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Choi

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(54) **MULTIPORT CYLINDER DRYER WITH LOW THERMAL RESISTANCE AND HIGH HEAT TRANSFER**

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(21) Appl. No.: **09/648,693**

(22) Filed: **Aug. 25, 2000**

(51) **Int. Cl.**[7] **F26B 11/02**
(52) **U.S. Cl.** **34/114**
(58) **Field of Search** 34/114, 108, 109, 34/110, 111, 112, 113, 115, 118, 457, 117

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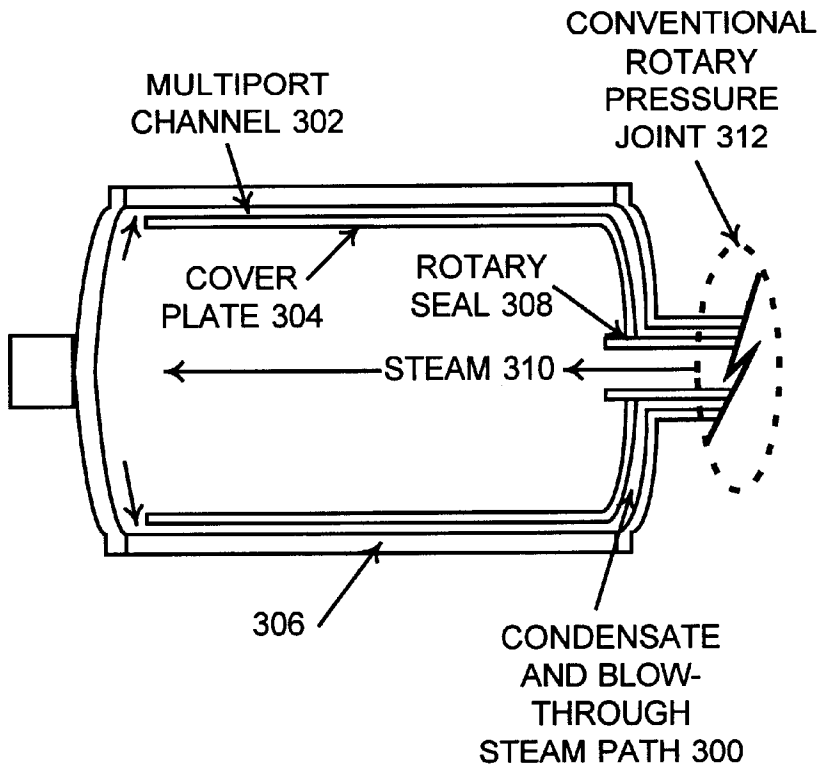
(57) **ABSTRACT**

A multiport cylinder dryer for use with drying a web of pulp, paper, or similar material, and a method for drying a moving web of pulp, paper, or similar material are provided. The multiport cylinder dryer includes an outer cylinder dryer surface for transferring heat to a moving web to be dried. A plurality of multiport flow passages are positioned close to the outer cylinder dryer surface. The multiport flow passages are arranged for channeling steam flow for heating the cylinder dryer surface. The multiport cylinder dryer achieves significantly higher drying rates than conventional dryers by minimizing the condensate layer and maximizing the heat transfer surface area. The dominant heat transfer mode in the multiport cylinder dryer is convection, which is significantly more effective than conduction, the dominant heat transfer mode in conventional dryers.

