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3,553,849

ROTARY DRYER DRUM HAVING CLOSED INTERNAL CHANNELS

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2 Sheets-Sheet 1

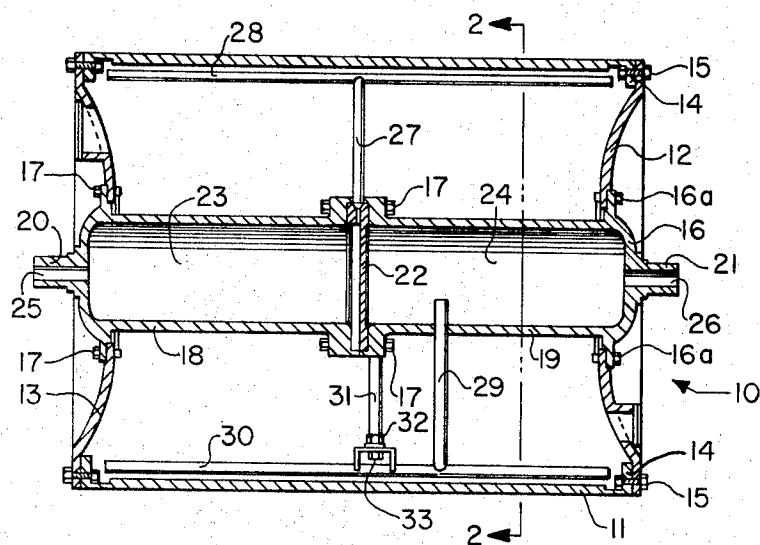


Fig. 1

Fig. 2

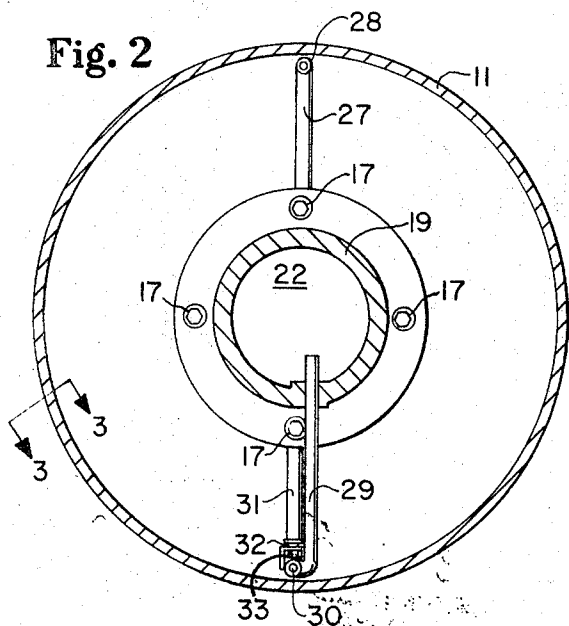


Fig. 6

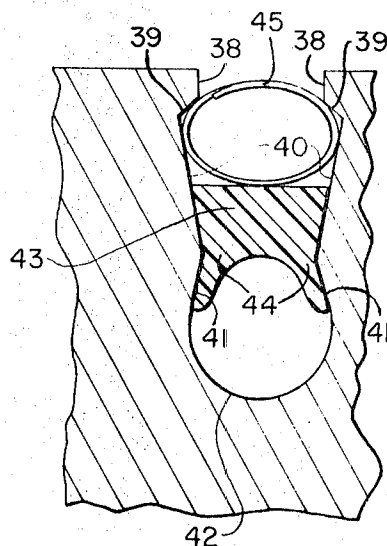
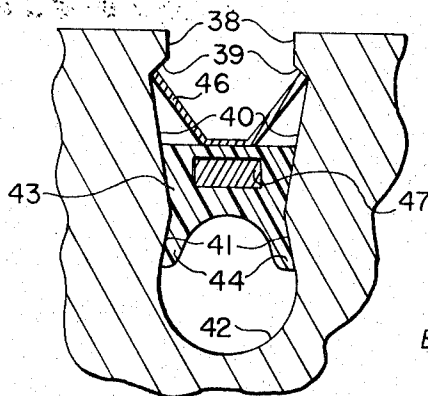


