Feb. 19, 1963 W. A. DICKENS 3,077,675

PAPER DRYING MACHINE

Filed Dec. 21, 1959 6 Sheets-Sheet 1

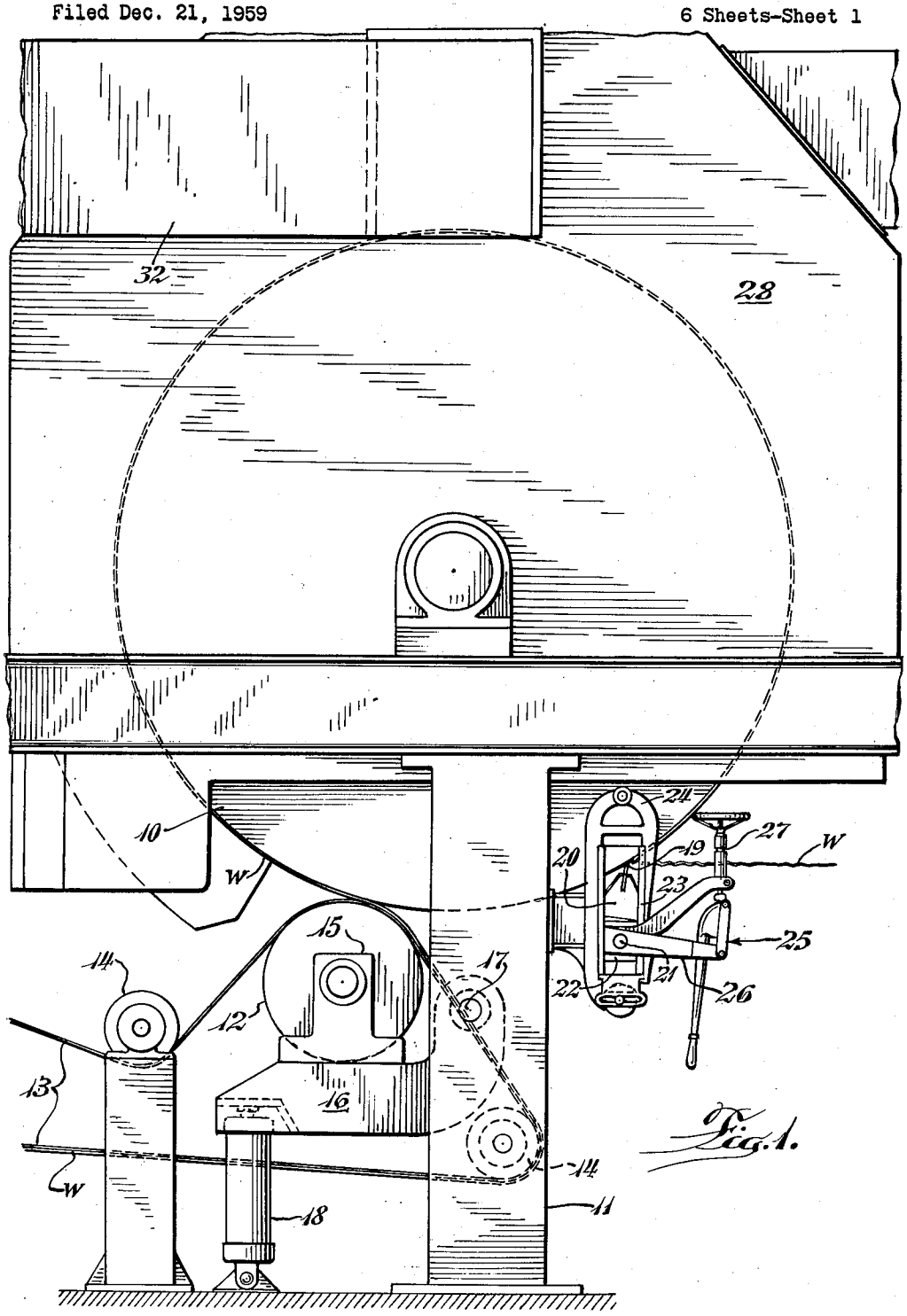


Fig. 1.

