

June 4, 1963

PER-OSKAR PERSSON

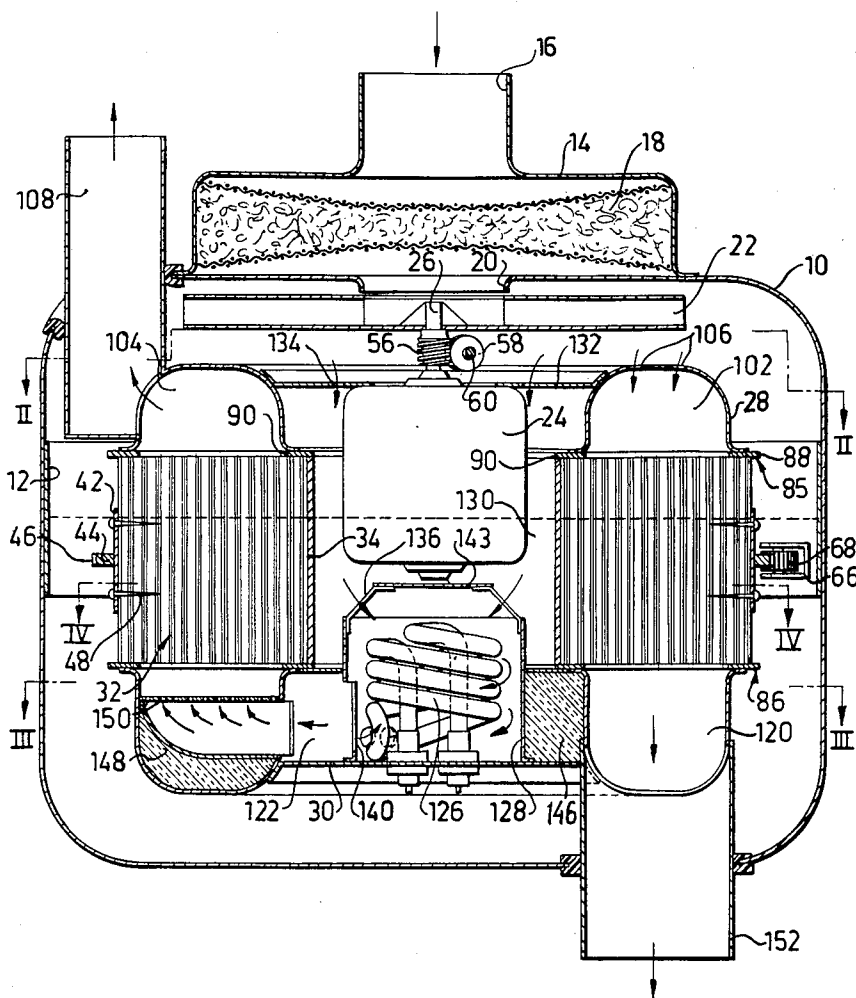
3,092,477

AIR CONDITIONING APPARATUS

Filed July 18, 1958

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Fig. 1



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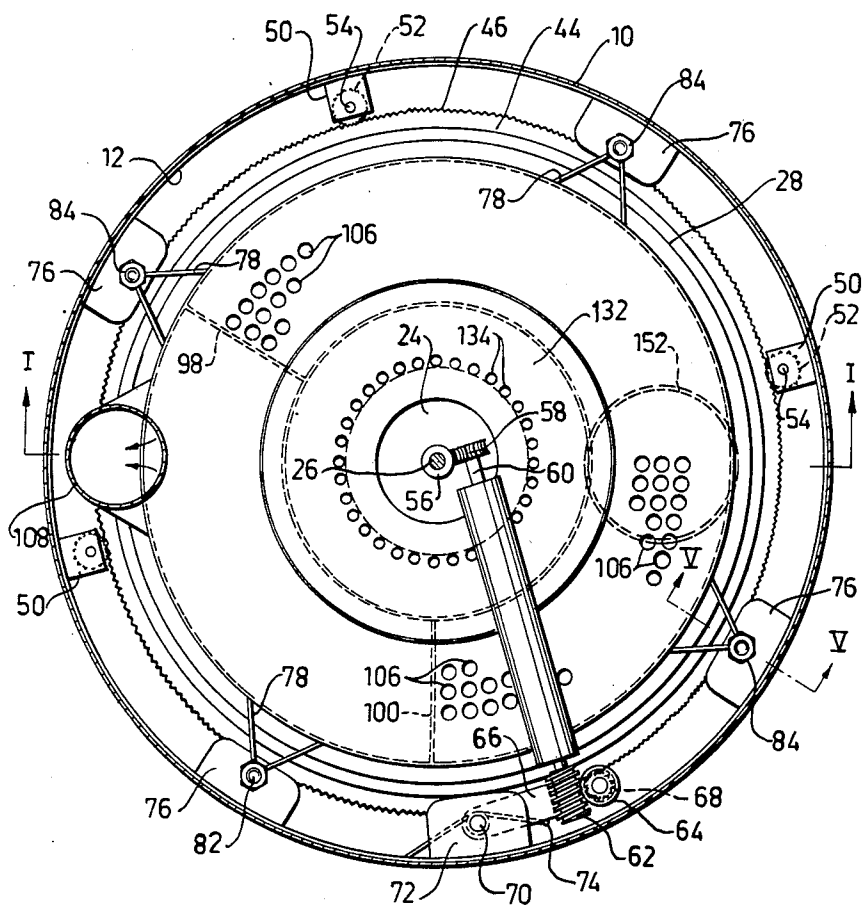
