Jan. 24, 1967 R. M. EISS ETAL 3,299,530

PAPERMAKING MACHINE

Filed March 11, 1965 4 Sheets-Sheet 1

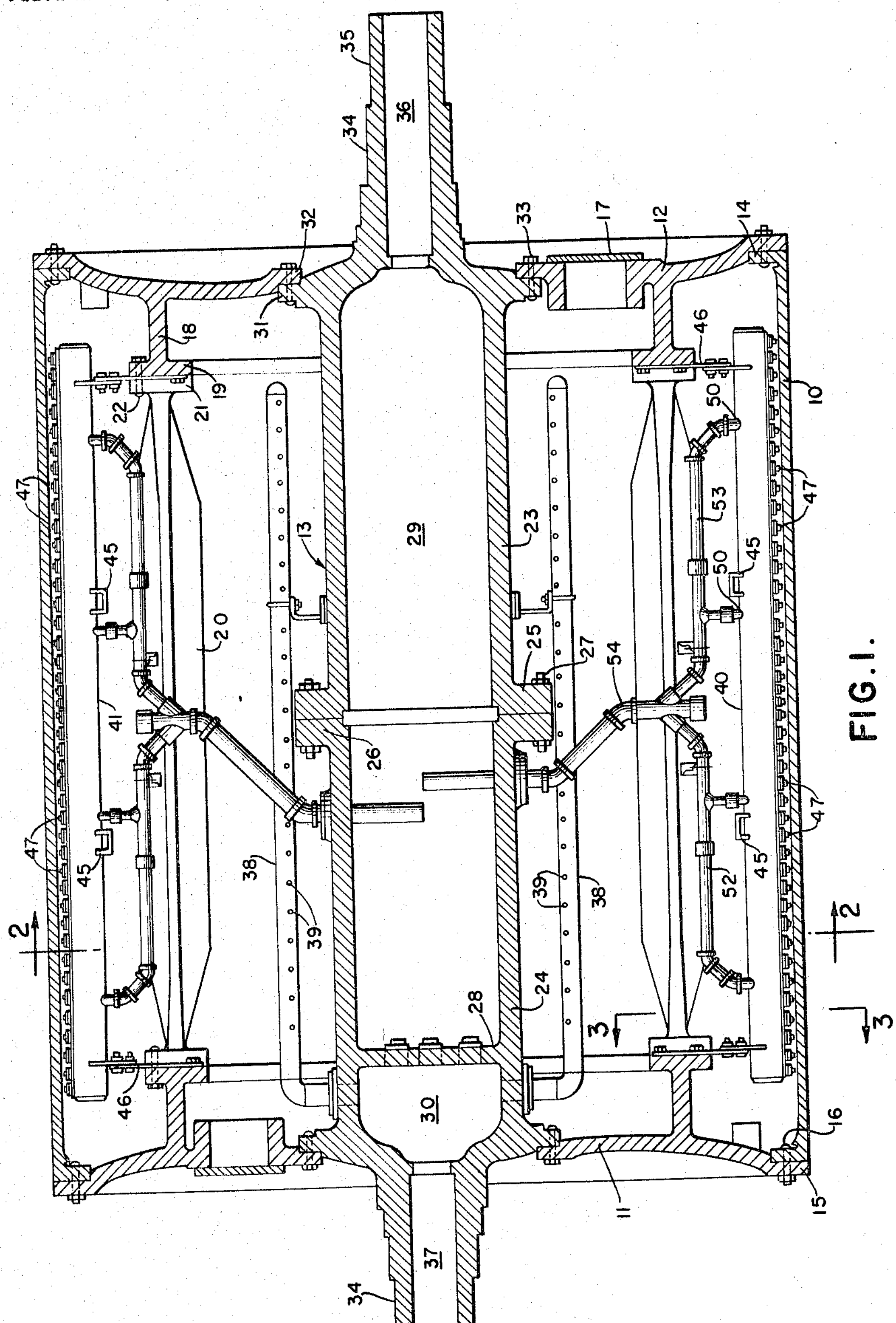

FIG. 1.

