April 12, 1960 G. D. DAY 2,932,091

HEATED SHELL DRUM DRYERS

Filed Oct. 8, 1956 3 Sheets-Sheet 1

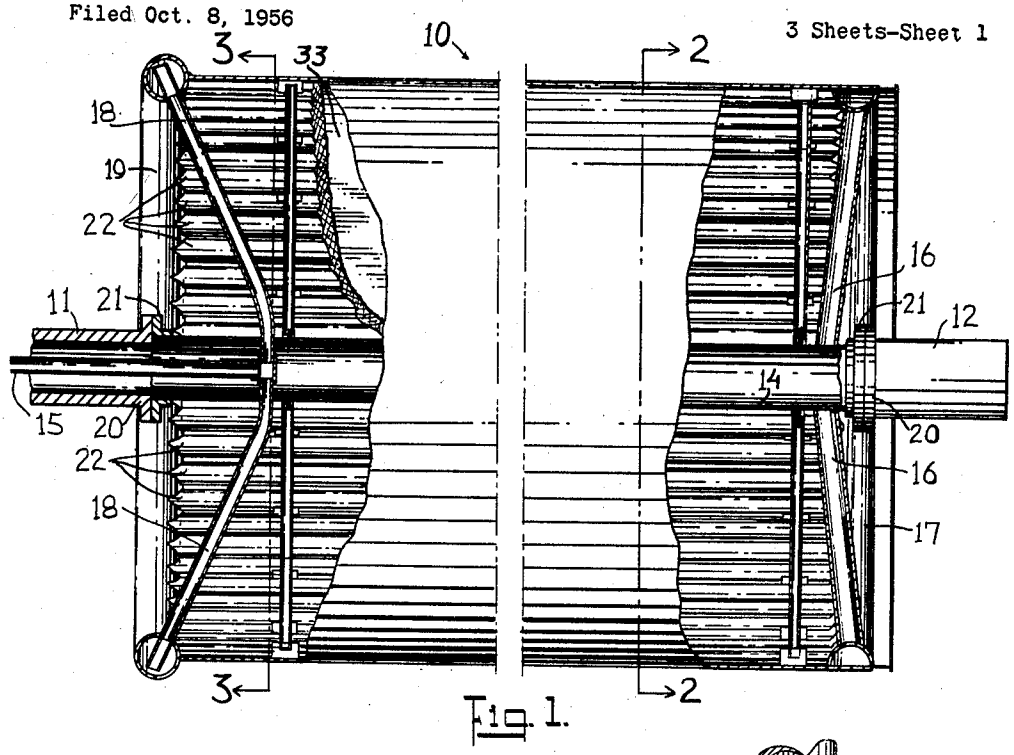


Fig. 1.

Fig. 2.

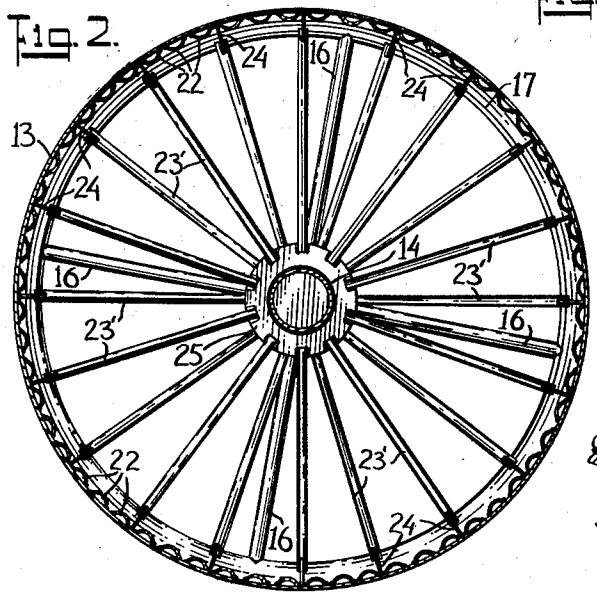
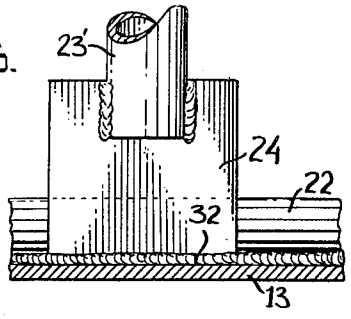


Fig. 5.