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Fig. 2



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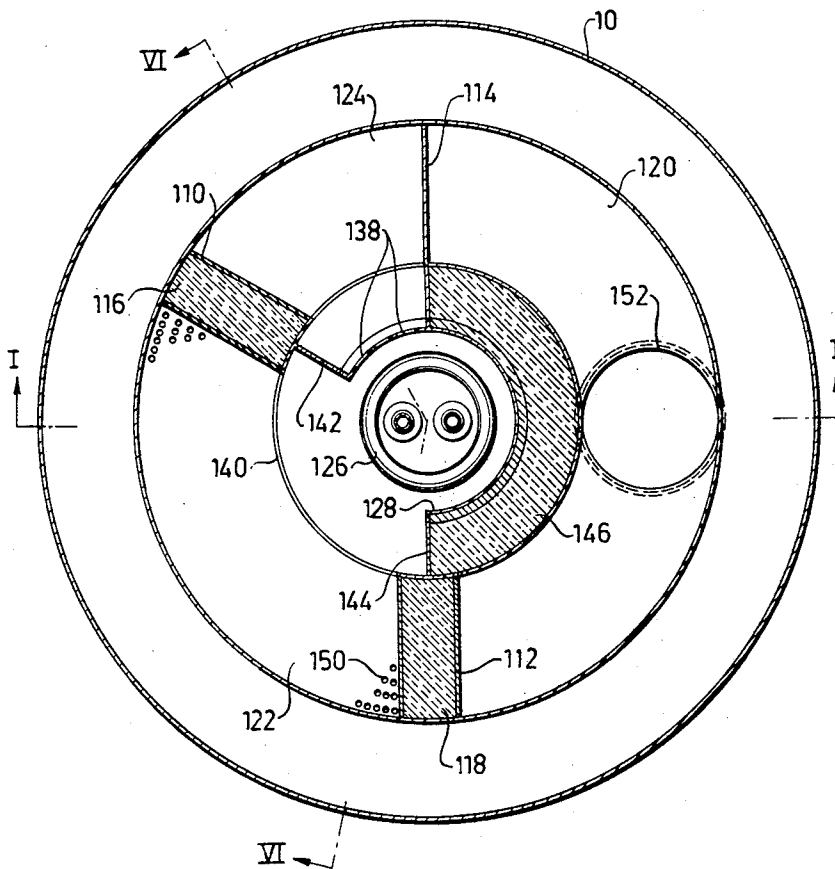
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Fig. 3