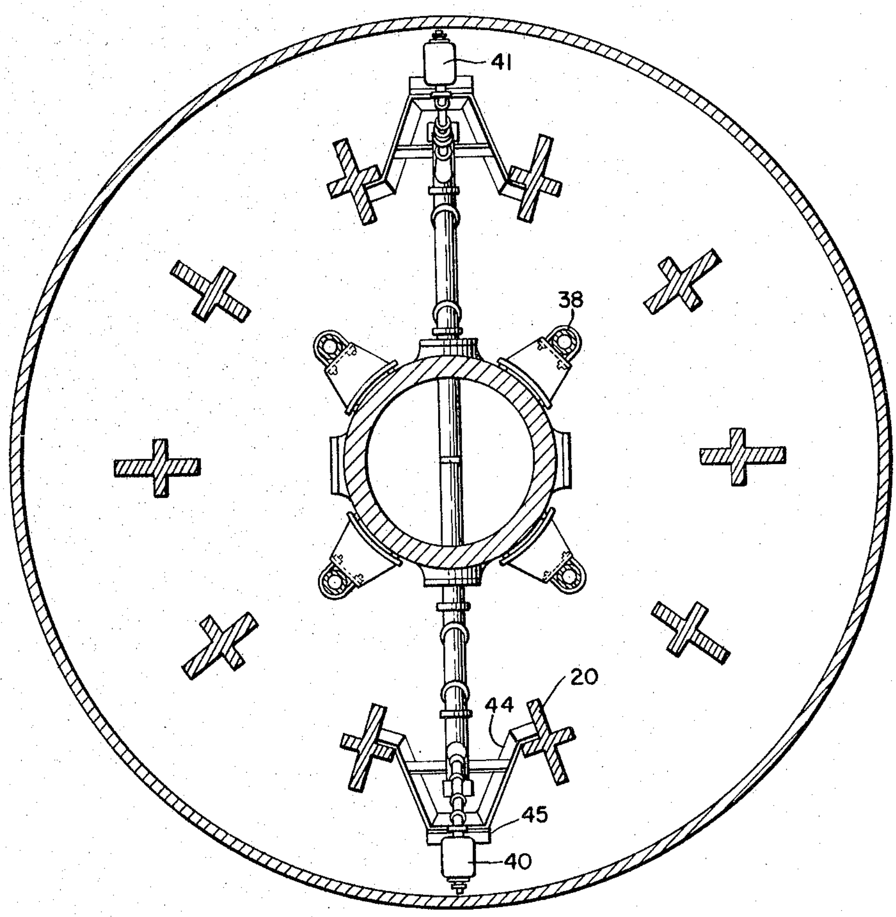

FIG. 2.

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PAPERMAKING MACHINE

Filed March 11, 1965 4 Sheets-Sheet 3

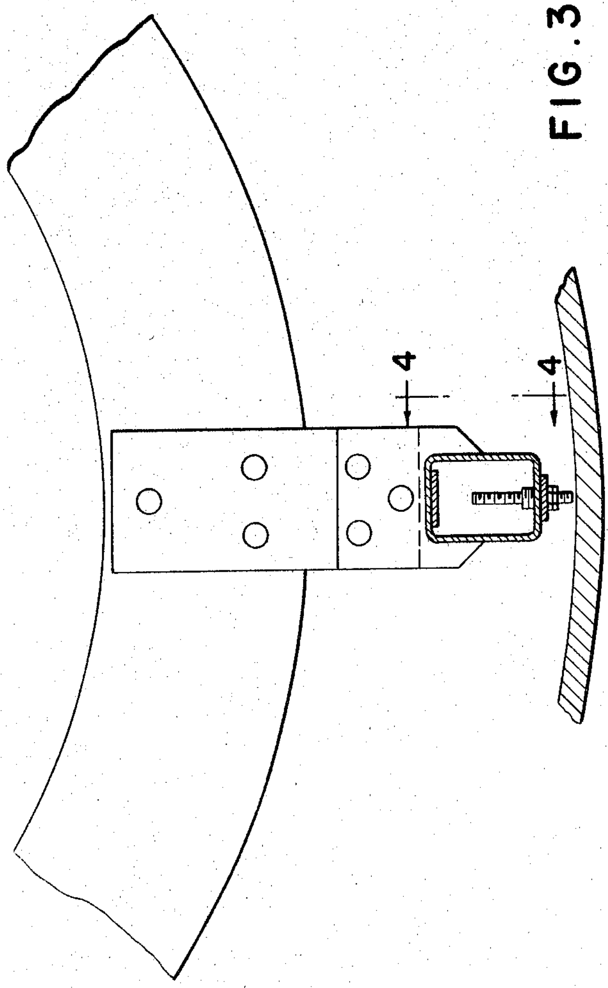

FIG. 3.

