pump dryer for clothes and other washables having a sealed rotatable clothes tumbling drum and means for circulating a stream of heated drying air in a

substantially closed path through the tumbling drum. The drum is journaled upon a combined bearing and air seal means at each end. A heat pump is incorporated as the source of heat for the drying air, as a means for recirculating heat from the drying air exhausted from the tumbling drum, and as a means for removing entrained moisture from the exhausted drying air. The dryer is adapted to operate from a 110 volt household power supply and requires no air vent to the outside.

DE102016200308A1 discloses a household appliance, in particular a tumble dryer, comprising an air duct and a fan unit, which is arranged in the air duct and can generate a flow along a flow direction S, and comprising a throttle device which is arranged in a section of the air duct and which has at least one throttle duct, characterized in that the throttle device is arranged downstream of the fan unit, and that the at least one throttle duct runs essentially parallel to the section of the air duct.

JP 2017 000483 A discloses a dryer comprising a tubular wind direction controller.

Summary

[0004] It is an object to obtain a tumble dryer comprising a heat pump system, which has an improved performance.

[0005] This is at least partly achieved by means of a tumble dryer as defined by claim 1. The tumble dryer comprising a heat pump system and an air flow circuit for circulation of an air flow. The air flow circuit comprises a condenser, a drying drum, a fan arrangement, an air flow duct, and an evaporator. The air flow duct comprises a constriction/diffuser, arranged upstream of the evaporator. The constriction is provided with a plurality of openings, distributed over a cross section of the air flow duct and the constriction creates a pressure drop in the air flow that is circulated in the air flow duct, when the air flow flows from a first side of the constriction to a second side of the constriction. The openings in the constriction are adapted to distribute the air flow over the cross section of the air flow duct.

[0006] By arranging a constriction with openings in the air flow duct upstream the evaporator, it becomes possible to allocate the air flow more evenly on a larger part of the evaporator surface. This leads to that a more effective dehumidification of the air flow can be obtained in the evaporator, a shorter drying time in the drying drum, higher performance, and energy savings of the heat pump system.

[0007] The openings may constitute at least 1/3 of surface of the constriction.

[0008] To obtain the desired air flow distribution across the surface of the evaporator, the percentage of openings may depend on the size of the air flow duct and hence the

size of the laundry dryer. However, it may be advantageous if at least 1/3 of the constriction surface may consist of openings to have the desired air flow distribution. The distance between the constriction and the surface of the evaporator is between 0-300 mm, preferably between 10 mm and 40 mm.

[0009] The constriction is a perforated plate. For example, the perforated plate may be a sheet metal, or a metal mesh may be arranged in the air flow duct to provide a constriction. These solutions are simple and inexpensive to manufacture.

[0010] The tumble dryer's rotatable drum may comprise a circular rear wall with air inlet openings and a radial cylindrical wall with air outlet openings. A space outside the drum's cylindrical periphery may be configured as a duct leading to a filter placed below the drum. This reduces air flow restrictions, and allows the use of a large filter, even about as wide as the diameter of the drum.

Brief description of the drawings

[0011] The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, with reference to the appended drawings, where the same reference numerals will be used for similar elements, wherein:

Fig 1 shows a schematic view of a tumble dryer.

Fig 2 shows a schematic cross section side view of a tumble dryer comprising a heat pump system, with interior parts exposed.

Fig 3 shows an enlarged view of the dotted portion X in Fig 2.

Fig 4 shows a schematic view of a constriction example according to the disclosure.

Fig 5 shows a schematic view of another constriction example according to the disclosure.

Detailed description of the exemplary embodiments

[0012] Fig. 1 illustrates schematically a tumble dryer 1 comprising a parallelepiped-shaped housing 2. A door 5 is attached by hinges 7 to a front wall 3 of the housing 2 for input of wet laundry to be dried and for output of dry laundry.

[0013] Fig 2 illustrates a cross section view of a tumble dryer 1 comprising a heat pump system 22 and an air flow circuit 21. The air flow circuit 21 comprises a drying drum 11, a fan arrangement 13, an air flow duct 18, an evaporator 15 and a condenser 19.