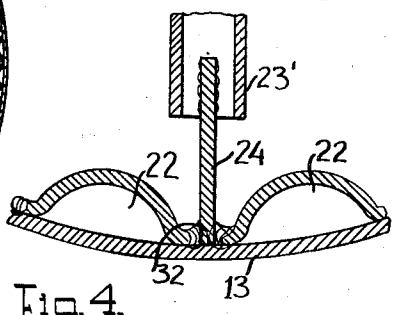


Fig. 4.

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HEATED SHELL DRUM DRYERS

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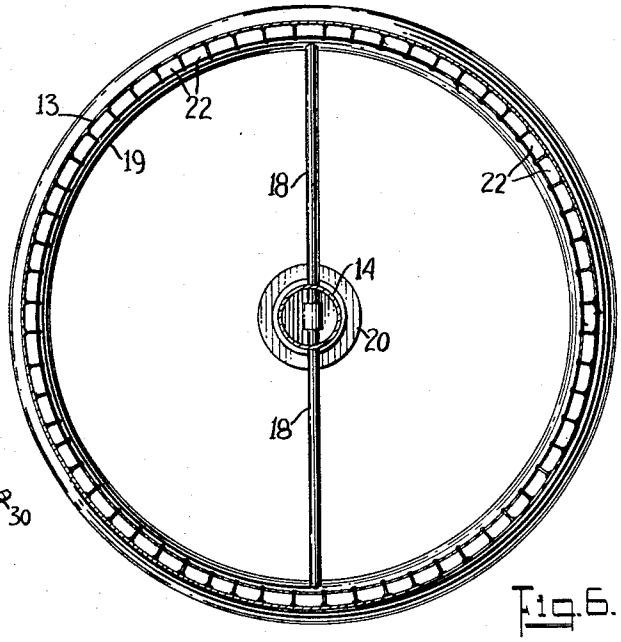


Fig. 6.

Fig. 9.

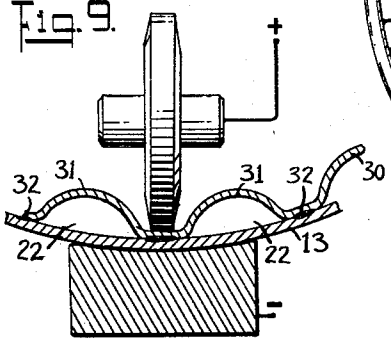
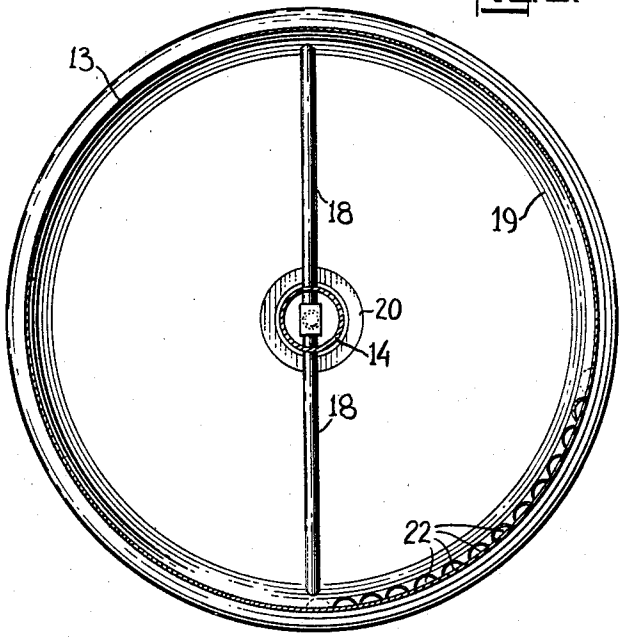


Fig. 3.



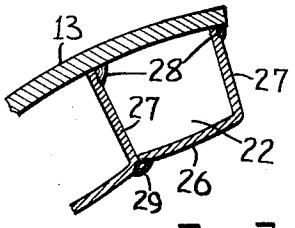


Fig. 7.