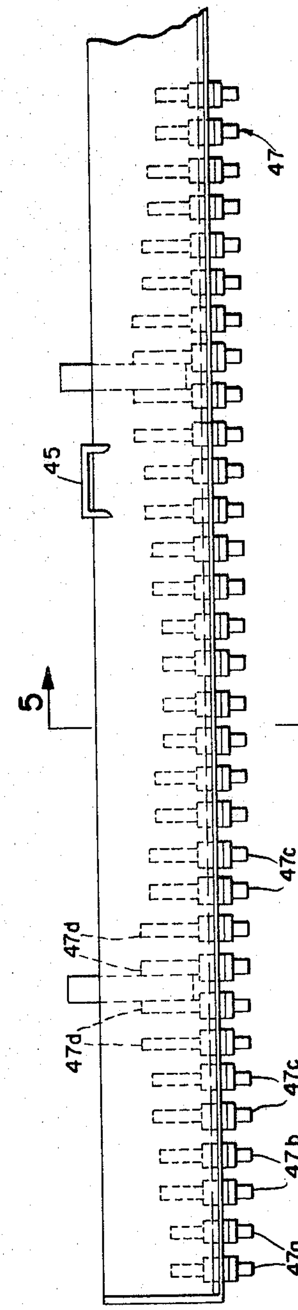

FIG. 4.

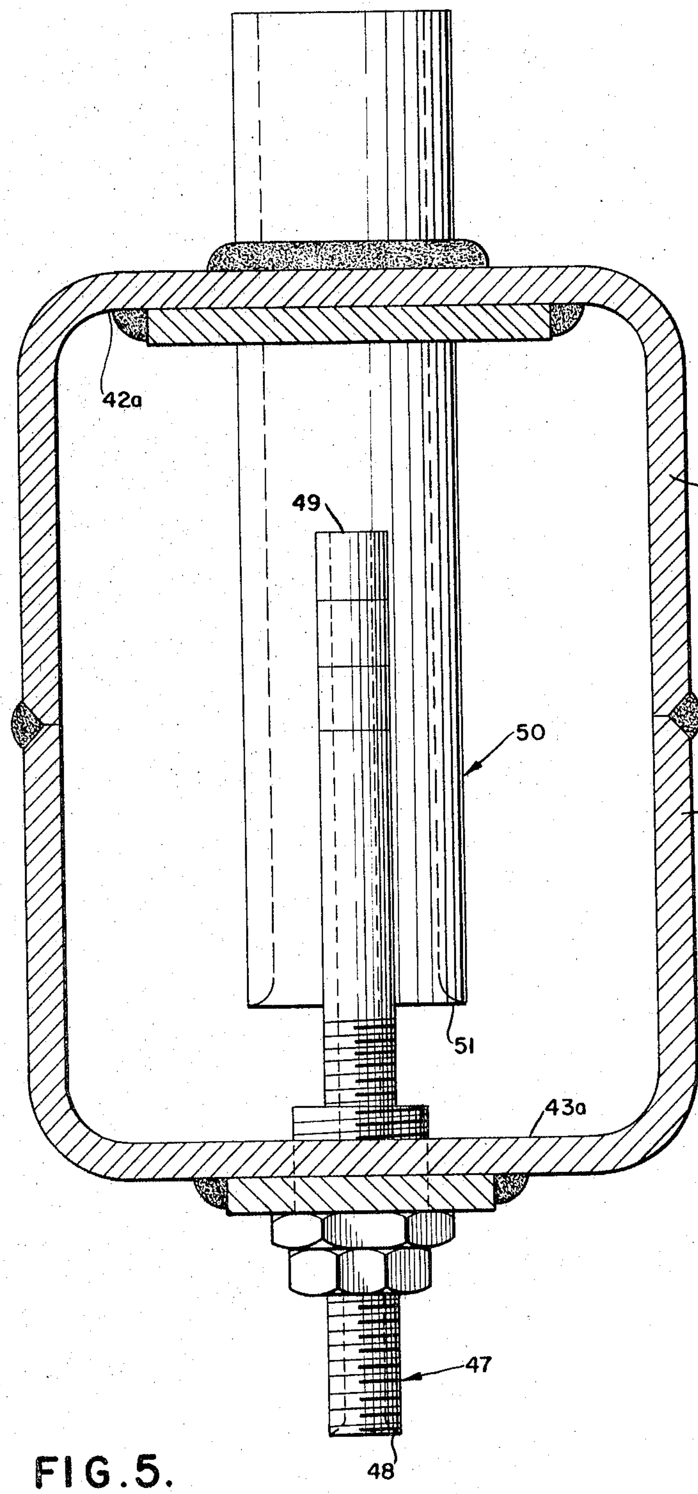

FIG. 5.