14 Claims, 3 Drawing Sheets



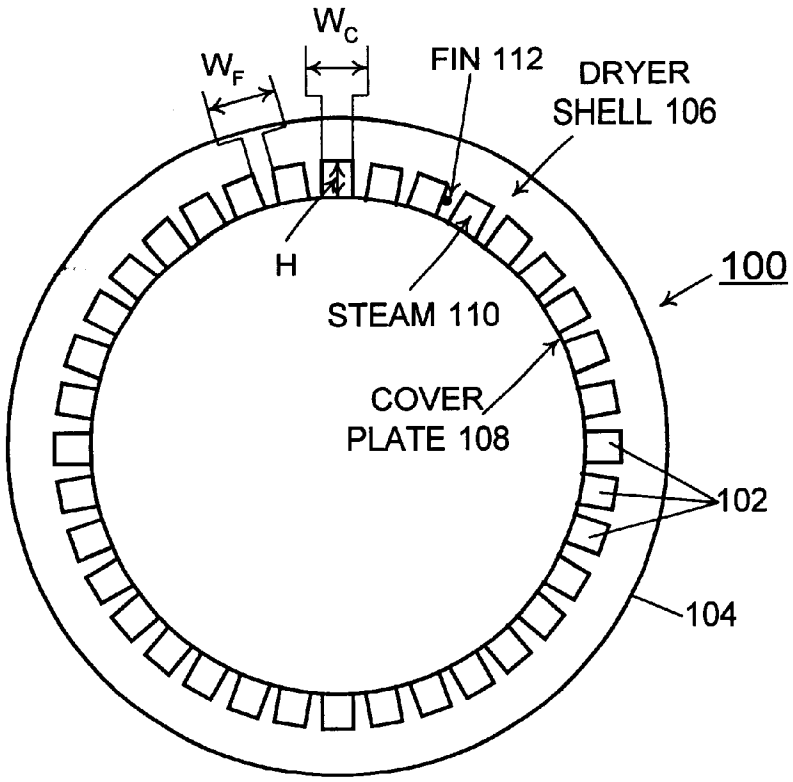

W_C
W_F
FIN 112
DRYER SHELL 106
H
STEAM 110
100
COVER PLATE 108
102
104

FIG.1A

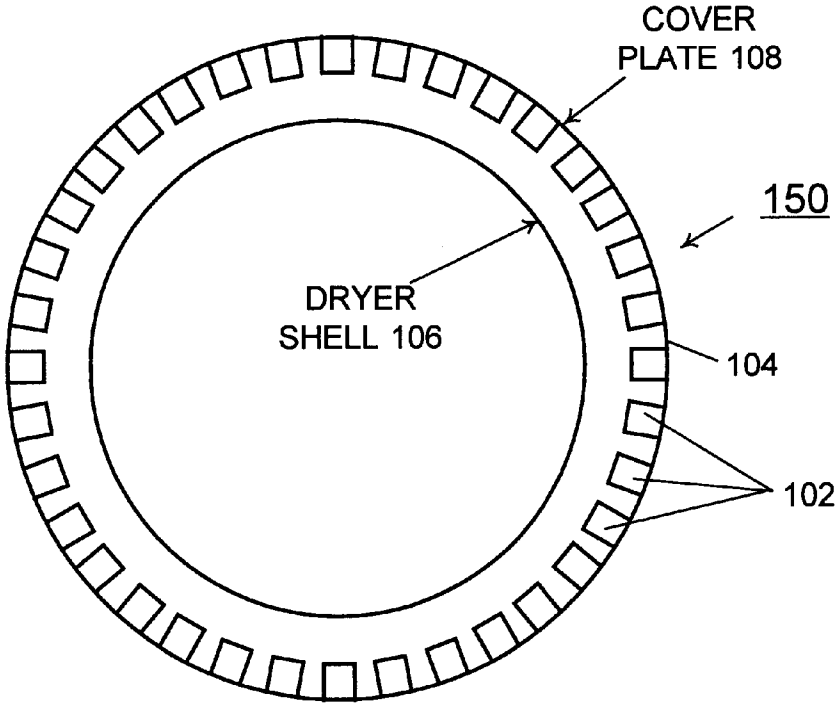

COVER PLATE 108
150
DRYER SHELL 106
104
102

FIG.1B

