March 7, 1967 C. G. MUNTERS 3,307,617

METHOD IN THE MANUFACTURE OF AN EXCHANGER PACKING AND EXCHANGER PACKING MANUFACTURED ACCORDING TO SAID METHOD

Filed Jan. 28, 1963 2 Sheets-Sheet 1

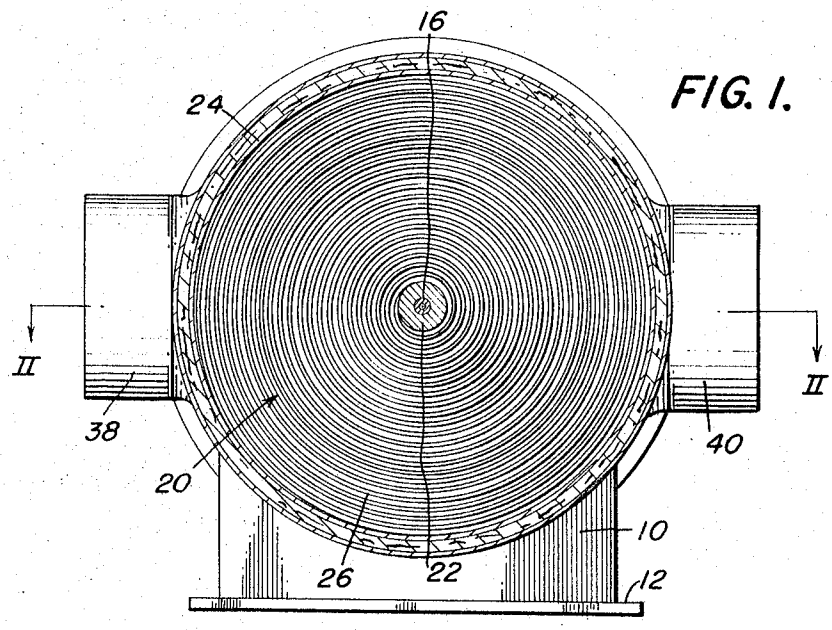


FIG. 1.

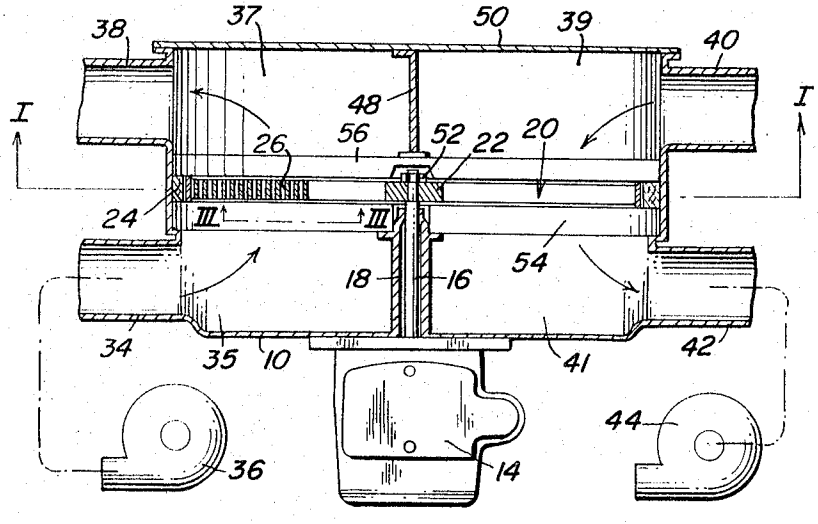


FIG. 2.

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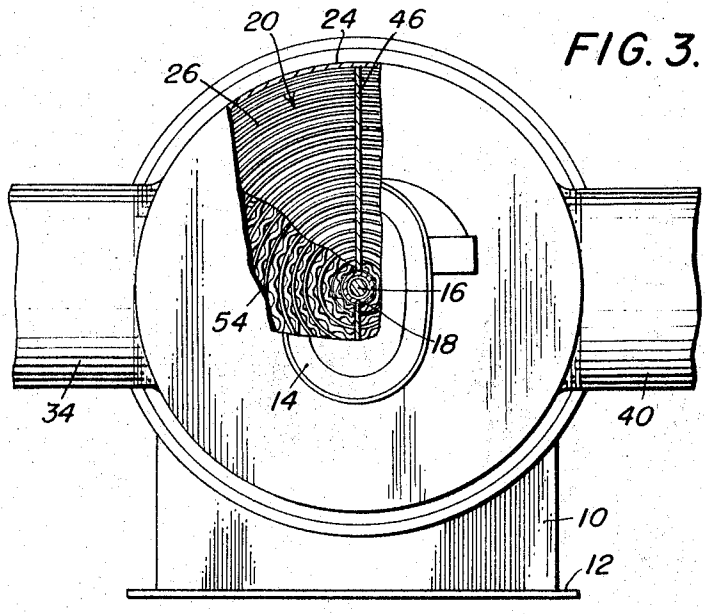


FIG. 3.