[0014] Wet laundry to be dried is fed into the drying drum 11 through a door 5 arranged at the front side 3 of the tumble dryer 1. Warm, dry air may be used for removing moisture from the wet laundry. An air flow may be circulated in an air flow circuit 21, moved through

the circuit 21 by a fan arrangement 13. In the shown embodiment, the fan arrangement 13 is situated below the drying drum 11 but before the evaporator 15. The fan arrangement 13 could alternatively be located between condenser 19 and the drying drum 11. Due to space considerations in the shown embodiment, the location of the fan arrangement 13 below the drying drum 11 has been selected.

[0015] When the wet laundry is dried in the rotating drying drum 11, moisture is transferred from the wet laundry to the air flow that is circulated in the drying drum 11. The warm, humidified air leaves the drying drum 11 and is circulated to the evaporator 15 through an air flow duct 18. The indicated air flow duct 18 is located in front of the evaporator 15 directly upstreams thereof with respect to the direction of the air flow. Needless to say the air flow circuit 21 includes a number of ducts and passages to form a closed circuit.

[0016] The air flow may be passed through a filter 12 for separation of particles or lint from the air flow before it enters the evaporator 15. In the embodiment shown, the filter 12 is arranged below the drying drum 13 but above the fan arrangement 15, although other positions are possible.

[0017] In the illustrated example, a high-capacity tumble dryer mainly intended for professional use or for use in shared laundry facilities. Such tumble dryers may comprise a drum 11 with air inlet openings in its circular rear wall and air outlet openings in its radial cylindrical wall, particularly in the front part thereof to provide a process air flow through the drum. This may be combined with a lint removing filter located below the drum, rather than with a filter provided at an outlet located in connection with the front wall door 5. The space outside the drum's cylindrical periphery may be configured as a duct leading to the filter 12 under the drum 11. To a great extent however, the improvements described herein may also be used in connection with typical domestic tumble dryers intended for use a couple of times per week.

[0018] The warm, humidified air is passed through the air flow duct 18 into the evaporator 15, which is made up of ducts (not shown) where warm, humidified air and a refrigerant are led alternately in the ducts and the air flow is cooled down and dehumidified through heat exchange to the refrigerant.

[0019] The cooled, dehumidified air is then circulated from the evaporator 15 to the condenser 19, where the air flow is heated again through heat exchange with the refrigerant.

[0020] The warm air flow is then blown into the drying drum 11 again. The arrow 21 indicates the circulation of the air flow in the air flow circuit.

[0021] The refrigerant is lead through a refrigerant circuit, where a compressor 17 compresses the refrigerant, and where the refrigerant is condensed in the condenser 19 and vaporized in the evaporator 15 after passing an expansion valve (not shown).

[0022] The heat pump system 22, comprising the eva-

porator, the compressor 17 and the condenser 19 and the expansion valve, may be arranged behind the drying drum 11 and the fan arrangement 13, along the rear side 9 of the tumble dryer 1 and may be enclosed with an insulating shell 23 with openings to let the air flow in and out.

[0023] A constriction/diffuser 16 is arranged upstream the evaporator 15 in the air flow duct 18 as seen in figs 2 and 3. The constriction 16 is provided with a plurality of openings 23 (cf. figs 4 and 5), distributed over a cross section of the air flow duct 18 and thus over the surface of the evaporator 15.

[0024] The constriction 16 creates a pressure drop in the air flow that is circulated in the air flow duct 18, when the air flow flows from a first side A of the constriction 16 to a second side B of the constriction 16. By arranging a constriction 16 with openings in the air flow duct 18 upstream the evaporator 15, it becomes possible to allocate the air flow on a larger part of the evaporator 15 surface.

[0025] This leads to a more even distribution of the incoming air over the surface of the evaporator 15, i.e. the air flow variance over the evaporator surface becomes reduced as compared to if an unobstructed air flow duct 18 would be used. This in turn leads to a more effective dehumidification of the air flow can be obtained in the evaporator 15, a shorter drying time in the drying drum 11, higher performance and energy savings of the heat pump system 22. The area of the constriction 16 may take up the full cross section of the flow duct 18.

