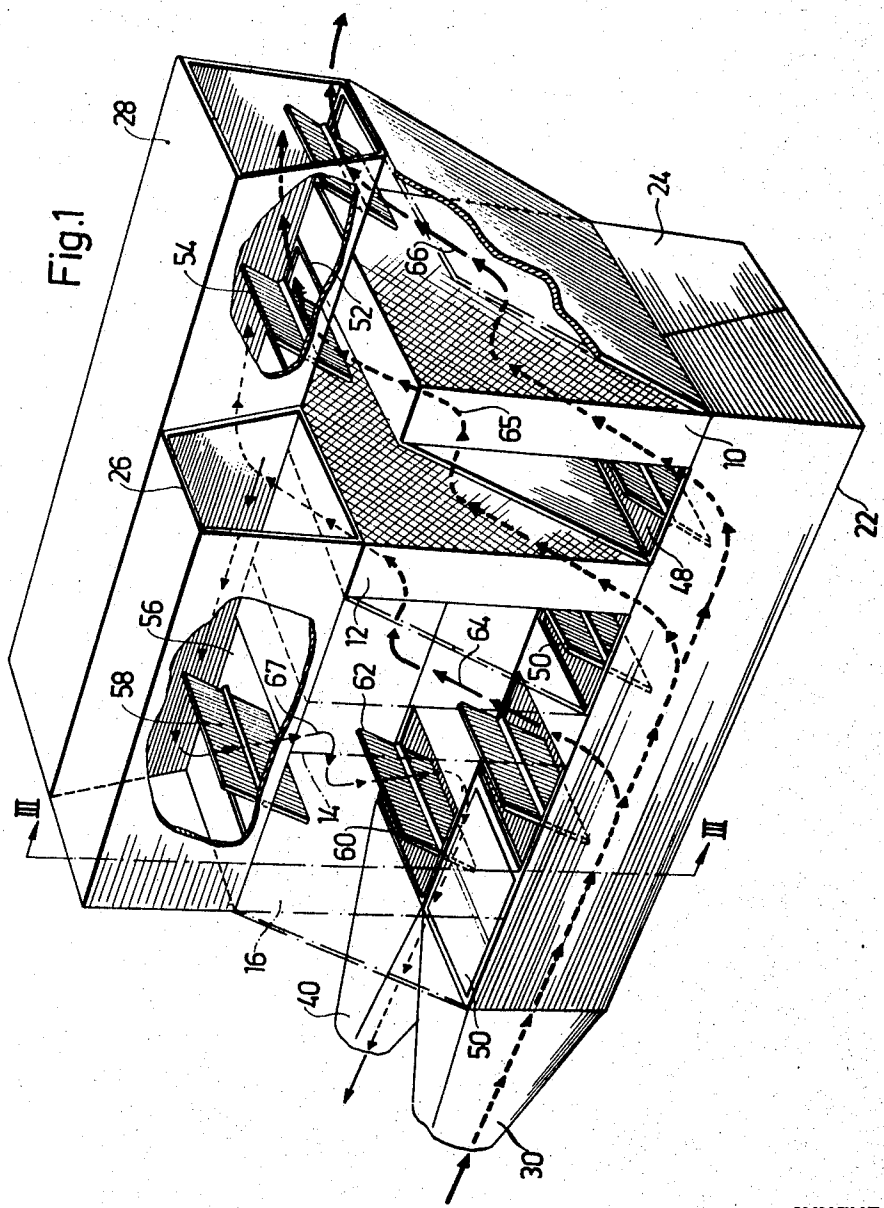
Feb. 13, 1968 C. G. MUNTERS ETAL 3,368,327