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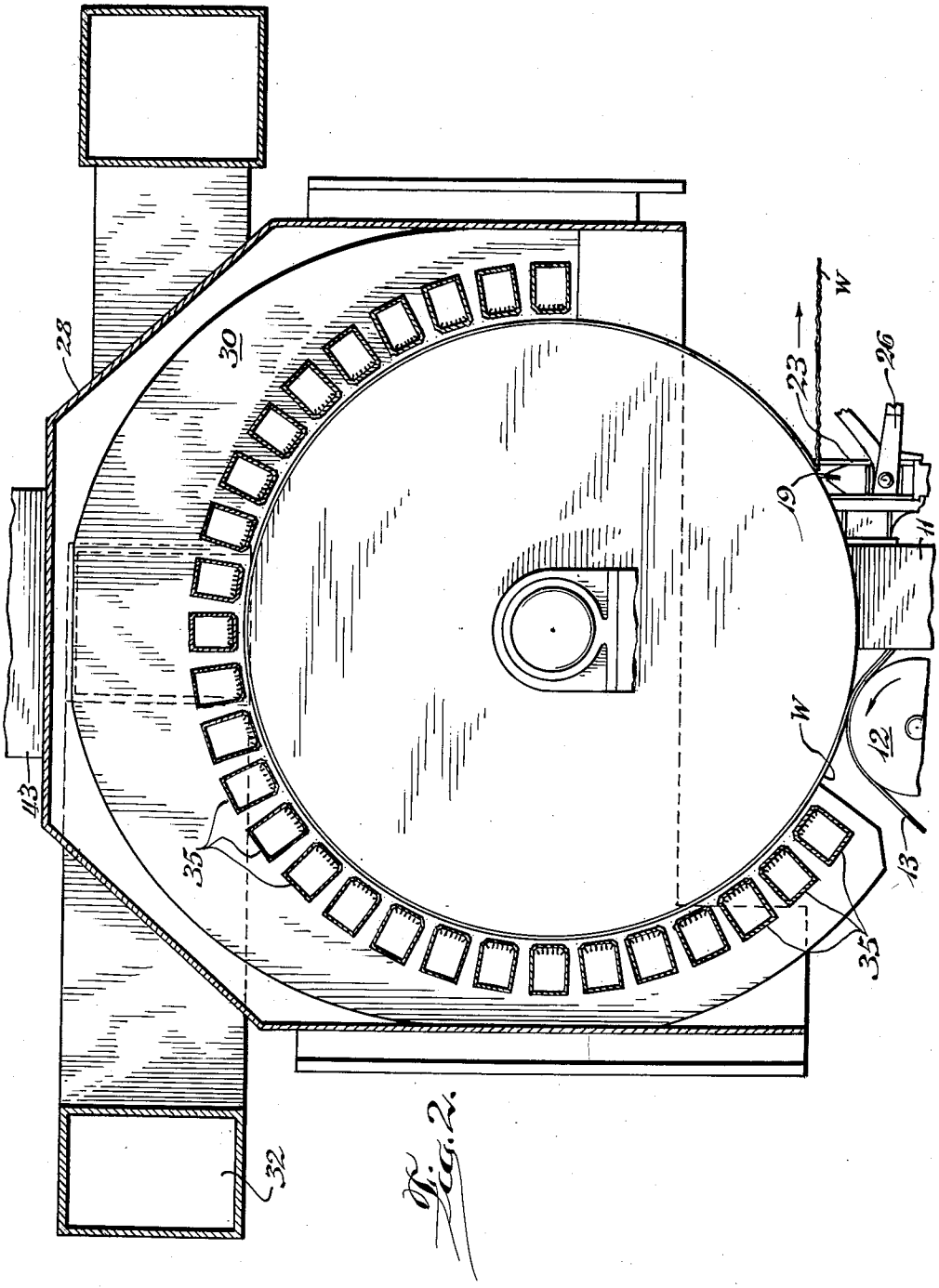


Fig. 2.

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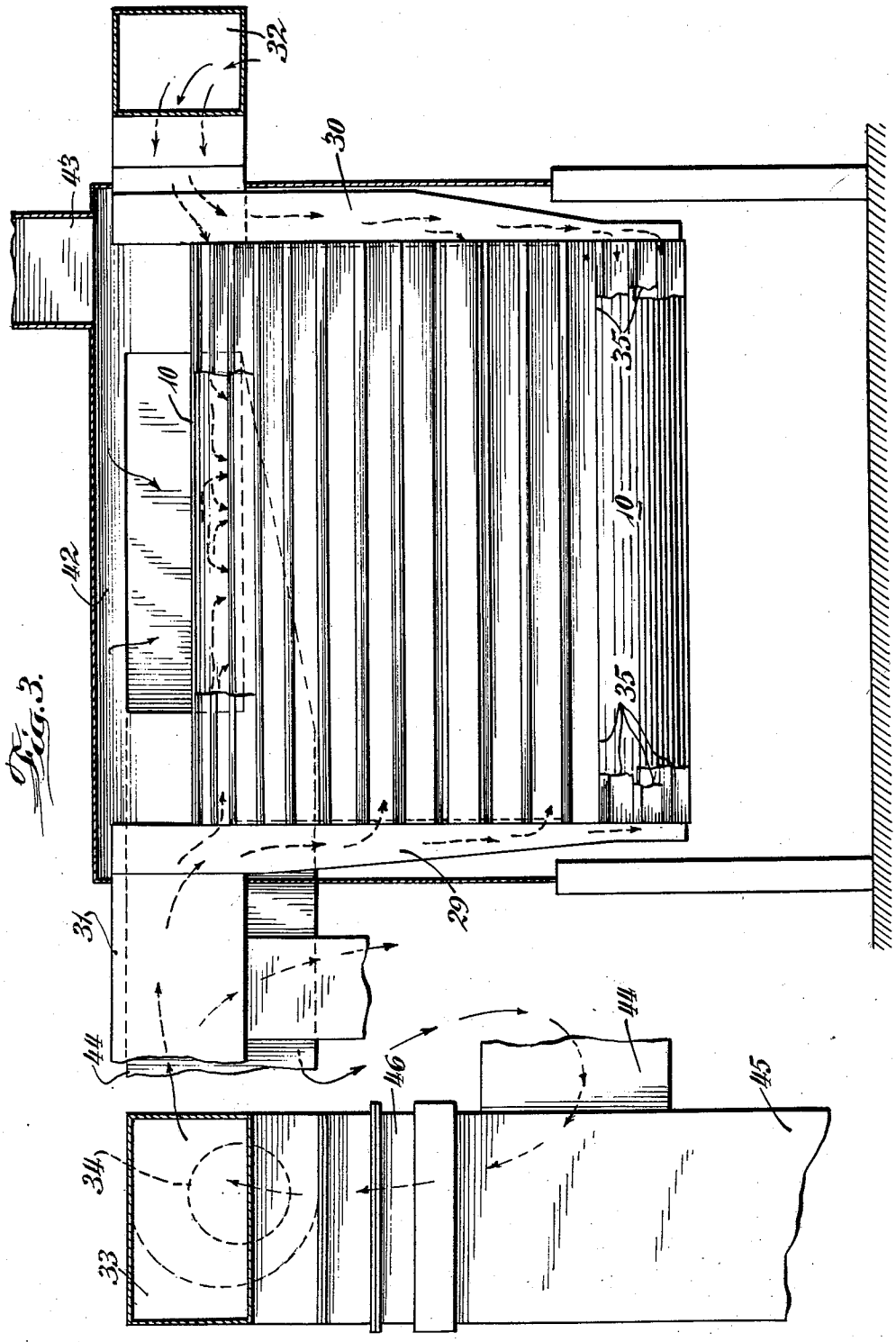