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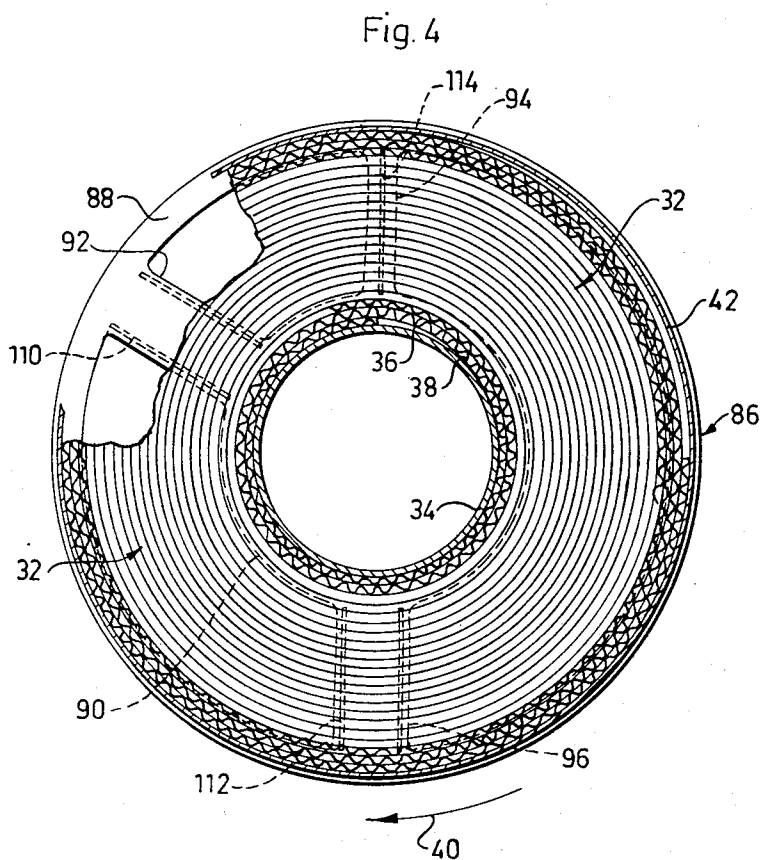
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Fig. 6