REGENERATIVE MOISTURE EXCHANGER FOR GASEOUS MEDIA

Filed June 29, 1965

3 Sheets-Sheet 1

Fig.1



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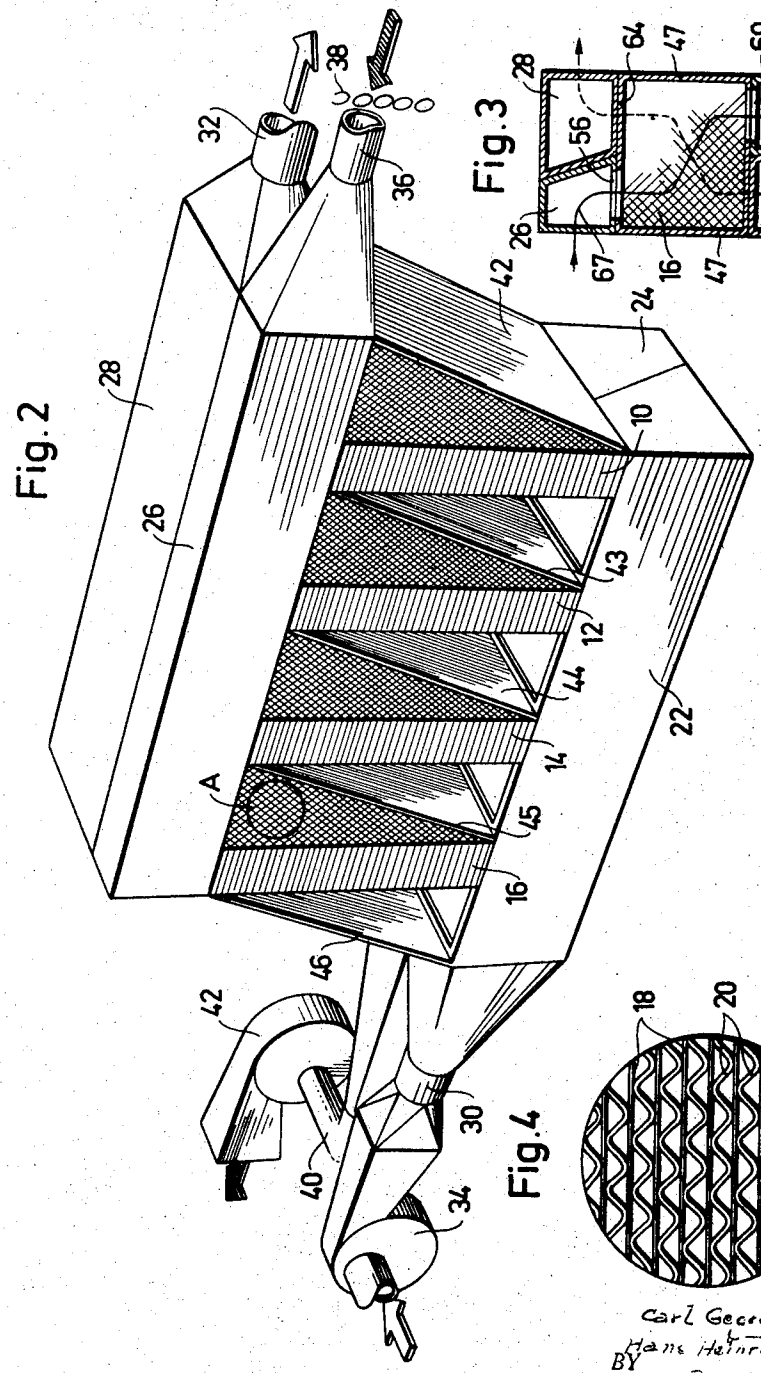
Filed June 29, 1965 3 Sheets-Sheet 2



