Feb. 6, 1968 J. F. COX, JR 3,367,042

ROTARY HEAT EXCHANGER WITH RIBBED INNER LINER OF HIGHER THERMAL CONDUCTIVITY THAN OUTER SHELL

Filed Aug. 1, 1966 2 Sheets-Sheet 1

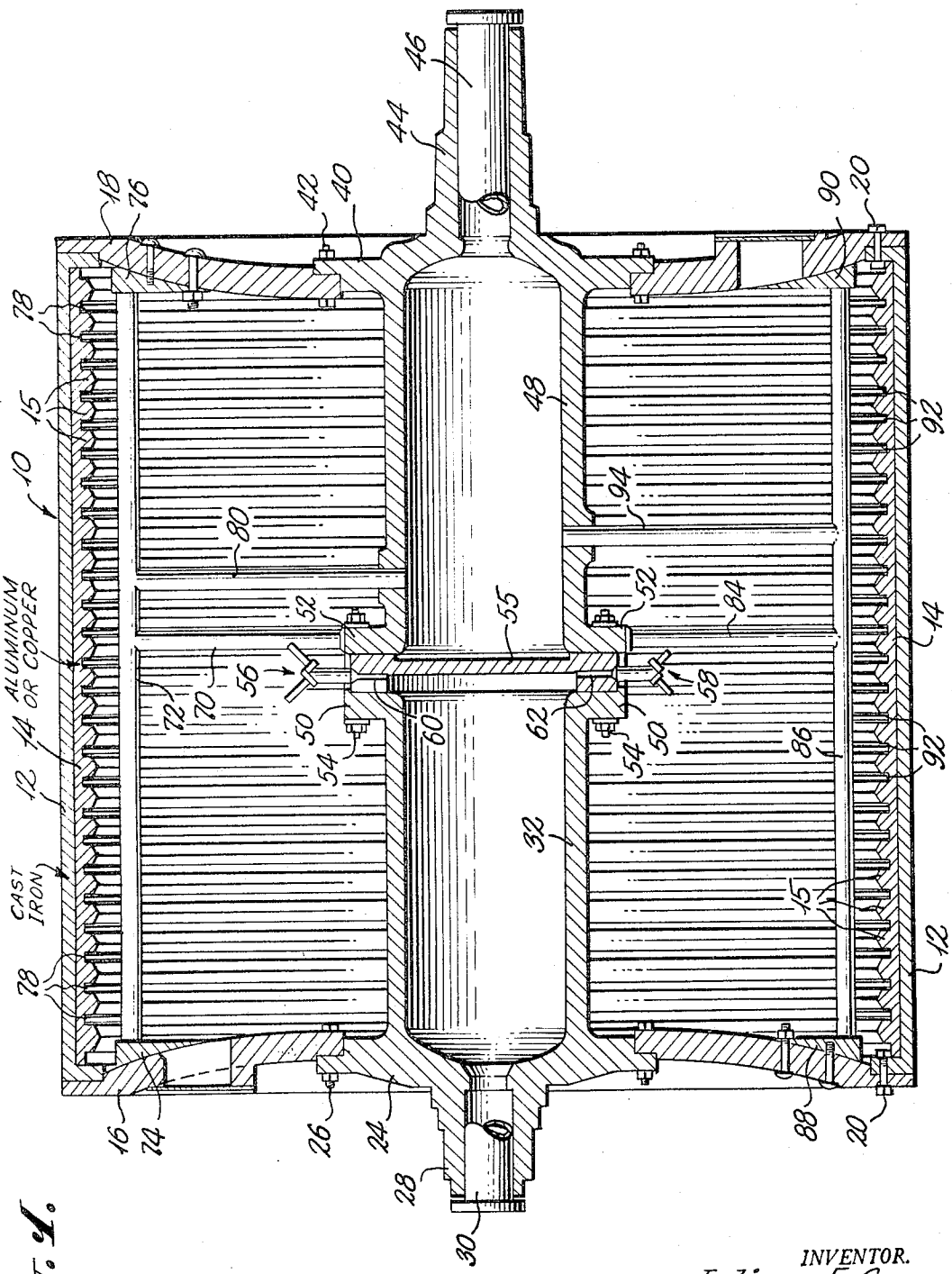


Fig. 1.