Fig. 3.

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Fig. 4.

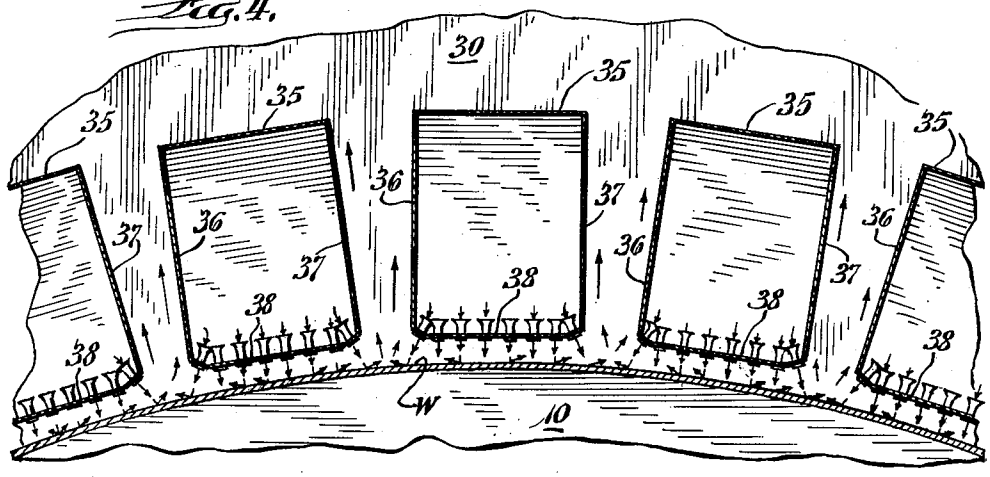
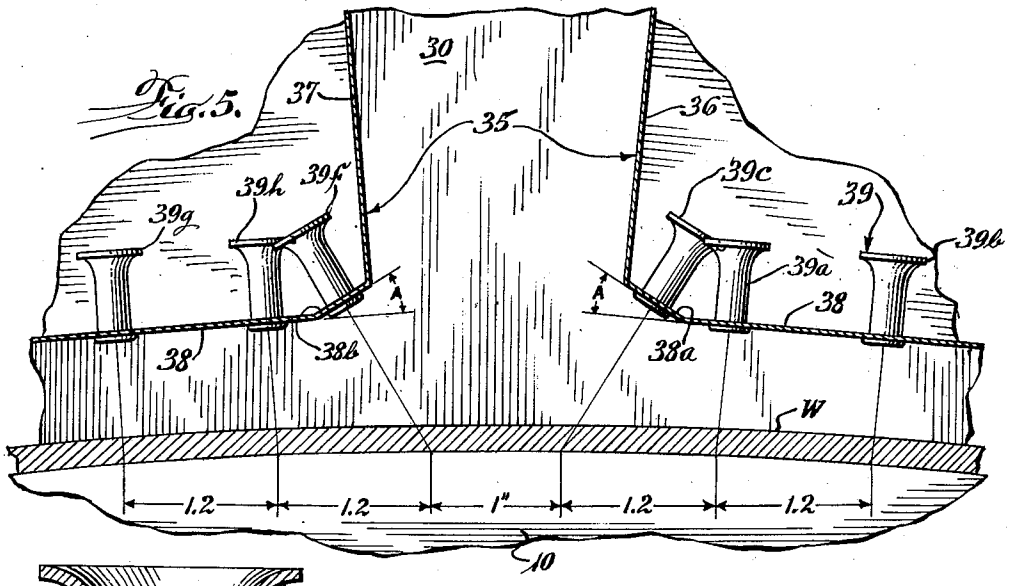


Fig. 5.



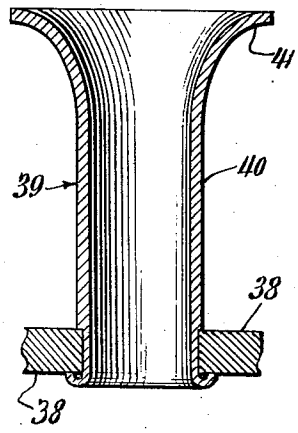


Fig. 6.

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Fig. 7.

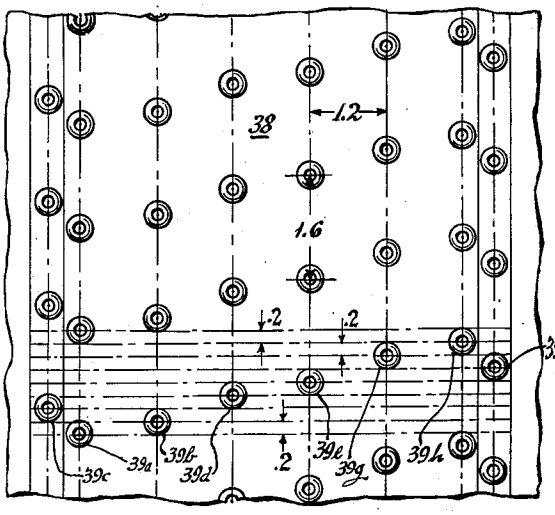


Fig. 10.