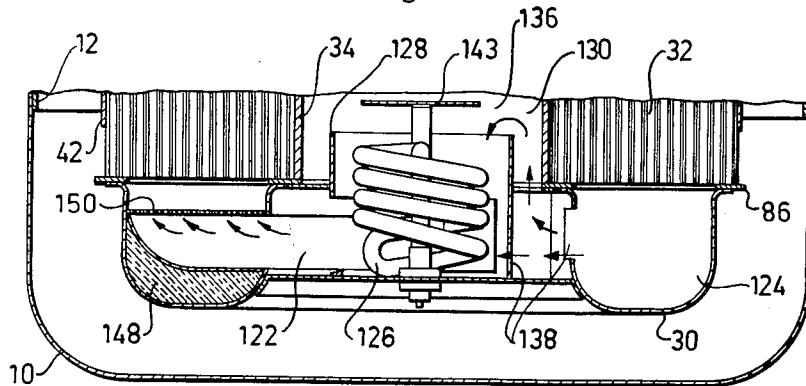


Fig. 5

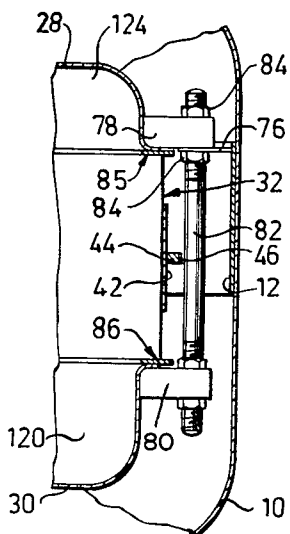
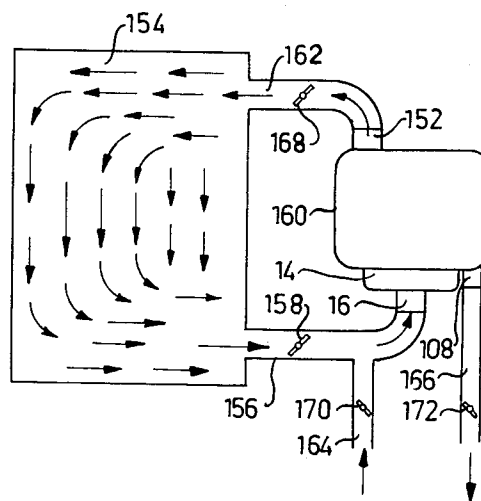


Fig. 7



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## AIR CONDITIONING APPARATUS

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2 Claims. (Cl. 55-196)

The present invention relates to an apparatus for conditioning one air stream by means of a second air stream. This conditioning is intended to be in the nature of a drying of the first air stream which has a higher relative humidity than the second air stream. The apparatus includes a casing in which a disc-shaped rotor is mounted, and the casing preferably includes a plurality of thin partitions forming axially-extending passages, and the rotor moves cyclically between two of such passages, one of the passages being traversed by the first air stream and the other passage by the second stream. In the event that the first air stream is to be dried, the second air stream should consist of air which has a lower relative humidity, and which is preferably attained by a heating device arranged in said stream for heating the same before it passes through the rotor. The sheets or partitions are preferably composed of a non-metallic, fibrous material such as asbestos which, when intended for use in a drying apparatus, is preferably inorganic in order to be able to withstand the temperatures to which either of the air streams are heated. Furthermore, the sheets for use in such a drying apparatus should be hygroscopic, i.e., impregnated with a hygroscopic substance, preferably a salt, such as lithium bromide.

The ducts or passages provided in the rotor packing are suitably formed by corrugating at least every other sheet or providing them with undulations or the like.

In some instances it is of special advantage to make the ducts narrow by spacing the sheets or layers, which form the same, from one another for an average distance of the order of 1.5 mm. and preferably less than 1 mm. This results in a high transfer coefficient and an increased capacity per unit of volume of packing.

One of the objects of the invention is to provide a continually-functioning apparatus of the kind described, and one which is compact in construction; one which possesses a high capacity in proportion to its volume; which has a high transfer coefficient and which is simple and reliable in operation.

These and other objects are attained by the described apparatus, a more particular description of which will appear hereinafter and be set forth in the claims appended hereto.

In the accompanying drawings, wherein an illustrative embodiment of the invention is disclosed,

FIG. 1 is a longitudinal sectional view through a drying apparatus constructed according to the invention, the view being taken along the line I—I in FIGS. 2 and 3;

FIGS. 2, 3 and 4 are respectively cross sectional views taken along the lines II—II, III—III and IV—IV in FIG. 1;

FIG. 5 is a partial sectional view of the apparatus taken along the line V—V in FIG. 2;

FIG. 6 is a longitudinal sectional view of the lower portion of the apparatus taken along the line VI—VI of FIG. 3, and

FIG. 7 is a schematic view showing the connection of the apparatus to a room in which the air is to be dried or de-humidified.

Referring to the drawings, the reference numeral 10 indicates a substantially cylindrical casing which is divided centrally into two halves held together by means of a coupling ring 12. At one side of the casing is a

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manifold 14 having a central duct 16, and in which a filter 18 is mounted for the purification of the incoming air stream. Inside of a central opening 20 at the same side of the casing, located a centrifugal fan 22 which is journaled on the axle 26 of an electric motor 24.

Within the casing 10 is mounted an upper manifold 28 and a lower manifold 30 and between these two manifolds is located a rotor, generally indicated by the reference numeral 32. This rotor consists of an asbestos sheet spirally wound on a hub 34, and which sheet comprises alternating plain layers 36 and corrugated layers 38 with the corrugations thereof extending axially as will appear from FIG. 4. In this manner axially-extending ducts or passageways are formed between the layers and which are separated from one another peripherally.