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HEATED SHELL DRUM DRYERS

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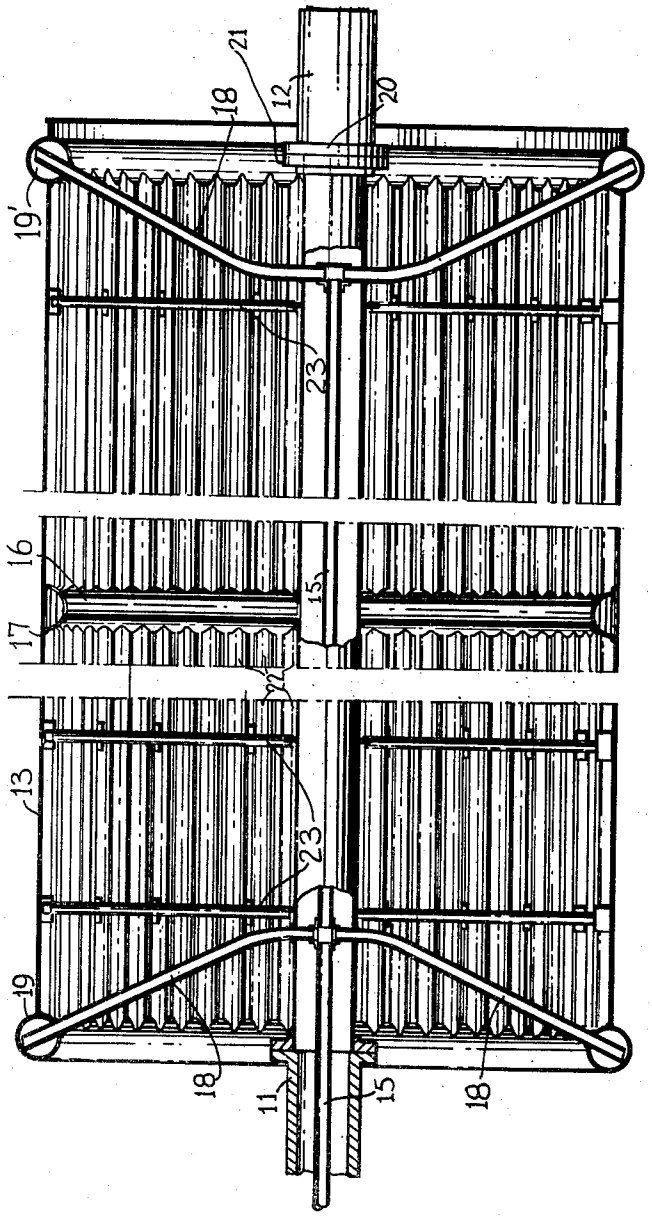

Fig. 6

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HEATED SHELL DRUM DRYERS

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Application October 8, 1956, Serial No. 614,516

9 Claims. (Cl. 34—124)

This invention relates to improvements in rotatable heated rolls, and in particular relates to a thin-shelled drum form of dryer adapted to be heated internally for the drying of a web of paper passing over the external surface of the drum as in the drying end of a paper-making machine.

The invention also extends to the construction of a heated shell over whose surface uniformity of temperature is required for use in any application where an extended surface is required to be maintained at a given temperature.

Conventional dryer rolls in paper-making machines have numerous disadvantages and defects. Cylindrical driers according to present practice in the paper industry for the drying of moist webs of paper issuing from a Fourdrinier machine are massive structures, with heavy shells of cast iron or steel several inches thick. Steam at elevated pressure is admitted into the hollow cylinder to heat the shell and the heat of condensing steam is conducted through the metal to the surface of the roll where the web contacts it to cause evaporation of water in the web. Condensate gathers in the shell and is removed by gathering means. It is well known that in order to attain an exterior surface temperature on such a working roll above the boiling point of water at atmospheric pressure, it is necessary to employ rather high steam pressures corresponding to temperatures several tens of degrees above the desired surface temperature. This is due in part to the effect of a film of condensate which gathers on the inner wall of the cylinder and acts as a barrier to effective heat flow. In addition the condition of the metal surface on the inside of the drier, which is usually rough and scaly, represents a further barrier to heat flow and is variable in its effect over different parts of the roll, so that the temperature of the surface may vary locally to the detriment of uniformity of the finished web.