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PAPERMAKING MACHINE

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6 Claims. (Cl. 34—124)

The invention relates to steam heated drier drums, which may be used in papermaking machines, for example, and more particularly to condensate drainage devices for such drier drums.

Papermaking machine drying sections generally include a plurality of drier drums, each of which comprises a cylindrical shell, spaced heads extending radially across the shell to close the open ends thereof, carrying means for journalling the shell, means for introducing steam into the interior of the shell, and means for withdrawing steam condensate therefrom. The paper web travels serially over these drums in such a drying section. A Yankee drier drum has substantially the same structural arrangement as the drier drums in the drying sections just mentioned; however, a Yankee drier drum is ordinarily of substantially greater diameter; and only a single one of these drums is generally used, as in connection with tissue or lightweight webs.

On modern high speed tissue making machines, the machines and the associated drier drums run at speeds up to 4,000 to 5,000 feet per minute. Steam condensing on the inner wall of a rotating drier drum in such a machine forms condensate which must be continually removed in order to obtain good heat transfer. The condensate is held against the shell by centrifugal force which presses the fluid out in a thin sheet covering the entire inner wall of the drum. The sheet of paper or tissue being dried on the outer wall of the drum is usually very sensitive to any change in heat transfer through the wall; and, assuming that a condensate removal system causes the sheet of condensate within the drum to be of unequal thickness, the heat transferring characteristics of the drum across its surface are changed, so that the paper or tissue is thereby caused to run wet in streaks or bars according to the pattern created by the condensate removal system.

Available condensate siphons draw off the condensate locally at a number of places within the drum and may include two or more manifolds extending lengthwise of the drum adjacent its inner surface and having outlet tubes connecting the manifolds with a journal of the drum through which the condensate may discharge. The condensate inlets to the manifolds are substantially open with respect to the outlet tubes, and there is no substantial pressure drop between the inlets and outlets tubes; and, therefore, the rate at which the condensate is drawn off is greater in the areas of the outlet tubes than in areas away some distance from these tubes. The condensate is thus not uniform in thickness on the inside of the drum, and the drying rate of the drum thus is not uniform on the complete drum surface. In one particular type of manifold condensate withdrawal system, a pair of manifolds extend lengthwise of the drier drum adjacent the inner drum surface, and each of these manifolds has a plurality of holes drilled into it extending generally tangentially of the inner drum surface. The steam sweeps across the face of the sheet of water condensate into these holes and sweeps water from the inside surface of the drum into these holes and thereby into the associated manifold. Since centrifugal force is effective on the condensate entering the manifolds, it tends to lie in the bottom of each manifold; however, immediately in front of the outlet tubes that connect the manifold with the journal of the drier drum, the steam velocity is high enough to draw up water from the inside surface of the manifold at these points so that the inlet holes in the lower face of the manifold adjacent to the outlet tubes draw condensate more effectively than those located some distance from each side of the outlet tube. This unequal flow through the manifold inlet openings causes an undesirable, unequal temperature profile across the drier drum.

It is an object of the present invention to provide an improved condensate removal system of the manifold type which is so constructed that there is a substantially equal rate of condensate withdrawal by the manifolds from one end to the other end of the drum.

In brief, we accomplish this object by providing a plurality of longitudinally extending manifolds within a drier drum, each having a plurality of spaced small diameter withdrawal tubes extending into it and terminating in close proximity to the inner surface of the drier drum so that condensate may enter the tubes from the internal drum surface. Each manifold has a smaller number of larger diameter outlet tubes connecting it with the axle and journal of the drier drum through which condensate may flow, and these larger diameter tubes extend into the manifold beyond the inner ends of the small diameter tubes. A pond of water tends to collect due to centrifugal force within each manifold on its outermost surface, and the larger diameter tubes draw from the pond of water rather than directly from the small diameter tubes and tend to even out the draw and condensate flow through the small diameter tubes. The small diameter withdrawal tubes remote from the larger diameter outlet tubes are also preferably made shorter than the small diameter tubes closer to the large diameter outlet tubes for further evening of the flow of condensate through the small diameter tubes. This construction in which the small diameter tubes extend radially inwardly farther than the inlet ends of the larger diameter tubes also overcomes condensate flooding at the inner ends of the small diameter tubes which would tend to block condensate flow through the small diameter tubes.