FIG. 4.

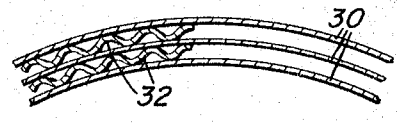


FIG. 5.

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METHOD IN THE MANUFACTURE OF AN EXCHANGER PACKING AND EXCHANGER PACKING MANUFACTURED ACCORDING TO SAID METHOD

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1 Claim. (Cl. 165—10)

This invention relates to improvements in the manufacture of exchanger packings and also to exchanger packings manufactured with utilization of said improvements.

More particularly this invention relates to a method in the manufacture of an exchanger packing composed of elements, such as thin layers or sheets which directly or possibly indirectly by means of distance pieces bear against one another at mutually spaced places and therebetween form passages open from end to end and extending through the packing. Of the layers usually at least every second is corrugated, the places of mutual contact of the layers being formed by the ridges of the corrugations.

For utilization in an important field of application of the invention the layers are to advantage constituted of sheets or foils of a fibrous material which preferably is non-metallic and inorganic as is the case with asbestos. An essential field of use of the invention is the transfer of moisture and/or heat, in particular between two air currents. For this purpose the exchanger packing preferably has the structure of a rotor adapted to move along a closed path between two passages transgressed by the two air currents.

One main object of the invention is to provide an exchanger packing in which the layers have high mechanical strength, especially in wet condition which latter condition is actual when the exchanger packing during its operation comes into contact with a liquid such as water.

Another object of the invention is to provide an exchanger packing possessing hygroscopic properties and a high drying effect. These two objects may be aimed at by the exchanger packing of the invention either separately or in combination.

It is known in prior art to increase the wet strength of sheets of a fibrous material by treating with substances which together produce a nonsoluble deposit of calcium silicate on the sheets or the fibres thereof. On the other hand there are used in moisture exchangers hygroscopic water-soluble salts, primarily lithium compounds. It has also been proposed to provide silica gel in a finely divided, solid form on the layers of an exchanger packing.

The invention involves such a processing which has as its distinctive feature of impregnating the layers with a composition of matter in liquid state of such kind as to form a gel which thereupon is concentrated by evaporation until a solid substances remains on the layers. According to a particular important embodiment of the invention the composition of matter is of a kind containing silicon or a silicic acid compound so that the deposit remaining after the concentration is constituted by a silicon dioxyde substance. If the layers are of a fibrous material such as asbestos which in itself has an insufficient wet strength, the impregnation according to the invention imparts to the layers a fully sufficient strength. Due to the fact that the solid substance such as silicon dioxyde is precipitated from a liquid in intimate contact with the fibres to constitute a gel this latter is distributed over the fine fibres in a molecular state or condition and thereby forms a homogeneous reinforcement of the carrier fibres.

The deposit of silicon dioxyde on the layers remains hygroscopic in a heat treatment up to a predetermined value, which means that it gets similar properties as silica gel and therefore even alone may constitute the hygroscopic constituent in an exchanger packing for transfer of moisture or heat and moisture. Due to the particularly thin and even deposit on the fibres which deposit, moreover, is porous so that a very large surface of contact is obtained between the moisture-active solid substance and the air, the drying effect calculated on the volume or the density of the exchanger packing becomes very high. In the same degree as the heat treatment is effected at increased temperature, the silicon dioxyde substance in its solid condition becomes more stable. Whereas a heat treatment at a lower temperature, such as at 200° C. or therebelow imparts to the silicon dioxyde a reversible function so as to some extent to be restorable into its gel condition it will at a higher temperature such as up to 600 or 700° C. be more and more anhydrous and at the same time stable as to its composition. In other words the silicon dioxyde will no longer be capable but to a limited degree to pick up moisture, but it is at the same time practically water-insoluble. A deposit of silicon dioxyde obtained by a heat treatment exceeding 200° C. has surprisingly experience to give to a moisture exchanger packing the capacity of dehumidifying air to lower continuous absolute and relative moisture content than hitherto possible to obtain by use of the most effective hygrosdopic salts such as lithium chloride. This valuable effect which in particular is of deciding importance for some kinds of air conditioning appears at least partly to reside in the feature that the silicon dioxyde deposit causes more favourable conditions for the intercalation of the salt crystals on the layers of the exchanger packing or the fibres of said layers.