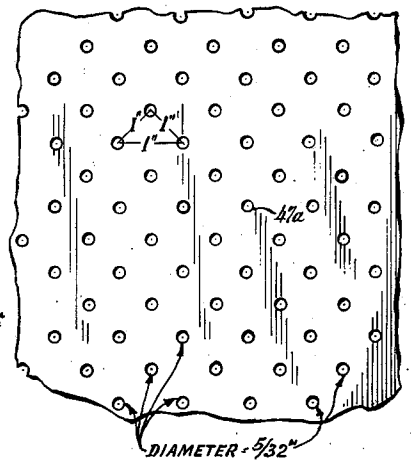


Fig. 8.

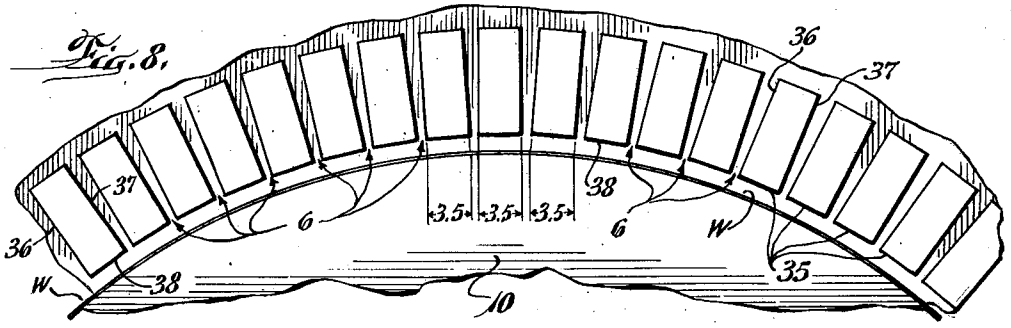
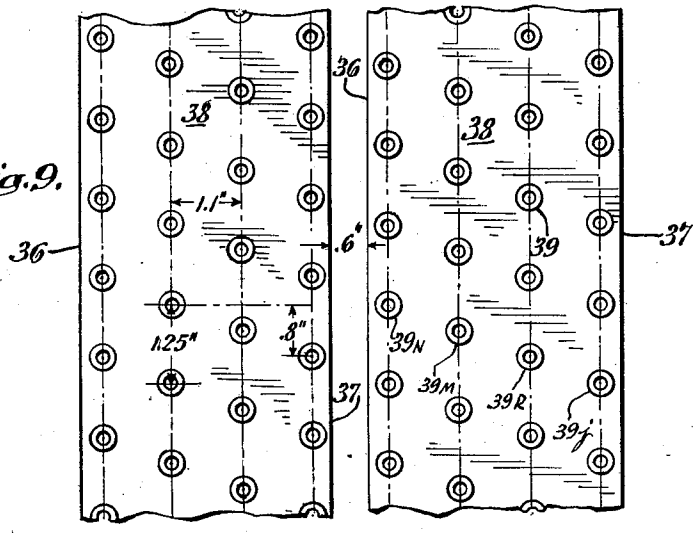


Fig. 9.



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Fig. 11.

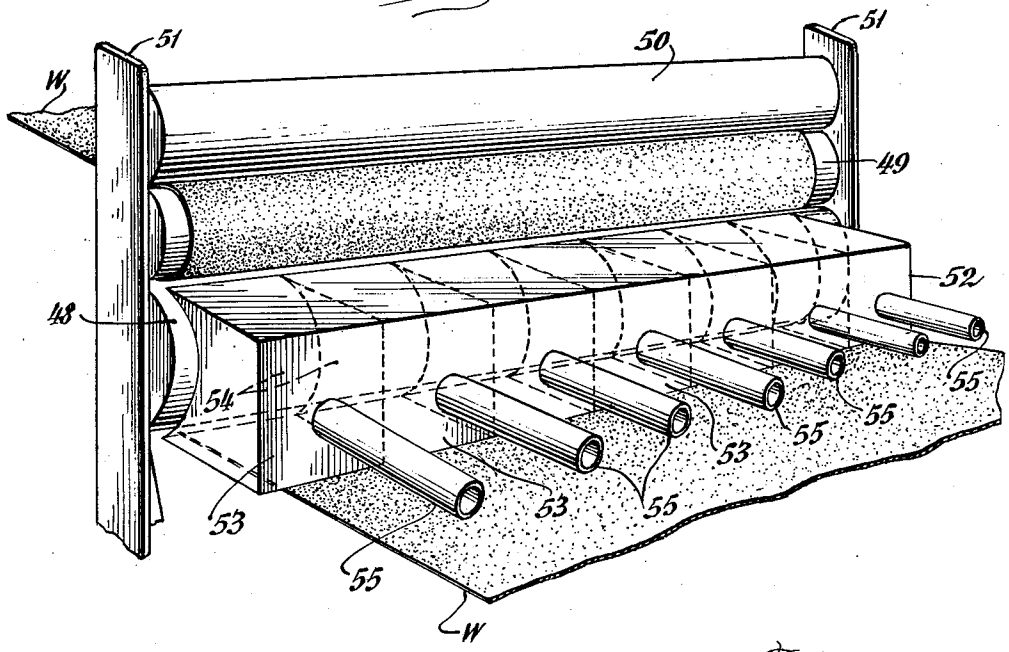


Fig. 13.