The invention consists of the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above-stated objects, and such other objects, as will be apparent from the following description of a preferred form of the invention, illustrated with reference to the accompanying drawings, wherein:

FIG. 1 is a longitudinal sectional view of a Yankee drier drum incorporating the principles of the invention;

FIG. 2 is a sectional view taken on line **2—2** of FIG. 1;

FIG. 3 is a sectional view on an enlarged scale taken on line **3—3** of FIG. 1;

FIG. 4 is an elevational view taken on line **4—4** of FIG. 3; and

FIG. 5 is a sectional view on an enlarged scale taken on line **5—5** of FIG. 4.

Like characters of reference designate like parts in the several views.

Referring now to the drawings, the illustrated drier drum may be seen to comprise a thin cylindrical outer shell **10** which is rigidly secured at its ends to a pair of relatively flat ring-shaped heads **11** and **12** supported by a hollow central axle or shaft **13**. The shell **10** is provided at each with an integral bolting flange **14** which is machined to mate with a similar peripheral flange **15** on the adjacent head. The rigid attachment of the shell to each head may be made, as shown, by means of a plurality of bolts **16** inserted from the inside of the shell and drawn up by nuts on the outside of the head. Each of the heads **11** and **12** is provided with a manhole **17** to provide access to the interior of the drum for assembly and maintenance.

A short cylindrical section **18** provided at its inner end with a machined bolting flange **19** is formed integrally with each of the heads **11** and **12** and extends inwardly at a radial location and is intermediate the inner and outer edges of the head. A plurality of heavy staying members **20** extend between the heads longitudinally of the drier and are fixed with respect to the flanges **19** by means of flanges **21** formed on the staying members and bolts **22** that extend through the flanges **19** and **21**. The purpose of the staying members **20** is to control the bowing of the heads **11** and **12** and to eliminate stress occurring in the shell **10** at or near its connections to the heads.

The shell **10** and heads **11** and **12** are of cast construction, and the central shaft **13** is also of cast construction and is formed in two halves **23** and **24**. The halves **23** and **24** are provided with flanges **25** and **26**, and bolts **27** extend through the flanges to fix the halves **23** and **24** together. A separator **28** is formed in the half **24** so as to provide two separate compartments **29** and **30** in the axle **13**.

The shaft **13** near each end is provided with an enlarged bolting flange **31**, and each head **11** and **12** is provided with a flange **32** that meets with the flange **31**; and the flanges **31** and **32** are fixed together by means of bolts **33**. The shaft **13** is extended at each end to provide journals **34** for rotatably supporting the drier in suitable bearings, a shaft extension **35** being provided at one end of the shaft **13** for mounting a driving gear or sprocket or the like. The shaft **13** at its end is provided with bores **36** and **37**, respectively, in communication with the chambers **29** and **30**; and the bores **37** and **36** may be utilized, respectively, for providing steam under pressure into the compartment **30** and for withdrawing the steam condensate from the compartment **29**.

A drier drum, substantially as so far described, is disclosed in Patent 3,099,543, issued to Malmstrom et al. on July 30, 1963, and assigned to the same assignee as the present application.

Steam under pressure is supplied to the interior of the drier drum by means of steam supply pipes **38** having rows of steam discharge openings **39** formed therein and extending axially of the drier drum along the shaft **13**. The pipes **38** are connected to the compartment **30**.

The condensate removal system of the invention comprises a pair of manifolds **40** and **41** positioned oppositely from each other with respect to the shaft **13** and located adjacent the inner surface of the shell **10**. Each of the manifolds **40** and **41** is rectangular in cross section, as shown in FIG. 5, and comprises a pair of elongated hollow shells **42** and **43**, which are welded together at their edges. Each manifold **40** and **41** is supported from adjacent staying members **20** by means of A-shaped brackets **44**. Each of the brackets **44** has one of its legs bolted to a staying member **20** and carries a U-shaped bar **45** on its uppermost portion which is indented to receive a manifold **40** or **41**, and the manifold is welded to the bar **45**. Each manifold is supported from the sections **18** by means of brackets **46** which are welded to the manifold adjacent its ends and which are bolted to the sections **18**.

A plurality of small diameter tubes **47** extend radially through the outermost wall **43***a* of each of the manifolds **40** and **41**. The tubes have their outer ends **48** terminating adjacent the inner surface of the shell **10** and have their inner ends **49** terminating well within the associated manifold, preferably at least to the center of the manifold. In the particular embodiment of the invention illustrated, each of the manifolds **40** and **41** is provided with thirty-two of the small diameter tubes **47** which are located on 2¼ inch centers.