Fig. 7



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Fig. 3

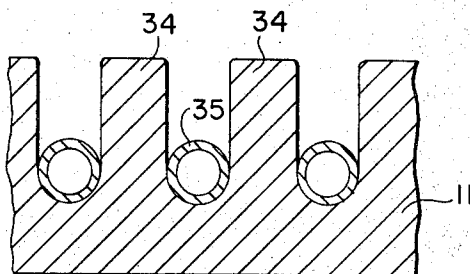


Fig. 4

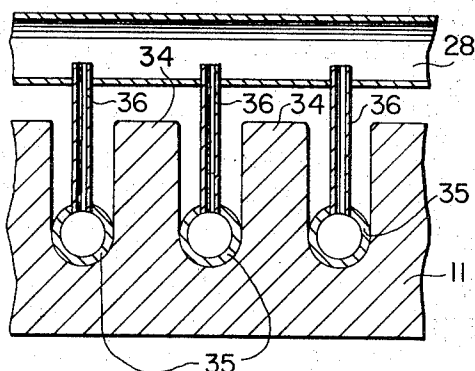
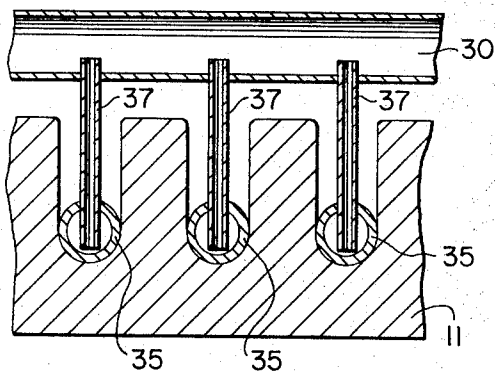


Fig. 5



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ROTARY DRYER DRUM HAVING CLOSED INTERNAL CHANNELS

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8 Claims

ABSTRACT OF THE DISCLOSURE

A rotary, cylindrical dryer drum with a plurality of internal, circumferential channels. The channels are provided by circumferential grooves formed in the inner surface of the shell of the dryer and include conduit-defining means disposed within the grooves. Each of the channels forms an annular conduit and includes an inlet for introducing a heat transfer fluid into the channel and an outlet for removing the heat transfer fluid from the channel.

BACKGROUND OF THE INVENTION

This invention relates to rotary, cylindrical dryer drum structures and more particularly to a rotary, cylindrical dryer drum structure wherein an internally grooved dryer shell is provided with conduit-defining means positioned in the grooves to form annular conduits in the shell.

Heretofore, rotary dryer drums employed in paper-making apparatus have been extremely ponderous structures, principally because the steam utilized to heat the drum, and thereby dry the paper which passes thereover, was introduced directly into the interior of the drum, thereby subjecting the entire drum structure, both shell and heads, to the combined pressures and thermal effects of the hot steam. As a result, both the shell and the heads of the drum had to be massive structures to withstand such stresses. As the shell thickness is increased to withstand the higher steam pressures necessary for more efficient drying, the rate of heat transfer through the shell is reduced because of its increased thickness.

In addition to the effects on the shell itself, the pressure and thermal effects of the steam have a particularly adverse effect at the shell-head junctions, where the loading and resultant stress pattern is particularly complex, and generally require that a large, tapered flange be formed at the end of the shell in order to withstand the stresses occasioned by the end loads that are applied at this particular portion of the shell by the deflection of the heads of the drum. However, tapering the shell end flanges reduces the heat transfer rate at the end of the shell and thus either longer dryers are needed or the width of the web must be reduced to assure uniform drying across the entire width of the web being dried.

Various approaches have been proposed to improve the heat transfer through the shell while not unduly compromising its structural integrity. For example, Justus et al. in U.S. Pat. 3,241,251 disclose a rotary dryer drum structure which includes a plurality of internal, circumferential grooves on the inner surface of the shell to reduce the effective thickness thereof for heat transfer purposes and yet to retain the thickness necessary for structural purposes. Although the structure shown and described in the Justus et al. patent is eminently suitable for drying paper

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webs, it has been found that the circumferential grooves cannot be carried to the extremes of the drum because of the hereinabove-discussed stress pattern that exists at the shell-head junction. As a result, the entire surface of the drum cannot satisfactorily be used for uniformly drying paper because of the non-uniformity in drying rate across the drum, and the web to be dried must thus be confined to a width less than the entire width of the outer shell of the drum. However, the heat transfer at the junction of the head and shell can be further improved by employing transverse grooves in the shell flange as shown and described by Vonderau in U.S. Pat. 3,258,851.