In this construction of the rotor, a plain and a corrugated web are joined together by means of an adhesive, such as water-glass, which is applied along the ridges or apices of the corrugations. These joined webs are then wound on the hub 34 without the windings or turns being joined together. The direction of the winding is opposite to the direction of rotation of the rotor, according to the arrow in FIG. 4. About the periphery of the rotor is a rim 42 having a width less than the width of the packing, and which is provided with a central rib 44 having a toothed outer edge 46. A number of pins 48 (FIG. 1) extend through the rim and into the packing and serve to hold the rim 42 about the periphery of the packing.

On the coupling ring 12 are mounted a number of bearing brackets 50, in the present case three in number, (FIG. 2) and these brackets are spaced from one another at an angle of approximately 90 degrees. In these brackets are gear 52 journaled on spindles 54. These gears 52 are so toothed that they mesh with the teeth 46 of the rib 44, and this arrangement serves to center the rotor 32 radially.

The axle 26 carries a worm 56, which engages the worm gear 58 on an axle 60. The axle 60 projects beyond the periphery of the rotor 32, where it carries a worm 62 which engages a worm gear 64 journaled on the free end of an arm 66. The worm gear 64 meshes with a gear 68 in driving engagement with the teeth 46 of the rib 44. The arm 66 is pivotally mounted on a spindle 70, which in turn is mounted in a bearing block 72 secured to the coupling ring 12. A torsion spring 74 has one end contacting against the coupling ring 12 and its other end in contact with the arm 66 and with its central portion wound around the spindle 70. This spring 74 urges the arm 66 and the gear 68 toward the rib 44 so that the teeth of gear 68 will be in driving arrangement with the teeth 46 of rib 44. The arm 66 is at right angles to the axle 60 so that possible radial displacement of the gear 64 will cause as little change as possible in the engagement of the worm 62 with the gear 64. The urge of the spring 74 is preferably so strong that the gear 68 will serve as a fourth bearing for the radial centering of the rotor. If desired, a bearing wheel, such as those shown at 50 may be provided adjacent to the gear 68. The transmission ratio is so arranged that the rotor 32 revolves very slowly, such as on the order of 2 to 15 revolutions per hour.

The coupling ring 12 carries a number of brackets 76 (in the illustration of FIG. 2, four in number) and the manifolds 28 and 30 carry angular struts 78 and 80 (FIG. 5). Bolts 82 extend axially between the struts 78 and 80 as well as through the brackets 76 and these bolts are held in place between the struts 72 and the brackets 76 by means of the nuts shown at 84. Between the rotor 32 and the manifolds 28 and 30 are disc-shaped sealing members, generally indicated by reference numerals 85 and 86 respectively. Each of these sealing members con-

sists of an outer ring 88 and an inner ring 90 and which rings are connected to one another by means of struts or spokes. The lower sealing member 86 has three spokes 92, 94 and 96 (FIG. 4) while the sealing member 85 has only two spokes shown at 92 and 96, and which form the same angle with respect to one another as in the sealing member 86. The rotor 32 is held in its axial position between the sealing members 86 with the aid of the manifolds 28 and 30, and by the bolts 82 and the nuts 84 holding the elements together. The sealing members 85, 86 have plain and preferably polished surfaces against which the packing bears during the rotation of the rotor.