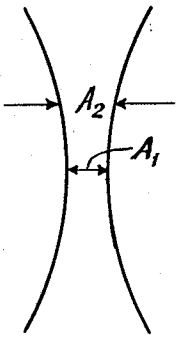


Fig. 12.

United States Patent Office 3,077,675 Patented Feb. 19, 1963

3,077,675
PAPER DRYING MACHINE

William A. Dickens, Neenah, Wis., assignor to Kimberly-Clark Corporation, Neenah, Wis., a corporation of Delaware

Filed Dec. 21, 1959, Ser. No. 860,914
2 Claims. (Cl. 34—122)

This invention relates to papermaking machines and more particularly to rolls of such machines which have air applied to them for either cooling or heating the rolls. Such a roll may be the large cylinder or Yankee drier drum of a paper machine on which the moist paper is pressed for drying and glazing.

Air is conventionally applied to paper web on a Yankee drier drum by means of a hood located over the drier drum. A plurality of rows of round cross section pipes may be arranged around the periphery of the drum which may vary from 8 to 12 feet in diameter. The pipes are each provided with a series of nozzles directing air from the interior of the pipe on to the periphery of the drum, and the pipes are spaced apart just sufficiently to allow for the expended air to find its way between adjacent nozzles and pipes.

A more uniform application of air to the drum may be obtained using a plurality of ducts or plenum chambers within the hood disposed about the drier drum and extending parallel to the axis of the drum. Each of these ducts has a plurality of apertures or nozzles extending through the wall of the duct facing the surface of the drum, and the apertures or nozzles are arranged in a pattern so that air is substantially uniformly applied on the surface of the drum beneath the duct.

The ducts are generally between 4 to 20 inches wide and have about 2 or 3 inches spacing between them. The spacing is provided so that any wadding or paper accumulating on the drier drum or on the surfaces of the ducts facing the drier drum may be removed by drawing the wadding or paper through the spaces between the ducts.

The provision of such spacing between the ducts, however, has caused the application of air to the surface of the drum to be non-uniform throughout the part of the drum subtended by the ducts due to the fact that there has been no provision for directing air from any of the ducts on to the surfaces of the drum opposite the spaces between the ducts.

It is an object of the present invention to provide an improved apparatus for directing air on to a drum substantially uniformly throughout the part of the drum subtended by the air application apparatus. In particular, it is an object of the invention to provide diagonally extending apertures or diagonally extending nozzles adjacent the edges of the ducts above mentioned for directing air on the surfaces of the drum opposite the spaces between the ducts for achieving this uniformity of air application.

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 preferred forms of the invention, illustrated with reference to the accompanying drawings wherein:

FIG. 1 is a side view of a Yankee drier with which a drier hood utilizing the principles of the invention may be utilized;

FIG. 2 is a transverse sectional view of the hood;

FIG. 3 is a longitudinal sectional view of the hood;

FIG. 4 is a fragmentary view similar to FIG. 3, on an enlarged scale, showing a plurality of plenum chambers in the hood;

FIG. 5 is a fragmentary sectional view similar to FIG. 4 on a still further enlarged scale;

FIG. 6 is a sectional view of a nozzle with which the plenum chambers are each equipped;

FIG. 7 is a plan view of a plenum chamber showing the spacing and distribution of the nozzles in the plenum chamber;

FIG. 8 is a schematic elevational view of a drier hood with a plurality of plenum chambers of modified form;

FIG. 9 is a plan view of the modified plenum chambers showing the spacing and distribution of nozzles therein;

FIG. 10 is a fragmentary view of a face of a plenum chamber provided with orifices in lieu of nozzles;

FIG. 11 is a perspective view of a breaker stack provided with a cooling system embodying the principles of the invention;

FIG. 12 is a transverse sectional view of the breaker stack; and

FIG. 13 is a schematic showing of an orifice and the flow of fluid therethrough.

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

Referring now to the drawings and particularly to FIG. 1 thereof, the illustrated machine comprises the usual drum or cylinder **10** mounted for rotation on the frame **11** and provided with the usual pressure roll **12**. The paper web to be dried by the roll **10** is carried by a felt web **13** which travels around felt rolls **14**. The roll **12** is rotatably mounted in brackets **15** each attached to an arm **16**. Each arm **16** is pivoted at **17** to the frame **11**, and the pressure roll **12** is forced against the surface of the drum **10** by a ram **18** which bears against each arm **16**.

The dried paper web is removed from the surface of the drum **10** by a creping doctor which includes a doctor blade **19** movably secured within a blade holder **20**. The ends of the holder are provided with shafts **21** which are rotatably mounted within guide blocks **22**. The blocks **22** in turn are each slidably mounted within a slide assembly **23** attached to pivot frame **24** pivotally carried by frame **11**. Through the slide arrangement provided by the slide blocks **22** and slide assembly **23**, the vertical position of the doctor blade **19** can be varied, as desired, to obtain the best creping angle.

The doctor blade holder **20** and the blade **19** are pivoted by a toggle mechanism **25** which is attached through a lever arm **26** to one of the shafts **21**. In addition, a spring loading mechanism **27** is connected through the toggle mechanism **25** to provide a resilient contact for the doctor blade against the surface of the drum **10**.