In spite of the improvements in drying structures taught by those patents, the heat transfer medium, which is the case of paper dryers is generally steam, is still introduced directly into the interior of the drum and contacts both the shell and the heads. Since the contact need only be made the shell, through which it is desired that the heat transfer take place, the heating and pressurizing of the heads is unnecessary and contributes to the weight and cost of such dryers because the heads must be designed and fabricated to withstand the high pressure and thermal loads imposed thereon, and the shell ends must be designed with the head deflections and loads in mind. In addition to the weight and costs aspects of such dryers, the pressurization of a large rotating drum can pose significant safety problems.

SUMMARY OF THE INVENTION

Briefly stated, in accordance with one aspect of the present invention, a rotatable, cylindrical dryer drum is provided which comprises a cylindrical shell and a head at each end of the shell to close the same, the heads including means for rotatably supporting the drum and means for introducing and removing a heat transfer medium to and from portions of the interior of the drum. The shell has a plurality of internal circumferential grooves formed therein and has conduit-defining means disposed within those grooves for defining annular conduits to insure close proximity between the shell heat transfer surface and the heat transfer medium. Means are provided for introducing a heat transfer fluid into each of the annular conduits and for removing the heat transfer fluid therefrom.

It is an object of the present invention to provide a rotary dryer drum construction having improved heat transfer characteristics and improved safety with attendant reductions in both the cost and the weight of the dryer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view of a rotatable, cylindrical dryer drum according to the present invention showing the various internal and external parts thereof in operative relationship.

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1.

FIG. 3 is an enlarged, fragmentary cross-sectional view of a portion of the shell taken along the line 3—3 of FIG. 2 and showing the annular conduits formed in the shell and one form of conduit-defining means positioned therein.

FIG. 4 is an enlarged, fragmentary cross-sectional view of a portion of the shell wall showing a form of conduit-defining means positioned within the grooves and a means

for introducing the heat transfer fluid to the annular conduits thereby formed.

FIG. 5 is an enlarged, fragmentary cross-sectional view similar to FIG. 4 but showing a means for removing the heat transfer fluid from the annular conduits.

FIG. 6 is a fragmentary cross-sectional view showing an alternative conduit-defining means positioned within a groove for defining an annular conduit therein.

FIG. 7 is an enlarged, fragmentary cross-sectional view showing another configuration of conduit-defining means positioned within the grooves.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and particularly to FIGS. 1 and 2, there is shown a dryer drum 10 of the present invention formed from a hollow cylindrical shell 11 of predetermined axial length. Shell 11 can be made of cast iron or the like and has circumferential grooves on its inner surface, as more completely described hereinafter. The grooves and their inlet and outlet tubes are not shown in FIGS. 1 and 2 because size relationships would render their representation difficult. The ends of shell 11 can be closed by means of heads 12 and 13, which can be inwardly dished as shown and which can be secured to the ends of shell 11 at shell flanges 14 as by means of bolts 15. Heads 12 and 13 can be of substantially annular construction and can have a central opening to which is connected a central shaft 16 as, for example, by means of bolts 16a. Central shaft 16 is preferably hollow and is provided in two distinct portions 18 and 19 as shown in FIG. 1. Extending from the ends of central shaft 16 are a pair of journals 20 and 21 which are adapted to be carried in trunnions (not shown) so that the drum can be rotated. When central shaft 16 is divided into two portions, an imperforate, pressure- and temperature-resistant divider member 22 is positioned therebetween to define two separate chambers 23 and 24. Chambers 23 and 24 are in communication with the outer ends of journals 20 and 21, respectively, by means of passageways 25 and 26 through journals 20 and 21, respectively.

A hollow tube 27 mounted on central shaft 16 provides communication between chamber 23 and tubular distributor 28, the structure and function of which will be explained in further detail hereinafter. The heat transfer fluid is admitted through passageway 25 in journal 20 to chamber 23 through tube 27 and to distributor 28. Similarly, a hollow tube 29 is connected with chamber 24 to provide communication between chamber 24 and condensate return header 30, the structure and operation of which will also be illustrated and described in further detail hereinafter. The position of condensate return header 30 can be radially adjusted by means of supporting stud 31 which has a pair of locking nuts 32, 33 that can be loosened and turned to change the radial position of condensate return header 30. Condensate return header 30 is in communication with passageway 26 in journal 21 through chamber 24 and support tube 31.