Hence although the drier may be operated with steam at a definite inlet pressure, for example ten pounds per square inch gauge, the working temperature at the surface of the roll cannot be directly ascertained by the operator supervising the operation of a group of drier rolls. The steam temperature correlated to the gauge pressure is not a reliable indication inasmuch as the conversion factor allowing for effects of film, interior scale, and roll thickness is variable. This is a serious detriment to efficient operation, since it is well known in the art of paper-making that the output of dried web increases with increased roll surface temperature, at the rate of approximately one and one-half percent higher output for each degree Fahrenheit rise in temperature. Therefore with a given inlet steam pressure available to a machine, the substitution of improved drier rolls permits either that the total number of drier rolls in a train may be considerably reduced, or the rate of movement of the web over a given number of rolls may be considerably increased.

Existing cast-iron shell dryers are also defective in

that the steam filling the pressure vessel gives up heat to the ends walls closing the vessel, which are usually massive, heat flow thereinto being relatively unimpeded by a film of condensate, with the result that due to the conduction of heat from such heated ends of the vessel the margins of the web receive extra heat and dry faster. This effect is noted generally for a distance of about two feet inwardly along the roll face from the end walls of a large diameter dryer. Heretofore, in order to compensate for the relatively super-heated margins of the rolls, the web has been deliberately pre-squeezed non-uniformly over its width as it issues from the wet end of the machine, by crowning the presser rolls so as to leave more water in the margins of the web, with the object of achieving a concurrent attainment of dryness in all parts of its width after the web has traversed the entire train of dryers. The maintenance of rolls and heat input for this compensation involves considerable maintenance and delicate adjustment in order to achieve a uniform product of high quality.

A further objection to the prior art form of drier is that by the construction of a cast-iron thick shell vessel, the tensile forces across any longitudinal diametral plane become very large at the higher pressures of steam required to transfer heat at effective rates through the metal, with the consequence that there is hazard of bursting. It must be noted that the stored energy in a roll of large diameter, which may be ten feet, represents a very large destructive potential on rupture of the vessel. Accordingly the design has usually required extremely liberal safety factors, resulting in ponderous rolls and increased capital costs.

The present invention provides a construction of a dryer which avoids the large mass inherent in the design of a conventional thick-walled cast-iron pressure vessel forming the prior art drying rolls, by making a cylindric roll or casing an element of a heat exchanger comprising a series of steam ducts having parallel axes integral with the inner surface of the cylinder, the transverse dimensions of a duct being a small fraction of the diameter of a roll. Such construction makes possible the use of much higher drying temperatures and steam pressures with a greatly reduced thickness of shell material. With the system according to the present invention the effective surface temperature of the cylinder or roll in contact with the web of paper is substantially the same as that of the inlet steam; therefore the operator may closely determine the actual working temperature by the indication of the inlet steam pressure gauge. Moreover the design of a dryer constructed according to the principles of the invention makes it a relatively simple matter to ensure that all parts of the roll are at the same temperature, and the efficiency of the plant and uniformity of product may therefore be maintained near optimum without resort to special crowning of any presser rolls.

In carrying the present invention into effect, a dryer roll is realized as a metal cylinder or drum which is open at both ends, serving as an element of a heat exchanger comprising a large plurality of pipes, tubes or ducts integrally formed with and bonded to its inner surface and aligned parallel with each other and with the cylinder axis, for conveying steam admitted in common to all the said pipes or tubes by way of an annular header; a similar header spaced axially from the steam header and also communicating with each tube or duct serves to collect condensates; a series of axially spaced bracing structures or frames secured as bulkheads within the cylinder provide rigidity and serve as support for an axle within which steam is led to the steam header and condensate is conveyed from the condensate header.