A hood **28** is disposed about the drum **10** (see FIGS. 2 and 3). A pair of semi-annular headers **29** and **30** are provided within the hood **28** and are mounted on the frame **11**, being positioned adjacent opposite sides of the drum **10**. The headers **29** and **30** are connected respectively by supply ducts **31** and **32** to the outlet **33** of an air fan or blower **34** which is of large capacity and may be supported on a platform provided on the frame **11** or elsewhere. Each header **29** and **30** extends around at least ½ of the drum **10** and diminishes progressively in cross section away from the fan.

A plurality of ducts or plenum chambers **35** each having sides **36** and **37** and an inner wall **38** extends between the headers **29** and **30** (see FIGS. 2, 4 and 5). These ducts **35** extend parallel with the longitudinal axis of the drum **10** and are equally spaced apart. The ducts in an actual embodiment may, for example, be 5 or 6 inches wide and have spaces of about 2 inches between them. The actual drier drum in such a case may be expected, for example, to have a radius of about 5 feet.

The inner wall **38** of each of the ducts **35** is provided with a plurality of nozzles **39** extending through the wall. The nozzles are disposed in predetermined patterns with respect to each other; and each pattern includes a series of nozzles **39***a*, **39***b*, **39***c*, **39***d*, **39***e*, **39***f*, **39***g*, and **39***h*,

which are equally spaced from each other lengthwise of the duct as illustrated in FIG. 7. In a particular embodiment of the invention, each of the nozzles were spaced 0.2 inch from the nearest nozzle lengthwise of the duct, and the nozzles were spaced 1.2 inch from each other crosswise of the duct, with the exception of the nozzles 39*c* and 39*f*. Adjacent nozzles 39*a* are then spaced about 1.6 inch apart, and the same spacing exists for adjacent nozzles 39*b*, 39*d*, 39*e*, 39*g* and 39*h*.

All of the nozzles extend perpendicularly through the wall 38. The nozzles 39*c* and 39*f* are respectively carried by and extend through edge portions 38*a* and 38*b* of the wall 38 which extend at an angle A with respect to the main portion of the wall 38 (see FIG. 5). The nozzles 39*c* and 39*f* are thus located adjacent the sides of each of the ducts 35 and extend diagonally with respect to the other nozzles 39 so as to discharge air into the adjacent space between two of the ducts 35.

Each of the nozzles 39 comprises a tubular portion 40 (see FIG. 6) which extends through the wall 38 and which terminates substantially at the surface of the wall adjacent the surface of the drum. The nozzles comprise also an outwardly flared portion 41 located within the duct 35.

It will be noted that the hood 28 encloses all of the ducts 35 and that portion of the drum 10 over which the ducts 35 lie. The hood is spaced apart from the drum surface and ducts 35 to provide collecting space 42 for exhaust or spent air blown against the paper W from the ducts 35 and which passes outwardly to the space 42 between the ducts 35. An exhaust duct 43 is provided in the hood 28 and in communication with the space 42. The hood 28 has a recirculating air duct 44 connected to and communicating with the space 42. The duct 44 is connected directly to make up air duct 45 that supplies the fan 34, so that the air supplied to the ducts 35 from the fan 34 by means of ducts 31 and 32 and headers 29 and 30 consist of a mixture of make up air drawn in from the surrounding air through duct 45 and recirculated air withdrawn from the space 42 via duct 44. Preferably the duct 44 is connected to the duct 45 in advance of the usual heater 46, so that the mixture of make up and recirculating air reaching the fan 34 will be thoroughly heated.

Under operating conditions, air from the ducts 44 and 45 consisting of make up air and exhaust air passes through the heater 46 wherein it is thoroughly heated and is blown from the fan 34 through outlet 33 into ducts 31 and 32, passing therefrom through headers 29 and 30 which distribute it to the ducts 35. The heated air then flows through the nozzles 39 on to the adjacent surface of the drier drum 10. The nozzles 39*a*, 39*b*, 39*d*, 39*e*, 39*g* and 39*h* extending perpendicularly through the center part of each duct wall 38, which is placed to be perpendicular at its center to a radial line passing through the center of the drum 10, direct air normally on the surface of the drum 10; and the nozzles 39*c* and 39*f*, extending sidewardly with respect to the center part of the wall 38, direct air on to the outer surface of the drum 10 opposite the spaces between the ducts 35, so as to blanket the surface of the drum 10 with heated air substantially uniformly from one end of the hood 28 to the other, from its entrance end to its exit end for the web W.

It will be noted from FIG. 5 that the center lines of the nozzles 39*a*, 39*b*, 39*d*, 39*e*, 39*g* and 39*h* intersect the surface of the drier drum 10 substantially 1.2 inches apart. The center lines of nozzles 39*f* and 39*c* of adjacent ducts 35 intersect the surface of the drum 10 substantially at the same distance from each other and from the center lines of adjacent nozzles 39*a* and 39*h*, so that the application of air is substantially uniform not only beneath the ducts 35 but also opposite the spaces between the ducts. In the particular embodiment illustrated, the ducts 35 have a width of 7½ inches, and there is approximately 2 inches between ducts. The side parts 38*a* and 38*b* of the walls carrying the nozzles 39*f* and 39*c* extend at an angle A with respect to the main parts of the walls 38 so as to achieve this uniform air distribution.