Each of the manifolds **40** and **41** has four equally spaced, relatively large diameter condensate withdrawal tubes **50** extending into it through its innermost wall **42***a*. The outer end **51** of each of the tubes **50** is located adjacent to the outer wall **43***a* of the associated manifolds.

The tubes **50** of each of the headers are connected by means of branch pipes **52** and **53** with a central header **54** which is connected with the compartment **29** in the shaft **13**. The headers **54** are located equi-distantly from the heads **11** and **12** except that the headers are angled to the left as seen in FIG. 1, toward the separator **28**, to avoid the flanges **25** and **26** in passing through the shaft **13** into the compartment **29**.

The tubes **47** are preferably of different lengths, the tubes **47** located closer to the withdrawal tubes **50** being longer than the tubes remote from the withdrawal tubes **50**, in order that there shall be more restriction to the flow of condensate and steam through the small tubes **47** located closer to the withdrawal tubes **50** than through the other tubes **47**. Insofar as length is concerned, the tubes **47** in the illustrated embodiment may be designated as the different length tubes **47***a*, **47***b*, **47***c*, and **47***d*. The tubes **47***d* are longer than the tubes **47***c*, which in turn are longer than the tubes **47***b*, and the tubes **47***b* are longer than the tubes **47***a*. Between each group of tubes there may, for example, be a difference of length of ½ inch. The tubes **47***a* in the particular illustrated embodiment terminate substantially midway between the manifold walls **42***a* and **43***a*, and the tubes **47***b*, **47***c*, and **47***d* terminate respectively at additional distances of ½ inch from the outer wall **43***a* of the manifold. The withdrawal tubes **50** extend radially outwardly substantially closer to the outermost wall **43** than the inner ends of the shortest tubes **47***a*, the tubes **50** having their ends **51** located an inch, for example, from the wall **43***a* of the manifold while the short tubes **47***a* terminate 3 inches, for example, from the outer wall **43***a*.

Although, as will be obvious, the internal diameter and length of the tubes **47** may be varied; in one particular embodiment of the invention, the bores of the tubes **47** were .307 inch in diameter and the tubes varied in length from 5⅛ inches to 6⅝ inches. The tube ends **48** may be located, for example, from ⅛ inch to ⅜ inch from the internal surface of the shell **10**, and a good working distance in actual practice between the tube ends **48** and the internal shell surface has been found to be about 5⁄16 inch. The large diameter condensate withdrawal tubes **50** had an internal diameter of one inch in this embodiment.

In operation, moist paper web is directed onto the outer surface of the shell **10**, and the drum may be rotated by means of the sprocket or other driving mechanism on the extension **35** at a high speed, such as 4,000 to 5,000 feet per minute, for example. The web is dried as the drum rotates, and the web may be creped off the outer surface of the drum by means of a suitable creping blade (not shown).

Steam under pressure is supplied to the compartment **30** through the bore **37**, and the steam is directed into the internal compartment of the drum through the supply pipes **38** and the discharge openings **39** in the pipes **38**. The steam heats the drier drum, and, in doing so, it condenses into water; and the water condensate rims the internal surface of the shell **10** completely around the shell, to a depth of ¼ inch, for example. The condensate removal system, including the manifolds **40** and **41** and the small diameter tubes **47**, remove this condensate.

To maintain the surface temperature and the drying effect of the shell **10** as uniform as possible, the depth of the water condensate is maintained as uniform as possible about the internal surface of the shell **10**. Steam within the drier drum rushes to the ends **48** of the tubes **47** located close to the internal drum surface, since the pressure within the tubes **47** and in the connected manifolds **40** and **41** and compartment **29** is lower than the pressure of the steam within the drum. The steam, in entering the ends **48** of the small diameter tubes **47** sweeps across the inner turface of the drier drum, and atomizes the condensate existing on the inner drum surface. Thus, a steam-water mixture passes radially inwardly through the bores of the tubes **47** into the manifolds **40** and **41**. In order that such atomization occurs, the velocity of the steam entering the bores of the small diameter tubes **47** is high, and the velocity of the steam-water mixture within the tubes **47** may be, for example, about 110 feet per second. The small diameters of the bores within the tubes **47** provide this high velocity; and, due to the high velocity, the pressure within the bores of the tubes **47** is reduced from the pressure within the drum by about 5 pounds per square inch.

The steam-water mixture flowing radially inwardly through the tubes **47**, of course, is subject to centrifugal force due to the high velocity of rotation of the drier drum; however, since there is atomization in the vicinity of the ends **48** of the tubes **47**, the pressure of the steam within the drier drum is effective to move the water-steam mixture inwardly against the centrifugal force. It will be understood that if such atomization should not occur, it would be more difficult to move the undiluted condensate inwardly against centrifugal force due to its increased density.