[0026] In an open duct without such a constriction the air flow would in most cases be concentrated to the area at the center of the duct and consequently to the corresponding center area of the evaporator by a turbulent flow. This would lead to inefficient use of the evaporator and thus less water would be extracted from the air flow. Additionally, if the evaporator has a number of parallel circuit tubes, refrigerant fluid in some tubes may be heated to an insufficient degree such that liquid refrigerant leaves the evaporator, which is undesired. Such problems can be avoided to a great extent with a constriction as described herein.

[0027] The distribution of the air flow across the surface of the evaporator 15 depends on the distance d between the constriction 16 and surface of the evaporator 15. To obtain the desired distribution, the distance d may be between 0-300 mm. Preferably a distance d between 10 mm and 40 mm is used.

[0028] Further, the percentage of openings 23 of the constriction 16 surface affects the distribution of the air flow over the surface of the evaporator 15. To obtain the desired air flow distribution over the surface of the evaporator, the percentage of openings depends on the size of the air flow duct 18 and hence the size of the tumble dryer 1. However, at least 1/3 of the constriction 16 surface may consist of openings 23 to provide the desired air flow distribution. As an example, for a small tumble dryer, 35% of the constriction 16 surface may be openings 23 and for a large tumble dryer, 50% of the constriction 16

surface may be openings 23. An individual opening may typically be around 3 mm.

[0029] The constriction 16 with a plurality of openings 23 may be designed in different ways. The shape of the constriction 16 may have the shape of a rectangular plate to fit in the air flow duct 18. Other alternative embodiments are possible as they fit with the corresponding design of the air flow duct 18.

[0030] Fig 4 shows one embodiment of a constriction 16, where the constriction 16 is a piece of sheet metal, such as stainless steel, with perforations. The perforations being evenly distributed over the sheet metal surface. The perforations can be made by punching of the sheet metal. Typically, the sheet metal piece thickness may be in the range 0,5-3 mm, preferably about 1 mm. The perforations may be e.g. circular or almost circular openings e.g. with about 3 mm diameter. The openings may have triangular spacings e.g. with 5 mm cc distances between adjacent openings in a triangular configuration. The entire sheet metal piece may be provided with openings in this way.

[0031] Fig 5 shows an alternative embodiment of the constriction 16, where the constriction 16 is a metal mesh, where metal wires have been arranged to form a grid with evenly spaced openings over the surface of the grid.

[0032] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. A tumble dryer (1) comprising a heat pump system (22) and an air flow circuit (21) for circulation of an air flow, the air flow circuit (21) comprising a condenser (19), a drying drum (11), a fan arrangement (13), an air flow duct (18) and an evaporator (15), wherein the air flow duct (18) comprises a constriction (16), with a plurality of openings (23), arranged upstream the evaporator (15), and is adapted to create a pressure drop in the air flow that is circulated in the air flow duct (18), wherein the drying drum comprises a circular rear wall with air inlet openings and a radial cylindrical wall with air outlet openings, wherein a space outside the radial cylindrical wall is configured as a duct leading to the constriction, and **characterised in that** the constriction (23) is a perforated plate.
2. Tumble dryer (1) according to claim 1, wherein the constriction (16) is provided with a plurality of openings (23), distributed over a cross section of the air flow duct (18), and is adapted to create a pressure drop in the air flow that is circulated in the air flow duct (18), when the air flows from a first side (A) of the constriction (16) to a second side (B) of the constrict-

tion (16), and wherein the openings (23) in the constriction (16) are adapted to distribute the air flow over a surface of the evaporator (15).

3. Tumble dryer (1) according to claim 1 or 2, wherein the openings (23) constitute at least 1/3 of surface of the constriction (16). 5
4. Tumble dryer (1) according to any of the preceding claims, wherein a distance (d) between the constriction (16) and the surface of the evaporator (15) is between 0-300 mm, preferably between 10 mm and 40 mm. 10
5. Tumble dryer (1) according to claim any of claims 1-4, wherein the perforated plate is a metal mesh. 15
6. Tumble dryer according to any of the preceding claims, wherein the rotatable drum (11) comprises a circular rear wall with air inlet openings and a radial cylindrical wall with air outlet openings. 20
7. Tumble dryer according to claim 6, wherein a space outside the drum's (11) cylindrical periphery is configured as a duct leading to a filter (12). 25
8. Tumble dryer according to claim 6 or 7, wherein a filter (12) is placed below the drum (11). 30