Other objects and advantages inherent in the invention will become apparent from the following description when taken in conjunction with the accompanying drawing which shows, by way of example, the invention applied to a rotary transferrer of heat and/or moisture.

In the drawing:

FIGURE 1 is a section taken along the line I—I of FIGURE 2.

FIGURE 2 is a section taken along the line II—II of FIGURE 1.

FIGURE 3 shows the apparatus in external projection partly in section taken along the line III—III of FIGURE 2.

FIGURES 4 and 5 are fragmentary sections showing alternative forms of construction of the rotor mass.

Referring to the drawings reference numeral **10** indicates a casing which may be connected to a horizontal support by means of a flange **12**. The motor **14** may be mounted directly on the casing **10** and is provided with a shaft **16** which rotates in the sleeve **18** extending inwardly from the casing. The sleeve supports the rotor, generally indicated at **20**, and may have a hub portion **22** and a rim portion **24** between which a spirally wound web is supported. The web is preferably made of non-metallic fibrous sheet material, such as cellulose or asbestos paper and the like of of paper modified by asbestos fibers, glass fibers, plastic fibers and others.

The sheets may be as thin as $\frac{1}{10}$ millimeter. Preferably, the motor or sorption mass is built up to form alternate flat sheets **30** and corrugated sheets **32** shown in FIGURE 5 of the drawing. It may also be composed of sheets **26** spaced apart by ridges **28** as shown in FIGURE 4 or may have a honeycomb form.

The distance between the flat sheets, or in other words, the height of the corrugations in sheet **32** may vary for particular conditions of application. The closer the spacing of the sheets **30**, the greater surface area per unit of

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volume of the exchanger packing and the greater becomes the transfer co-efficient. The flat and corrugated sheets 30 and 32 divide the packing into a plurality of closely adjacent cells or passages open at both ends at opposite sides of the wheel and extending axially therethrough.

When the packing is used in an air conditioning system, as a transferrer of thermodynamic characteristics of air, the flat sheets may be spaced from one another less than 3 milimeters and preferably less than 2 millimeters.

The wheel 20 when acting as moisture transferrer is rotated at a very slow rate of speed, such as on the order of 1 to 10 revolutions per hour. When the wheel is used as a heat transfer element, it is rotated at a much higher speed.

As shown in FIGURE 2, one of the air streams, such as that from an enclosure, is impelled through the duct 34 into the compartment 36 by means of the fan 36 and blown through the passages or cells formed by the flat and corrugated sheets 30 and 32, into the compartment 37 and hence exhausted through the duct 38.

Another air stream, such as outdoor fresh air, is drawn by fan 44 through the duct 40 into the compartment 39, through the passages of the wheel 20 at the right hand half thereof and counter current to the air stream flowing through the passages in the left hand half of the wheel; hence into compartment 41 and through the duct 42 to the enclosure to be conditioned.

The compartments 35 and 41 are separated from one another by means of a partition 46 (FIGURE 3) while compartments 37 and 39 are separated from one another by means of partition 48. Partition 48 may be attached to a cover 50 which can be removed to provide access to the wheel. The wheel may be removed from the casing 10 by first unscrewing the nut 52 from the shaft 16.

In order to counteract leakage of air between the compartments, stationary sealing elements 54 and 56 may be arranged in the casing at the faces of the wheel. In the example shown in the drawing, these sealing elements comprise a corrugated structure having large passages relative to the passages in the rotor mass.

However, sealing elements may also be mounted on the edges of the partitions 46 and 48 to bear against the faces of the wheel. Such sealing elements may be in the form of shoes mounted on the edges of the partitions 46 and 48 and yieldingly pressed against the sides of the wheel.

The bonding together of the sheets or foils at the places of contact may be effected by means of conventional methods and glueing agents, preferably of inoganic kind such as water glass. The bonding may even at least partially be made by means of the gel. If the packing is assembled of so-called single-well webs which are wound in layers one upon the other the one plane and one corrugated strip of the web may be bonded together by means of water glass or the like in the machine for manufacture of single-well. The individual webs of the assembled single-well web structure may then be glued to one another by the treatment according to the invention.