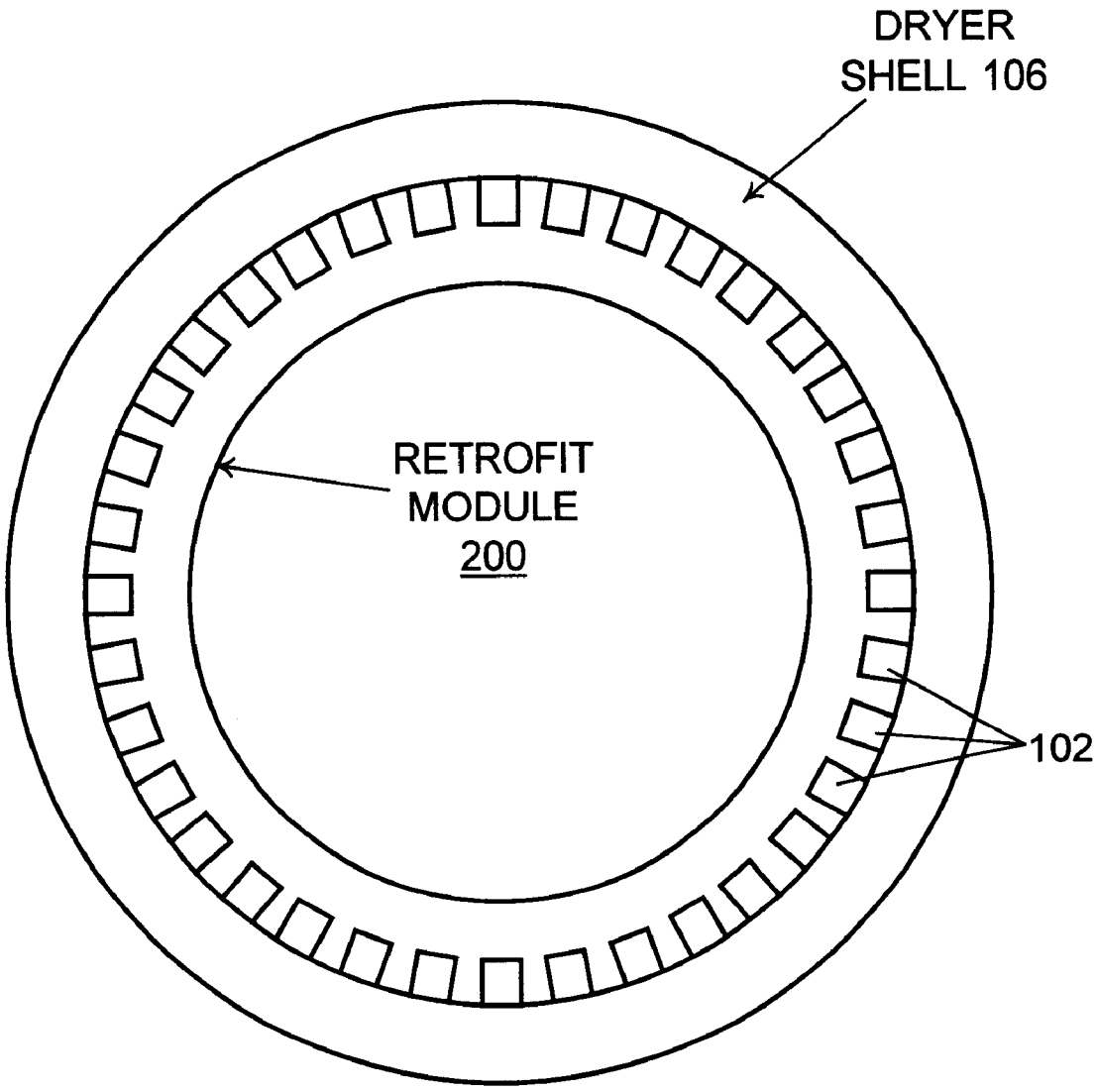


FIG.2

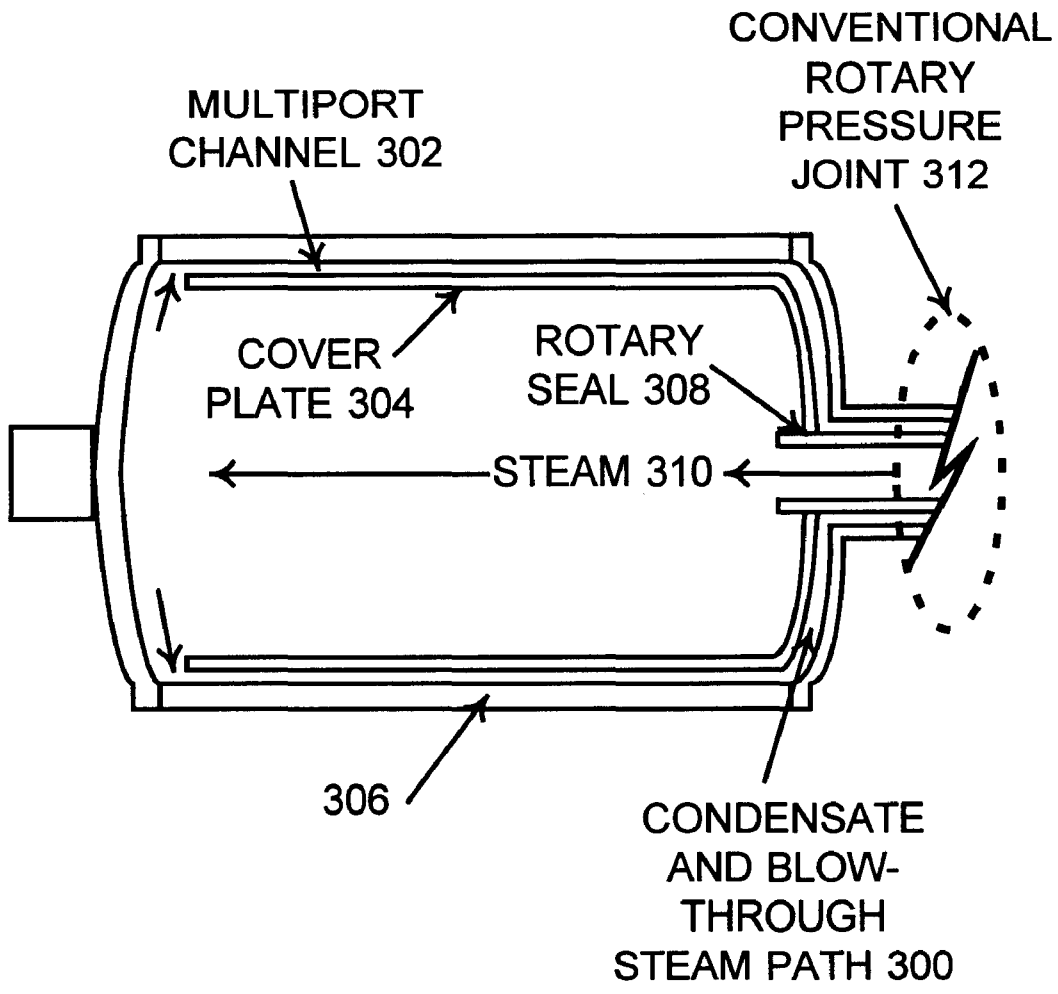

CONVENTIONAL
ROTARY
PRESSURE
JOINT 312
MULTIPORT
CHANNEL 302
COVER
PLATE 304
ROTARY
SEAL 308
STEAM 310
306
CONDENSATE
AND BLOW-
THROUGH
STEAM PATH 300

FIG.3

MULTIPORT CYLINDER DRYER WITH LOW THERMAL RESISTANCE AND HIGH HEAT TRANSFER

CONTRACTUAL ORIGIN OF THE INVENTION

The United States Government has rights in this invention pursuant to Contract No. W-31-109-ENG-38 between the United States Government and Argonne National Laboratory.