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Filed Aug. 1, 1966 2 Sheets-Sheet 2

Fig. 2.

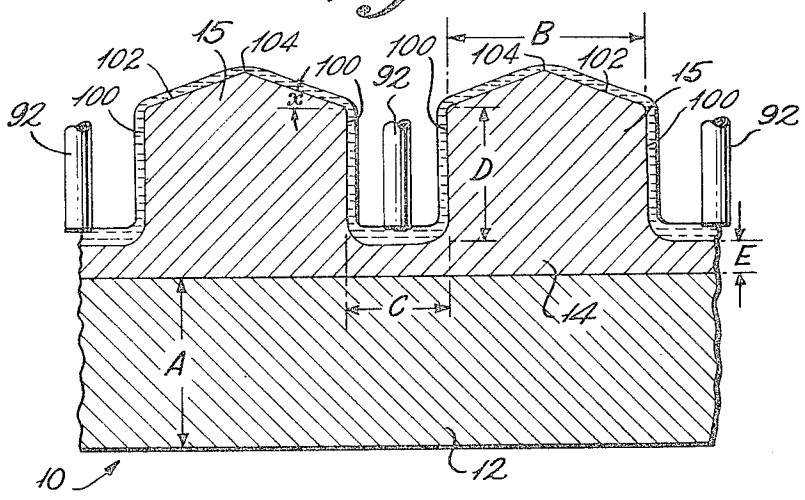
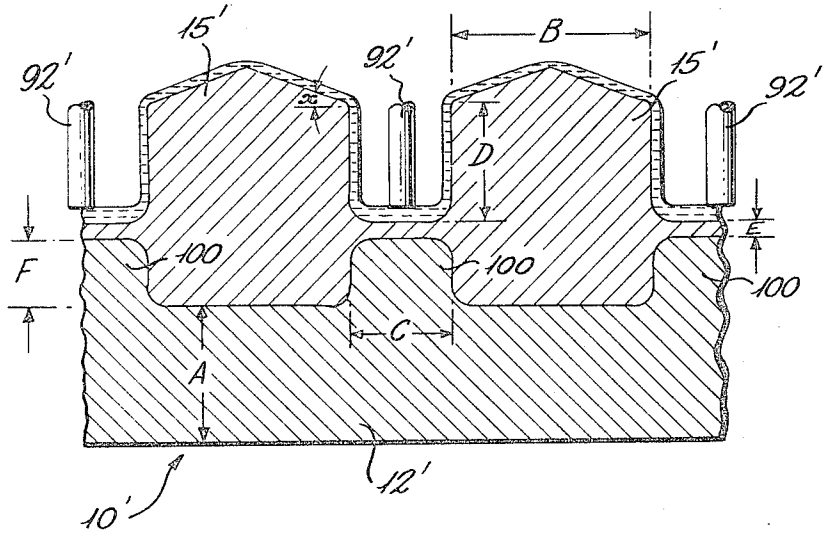


Fig. 3.



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ROTARY HEAT EXCHANGER WITH RIBBED INNER LINER OF HIGHER THERMAL CONDUCTIVITY THAN OUTER SHELL

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ABSTRACT OF THE DISCLOSURE

A Yankee drier for drying a web of paper comprises a generally cylindrical shell closed at opposite ends thereof and journalled for rotation about its longitudinal axis. Means is provided for introducing steam into the drier and exhausting same therefrom. The shell includes an outer shell portion and a liner disposed inwardly thereof and in contact therewith, the liner being formed of a material having higher thermal conductivity than the outer shell portion. A plurality of spaced radially inwardly extending ribs extend continuously about the inner periphery of the liner in a circumferential direction.

The present invention relates to a new and novel rotary pressure vessel, and more particularly to a Yankee drier or the like having a ribbed liner of high thermal conductance on the inner periphery thereof.

The present invention is particularly directed to Yankee driers employed for drying a web of paper which is run over the smooth outer surface of the Yankee drier shell to be smoothed, dried or glossed by the application of heat, and in some instances pressure.