Patentansprüche

1. Wäschetrockner (1), umfassend ein Wärmepumpensystem (22) und einen Luftstromkreislauf (21) zur Zirkulation eines Luftstroms, wobei der Luftstromkreislauf (21) einen Kondensator (19), eine Trockentrommel (11), eine Gebläseanordnung (13), einen Luftstromkanal (18) und einen Verdampfer (15) umfasst, wobei der Luftstromkanal (18) eine Verengung (16) mit einer Vielzahl von Öffnungen (23) umfasst, der stromaufwärts des Verdampfers (15) angeordnet und so angepasst ist, dass er einen Druckabfall in dem Luftstrom erzeugt, der in dem Luftstromkanal (18) zirkuliert, wobei die Trockentrommel eine kreisförmige Rückwand mit Lufteinlassöffnungen und eine radiale zylindrische Wand mit Luftauslassöffnungen umfasst, wobei ein Raum außerhalb der radialen zylindrischen Wand als ein Kanal konfiguriert ist, der zu der Verengung führt, und **dadurch gekennzeichnet ist, dass** die Verengung (23) ein Lochblech ist. 35
2. Wäschetrockner (1) nach Anspruch 1, wobei die Verengung (16) mit einer Vielzahl von Öffnungen (23) bereitgestellt ist, die über einen Querschnitt des Luftstromkanals (18) verteilt sind, und so angepasst ist, dass sie einen Druckabfall in dem Luftstrom erzeugt, der in dem Luftstromkanal (18) zirkuliert, 40

wenn die Luft von einer ersten Seite (A) der Verengung (16) zu einer zweiten Seite (B) der Verengung (16) strömt, und wobei die Öffnungen (23) in der Verengung (16) so angepasst sind, dass sie den Luftstrom über eine Fläche des Verdampfers (15) verteilen.

3. Wäschetrockner (1) nach Anspruch 1 oder 2, wobei die Öffnungen (23) mindestens 1/3 der Fläche der Verengung (16) bilden. 10
4. Wäschetrockner (1) nach einem der vorhergehenden Ansprüche, wobei ein Abstand (d) zwischen der Verengung (16) und der Fläche des Verdampfers (15) zwischen 0-300 mm, vorzugsweise zwischen 10 mm und 40 mm, beträgt. 15
5. Wäschetrockner (1) nach einem beliebigen der Ansprüche 1-4, wobei das Lochblech ein Metallgitter ist. 20
6. Wäschetrockner nach einem der vorhergehenden Ansprüche, wobei die drehbare Trommel (11) eine kreisförmige Rückwand mit Lufteinlassöffnungen und eine radiale zylindrische Wand mit Luftauslassöffnungen umfasst. 25
7. Wäschetrockner nach Anspruch 6, wobei ein Raum außerhalb des zylindrischen Umfangs der Trommel (11) als ein Kanal konfiguriert ist, der zu einem Filter (12) führt. 30
8. Wäschetrockner nach Anspruch 6 oder 7, wobei ein Filter (12) unterhalb der Trommel (11) platziert ist. 35