FIELD OF THE INVENTION

The present invention relates to a multiport cylinder dryer having improved thermal resistance and improved heat transfer for use in drying pulp and paper.

DESCRIPTION OF THE RELATED ART

The pulp and paper industry is among the most capital intensive manufacturing industries in the United States. The large dryers that remove residual water from the pulp and paper are the costliest components associated with paper-making. These dryers also consume more energy than other components of the paper machine and offer significant opportunities for applying cost saving measures. A need exists for a mechanism to significantly improve the heat transfer from conventional steam cans.

Conventional steam dryer cans are simply large cast iron cylinders into which pressurized steam is used to heat the cylinder walls. This type of steam can is a very simple heat transfer device. Heat is transferred from the steam inside the dryers to the wet sheet outside the dryers, providing the energy required for evaporation. As the heat is transferred from the steam, most of the steam condenses inside the dryer cans. The condensation that is formed often interferes with heat transfer to the wall.

Drying is one of the most common unit operations used in diverse processes in the agricultural, ceramic, chemical, food, pharmaceutical, pulp and paper, mineral, polymer, and textile industries. Therefore, the dryer technology is cross-cutting with a range of applications and many industries could expect significant benefits from an improved cylinder dryer.

A principal object of the present invention is an improved cylinder dryer for use in drying pulp and paper and the like.

It is another object of the present invention to provide such an improved cylinder dryer having improved thermal resistance and improved heat transfer.

It is another object of the present invention to provide a multiport cylinder dryer having improved thermal resistance and improved heat transfer for use in drying pulp and paper and the like.

It is another object of the present invention to provide such multiport cylinder dryer for maximizing drying rates in drying pulp and paper and the like.

It is another object of the present invention to provide such multiport cylinder dryer for maximizing drying rates in drying pulp and paper and the like by maximizing heat transfer from steam into the material to be dried, such as pulp and paper and the like.

SUMMARY OF THE INVENTION

In brief, a multiport cylinder dryer for use with drying a web of pulp, paper, or similar material, and a method for drying a moving web of pulp, paper, or similar material are provided. The multiport cylinder dryer includes an outer cylinder dryer surface for transferring heat to a moving web to be dried. A plurality of multiport flow passages are positioned close to the outer cylinder dryer surface. The multiport flow passages are arranged for channeling steam flow for heating the cylinder dryer surface.

In accordance with features of the invention, the multiport cylinder dryer achieves significantly higher drying rates than conventional dryers by minimizing the condensate layer and maximizing the heat transfer surface area. The dominant heat transfer mode in the multiport cylinder dryer is convection, which is significantly more effective than conduction, the dominant heat transfer mode in conventional dryers.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above and other objects and advantages may best be understood from the following detailed description of the preferred embodiments of the invention illustrated in the drawings, wherein:

FIGS. **1A** and **1B** are diagrams illustrating multiport cylinder dryers in accordance with the present invention;

FIG. **2** is a diagram illustrating another multiport cylinder dryer in accordance with the present invention; and

FIG. **3** is a diagram illustrating an example blow-through steam path in a multiport cylinder dryer in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Having reference now to the drawings, in FIG. **1A**, there is shown a multiport cylinder dryer of the preferred embodiment generally designated by the reference character **100**. Multiport cylinder dryer **100** is a dryer type used for the paper industry, where heat from steam is transferred across a cylinder wall to a web of moving paper. As shown in FIG. **1A**, multiport cylinder dryer **100** includes a plurality of ports or multiport longitudinally oriented flow passages **102** close to the cylinder dryer surface **104**.

In accordance with features of the invention, the new concept of a multiport dryer **100** is to flow the steam through multiport longitudinally oriented flow passages **102** close to the cylinder dryer surface **104**. This innovative multiport dryer **100** achieves significantly higher drying rates than conventional dryers by minimizing the condensate layer and maximizing the heat transfer surface area. Also, the dominant heat transfer mode in the new multiport dryer design is convection, which is markedly more effective than conduction, the dominant heat transfer mode in conventional dryers. All of these factors contribute to extremely high coefficients of condensing heat transfer. The innovative multiport dryer **100** of the preferred embodiment can be used to reshape next-generation dryers.