There is some condensation taking place within the manifolds **40** and **41**, and the water-steam mixture in passing through the tubes **47** also tends to separate into water and steam components; however, since the tube ends **51** are located quite close to the outer walls **43***a* of the manifolds **40** and **41**, substantially the same atomizing action takes place on these walls as takes place at the ends **48** of the tubes **47**. Due to centrifugal force, water in the manifolds **40** and **41** tends to pond on the outer surface **43***a*, and the steam in sweeping across the ends **51** of the tubes **50** tends to atomize any water on the outer walls **43***a* of the manifolds **40** and **41** and draws it along with the steam as a water-steam mixture radially through the tubes **50** and into the compartment **29** of the shaft **13** by means of the pipes **52, 53** and **54**. The velocity of the steam-water mixture through the tubes **50** may be, for example, 80 to 90 feet per second.

The compartment **29** is connected through the bore **36** within a suitable steam condensate separator (not shown), and the pressure of steam within the compartment **29** is controlled by any suitable valve means (not shown). It will be understood, of course, that the steam pressure drops, in general, from the tube ends **48** through the manifolds **40** and **41** and through the pipes **53** and **54** and through the compartment **29**, as the steam-water mixture flows to the separator. The steam pressure, for example, may drop from about 125 pounds per square inch within the drier drum to 110 pounds per square inch within the bore **36**.

Due to the atomization of the condensate on the outer walls **43***a* of the manifolds **40** and **41**, the walls **43***a* are swept relatively clean of water so that there is no flooding of the manifolds, and hence no impedance by flooding to any flow of a water-steam mixture through the small diameter tubes **47**. The tubes **47** cannot be blocked particularly due to the fact that the inner ends **49** of the tubes are located closed to the center of rotation of the shell **10** than are the ends **51** of the tubes **50**, and hence the inner ends **49** of the tubes **47** protrude clear of any water ponded on the surfaces **43***a*.

It will be observed that the steam-condensate mixture travels from the ends **48** of the tubes **47** to the compartment **29** in two stages in each of which there is a sweeping action of the steam across a surface atomizing the water condensate; and the structure providing this two-stage action has been found to provide more uniformity of condensate removal lengthwise of the drier drum and lengthwise of the manifolds **40** and **41** than if there were a simple direct connection between each of the small diameter tubes **47** and the compartment **29**. If there are any water ponds on the surfaces **43***a* caused by centrifugal forces, the large diameter tubes **50** tend to be immersed in these water ponds; and the atomizing action at the ends **51** of the tubes **50** functions to provide substantially the same reduced pressure within the manifolds **40** and **41** from one end to the other end of each manifold. Therefore, all of the small diameter tubes **47** have nearly the same pressure effective at their inner ends **49** so that condensate flow in all of the tubes **47** is fairly uniform.

In order to take care of the slight variations in pressure that exist within the manifolds **40** and **41** adjacent and remote from the outlet tubes **50**, the tubes **47***d* located close to the tubes **50** have been made longer than the tubes **47***a* remotely located with respect to the tubes **50**, and the intermediate tubes **47***b* and **47***c* are intermediate in length with respect to the tubes **47***a* and **47***d*. The impedance to flow of the water-steam mixture through the tubes **47**, of course, increases with the length of the tubes **47**; and, since there is a slightly greater tendency to draw water-steam mixture out of the tubes **47** located closer to the outlet tubes **50**, the tubes **47** remotely located with respect to the outlet tubes **50** have been made shorter so as to equalize the flow of water condensate mixture through the various tubes **47**. Also, in equalizing the flow, the headers **54** have been located centrally within the drier drum, except for the slanting portions of the headers **54** leading to one side of the flanges **25** and **26**.

The above-described condensate removal system advantageously is non-flooding with respect to the small diameter tubes **47** due to the fact that the large diameter tubes **50** extend in close proximity to the surface **43***a* of the manifolds and the tubes **47** extend inwardly beyond the ends **51** of the tubes **50**. The two-stage action of the condensate withdrawal system also assures quite substantial uniformity of condensate withdrawal from one end to the other end of each of the manifolds **40** and **41**, this two-stage action constituting the atomizing effect of the small diameter tubes **47** on the internal surface of the shell **10** and the atomizing effect of the ends **51** of the large diameter tubes **50** with respect to the adjacent internal surfaces **43***a* of the manifolds **40** and **41**. In order to correct any minor discrepancies of flow through the tubes **47**, the tubes **47** are also preferably made greater in length adjacent the outlet tubes **50**, as described.