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3 Sheets-Sheet 3

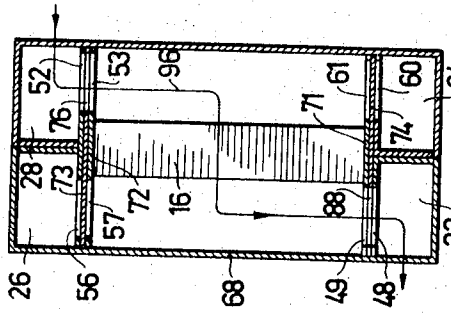

Fig.6

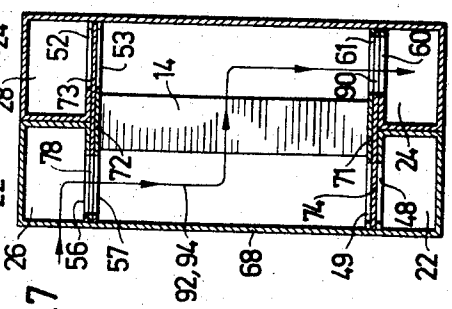

Fig.7

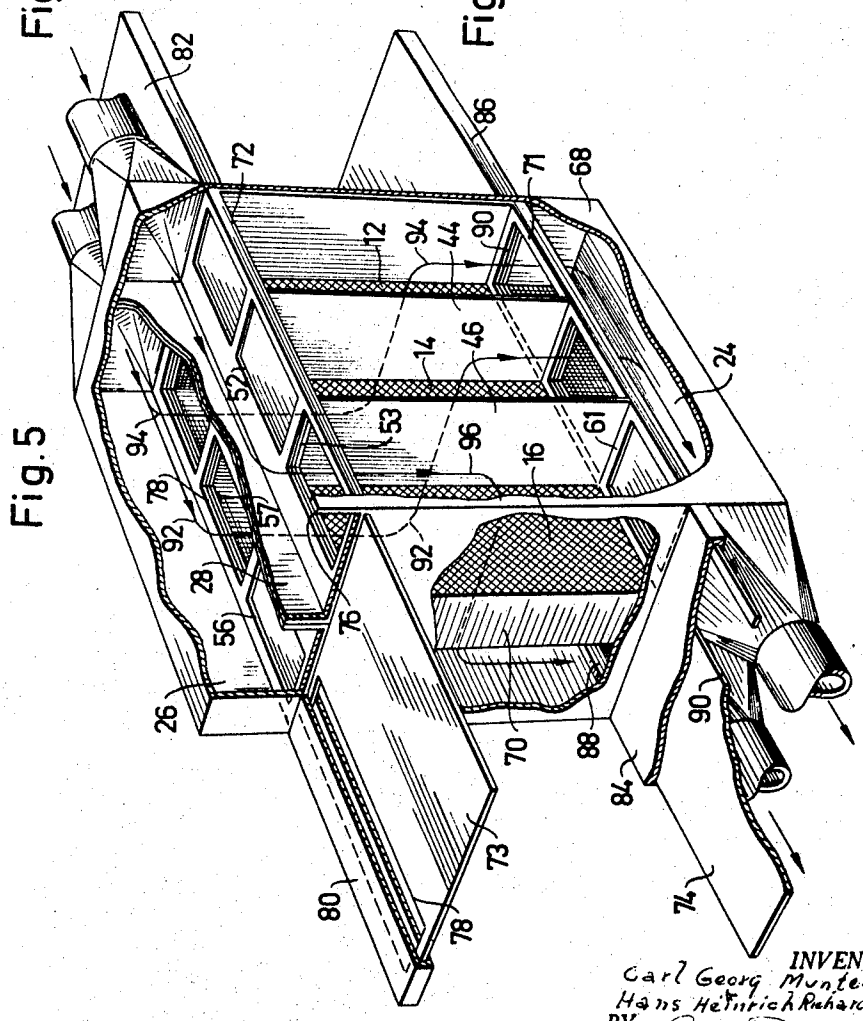

Fig.5

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REGENERATIVE MOISTURE EXCHANGER FOR GASEOUS MEDIA

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5 Claims. (Cl. 55—179)

This invention relates to a regenerative moisture exchanger for gaseous media.

More particularly this invention relates to a regenerative moisture exchanger for gaseous media, primarily two air streams of different temperatures and moisture contents. The moisture exchanger has an exchanger body or packing provided with means having hygroscopic properties, which alternately are passed by an air stream to be dried or dehumidified and an air or gas stream for regeneration or reactivation of the exchanger body or packing after that the same has separated a predetermined quantity of moisture from the first-mentioned stream. It is known to provide a moisture exchanger of this kind with at least three inlets and outlets for the two media and with sections of the exchanger body or packing corresponding thereto, which sections are stationary, valve members for alternate guiding of the media through the sections being provided in the inlets and outlets respectively.

One main object of the invention is to provide a moisture exchanger of this kind, and one which is particularly suited for very large air quantities per unit time for which thus the otherwise usual construction with a rotatable exchanger packing would result in enormous dimensions, whereas on the other hand a subdivision into a plurality of minor rotatable units should cause complications.

Further objects and advantages of the invention will become apparent from the following description considered in connection with the accompanying drawings which form part of this specification and of which:

FIG. 1 is a perspective view of a moisture exchanger constructed according to the invention and with parts removed and other parts broken away for clarity.

FIG. 2 is another perspective view of the same moisture exchanger with an enclosing casing removed.