For best results and most uniform application of air to the surface of the drum 10 from the nozzles 39, the spacing of nozzles 39 shall preferably be ⅝ inch to 2 inches from neighboring nozzles, both peripherally and longitudinally of the drum, and the nozzles shall preferably terminate ⅛ inch to 2 inches from the surface of the drum 10. In addition, the percentage free area for flow times the nozzle coefficient of discharge shall preferably be in the range from 1.3 to 2.7 percent. The free area for flow is the total area of all of the nozzles at their outlet ends divided by the total surface area of the sheet W to which air application is made from the nozzles. The nozzle coefficient corresponds to an orifice coefficient which may be explained with reference to FIG. 13. The orifice coefficient, referring to FIG. 13 which shows the flow of fluid through a simple orifice 47, is A_1 over A_2 where A_2 is the diameter of the orifice and A_1 is the smallest diameter of the fluid stream proceeding from the orifice. Analogously for a nozzle, with no fluid friction for a given pressure drop, the flow would be F_1 while, with the friction that actually exists, the flow is F_2. The nozzle coefficient of discharge would then be F_2 over F_1. The coefficient of discharge can be easily ascertained by those skilled in the art for orifices and nozzles of any shape using well known chemical engineering principles, such as set forth in "Principles of Chemical Engineering," Chapter 3, by Walker, Lewis, McAdams and Silliland, published by McGraw-Hill Book Co., New York, N.Y., 1937. With an ordinary simple orifice, its coefficient may be on the order of 6/10 while with a properly designed nozzle, the corresponding nozzle coefficient may be .94, indicating a substantial difference. Although the nozzles 39 are illustrated as directing the air on to the surface of the drum 10, it will be understood that simple orifices may instead be used; however, due to the different flow behavior of the orifices as compared to nozzles, the diameters of the orifices must be larger than the inside diameters of the nozzles to provide the same air flow. The same spacing of the orifices with respect to each other and to the drum surface and the same product of the free area for flow by the coefficient of discharge are preferably used for the orifices as for the nozzles.

The air that flows off the surface of the drum 10 returns to the fan 34, or as exhausted out of the system, flowing in the spaces between the ducts 35. For the purpose of simply returning the air that is discharged through the nozzles 39 subsequent to impingement on the outer surface of the drum 10, the spacing between the ducts 35 could be closer. However, at times, the wadding or paper, due to some defect, accumulates on the surface of the drum 10 and must be removed therefrom. The relative wide spacing between the ducts 35, which in the illustrated arrangement is about 2 inches, is provided so that this wadding or paper can be withdrawn from the surface of the drum between the ducts 35. The exhaust air in the hood space 42 exhausts in part through the duct 43, and the remaining part is drawn by the recirculation duct 44 for mixture with make up air in the duct 45 in advance of the heater 46. The provision of this recirculating arrangement for exhaust air provides the required amount of air for the ducts 35 with an appropriate capacity fan, about 10 percent to 40 percent of the air circulated being fresh or make up air and the balance being exhaust air.

In lieu of the arrangement of nozzles illustrated in FIG. 7, orifices may instead by utilized as previously mentioned. Also, other patterns of nozzles or orifices may be used in lieu of that illustrated in FIG. 7 to uniformly apply air to the surface of the drum 10. Referring to FIG. 10, orifices 47*a* disposed on triangular centers may be used as shown. The orifices may have a diameter of 5/32 inch and may be located on corners of equilateral triangles having 1 inch sides. Nozzles may be utilized

instead of the simple orifices in this arrangement, but as previously indicated, the nozzles if properly designed for minimum frictional loss will have a smaller diameter than the orifices for the same total air flow.

Substantially uniform application of air to the surface of the drum 10 may be achieved also without the diagonally extending nozzles 39*c* and 39*f* or corresponding diagonally extending orifices. This may be accomplished by locating the ducts 35 closer together such as is shown in FIGS. 8 and 9. In this particular embodiment, the ducts are 3.5 inches wide and have a spacing of 0.6 inch between them. As will be observed from FIG. 9 which shows the arrangement of nozzles in the walls 38 of these ducts, the nozzles 39 are provided in patterns of four which includes nozzles 39*j*, 39*k*, 39*m* and 39*n*. The nozzles 39*j* and 39*n* are located substantially as close to the side duct walls 36 and 37 as possible, and the nozzles are disposed on diagonal lines or lines disposed helically about the drum 10 extending in such a direction that the four nozzles in one duct 35 will align with four nozzles in an adjacent duct. The nozzles are equally spaced on these diagonally extending lines, and adjacent nozzles in adjacent ducts 35 will be spaced approximately the same distance as the nozzles in any of the ducts on these diagonal lines. The nozzles 39*j* are disposed on longitudinally extending lines and this is true of the other nozzles as well. The longitudinal lines in the illustrated embodiment are 1.1 inch apart, and the nozzles along each of these longitudinal lines are located 1.25 inch apart which assures an even distribution of air from each duct. Due to the close spacing between the ducts 35 and the location of the nozzles 39*j* and 39*n* as close as possible to the side walls 37, this uniformity of air application exists also between the ducts 35. This spacing of ducts and nozzles is particularly useful in connection with stronger and heavier papers that do not tend to bunch up and accumulate on the surface of the roll 10 necessitating the frequent removal of paper from the roll surface.