Revendications

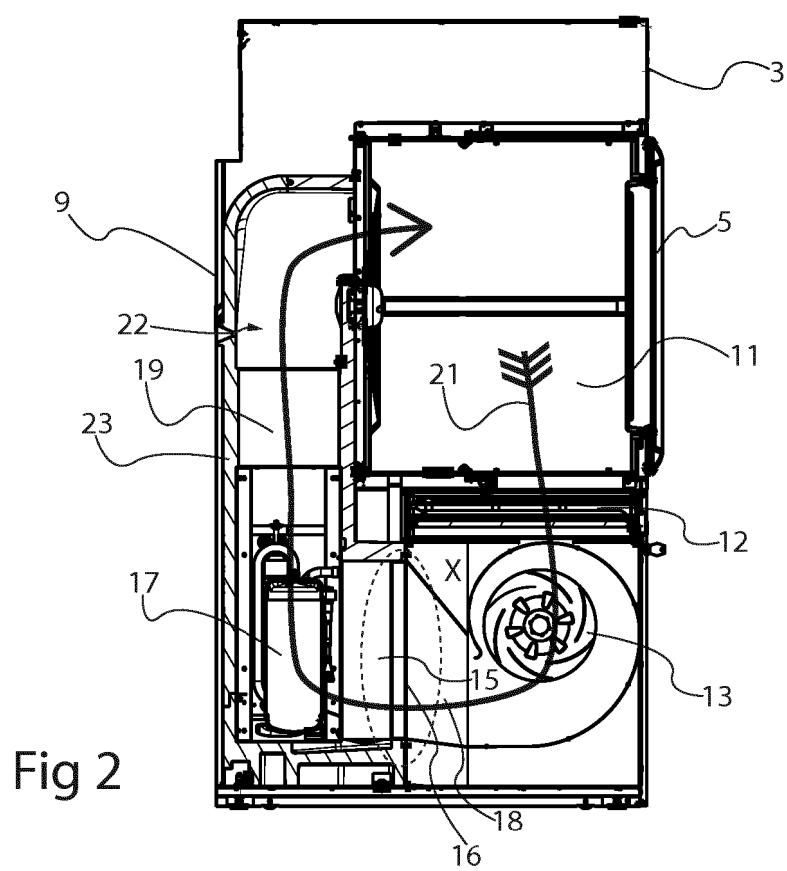
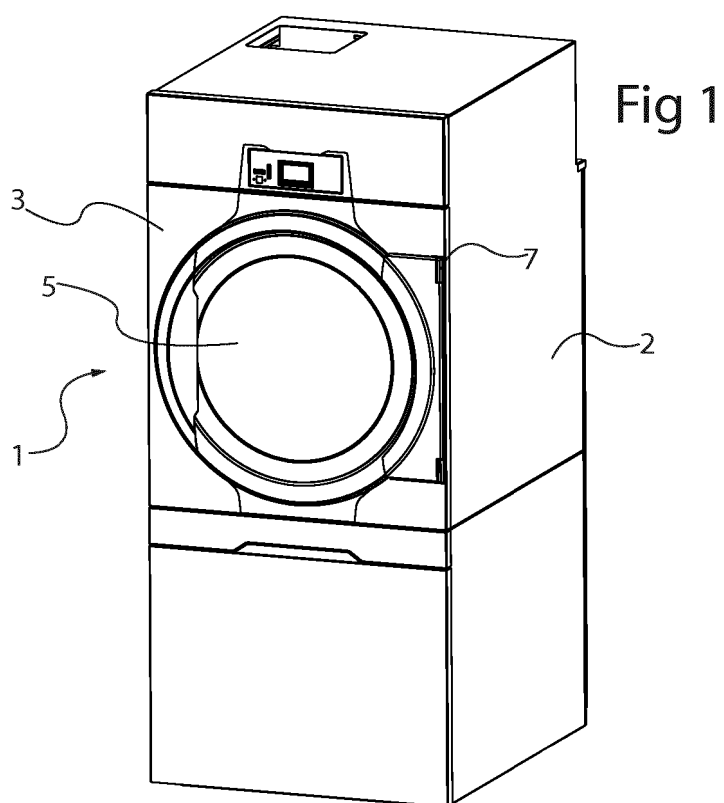
1. Sèche-linge (1) comprenant un système de pompe à chaleur (22) et un circuit de flux d'air (21) pour la circulation d'un flux d'air, le circuit de flux d'air (21) comprenant un condenseur (19), un tambour de séchage (11), un agencement de ventilation (13), une conduite de flux d'air (18) et un évaporateur (15), dans lequel la conduite de flux d'air (18) comprend un étranglement (16), avec une pluralité d'ouvertures (23) disposées en amont de l'évaporateur (15) et est adaptée pour créer une chute de pression dans le flux d'air qui est mis en circulation dans la conduite de flux d'air (18), dans lequel le tambour de séchage comprend une paroi arrière circulaire avec des ouvertures d'entrée d'air et une paroi cylindrique radiale avec des ouvertures de sortie d'air, dans lequel un espace à l'extérieur de la paroi cylindrique radiale est configuré comme une conduite menant à l'étranglement et **caractérisé en ce que** l'étranglement (23) est une plaque perforée. 40