Cylindrical shell 11 has a plurality of circumferential grooves on its interior surface as shown in FIG. 3. The grooves are defined by the spaces between adjacent circumferential ribs 34. Positioned within the grooves are means for defining an annular conduit therein such as, for example, metallic tube 35 positioned in the lowermost portion of the groove as shown in FIG. 3. Tube 35 is preferably rigidly positioned within the groove and in intimate contact with the bottom thereof. Such intimate contact can be achieved by actual face-to-face contact of the materials comprising the tube and the shell 11 at the bottom of the groove, or alternatively, by interposing a readily conformable high temperature adhesive between such materials, or by means such as welding or brazing the materials together in such location. It is important that there be a continuous conduction path, without any substantial amount of intervening air space or other material

between the exterior of tubes 35 and the lowermost surfaces of the grooves in shell 11 in order to insure good heat transfer from the heat transfer medium to the external surface of shell 11.

Each of tubes 35 forms a conduit for the heat transfer fluid, which can be steam or any other heat transfer medium. Since only tubes 35 carry the pressure load imposed by the heat transfer fluids, the thickness of shell 11 and that of heads 12 and 13 of the dryer need not be as great as they would otherwise have to be. In fact, the heads need not be closed and can be replaced by other supporting structure, such as for example, spokes.

As shown in FIG. 4, the steam or other heat transfer fluid is conveyed to the annular conduits through a plurality of inlet tubes 36 which provide a communication path between annular tubes 35 and distributor 28. Similarly, as shown in FIG. 5, the heat transfer fluid, or in the case of steam the condensate, is removed from annular tubes 35 by means of a plurality of outlet tubes 37, each of which is slidable in tube 35 and provides a path of communication between a single annular tube 35 and condensate return header 30. When steam is the heat transfer fluid outlet tubes 37 are so positioned with respect to annular tubes 35 that one end of the former is relatively close to the portion of annular tube 35 which is closest to the outer surface of shell 11. The reason for this positioning is that during rotation of the drum, centrifugal force urges the condensate to the portion of annular tube 35 closest to the outer surface of the shell 11 and thereby presents a heat insulating layer which impedes the flow of heat from annular tube 35 to the outer surface of shell 11. It is desirable that the layer of condensate be removed to the greatest extent possible to permit unimpeded heat transfer. If positioned otherwise when steam is the heat transfer fluid, the condensate would not be removed from a tube 35 until it accumulated sufficiently to reach the radially outermost end of the associated tube 37.

From the foregoing description and the accompanying drawings, it can be seen that, in operation, steam is introduced through passageway 25 in journal 20 to chamber 23 and is carried by inlet tube 27 to distributor 28, whereupon it is conveyed to annular tubes 35 by means of inlet tubes 36 interconnecting annular tubes 35 and distributor 28. Since each annular tube 35 has a separate inlet tube interconnecting it with distributor 28, each annular tube 35 receives steam having substantially the same physical and thermal properties. As the steam passes through annular tube 35 and condensation takes place, the outlet tubes 37, which are preferably positioned opposite the inlet tubes 36 in order to balance the drum, convey the condensate from the annular tubes 35 to condensate return header 30 and thence to outlet tube 29 and through chamber 24 and passageway 26 in journal 21 by means of suction which is imposed by a vacuum pump (not shown). Thus the heat transfer fluid from one annular tube 35 does not pass into any other such annular tube and since the conditions of the steam in each annular tube 35 are substantially the same, the configuration herein described provides a dryer drum having a substantially constant temperature profile across its outer surface. Furthermore, since the heads of the dryer are not subjected to the pressure and temperature effects of the steam, the heads do not impose as great a load at the head end of the shell and thus the annular tubes can be positioned closer to the ends of the shell and thereby provide uniform heat distribution across substantially the entire axial length of the dryer drum.

Whereas the groove configuration shown in FIG. 3 has substantially parallel radial walls, another configuration for the walls of the groove and for the conduit-defining member placed therein is shown in FIGS. 6 and 7. As therein shown in cross section, the groove, which is symmetrical and of an inverted keyhole-like shape, has a rectangular opening defined by radial walls 38 followed

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by sharply outwardly and downwardly sloping walls 39 which intersect gradually tapering inwardly and downwardly extending walls 40. The lower ends of walls 40 are separated by a distance substantially equal to the width at the opening portion, and meet downwardly and outwardly tapering walls 41 which are tangential to curved portion 42, the lowermost part of the groove. An annular, conduit-defining member 43, positioned within and retained by the groove, has a cross section which corresponds with a portion of the cross section of the groove. The lowermost portion of member 43 has outwardly depending skirts 44 which are forced against downwardly and outwardly tapering walls 41 of the groove when pressure is applied in the conduit, thereby increasing the pressure and improving the seal therebetween. Annular conduit-defining member or seal 43 is preferably retained in position by a retaining member to prevent it from being dislodged from the groove by the pressure of the heat transfer fluid. A continuous coil spring 45 having an oval cross section as shown in FIG. 6 can be used for this purpose. Alternatively, annular conduit-defining member 43 can be retained in position by a plurality of circumferentially spaced, generally V-shaped spring members 46, as shown in FIG. 7. The stiffness of conduit-defining member 43 can be increased, if desired, by forming it around a stiffening member 47 which can be of flexible metal or the like.