By the practice of the present invention steam is

caused to flow with a relatively high velocity within the exchanger passages, and the temperature along the length of each tube or duct is maintained substantially uniform. In addition, due to the scrubbing action of the relatively high velocity steam, any condensate within the ducts or pipes is cleared away rapidly so that a film of appreciable thickness does not tend to build up as a barrier to flow of heat into the roll face. In fact, that part of each tube or duct lying radially inwardly of the cylinder improves the conduction of heat to the roll surface by providing a flow path along the metal wall of the duct to the integral joint made with the roll.

It is a primary object of the invention to provide a simple and economical construction of a dryer roll comprising a single cylindric shell having a plurality of steam conveying tubes or ducts secured to the inner periphery thereof.

Another object of the invention is the provision of a dryer roll having efficient scavenging of condensate from the inner surfaces of steam passages by the joint action of high velocity steam and by provision of a condensate header into which condensate is drained to prevent obstruction thereby.

Yet another object of the invention is the fabrication of a heat exchanger roll comprising a cylindric shell and an integrally bonded metal body having a plurality of parallel ducts formed therein separated by areas contiguous with the shell and permanently joined therewith.

It is a further object of the invention to realize a drier roll having excellent rigidity and freedom from deflection under load by employing a cylindric shell and a plurality of duct bodies spaced about the inner periphery thereof and aligned with the cylinder axis whereby to provide a high moment of inertia in any transverse section of the structure.

It is another object to provide a braced rigid roll structure concentric about an axle, employing a plurality of radial frames or spiders spaced axially along the length of the roll and secured both to the inner periphery of the roll and to the cylinder axle.

Yet another object is the provision of a drier roll of high efficiency and having greatly reduced mass without high sacrifice in rigidity and freedom of deflection, permitting reduction in the pass and strength of end shafts, bearings, and machine frames.

Still another object of the invention is the realization of a drier wherein variation of driving load due to variable accumulations of condensate is avoided.

A more complete understanding of the invention and of the best mode of carrying it into effect may be gained by a reading of the following specification wherein embodiments of the invention are described in conjunction with the accompanying figures of drawing:

Figure 1 is a side elevation view partly in section of a dryer constructed according to the invention;

Figure 2 is a section taken on the line 2—2 of Figure 1 showing the steam conveying passages joined to the shell;

Figure 3 is a section taken on the line 3—3 of Figure 1 showing the condensate collecting header and the axle passages;

Figure 4 is a section taken in a radial plane through an end of a spider element of Figure 2;

Fig. 5 is a view at right angles to the section of Figure 5 showing the end of the brace and its joint with the shell;

Figure 6 is a cross section similar to that shown in Figure 3 showing an alternative duct structure;

Figure 7 is a partial section of the ducts in Figure 6;

Figure 8 illustrates a construction and arrangement of steam and condensate headers for use with very wide webs; and,

Figure 9 describes a method of fabricating the heat exchanger.

Referring first to Figure 1, a dryer roll according to the invention generally designated at **10** comprises a pair of bearings **11** and **12** co-axially aligned with the axis of the roll, and a smooth cylindric roll body **13** coaxial with the axis of the shafts. A hollow thick-walled pipe **14** co-axial and co-extensive with the roll **13** serves as a duct for inlet steam, and is secured to pedestal flanges **21** at its ends. A condensate collecting pipe **15** is enclosed within one end of the tube **14** and is led out to a condenser system (not shown) by way of the hollow bearing **11**. Similarly high pressure steam is led from a source (not shown) by way of a hollow shaft **11** into the tube **14**, and is carried therealong to flow into the generally radially extending distributors **16** which are joined to the opposite end of the tube **14**. The distributors terminate in a circular header tube **17** joined to the inner periphery of one end of the roll A large plurality of parallelly spaced tubes **22** lying about the inner periphery of the roll **13** terminate upon and communicate with the tube **17**.

The tubes **22** are bonded in good heat-conducting relation to the roll body **13**, preferably by welded joints. As shown in Figure 9, a system of ducts **22** may be realized by laminating, upon the interior surface of a roll or shell **13** previously formed as a cylinder, a continuous strip of lighter gauge sheet metal **30** which is formed with curved portions **31** bowed away from the roll face and intervening strips **32**, the latter being integrally joined with the cylinder as by seam welding. Each duct is thereby formed separate and distinct from its neighbors whereby for a given pressure of steam filling the duct the unit stresses in the outer shell **13** are very considerably less than the tensile stress which is developed across a longitudinal diametral plane passed through a large diameter hollow roll of the prior art. A significant advantage of the construction lies in the improved moment of inertia of the resulting shell body in a transverse section due to the disposition of duct material lying radially inwardly of the shell, with a consequent stiffening of the structure against deflection.