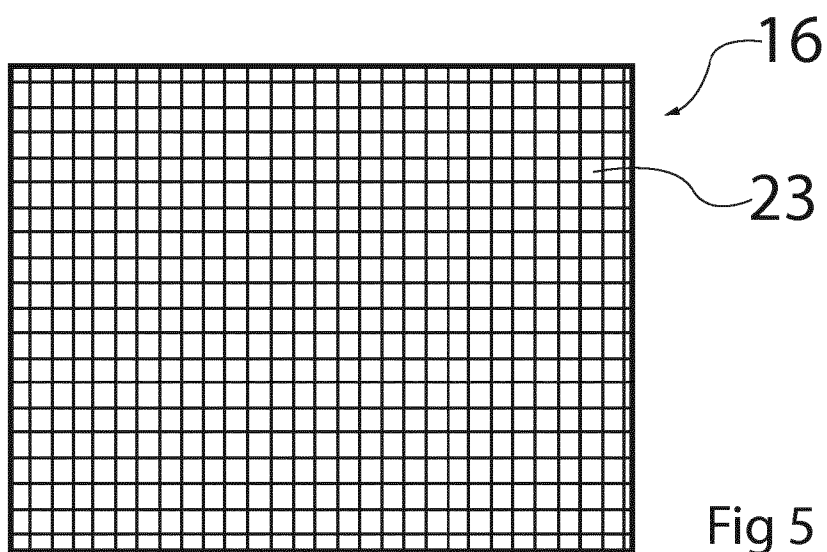
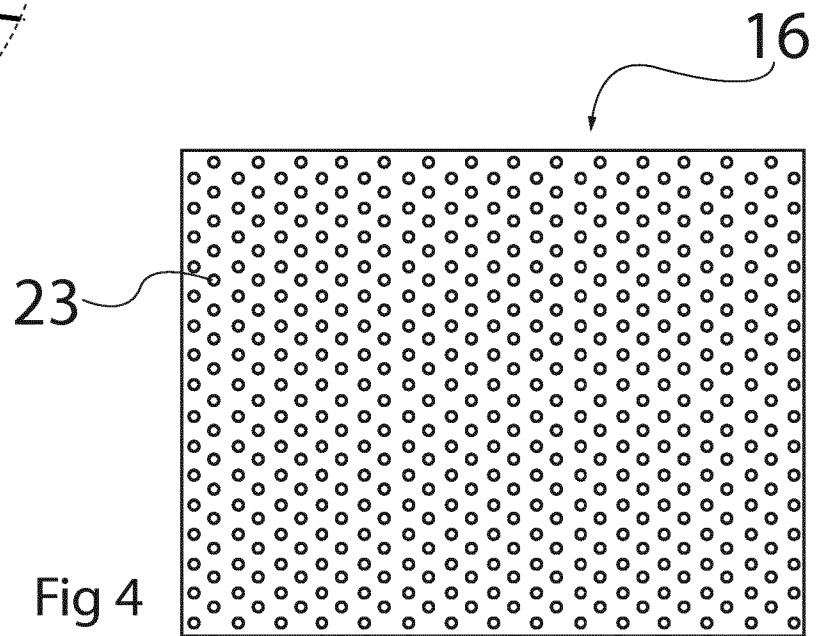
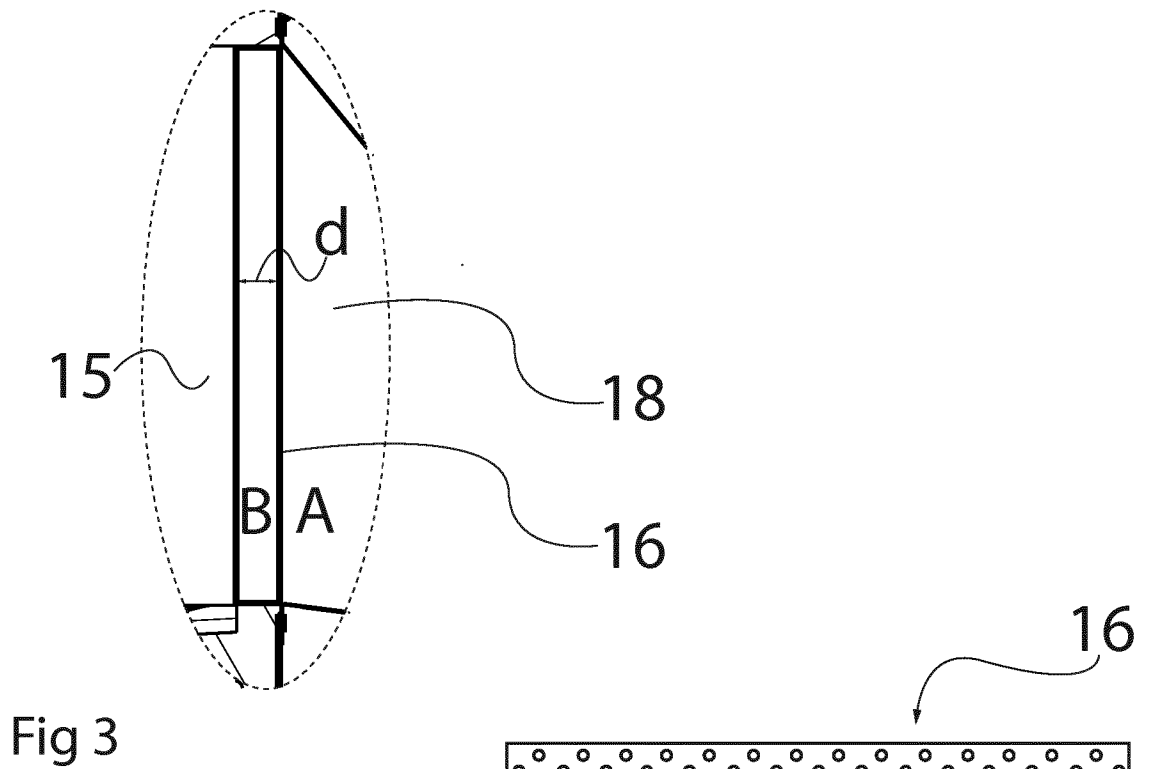
2. Sèche-linge (1) selon la revendication 1, dans lequel l'étranglement (16) est pourvu d'une pluralité d'ouvertures (23), distribuées sur une section transversale de la conduite de flux d'air (18) et est adapté pour créer une chute de pression dans le flux d'air qui est mis en circulation dans la conduite de flux d'air (18), lorsque l'air circule d'un premier côté (A) de l'étranglement (16) à un deuxième côté (B) de l'étranglement (16) et dans lequel les ouvertures (23) dans l'étranglement (16) sont adaptées pour distribuer le flux d'air sur une surface de l'évaporateur (15). 5 10
3. Sèche-linge (1) selon la revendication 1 ou 2, dans lequel les ouvertures (23) constituent au moins 1/3 de la surface de l'étranglement (16). 15
4. Sèche-linge (1) selon une quelconque des revendications précédentes, dans lequel une distance (d) entre l'étranglement (16) et la surface de l'évaporateur (15) est comprise entre 0 et 300 mm, de préférence entre 10 mm et 40 mm. 20
5. Sèche-linge (1) selon une quelconque des revendications 1 à 4, dans lequel la plaque perforée est une maille métallique. 25
6. Sèche-linge selon une quelconque des revendications précédentes, dans lequel le tambour rotatif (11) comprend une paroi arrière circulaire avec des ouvertures d'entrée d'air et une paroi cylindrique radiale avec des ouvertures de sortie d'air. 30
7. Sèche-linge selon la revendication 6, dans lequel un espace à l'extérieur de la périphérie cylindrique du tambour (11) est configuré comme une conduite menant à un filtre (12). 35
8. Sèche-linge selon la revendication 6 ou 7, dans un filtre (12) est placé au-dessous du tambour (11). 40

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REFERENCES CITED IN THE DESCRIPTION

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