Steam is admitted under pressure into the interior of the shell, and the shell is particularly designed to transfer the heat of condensation through the shell to the web being treated. Drying of paper and the like in web form requires high uniformity of heat transfer to the various portions of the shell to obtain the desired results.

It has been proposed in the prior art to provide integral ribs on the inner surface of the iron drier shell. The present invention represents an improvement over this type of arrangement.

In the present invention, a liner is provided on the inner surface of the outer cast iron drier shell, this liner having higher thermal conductivity than the cast iron portion of the shell. This liner is also provided with ribs of certain critical dimensions in order to provide optimum performance of the drier.

The provision of this liner serves to increase the rate of heat transfer through the shell, the liner preferably being made of a substance such as aluminum or copper and the like and being metallurgically bonded to the inside surface of the outer cast iron shell portion. With this arrangement, it has also been found that the rate of heat transfer is not affected by normal variations in condensate thickness or oscillation in condensate flow that occur above rimming speed of the drier.

The ribs formed on the liner limit the flow of condensate within the drier to a circumferential flow and ensure that no substantial longitudinal flow will occur.

Substantially uniform heat transfer to all portions of the outside surface of the shell is obtained, and at the same time the excellent strength and wear characteristics of the cast iron outer shell portion are maintained. The liner also serves to strengthen the shell somewhat, thereby adding to the structural rigidity of the construction.

The liner also serves to fill up small pores formed on the inner surface of the cast iron outer shell portion, thereby enhancing uniform heat transfer to a paper web passing over the shell, and further preventing leakage of steam through the outer shell portion. This eliminates the use of plugs in the cast iron drier shell.

The ribs are provided with a particular thickness and are spaced apart a particular distance in order to provide the desired results, the ribs having opposite side surfaces which extend substantially radially inwardly, the inner surfaces of the ribs being tapered to an apex or of crowned configuration. This apex or crown at the inner portion of each of the ribs aids in shedding condensate from the rib when the drier operates above rimming speed, thereby increasing the rate of heat transfer through the liner at such speeds.

The liner may be formed of various materials of high thermal conductivity such as aluminum or copper. These substances are desirable due to their availability and further their ability to adhere to a cast iron outer shell portion in a casting process.

An object of the present invention is to provide a new and novel Yankee drier or the like of such a construction as to provide an increased rate of heat transfer through the shell thereof.

Another object of the invention is the provision of a Yankee drier or the like wherein the rate of heat transfer is not affected by normal variations in condensate thickness or oscillations in the condensate flow that occur above rimming speeds of the drier.

A further object of the invention is to provide a Yankee drier which affords substantially uniform heat transfer to all portions of the outside surface of the shell thereof.

Yet another object of the invention is the provision of a Yankee drier or the like including supplementary means for preventing leakage of steam through the cast iron outer shell portion thereof, and wherein the overall strength of the construction is increased.

Other objects and many attendant advantages of the invention will become more apparent when considered in connection with the specification and accompanying drawings, wherein:

FIG. 1 is a longitudinal section through a Yankee drier according to the present invention;

FIG. 2 is an enlarged view of a portion of the structure shown in FIG. 1 illustrating certain details thereof; and

FIG. 3 is a view similar to FIG. 2 illustrating a modified form of the invention.

Referring now to the drawings wherein like reference characters designate corresponding parts throughout the several views, FIG. 1 illustrate a typical Yankee drier construction according to the present invention. A generally cylindrical shell is indicated generally by reference numeral **10** and includes an outer shell portion **12** formed of cast iron or similar material and having a smooth outer peripheral surface. A liner **14** formed preferably of aluminum or copper and the like is metallurgically bonded to the inner periphery of shell portion **12**, this liner having a plurality of ribs **15** formed on the inner portion thereof, these ribs defined in more detail hereinafter.

A first head **16** is provided at one end of the shell, and a second head **18** is provided at the opposite end of the shell, these heads being suitably secured as by bolts **20** to the shell and forming closures for the opposite ends thereof.