A series of steam condensing tests have shown that the condensing heat transfer coefficient for multiport dryers **100** is approximately 2642 Btu/hr-ft^2-° F. (15,000 W/m^{2}K), or about 7 times greater than that in a conventional dryer with spoiler-bar enhancement and about 20 times greater than that in a conventional dryer without spoiler bars.

Furthermore, the tests showed that dryer shell surface temperatures are more uniform in multiport dryers **100** than in conventional dryers.

Multiport cylinder dryer **100** of FIG. **1**A includes a cylinder dryer shell **106** with the multiple flow passages or ports **102** fabricated directly into the cylinder dryer shell **106**. A cover plate **108** together with the cylinder dryer shell **106** define the multiple flow passages or ports **102**. Steam **110** flows in or out through the multiple flow passages **102**. Two-phase flow can occur in part or all of the flow passages **102**. The flow passages **102** are also called mini-channels or microchannels, because the height H and the width Wc are typically less than 10 mm, and could be as small as 100 microns. A space Wf between channels **102** is typically less than the channel width Wc, as shown in FIG. **1**A. The channels **102** and an associated fin **112** can take on a wide variety of aspect ratios. Also, the channels **102** can be a variety of shapes. The cover plate **108** can be either a thermal conductor or an insulator.

Flow channels **102** can occur on either side of the dryer shell **106**. In the multiport cylinder dryer **100** of FIG. **1**A, the flow channels **102** are formed on the inside of the dryer shell **106**.

Referring also to FIG. **1**B, another multiport cylinder dryer **150** is shown. In FIG. **1**B, the same reference numbers are used for similar or identical components as used with respect to the multiport cylinder dryer **100** of FIG. **1**A. In the multiport cylinder dryer **150** of FIG. **1**B, the flow channels **102** are formed on the outside of the dryer shell **106**. A cover plate **108** is used together with the cylinder dryer shell **106** to define the multiple flow passages or ports **102**. The cover plate **108** in the multiport cylinder dryer **150** completes the enclosure of the passages **102** and provides the outer drying surface **104**. In the multiport cylinder dryer **150** of FIG. **1**B, the cover plate **108** is thin and should also have a high thermal conductivity. Contact resistance between the cover plate **108** and the cylinder dryer shell **106** must also be kept small.

The flow channels **102** can be formed by various techniques, such as cutting, stamping, milling slots or corrugating plates. Tubes can be used to form multiport channels to serve as "pressure vessels," allowing for a thinner dryer shell **106** which can be fabricated less expensively than casting. The cover plate **108** can be permanently attached to the cylinder dryer shell **106** by welding. Alternatively, the cover plate **108** can be mechanically clamped to the cylinder dryer shell **106** which allows removal if needed.

Multiport cylinder dryer **100** of FIG. **1**A and multiport cylinder dryer **150** of FIG. **1**B are arranged for new applications. It should be noted that the multiport cylinder dryer **150** shown in FIG. **1**B can be used as a retrofit module for retrofit applications. Retrofit modules are installed inside existing dryers as shown in FIG. **2**.

In FIG. **2**, the same reference numbers are used for similar or identical components as used with respect to the multiport cylinder dryer **100** of FIG. **1**A. A basic embodiment of a multiport cylinder dryer **200** of the invention for retrofit applications is shown in FIG. **2**. The retrofit module **200** in FIG. **2** has no cover plate because the inner surface of the existing dryer shell **106** acts as the cover plate for the grooves in the retrofit module **200** to form the flow channels **102**. However, when a retrofit module has a cover plate, the area between the cover plate **108** and existing dryer shell **106** may have to be filled with thermally conducting materials to minimize contact resistance between the cover plate and dryer shell.