If desired the layers may be constituted by a carrier of a ceramic, possibly porous material which has been heated to sintering temperature so as to obtain a solid, coherent structure.

The impregnation according to the invention may according to one embodiment of the invention be carried out by means of an organic silicic acid compound, preferably ethyl silicate or silicic acid esters. When such compound is brought into contact with or absorbs moisture it assumes a gel-like state. Thus the layers or sheets of the exchanger packing are covered with the compound and thereupon exposed to the action of the moisture. Simultaneously with the formation of the gel alcohol escapes. When the formation of the gel is finished water commences to be driven out from the gel and gradually a solid cover comes into existence. This cover contains silicon dioxyde and some water. This process is accelerated by increase of the temperature. Up to some predeterminable temperature the solid cover may be restored to the gel state by picking up of water to some extent, but by further increase of the temperature the silicon dioxide assumes a more and more irreversible state and thus becomes stable.

According to another method, hereinafter to be denominated as the acid method, the layers, such as the asbestos sheets are initially impregnated with water glass and subsequently with an acid such as hydrochloric acid or sulfuric acid whereby a gel is produced as a product of a chemical reaction. Residues of the acid and other soluble reaction products are removed by rinsing with water provided that the cover of gel on the sheets permits it. The gel may be subjected to a partial drying treatment prior to said rinsing procedure. The gradual concentration of the gel by evaporation is continued in the same manner as described hereinbefore.

The reinforcement imparted to the fibrous carrier is dependent on the glueing capacity of the precipitations on the fibers, said capacity becoming better with increase of the quantity of silicon contained in the starting substances for the impregnation. The proportion between the silicon and alkaline constituents in the water glass must be of an order of magnitude of at least 3:1, especially in the acid method. This does not imply that the concentration of the two substances necessarily must be high; rather diluted water glass may be used. At all events the acid concentration must be so high that the silicon dioxide cannot take colloidal state instead of being formed as a gel.

As is evident from the preceding explanations the solubility in water of the precipitated silicon dioxide is in relation to the reversibility of the capacity to pick up water imparted to the silica gel. A concentration by evaporation of the gel at relatively low temperatures increases the water-solubility. A concentration by evaporation at relatively high temperatures reduces the water-solubility but also the strength and the glueing capacity. This implies that the precipitated silicon dioxide becomes brittle or fragile upon treatment at high temperatures, in particular when all water has been stripped. As far as the mechanical strength of the individual layers is of importance one must always adjust the upper limit for the heat treatment to a predetermined value so as to meet the requirements of mechanical strength.

Usually sodium water glass is used even if potassium water glass may come into consideration. Potassium water glass produces together with sulfuric acid as a reaction product potassium sulfate which is distinguished from sodium sulfate by not containing any crystal water. When it is desired to avoid deformations of the exchanger packing caused by stripping of crystal water from reaction products possibly not removed by the rinsing procedure the use of potassium water glass may be of advantage.

As may be seen from co-pending patent application Serial No. 164,880 filed January 8, 1962, asbestos sheets often contain not only filaments of asbestos but also a bonding agent for the fibres of organic nature such as starch, for example. In the utilization of the present invention it may be desirable to remove these organic substances in order to eliminate the risk of fire. According to the patent an oxidation or degassing of the organic bonding agents is performed under which procedure attention must be paid to the temperature in the asbestos fibres which temperature must not be increased so much as to cause them to set their crystal water free and therewith to lose their mechanical strength. Such a treatment may without difficulty be combined with the treatment according to the present invention, the stabilization of the deposit of silicon dioxide on the fibres being effected simultaneously at a highest possible temperature below the temperature critical for the asbestos fibres.

While one more or less specific embodiment of the invention has been shown and described, it is to be under-

stood that this is for purpose of illustration only, and that the invention is not to be limited thereby, but its scope is to be determined by the appended claim.

What I claim is:

The method of increasing the moisture adsorptive capacity and structural strength of an annular heat and moisture exchange rotor body having cellular air spaces extending from end to end formed of layers of corrugated sheets of asbestos comprising wetting the assembled laminated corrugated sheet body with an aqueous solution of water glass to effect homogeneous concentrated impregnation of the assembled sheets and fibers thereof with the water glass, and then reacting said water glass in situ in the impregnated body with acid to convert the same to solid silica gel bonding the same structurally firm, washing out the acid and drying said body at a temperature above about 200° C. and below about 700° C. to convert said body to structurally rigid highly moisture adsorptive form.

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