It is entirely feasible to form the heat exchanger by using a ductile material for the sheet **30**, which is applied evenly over the inner surface and seam welded thereto at intervals leaving intervening areas unbonded, after which the bowed portions **31** are produced by hydraulically expanding the unbonded metal in a manner well known in the art.

It also lies within the scope of the invention to form the ducts by laying up a plurality of separate strips whose edges are aligned adjacently in parallel, and depositing metal between the butted ends by welding to produce fluid-tight joints and to bond them to the roll.

At their opposite ends the tubes are joined with a condensate header **19** generally similar in construction to the steam header but of a radius somewhat larger than that of the roll **13**, to the rim of which it is integrally joined. A number of syphons **18** extend generally radially within the header **19** towards the outermost radius thereof, and are connected at their inner ends with the pipe **15**. A layer of insulation **33** may be attached to the inner wall of the array of ducts **22** for the purpose of preventing heat loss to the dryer room.

A plurality of disc-like frames **23** are secured upon the tube **14** and have their outer edges bonded with the shell **13**. As best seen by reference to Figure 5, a frame comprises a plurality of radial angularly spaced spokes **23'** in the form of tubes whose outer ends are slotted in a diametral plane to receive a metal plate **24** which is welded to the tube, the outer edge of which plate being attached between a pair of adjacent tubes **22** and welded thereto and to the shell **13**. At the inner ends of a frame the tubes are similarly slotted in diametral planes as best shown by Figure 2 and are welded to a relatively thin metal disk **25** secured on the shaft.

In the construction of a frame the outer plates **24** are first joined with the ends of spokes **23'**, and the ring

25 is placed upon the shaft 14 in its proper position and secured thereto. The spokes are then put into place and are welded to the ring and to the inner face of the roll, preferably with plates 24 aligned axially upon the areas 32.

A modification of the arrangements for inlet of steam and removal of condensate in the design of very long rolls for use with wide webs is shown in Figure 8. The construction generally is as described hereinbefore, with the exception that the steam header 17 is positioned intermediate the ends of the roll, and a pair of condensate collecting headers 19, 19' are disposed at each end thereof. By this arrangement the quantity of condensate collected at either header is halved, and the scrubbing action in each duct is improved over that attained in an extremely long duct.

The operation of dryer rolls according to the present invention involves considerably less difficulty in starting up and bringing them to operating temperature since there is less mass of metal to be heated, and the volume of air to be purged from the system by incoming steam is far less than that involved in starting up pressure vessel types of drier rolls.

An alternative construction of a duct system affixed to the inner periphery of a cylindric shell is described with reference to Figures 6 and 7, wherein a plurality of passages 22 are realized by attaching metal strips, folded longitudinally approximately to an angle of 90 degrees to form walls 26 and 27, to both the inner surface of the shell 13 and to the fold region of a strip already in position. In fabricating such structure, a strip is placed in adjacent position to a preceding duct and one edge welded to the inner roll face by a weld 28, while the other edge is welded to the fold line of the previously attached duct, along the joint 29. In this manner a succession of ducts are laid up in progression about the inner periphery of the cylinder until the free edge of the first strip which was attached by its one end to the shell is joined with the fold line of the last strip, thereby completing a ring of ducts.

I claim:

1. A dryer roll comprising an open-ended internally braced sheet metal shell supported on a hollow shaft and having a cylindric face, a plurality of fluid-guiding ducts having parallel axes and having wall portions thereof co-extensive with and joined at spaced intervals to the inner surface of said shell and having remaining wall portions radially spaced inwards of said shell for conveying fluid in heat exchange relation with the inner surface of said shell, a first annular fluid distributing duct secured to the inner surface of said shell joined to and communicating with each of said fluid guiding ducts and having at least one fluid inlet duct connecting therewith, a second fluid-collecting annular duct having an outer diameter greater than the shell diameter spaced from said first fluid distributing duct and secured to one end of the shell and connecting with each of said fluid guiding ducts, and at least one fluid outlet duct extending radially into and terminating within said fluid gathering duct radially outwardly of the shell.