Preferably, annular conduit-defining member 43 is formed from resilient material to permit the hereinbefore-described pressure effect to assist in seating the member against the sidewalls of the groove and improve the seal therebetween. The retaining member serves to retain the annular member in position and prevent it from being forced from the groove by the steam pressure within the conduit. Annular conduit-defining member 43 can be molded from a resilient, high-temperature resistant rubber compound such as a silicone rubber, or it can be formed from a fluorocarbon resin such as polytetrafluoroethylene or a copolymer of tetrafluoroethylene and hexafluoropropylene. Tubes 36 and 37 pass through annular member 43 and because of the resilience of member 43 when formed from rubber or the like, a tight seal is provided between annular member 43 and tubes 36 and 37. In the embodiment shown in FIG. 7, the tubes 36 and 37 pass through stiffening member 47 and spring members 46.

While particular embodiments of the invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention and it is intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

1. In a rotatable dryer drum comprising a cylindrical shell, and means for rotatably supporting said cylindrical shell, said cylindrical shell having a plurality of internal, circumferential grooves formed therein, an improved heat transfer fluid conduit system comprising:

- (a) conduit-defining means disposed within said grooves for defining imperforate annular conduits therein in close heat transfer relation to said shell;
- (b) means for introducing a pressurized heat transfer fluid into said annular conduits, said introducing means comprising imperforate passageways connecting an exterior source of said heat transfer fluid to said annular conduits; and
- (c) means for removing said heat transfer fluid from said annular conduits, said removing means comprising imperforate passageways connecting said annular conduits to a point exterior of said drum, said passageways of said introducing means and said removing means being spaced from said shell whereby said

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shell of said drum may be heated by circulating pressurized heat transfer fluid through said conduit system without pressurizing non-conduit portions of said shell.

2. The dryer drum of claim 1 wherein said conduit-defining means comprises an annular metallic tube secured to the lowermost portion of said groove to provide a conduction path between said heat transfer medium and the external surface of said shell without an intervening air space.

3. The dryer drum of claim 1 wherein said conduit defining means consists of annular seals conforming in cross section to radially inward portions of the cross sections of said grooves to permit retention of said seals in said grooves, whereby said annular conduits are formed by the seals and the portions of said grooves located radially outwardly from said radially inward portions of said grooves.

4. The dryer drum of claim 3 including separate retaining means for holding said conduit-defining means in a predetermined position within said grooves.

5. The dryer drum of claim 4 wherein said conduit-defining means comprises a resilient annular member including internal stiffening means.

6. The dryer drum of claim 5 wherein said retaining means comprises a spring member which cooperates with the sides of said grooves to retain said annular member in position.

7. In a rotatable dryer drum comprising a cylindrical shell, means for rotatably supporting said cylindrical shell, said cylindrical shell having a plurality of internal, substantially parallel circumferential grooves formed therein, the improvement comprising a heat transfer fluid conduit system comprising:

- (a) conduit-defining means disposed within said grooves in close heat conduction relation thereto for defining a multiplicity of substantially imperforate parallel annular conduits, said conduit-defining means each including an inlet and an outlet, said inlets being in substantially symmetrical circumferential relationship with said outlets; and
- (b) imperforate inlet conduit means and outlet conduit means having passageways associated with said inlets and outlets, said inlet conduit means and said outlet conduit means each extending from a point exterior of said drum to the interior thereof, said inlet conduit means being branched within said drum and flow-connected to each said inlet, said outlet conduit means being branched within said drum and flow-connected to each said outlet, said passageways of said inlet conduit means and outlet conduit means being spaced from said shell, whereby a pressurized heat transfer fluid can be circulated through said conduit system without thereby pressurizing non-conduit portions of said drum.

8. The dryer drum of claim 7 wherein each said conduit-defining means comprises a resilient annular seal conformable in cross section to a portion of the cross section of said grooves, and means for retaining said seal in said groove, whereby said annular conduits are formed by the lower portions of said grooves cooperating with said seals.

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