A plate **24** is bolted to head **16** and includes a journal **28** which is hollow and receives an inlet tube **30** through which steam is introduced into the drier. Journal **28** is adapted to be rotatably supported in a suitable conventional manner. Inlet tube **30** is adapted to feed steam into the interior of a hollow tubular portion **32** integral with plate **24**.

A plate **40** is secured by bolts **42** to head **18**, plate **40** including an integral journal **44** which is hollow and which receives an outlet tube **46** for removing steam from

the drier as hereinafter explained. Journal **44** is adapted to be suitably rotatably supported in a conventional manner. The outlet tube **46** is in communication with the hollow interior of a tubular portion **48** formed integral with plate **40**.

The inner ends of tubular portions **32** and **48** are provided with flanges **50** and **52** which extend radially outwardly thereof and which are bolted to one another by bolts **54**. A plate **55** is sandwiched between flanges **50** and **52**, and is secured in the operative position illustrated. Steam nozzles **56** and **58** are mounted within the outer ends of openings **60** and **62** respectively formed in plate **55**, whereby steam introduced through the inlet tube **30** passes through the tubular portion **32** and thence outwardly through openings **60** and **62** in steam nozzles **56** and **58** into the interior of the drier shell.

Means for removing condensate from the interior of the shell includes a support member **70** extending radially outwardly from the flange portion **52** and supporting a longitudinally extending hollow pipe **72** supported at brackets **74** and **76** at the opposite ends thereof, these brackets being mounted upon heads **16** and **18** respectively. A plurality of straws or tubes **78** extend from pipe **72** into the bottom of the grooves provided between adjacent ribs **15** formed on the liner **14**, these tubes serving to pick up condensate in the grooves which is then carried to the pipe **72** and thence through a radially extending conduit **80** to the interior of the tubular portion **48**.

A second support member **84** extends radially outwardly from flange **52** and supports a hollow pipe **86** at a position substantially diametrically opposite to the previously described pipe **72**. Pipe **86** is supported at the opposite ends thereof by brackets **88** and **90** mounted on the heads **16** and **18** respectively. A plurality of straws or tubes **92** extend radially outwardly from pipe **86** into the bottom of the grooves formed between adjacent ones of the ribs **15** on the liner. Condensate received by tubes **92**, which, of course, are open at the outer ends thereof, is directed to pipe **86** and thence through a radially inwardly extending conduit member **94** to the interior of the hollow tubular portion **48** whereupon the condensate may pass outwardly through the outlet tube **46**.

Referring now to FIG. 2 of the drawings, an enlarged view of the lower portion of the shell shown in FIG. 1 is illustrated wherein certain critical dimensions of the various components are illustrated. As shown in this figure, the dimension A represents the thickness of the cast iron iron outer shell portion **12**. The dimension B represents the width of an individual rib **15** in a direction extending substantially parallel with the longitudinal axis of the shell. The dimension C represents the space between facing side surfaces **100** of adjacent ones of said ribs, it being noted that these side surfaces extend substantially radially inwardly. The dimension D represents the height of the ribs, and the dimension E represents the root thickness of the liner.

The dimension A for all practical sizes of Yankee driers will lie within a range of about 0.25 inch to about 2.0 inches. The width of the rib B should lie within a range of bout 0.25 inch to about 1.50 inches, and with the configuration shown in FIG. 2, wherein no ribs are formed on the outer shell portion **12**, the optimum value of the distance B is about 1.25 inches.

The distance C should lie within the range of about 0.25 inch to about 1.5 inches, and a spacing of about 0.5 inch is considered to be an optimum spacing.

The dimension D should lie within the range of about 0.25 inch to about 1.25 inches, and the dimension E should lie within the range of about 0.001 inch to about 0.125 inch.

It will be noted that the inner surface **102** of each of the ribs is tapered to an apex **104** these inner surfaces defining an angle x as seen in FIG. 2 with an adjacent side surface of the associated rib of approximately 15°.

With the dimensions as set forth hereinabove, the arrangement has been found to provide optimum performance.