We wish it to be understood that the invention is not to be limited to the specific constructions, arrangements and devices shown and described, except only insofar as the claims may be so limited, as it will be understood to those skilled in the art that changes may be made without departing from the principles of the invention. In particular, we would like to have it understood that, although the tubes **47** are shown exactly radially, these tubes could, if desired, be set at an angle with respect to radii of the drier drum and also with respect to the tubes **50**. Also, it will be understood that, although we have disclosed only two manifolds **40** and **41**, additional similar manifolds may be added to the construction.

What is claimed is:

1. A hollow drier drum having journals for rotatably mounting the drum, a steam supply connection for didecting steam into the drum, a manifold in said drum and lying adjacent to the inner surface of the drum, a plurality of water condensate removal tubes extending into and carried by said manifold and terminating closely adjacent to the inner drum surface, and a water condensate removal pipe connected to a condensate removal connection and extending outwardly into said manifold, said pipe extending farther outwardly radially than the inner ends of said tubes so as to prevent blockage by condensate of said tubes.

2. A hollow drier drum having journals for rotatably mounting the drum, a steam supply connection for directing steam into the drum, a plurality of manifolds in said drum lying adjacent to the inner surface of the drum and equi-distantly spaced from each other, a plurality of water condensate removal tubes extending generally radially into and carried by each of said manifolds and terminating on their outer ends closely adjacent to the inner drum surface, and a plurality of condensate removal pipes connected to a condensate removal connection and extending generally radially into each of said manifolds, said pipes having their outer ends terminating closer to the outermost wall of said manifolds than the inner ends of said tubes so as to prevent blockage of condensate of said tubes.

3. A drier drum having journals for rotatably mounting the drum, a steam supply connection for directing steam into the drum, a plurality of manifolds in said drum and extending generally axially of the drum adjacent to the inner drum surface and equi-distantly spaced from each other, a plurality of water condensate removal tubes extending generally radially into and carried by each of said manifolds and terminating on their outer ends closely adjacent to the inner drum surface, and a plurality of water condensate removal pipes connected to a condensate removal connection and extending generally radially into each of said manifolds and equi-distantly spaced along the length of the manifold, the inner ends of said tubes extending further inwardly radially of the drum than the outer ends of said pipes and certain ones of the tubes adjacent to said pipes in each of said manifolds being longer than other ones of said tubes which are more remote from said pipes for equalizing the flow of condensate through said tubes and into said manifolds.

4. A hollow drier drum having journals for rotatably mounting the drum, a steam supply outlet in said drum and connected to one of said journals for directing steam into the drum, a plurality of manifolds in said drum and extending generally axially of the drum adjacent to the inner drum surface and equi-distantly spaced about the drum, a plurality of water condensate removal tubes of relatively small diameter extending radially into and carried by each of said manifolds and terminating closely adjacent to the inner drum surface, a plurality of water condensate removal pipes extending radially into each of said manifolds and having a water removal connection with the other of said journals, said pipes being substantially less in number than the number of said tubes and

being of larger internal diameter than said tubes and being equally spaced along each of said manifolds, said pipes terminating closely adjacent to the outermost surfaces of said manifolds and said tubes terminating within the manifolds farther from said outermost manifold surfaces than said pipes.

5. A hollow drier drum having journals for rotatably mounting the drum, a steam supply connection for directing steam into the drum, a manifold in said drum and lying adjacent to the inner surface of the drum, a plurality of water condensate removal tubes extending into and carried by said manifold and terminating closely adjacent to the inner drum surface, a condensate removal connection, and water condensate removal piping connected to said condensate removal connection and to said manifold and terminating farther outwardly in the manifold than the inner ends of said tubes so as to prevent blockage by condensate of said tubes.

6. A hollow drier drum having a hollow central axle with end journals for rotatably mounting the drum, a steam supply connection for directing steam into the drum, a plurality of manifolds in said drum and equally spaced about the drum and lying adjacent to the inner surface of the drum, a plurality of water condensate removal tubes extending into and carried by each of said manifolds and terminating closely adjacent to the inner drum surface, said axle being vented through one of said journals so as to provide a water condensate removal connection, and water condensate removal piping connected to said axle and also connected to each of said manifolds at a place in each of said manifolds located farther outwardly than the inner ends of said tubes so as to prevent blockage of condensate of said tubes.

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