The upper manifold 28 is divided into two chambers 102, 104 by means of two radial walls or partitions 98 and 100 (FIG. 2). The partitions or walls 98 and 100 are located directly opposite to the spokes 92 and 96 of the upper sealing means 85. The chamber 102 is connected with the room by means of perforations 106 in its wall facing the pressure side of the fan 22. The chamber 104 is connected to a conduit 108 which leads to a chimney communicating with atmosphere. The lower manifold 30 is provided with radial partitions 110, 112 which are located opposite the partitions 98, 100 in the upper manifold, and another partition 114, which might be located substantially diametrically opposite the partition 112. The partitions 110 and 112 respectively include layers 116, 118 of an insulating material such as mineral wool. The three spokes 92, 94 and 96 of the lower sealing members 86 are located directly opposite the partitions 110, 114 and 112 respectively. Thus, as shown in FIG. 3, the lower manifold will have three chambers, 120, 122 and 124, of which the chamber 120 will be located axially directly opposite the upper chamber 104 while the chambers 122, 124 together extend over about the same angle as and are located opposite the upper chamber 102.

A suitable heating element 126 is surrounded by a cover 128 and the heating element and its cover are partly housed in the radial space 130 in the central opening of the rotor. The motor 24 also extends partly into this space. A plate 132 on the upper manifold 28 is provided with perforations 134, through which the pressure side of the fan 22 communicates with the space 130. A small amount of the air impelled by the fan in the apparatus passes through these openings 134 and flows about the motor 24, which is thereby cooled simultaneously as this flow is heated.

Thereafter, the flow of air passes through an opening 136 in the cover 128 to the heating element 126. The chamber 124 is connected with the cover 128 by means of the relatively small openings 138 and partly by means of the upper opening 136 as will be observed in FIG. 6. The side of the cover facing the chamber 122 is open, as indicated at 140 in FIG. 3, while at the same time the radial partitions 142, 142 prevent an overflow to the chamber 124 or to an insulating layer 146 located between the chamber 122 and the cover. A similar insulating layer 148 is located under the chamber 122. This chamber has a perforated plate 150 in front of the rotor 32. A conduit 152 leads from the chamber 120 to conduct the conditioned air. The upper side of the cover 128 is provided with a lid 143 (FIG. 1) which has for its purpose to deflect heat radiation from the heating element 126 and prevent it from excessively reaching the motor 24.

In FIG. 7 the reference numeral 154 indicates the room in which the air is to be dried. A conduit 156 leads from the room to the collar 16. The air conditioned in the apparatus 160 is returned to the room by means of the conduit 162 which is connected to the collar 152. Outside or fresh air may be added to the circuit by means of a conduit 164 connecting with the conduit 156. Valves or dampers 158, 168, 170 and 172 may be provided in the conduits.

The operation of the apparatus is substantially as follows:

The fan 22 draws in air from the room 154 through

the conduit 156 and the collar 16. From the pressure side of the fan, the air streams through the perforations 106 into the chamber 102. The air thereafter passes sectors of the packing of the rotor 32 located between the spokes 92 and 96 of the sealing means 85. A portion of the moisture content of the air is picked up by the packing of the rotor. The main portion of the dehumidified air passes into the lower chamber 120 and thereafter through the conduit 152, 162 back to the room 154. A smaller portion of the air passes through the passageways of the rotor to the chamber 124, which is situated between the lower sealing member spokes 92 and 94. Smaller branch streams, the purpose of which in the first instance is to cool the packing which has been heated during the regeneration, pass from the regenerating zone to the dehumidifying zone. The branch stream passes through the openings 136, 138 in the manifold 128 and is heated by the heating element 126 to a temperature above 75° C. such as on the order of 150° C. or higher. In the manifold 128 the branch stream is mixed with the small amount of air which has passed through the space 130 about the motor 24 through the openings 134. Thereafter, the branch stream passes into the chamber 122 through the perforated plate 150, which assures an even distribution of the air stream, and therefrom through the rotor over the sector defined by the spokes 92, 96 of the upper and lower sealing discs 85, 86. The packing of the rotor which, during its passage through the drying zone has picked up moisture from the room air, is now regenerated, and the spent air is exhausted through the upper chamber 104 and conduits 108 and 106 to the atmosphere. In view of the fact that a portion of the room air itself is used for the regeneration process, this portion may be replaced by means of the conduit 164 which is connected with the atmosphere. The desired addition of fresh air and the pressure required for this purpose in the system is regulated by means of the dampers or valves shown in FIG. 7.