Referring now to FIG. 3, a modification is illustrated wherein the drier is in all respects similar to that previously described with the exception that the outer shell portion is provided with ribs. Similar parts will be given similar reference numerals primed, and it will be noted that the outer shell portion **12'** is provided with spaced ribs **100** which extend continuously around the outer periphery thereof and which extend radially inwardly from the shell. The liner is metallurgically bonded to the outer shell portion in this modification and is provided with a plurality of ribs **15'** corresponding to the ribs **15** previously described.

The dimensions A, B, C, D and E correspond to the dimensions previously described. An additional dimension F indicates the height of the ribs **100** formed on the outer shell portion.

In this modification, the dimensions A and B should lie within the same ranges as discussed previously, but with this arrangement, the optimum value for dimension B is about 1.5 inches. The dimensions C, D and E should also be within the same ranges as previously discussed with the optimum value of dimension C being the same. The dimension F should lie within the range of about 0.25 inch to about 1.25 inches, and the angle x may again be 15° in this modification.

It is apparent from the foregoing that there is provided according to the present invention a new and novel rotary pressure vessel such as a Yankee drier or the like having a construction which provides an increased rate of heat transfer through the shell thereof. The rate of heat transfer is not affected by normal variations in condensate thickness or oscillations in condensate flow that occur above rimming speeds of the drier. Substantially uniform heat transfer to all portions of the outside surface of the shell is afforded. The liner prevents leakage of steam through the cast iron outer shell portion, and further enhances the structural rigidity of the overall drier construction.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, and since the scope of the invention is defined by the appended claims, all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents are therefore intended to be embraced by those claims.

I claim:

1. A Yankee drier or the like comprising a generally cylindrical shell, a head at each end of said shell forming closures for opposite ends of the shell and including means for journalling the shell for rotation about its longitudinal axis, said shell including an outer shell portion, a liner disposed inwardly of said outer shell portion and in contact therewith, said liner being formed of a material having higher thermal conductivity than said outer shell portion, said liner including a plurality of spaced radially inwardly extending ribs, said ribs extending continuously about the inner periphery of said liner in a circumferential direction.

2. Apparatus as defined in claim **1**, wherein said liner is metallurgically bonded to the inner periphery of said outer shell portion.

3. Apparatus as defined in claim **1**, wherein the opposite side surfaces of each of said ribs on said liner extend substantially radially inwardly, and the inner surface of each of said ribs tapers inwardly to an apex.

4. Apparatus as defined in claim **1**, wherein the space between the facing surfaces of adjacent ribs in a direction parallel with the longitudinal axis of said shell is within the range of about 0.25 inch to about 1.25 inches.

5. Apparatus as defined in claim **1**, wherein the width of each of said ribs in a direction extending parallel

with the longitudinal axis of said shell is within the range of about 0.25 inch to about 1.50 inches.

6. Apparatus as defined in claim 1, wherein the space between facing surface of adjacent ribs in a direction extending parallel with the longitudinal axis of said shell is within the range of about 0.25 inch to about 1.25 inches, and the width of said ribs in a direction extending parallel with the longitudinal axis of said shell is within the range of about 0.25 inch to about 1.50 inches.

7. Apparatus as defined in claim 1, wherein said outer shell portion defines a smooth outer peripheral surface, said outer shell portion being formed of cast iron, said liner being metallurgically bonded to the inner periphery of said outer shell portion, each of said ribs having opposite side surfaces extending radially inwardly and including an inner surface which is tapered to an apex, the space between the facing side surfaces of adjacent ribs in a direction extending substantially parallel with the longitudinal axis of said shell being within the range of about 0.25 inch to about 1.25 inches, and the width of each of said ribs in a direction extending substantially parallel with the longitudinal axis of said shell being within the range of about 0.25 inch to about 1.50 inches.

8. Apparatus as defined in claim 7, wherein said space is approximately 0.5 inch.

9. Apparatus as defined in claim 7, wherein said outer shell portion has radially inwardly directed ribs formed thereon, the radial dimension of said last-mentioned ribs being within the range of about 0.25 inch to about 1.25 inches.

10. Apparatus as defined in claim 9, wherein each of said ribs has a width of approximately 1.50 inches.

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