Referring also to FIG. **3**, there is shown an example blow-through condensate and steam path **300**, for example, such as in the multiport cylinder dryer **100** in accordance with the present invention. A multiport channel **302** is defined between a cover plate **304** and a dryer shell **306**. Multiport channel **302** includes multiple flow channels or ports **102**, such as shown in FIG. **1**A. A rotary seal **308** is provided at an inlet of a steam **310**. A conventional rotary pressure joint **312** is shown with the inlet of a steam **310**.

While the present invention has been described with reference to the details of the embodiments of the invention shown in the drawing, these details are not intended to limit the scope of the invention as claimed in the appended claims.

What is claimed is:

1. A multiport cylinder dryer for use with drying a web of pulp, paper, or similar material, said multiport cylinder dryer comprising:

an outer cylinder dryer surface for transferring heat to a moving web to be dried;

a plurality of multiport longitudinally oriented flow passages, said longitudinally oriented flow passages positioned close to said outer cylinder dryer surface; and

said multiport longitudinally oriented flow passages for channeling steam flow longitudinally substantially without circumferential steam flow between said multiport longitudinally oriented flow passage for heating said cylinder dryer surface and providing convection with phase change substantially as a heat transfer mode for the multiport cylinder dryer.

2. A multiport cylinder dryer as recited in claim **1** wherein said plurality of multiport flow passages are located on an inside of a dryer shell and further includes a cover plate for forming said multiport flow passages for improved steam flow.

3. A multiport cylinder dryer as recited in claim **1** wherein said plurality of multiport flow passages are located on an outside of a dryer shell and further includes a cover plate for forming said multiport flow passages for improved steam flow and said cover plate providing said outer cylinder dryer surface for transferring heat to a moving web to be dried.

4. A multiport cylinder dryer as recited in claim **3** wherein said cover plate has a high thermal conductivity.

5. A multiport cylinder dryer as recited in claim **1** wherein said plurality of multiport flow passages are formed by cutting, stamping, milling slots or corrugating plates.

6. A multiport cylinder dryer as recited in claim **1** wherein said plurality of multiport flow passages channels two-phase steam flow in a blow-through condensate and steam path without forming substantial steam condensation; whereby thermal resistance associated with condensate is limited.

7. A multiport cylinder dryer as recited in claim 1 wherein said plurality of multiport flow passages providing a defined steam heat transfer surface area include a set space between channels of less than a channel width.

8. A multiport cylinder dryer as recited in claim 1 wherein said plurality of multiport flow passages providing steam heat transfer to said outer cylinder dryer surface include a channel width and a channel height of less than 10 mm and a set space between channels of less than said channel width.

9. A multiport cylinder dryer as recited in claim 1 wherein said plurality of multiport flow passages are microchannels, each having a height and a width of less than 10 mm.

10. A multiport cylinder dryer as recited in claim 1 wherein said outer cylinder dryer surface has a generally uniform surface temperature.

11. A multiport cylinder dryer as recited in claim 1 wherein said outer cylinder dryer surface is provided by a cylindrical dryer shell and said plurality of multiport flow passages engage an inside surface of said cylindrical dryer shell for forming said multiport flow passages.

12. A multiport cylinder dryer as recited in claim 1 wherein said multiport flow passages include a height and a channel width of less than 100 mm.

13. A multiport cylinder dryer as recited in claim 12 wherein said multiport flow passages include a space Wf between channels of typically less than said channel width Wc.

14. A method for drying a moving web of pulp, paper, or similar material comprising the steps of:

providing an outer cylinder dryer surface for transferring heat to the moving web;

providing a plurality of multiport longitudinally oriented flow passages, said longitudinally oriented flow passages positioned close to said outer cylinder dryer surface; and

channeling steam flow longitudinally through said plurality of said multiport longitudinally oriented flow passages substantially without circumferential steam flow between said multiport longitudinally oriented flow passages for heating said cylinder dryer surface and providing convection with phase change substantially as a heat transfer mode for the multiport cylinder dryer.

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