The apparatus constructed according to this invention acquires a high heat economy due to the fact that the heat picked up by the motor mass during the regeneration is recaptured and used for the pre-heating of the regeneration air stream. The same situation applies to the cooling air for the motor, which for this reason, can be of a very simple type and can have per se a poor coefficient of performance. By arranging the different parts in accordance with the above requirements, the apparatus as a whole will have a high capacity per unit of volume.

The herein-described mounting of the rotor 32 assures a complete seal between the different chambers in the manifolds 28 and 30 without any great necessity for preciseness in construction, while at the same time the cross spokes support the packing layers which are located above the chambers and which are passed by the air. The rotor 32 thus does not have to be carefully centered about the rotation axle of the motor 24. The sealing discs 85, 86 do not have to extend at right angles to this axle since the rotor packing, due to the fact that the convolutions are not united together, can adjust itself to their displacement while still maintaining a frictional contact with the sealing discs.

The momentum which arises through friction against the sealing discs, is transferred to the driving means through the packing and due to the fact that the layers thereof are wound in a direction opposite to the direction of rotation of the rotor, the counter momentum will tend to unwind the spiral but which is prevented by the surrounding band 42. Therefore, the packing, despite the fact that it is composed of a material which in itself possesses poor durability, can transmit the momentum which arises during the rotation of the rotor. The peripheral drive of the rotor results in a reduction of the force required for the rotation of the rotor and which is important by reason of the limited durability of the rotor material.

The edge portions of the spirally-wound packing

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against which the sealing discs slidably contact may be stiffened or hardened by impregnation with a suitable substance such as sodium silicate.

While a single embodiment of the invention is described herein, it is obvious that the same is not to be restricted thereto, but is broad enough to cover all structures coming within the scope of the annexed claims.

What is claimed is:

1. An apparatus for drying air comprising, means defining a first passage for a stream of air to be dried, means defining a second passage for a regenerating stream, means for passing said streams through said passages, an annular rotor including an air-permeable mass of solid sorbent material mounted to move cyclically between said passages and having passages for the axial flow of said streams, the means defining the first passage including means to bring the air to be dried to pass through the rotor in one direction, the annular rotor having a central aperture forming part of said second passage, the means defining the said second passage including means to bring the regenerating stream to pass through said aperture in the same direction as the air to be dried and then back through the sorbent material of the rotor in the opposite direction, heating means for heating the regenerating stream to dry the sorbent material as it passes through the second passage, and motor means for moving the sorbent material, said motor means and said heating means being mounted in and coaxially with said aperture,

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said motor means being mounted in front of said heating means in the direction of the passage of the regenerating stream through said aperture, whereby the regenerating stream will be preheated by said motor means and heated by said heating means prior to passing through the sorbent material of the rotor and whereby said motor means will be cooled by the passage of the regenerating stream thereover.

2. An apparatus according to claim 1 in which said second passage forms a branch of said first passage in advance of the annular rotor.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |                    |               |
|-----------|--------------------|---------------|
| 1,994,515 | Hausen et al. .... | Mar. 19, 1935 |
| 2,286,920 | Miller .....       | June 16, 1942 |
| 2,507,608 | Miller .....       | May 16, 1950  |
| 2,560,349 | Inglis .....       | July 10, 1951 |
| 2,643,098 | Rigby et al. ....  | June 23, 1953 |
| 2,724,044 | Campbell .....     | Nov. 15, 1955 |
| 2,738,958 | Hodge .....        | Mar. 20, 1956 |
| 2,803,439 | Fikenscher .....   | Aug. 20, 1957 |
| 2,813,768 | Renn .....         | Nov. 19, 1957 |

##### FOREIGN PATENTS

|         |                     |              |
|---------|---------------------|--------------|
| 208,523 | Australia .....     | June 5, 1957 |
| 311,889 | Great Britain ..... | May 23, 1929 |