The same uniformity of air application may also be had, using the air for cooling instead of heating. This may be in connection with a breaker stack conventionally located behind the drier in a paper machine, such as behind a Yankee drier drum 10. Referring to FIGS. 11 and 12, such a breaker stack may comprise a large bottom roll 48 and upper rolls 49 and 50 supported by a frame 51. The paper web W may pass through the nips of the rolls 48, 49 and 50 as shown in FIG. 12. Due to lack in uniformity in the rolls of the breaker stack or due to lack of uniformity in thickness of the paper web W, for example, one or more of the rolls 48, 49 and 50 may become non-uniformly heated on its surface. Such non-uniform heat distribution on the surface of a roll tends to cause the roll to be undesirably non-uniform in diameter. Therefore, it may be desirable to cool certain sectors of the roll without cooling other sectors so as to bring the roll surface to a uniform temperature across the length of the roll or, more generally, to change the existing temperature profile, giving it a desired different temperature profile. A hood 52 having a plurality of semicircular plenum chambers 53, with arcuate walls 54 in close proximity to the roll 48, may be provided for the roll 48, for example. The walls 54 are provided with the orifices 47 or with the nozzles 39, which are arranged with respect to each other in the same manner as previously described. An air inlet pipe 55 is provided for each of the chambers 53. The same space between the wall 54 and the surface of the roll 48 is preferably provided as between the walls 38 and the surface of the drum 10; the same hole or nozzle spacing of ⅝ inch to 2 inches is desirable; and the same percent free area for flow times nozzle or orifice coefficient of 1.3 to 2.7 percent is preferably used, so that the same uniformity of air application is achieved for uniformly and effectively cooling the sector of the roll opposite the plenum chamber 53 to which the cooling air is supplied.

The utilization of the orifice or nozzle spacing of ⅛ inch to 2 inches, the use of the range of 1.3 to 2.7 percent free area for flow times nozzle or orifice coefficient, and the location of the surface in which the orifices or nozzles are disposed between ⅛ inch and 2 inches of the surface of the roll assures not only uniform air application but provides a desirably high volume of air flow and heat transfer to the surface of the roll, as well as a maximum mass transfer, which in the case of the Yankee drier roll is a maximum drying effect.

It will be observed that both the heating and cooling embodiments of the invention provide generally arcuate surfaces extending around the rolls. In the FIG. 4 embodiment, the generally arcuate surface is provided by the plane walls 38 together with the diagonally extending end zones 38*a* and 38*b* of the plenum chambers 35. The generally arcuate surface in the FIG. 8 embodiment is provided by the walls 38 between the side walls 36 and 37 which are located closely together for adjacent plenum chambers. The generally arcuate surfaces are at an approximately uniform distance from the external surfaces of the rolls, and the orifices or nozzles extend perpendicularly through the walls in which they are disposed and are so spaced in patterns that the air jets impinging on the rolls are spaced substantially uniformly arcuately of the rolls from substantially one end of the hood to the other and are also uniformly spaced longitudinally of the rolls.

Due to the fact that there is a uniform application of air for the complete surface of the rolls beneath the drier hood, the drying effect achieved is greater than that achieved by conventional air application apparatus that does not provide this uniformity, since the spacing between adjacent ducts or plenum chambers is in effect wasted insofar as air application to roll surface is concerned.

Although I have described my improved uniform air application system in connection with cylindrical rolls, it will be apparent that the system may also be used in connection with surfaces of other shapes, such as with flat surfaces. The air application system when used in connection with rolls for either heating or cooling the rolls may be used to control the surface temperature profile across the rolls and thus control the diameter profile of the rolls. Such control of diameter profile is particularly important in connection with breaker stacks in which rolls that are unduly large in diameter in certain sectors along their length will cause variation in thickness and other characteristics across the width of the paper passing through the breaker stacks. My improved air application system is not only useful with surfaces and rolls of steel but is also useful in connection with surfaces and rolls of nylon or other material suitable for drying or breaker and calender rolls, particularly for diameter control of the latter.

I wish it to be understood that the invention is not to be limited to the specific constructions and arrangements 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.

What is claimed is:

1. In mechanism for applying air on a roll, the combination of a hood having a generally arcuate surface adapted to extend around the roll at an approximately uniform distance therefrom, means defining a plurality of plenum chambers in said hood extending longitudinally of the roll and including a wall for each chamber extending approximately parallel with the roll surface and which walls collectively define said generally arcuate surface, said walls each having a plane portion and two end zones extending at angles with respect to said plane

portion, and means for applying air to said plenum chambers, said plane portions and said end zones being provided with a plurality of openings extending transversely therethrough so spaced as to apply air jets at points which are substantially uniformly spaced longitudinally of the roll and also arcuately of the roll substantially from one end of the hood to the other.

2. A hood for applying air on a roll and having a generally arcuate surface to extend around the roll at an approximately uniform distance therefrom, said hood including means defining a plurality of air conducting plenum chambers in the hood which extend longitudinally of the roll and which have walls facing the roll and defining said arcuate surface and also have side walls, said side walls of adjacent ones of said plenum chambers being substantially equally spaced and defining air exhaust passages therebetween, said roll facing walls being provided with rows of openings therethrough extending longitudinally of the roll and including two side rows for each of said plenum chambers adjacent the opposite sides of the plenum chamber and including also at least one additional intermediate row, each of said rows in each of said roll facing walls being spaced a predetermined distance apart arcuately of the roll and said plenum chambers being so closely disposed to each other that the adjacent side rows of adjacent ones of said plenum chambers are also spaced substantially the same distance apart as the rows in each of said roll facing walls and the openings in immediately adjacent ones of said longitudinal rows being staggered and so located with respect to each other that the openings lie on lines extending helically around the roll so as to apply jets of air from said chambers on the surface of the roll which are substantially uniformly spaced both longitudinally of the roll and also arcuately of the roll.

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