FIG. 3 is a cross-section of the moisture exchanger following the line III—III of FIG. 1 in a reduced scale.

FIG. 4 shows the portion encircled by the circular line A in FIG. 2 of an exchanger packing, represented in a larger scale.

FIG. 5 is a perspective view of another embodiment of the invention with parts broken away.

FIGS. 6 and 7 are two cross-sectional views of this moisture exchanger of FIG. 5.

In the various embodiments the same reference numerals have been used for equivalent parts.

In the embodiment according to FIGS. 1–4 the moisture exchanger has exchanger bodies or packings **10**, **12**, **14**, **16**, which are disposed in parallel and mutually spaced relationship. The number of exchanger packings may vary depending on the desired capacity of the moisture exchanger. In the embodiment shown the exchanger has four packings. Each exchanger packing may be in the form of a body of square shape having thin layers arranged within a frame or the like, which layers according to FIG. 4 may be alternately plane and corrugated. The plane layers **18** and the corrugated layers **20** bear against one another and are suitably connected with one another along the ridges of the corrugations. The layers or sheets **18**, **20** are preferably of fibrous, and if desired, inorganic material such as asbestos to obtain best efficiency. The

mutual average spacing between the layers must be small, such as less than 1.5 millimeters. The spacing between two plane layers **18**, will then become less than 3 millimeters, such as 1–2 millimeters. The asbestos layers are further impregnated with a hygroscopic substance such as lithium chloride. Regarding the structural features and the manufacture of the exchanger packings reference is made to the co-pending United States patent applications Ser. No. 164,880 filed Jan. 8, 1962, now Patent No. 3,231,409 and 254,131 filed Jan. 28, 1963, now Patent No. 3,307,617.

The sheets or layers **18**, **20** form channels extending from end to end between the broad sides of the packings. The dimensions of the exchanger packings or bodies in the longitudinal extension of the channels may amount to 200 to 300 millimeters.

The exchanger packings **10** to **16** stand on two elongated boxes **22**, **24** and two elongated boxes **26**, **28** are disposed over the tops of said packings. The left-hand lower box **22** according to FIGS. 1 to 3, is connected through a fan **34** and a conduit **30** with an inlet for the air stream to be dried. This conduit may also be connected to an inlet for fresh air or to a space or room, the air of which is to be dried to a predetermined moisture content. The dried or conditioned air passes through the box **28** and a tubular exhaust piece **32** to that space or room in which the moisture content of the air is to be controlled. To the left-hand upper box **26** air is supplied through an intake **36** in which air has been preheated by a heater **38** or similar device so that the air attains a low relative moisture content and becomes capable in a corresponding degree to regenerate or reactivate the exchanger packings. The regenerating air escapes through the right-hand lower box **24** to a conduit **40** connected to a fan **42**. The consumed regenerating air may be exhausted into the surrounding atmosphere. Within the fresh air passages comprising the boxes **22**, **28**, a higher pressure is maintained than in regenerating air circuit, so that possible leakage of air occurs in the direction towards said circuit, for which reason the air contained therein is prevented from intermixing with the fresh air.

The exchanger packings **10** to **16** are separated from one another by inclined walls **42**, **43**, **44**, **45**, **46**. The partition walls **43** to **45** thus subdivide each interspace between the exchanger packings into two compartments, which extend over the total facial areas of the packings and have a breadth variable in a vertical direction. At the short sides of the packings, walls **47** made of sheet material are provided (FIG. 3). The left-hand box **22** is at its top side formed with recesses or openings **48** in its top, having at least one recess or opening for each exchanger packing, which recesses house valve members, such as pivoted flaps **50**. Furthermore, the upper right-hand box **28** has in base side recesses or openings **52** adjacent each exchanger packing. Provided in said recesses or openings are valve members such as pivoted flaps **54**. The upper left-hand box **26** on the regeneration side has recesses or openings **56** provided with valve members such as flaps **58** and the same structure is present in the right-hand box **24**, the recesses or openings of which are indicated at **60** and the flaps thereof **62**. The flaps are not shown in FIGS. 2 and 3.