2. A dryer roll as in claim 1 wherein said fluid inlet and said fluid outlet ducts extend coaxially within the shaft.

3. A dryer roll as in claim 1 having a plurality of axially spaced frames rigidly secured upon said hollow shaft, and wherein said shell is supported on the peripheries of said frames.

4. A rotatable dryer roll comprising a cylindric shell internally braced and rigidly mounted on an axial hollow shaft by a series of axially spaced transverse frames, an inner wall of fluted cylindric form bonded to the inner surface of said shell along the radially outwardly protruding ridges between the flutes to define with said shell a plurality of separate flow-guiding passages, a steam chamber of annular ring form bonded to the shell and to the inner wall in communicating relation with

said passages, a condensate header spaced axially from said chamber connecting with the ends of said passages and having an internal diameter greater than the internal diameter of said shell, at least one inlet duct connected with the steam chamber for supplying the latter with steam, at least one outlet duct connected with the condensate header for removing condensate and steam therefrom, the termination of an outlet duct within the header lying radially outwardly of the inner radius of the shell.

5. A roll as in claim 4 wherein said inlet and said outlet ducts extend coaxially within the said shaft.

6. A dryer drum comprising an outer sheet metal cylindric shell and an inner sheet metal wall laminated thereto and bonded along areas extending parallel to the cylinder axis and spaced about the periphery of the shell, the unbonded portions of the wall being formed convexly inwardly to define a plurality of passages for guiding fluid therein in direct heat exchange relation with said shell, a hollow annular metal body joined to the inner surface of the shell and connected with all of said passages, a header spaced axially from the said body secured to an end of the laminate and connecting with the ends of said passages, a shaft coaxial of the shell and rigidly mounted in support relation therewith, and pipes for ingress of fluid to the metal body and for discharge of fluid from the header respectively joined thereto and to respective conduits in said shaft.

7. A drum as in claim 6 wherein said shaft and shell are correlated and secured in fixed relation by a plurality of bracing frames disposed transversely of the cylinder axis and spaced along the shaft and secured to said shell and said shaft.

8. A dryer roll construction comprising a cylindric sheet metal shell internally braced and rigidly mounted on an axial hollow shaft by a series of axially spaced transverse frames, a plurality of sheet metal folded strips each having a longitudinal fold line to form a pair of walls whereof one wall is disposed in an axial plane passed radially through the cylinder with the free edge of said wall joined with the inner surface of the shell, and the other wall is disposed in a chordal plane parallel with the axis of the cylinder having its free edge joined to a like adjacent strip at the region of its fold line to form with said inner surface a series of separate ducts spaced about the inner periphery of the shell, a fluid chamber disposed on the inner surface of the roll joined to and communicating with each duct, a discharge header closing the open ends of said ducts and communicating with each and joined to an end of the shell, said header having a maximum internal diameter greater than the internal diameter of said shell, conduit means extending within said header having open ends terminating therein radially beyond the surface of the shell and joined to an axial passage within the shell, and fluid inlet conduit means joined with said chamber for supplying fluid thereto.

9. A rotatable drum dryer comprising a straight hollow shaft adapted to convey steam therethrough, an outer shell having a smooth cylindric outer surface, an inner shell mounted coaxially with said outer shell on said shaft, and defining together with said outer shell an annular space, a plurality of radial support members joined with said shaft and said inner shell, a plurality of partitions disposed between said shells and coextensive therewith, said partitions being regularly spaced about the periphery of the inner shell to define a corresponding number of parallel flow-guiding passages for conveying fluid therethrough in heat exchange relation with said outer shell, an annular steam chamber connecting with said passages, a condensate header spaced axially from said chamber closing an end of said annular space and connecting with said passages, a discharge conduit disposed within the shaft, at least one inlet pipe connecting said shaft with said chamber for supplying steam to said passages, and at least one pipe connected with said con-

duit and terminating in said header having its end disposed radially outwardly of the outer shell for discharging flow from said header.

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