Referring to FIG. 1, the flaps **50** located at the base to the left of each of the three exchanger packings **10**, **12**, **14**, are shown in open position, which is also the case with the flaps **54** in the upper right-hand box **28**. The result is that air sucked into the channel **30** by the fan **34** is urged upwards through the recesses **48** of the box **22** and thereupon enters the compartments thereabove, which on the left-hand side of FIGS. 1 and 2 are confined by the intermediate walls **43**, **44** and **45**, respectively.

The air passes now through the exchanger packings 10, 12, 14 over the entire front area thereof in three partial streams, which thereupon are collected in the right-hand upper box 28 and escape into the space or room to be conditioned. The partial streams are indicated by lines 64, 65, 66. In this embodiment are thus three exchanger packings operative for the drying of the air. The fourth exchanger packing 16, is, however, sealed against the boxes 22 and 28 due to the fact that the flaps 50 and 54 adjacent said exchanger packing are closed. Instead the flap 58 in the upper left-hand box 26 adjacent the exchanger packing 16, is in open position and so is also the remotest flap 62 in the right-hand lower box 24. The result is that simultaneously with the drying of three partial streams in the exchanger packings 10, 12, 14, the exchanger packing 16 is regenerated or reactivated by being passed by heated air which has a low relative moisture content. The regenerating air expels the moisture absorbed by the layers of the exchanger packing and is discharged through the channel 40. The regenerating air flows according to line 67 in a direction opposite to the air to be dried. It will become clear from the above that both kinds of streams upon introduction into the compartments in front of the exchanger packings are capable of becoming distributed over the entire front areas of the same.

After some time the reactivated exchanger packing 16 is connected to the drying air system by the opening of the co-operating flaps 50, 54 and the closing of the apertaining flaps 58, 52. Instead, that exchanger packing which during the longest time has been active in the drying operation is shut off from the drying air system by re-adjustment of its flaps instead of being passed in countercurrent by the hot regenerating stream. In this way a repeated resetting of the flaps is brought about at suitable time intervals so that permanently the greater number of exchanger packings is operative in the drying of the utilizable air, whereas one packing or a minor number of packings are subjected to reactivation.

In the embodiment according to FIGS. 5 to 7, a surrounding casing 68 encloses three packing sections 12, 14, 16, which on both sides are separated from one another by partition walls 44 and 46 projecting in this case perpendicularly to the sections. The sections are placed side by side and may together form an elongated body 70 extending through the whole moisture exchanger.

Positioned below and above the sections of the exchanger body are in the same manner as in the preceding embodiment are elongated boxes 20, 24, 26, 28, the sides facing one another being formed with openings or holes 48, 60, 56 and 52, respectively, laterally of each section. To these apertures or holes correspond openings or holes 49, 61, 57, 53 in the partition walls 71 and 72, respectively. The streams of air or gas are guided through the sections by means of plate-like slides 73, 74, which are slidably fitted in slots formed by the boxes and the walls 71, 72 at the upper and lower portions of the moisture exchanger. Each disc slide has apertures on both sides laterally of the exchanger body 70. Thus the disc slide 73 is provided on one side with a central aperture or opening 76 and on the other side with two lateral apertures or openings 78. The apertures 78 are disposed in spaced relation to one another externally of the aperture 76 and their length is double of that of last-mentioned aperture. Therefore, the disc slides obtain a length which, with two graduation steps, exceeds the total length of the three sections of the exchanger body 70. The valve slides 73 and 74 are at their ends enclosed by stationary casings 80, 82 and 84, 86, respectively, each of said casings having a length equal to two sections. The casing form slots which counteract lateral leaking out of air from the interior of the apparatus.

As represented in FIG. 5, the valve slide 73 has its opening 76 registering with the openings 53, 54 and thus the channel 28 is in communication with the compartment in front of the section 16, whereas the two remaining secions 12 and 14 are shut off from said channel. On the other side of the exchanger body 70 the one lateral opening 78 of the disc slide 73 is positioned straight in front of the sections 12 and 14 for which reason these sections are in communication with the box 26.

The disc slide 74 is formed in the same manner but its openings are mirror-reversed relatively to the openings or apertures of the disc slide 73. Thus the central short opening 88 of the disc slide 74 registers with the openings 48, 49 of the channel 22 and in this way connects this channel with the compartment in front of the section 18. On the opposite side of the exchanger body 70 the one elongated opening 90 of the disc slide 74 registers with the openings 60, 61, which are positioned between the compartments straightly in front of the sections 12, 14 and the channel 24.

Thus two of the sections of the exchanger body will always be passed by the air to be dried while one section is being regenerated by the hot reactivating gas. When the slides 73, 74 are set as shown in FIG. 5 the sections 12 and 14 will be transgressed according to lines 92, 94 by the air to be dried and the section 16 by the reactivating gas as indicated by line 96. By subsequently displacing both disc slides 73, 74 by one graduation step to the right, viewed according to FIG. 5, the flow paths are readjusted so that the central openings 76, 88 are located straight in front of the section 14 which now is regenerated. On either side thereof the two elongated openings 78 of the disc slide 73 will register with its pertaining section 12 and 16, respectively. The same is the case with the elongated openings 90 of the disc slide 74. These sections will thus be operative for drying or conditioning of air which enters through the channel 26 and escapes through the channel 24.

By displacement of the valve slides 73, 74 by still one graduation step to the right according to FIG. 5, their central openings 76 and 88, respectively, will be located straightly in front of the section 12, which is regenerated thereby. At the same time the left-hand elongated openings 78, 90 open connection between the channels 26, 24 and the sections 14, 16 which thereby become operative for the drying of fresh air. The right-hand elongated openings 78, 90 are located within the casings 82 and 86, respectively and are thus out of operation. By the next following resetting the positions of the individual parts as shown in FIG. 5 are restored and so on.

The valves may be reset by means of servomotors which are driven by a pressure fluid or by electricity. The resetting may be caused to take place automatically at regular time intervals or in response to hygrostates scanning the moisture content in one of or both air and gas streams.

In the embodiment according to FIGS. 5 to 7 the displacements of the disc slides shall take place intermittently. By providing a great number transverse walls 44, 46 with small space between them the displacements of the slides may be made continuous since minor strips of the sections are set free and sealed off each time by the slide openings.

The embodiment according to FIGS. 1 to 4 may be modified so that the partition walls 43, 44, 45 are modified to form valve flaps turnable about horizontal axes located approximately at the middle portion of said walls. These flaps are then caused to assume either the position shown in FIGS. 1 and 2 or a crossing position where they instead extend obliquely upwards to the left. In this way the valve system may be simplified substantially. The flaps may further be combined with plates articulated at their upper and lower edges and adapted to lay open or cover the openings in the boxes 22, 24, 26, 28 in the sequence described above.

While several more or less specific embodiments of the invention have been shown and described, it is to be un-

derstood that this is for purpose of illustration only and that the invention is not to be limited thereby but its scope

What we claim is:

1. A regenerative moisture exchanger for gaseous media comprising at least three sections of hygroscopic exchanger body inlets and outlets for the media, the sections being mounted stationarily and in spaced relationship to each other, valves arranged in the inlets and outlets for alternately directing the media through the sections, a common housing in which the sections are arranged in their spaced relationship, each of said sections being composed of substantially parallel thin sheets which co-operate in forming a plurality of passages extending between opposing faces of the sheets, said sheets being impregnated with a hygroscopic substance, said sheets having a substantially larger dimension in the surface extension of their flat sides than in the longitudinal direction of the passages between the sheets, the exchanger body and portions of the housing defining chambers between said body and housing, said chambers being connected in pairs over the exchanger passages, the inlets and outlets including casings connected to the housing, said casings extending transversely across all of the chambers, said casings having openings facing the chambers, and valve members provided for said openings in the wall portion of the casing facing the chambers.

2. A regenerative moisture exchanger according to claim 1 and characterized by the fact that the exchanger sections are spaced from one another with their flat faces directed toward one another, the chambers being arranged in pairs in the intermediate spaces between the sections.

3. A moisture exchanger according to claim 2, characterized by the fact that one pair of casings is arranged on each of two opposing short sides of the exchanger sections.

4. A moisture exchanger according to claim 3, characterized by the fact that the inlet and outlet casings connect to fans and are so arranged with respect to the chambers that two gaseous media pass simultaneously through the passages of the sections in counter-current relationship.

5. A moisture exchanger according to claim 4, characterized by the fact that the inlet casing for the air which is to be dried is connected with the pressure side of one of the fans while the outlet casing for the regenerating stream is connected to the suction side of the other fan so that a higher pressure will prevail in those sections where the drying takes place as compared with the sections which are simultaneously regenerated.

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