May 26, 1936. J. S. SWAUGER 2,042,198

SUCTION BOX COVER

Filed April 28, 1934 2 Sheets-Sheet 1

Fig. 1.

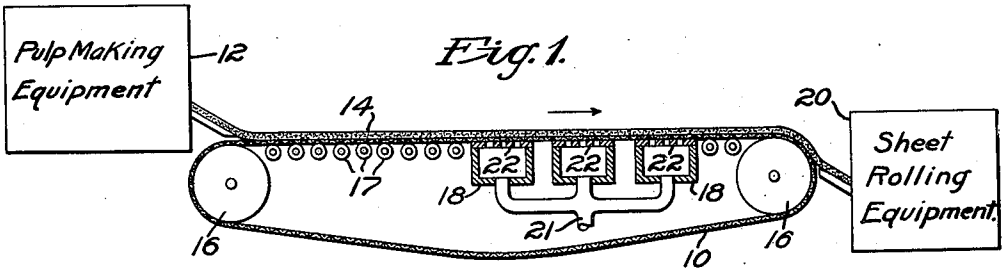


Fig. 2.

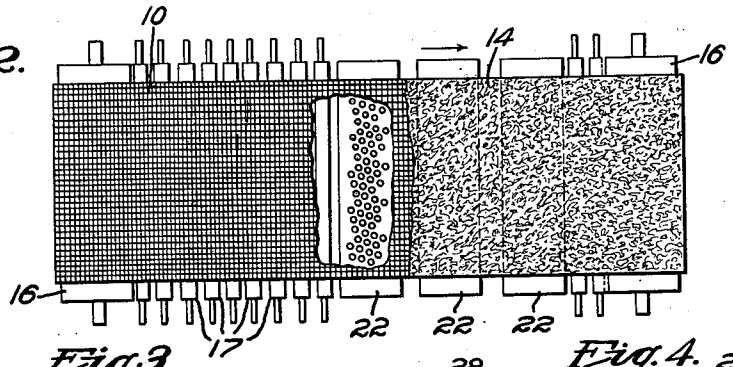


Fig. 3.

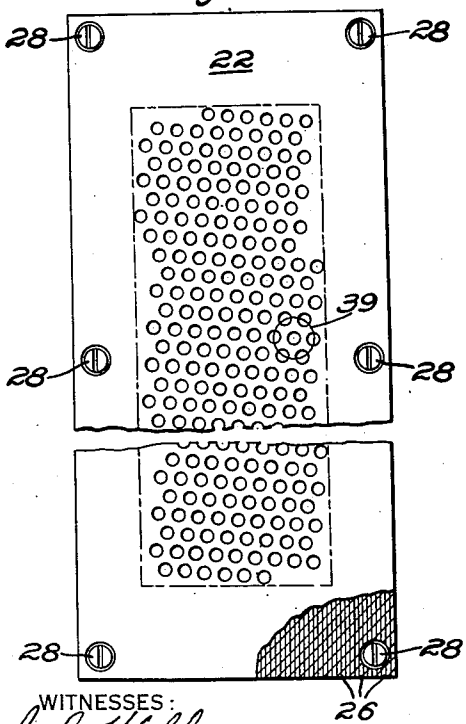


Fig. 4.

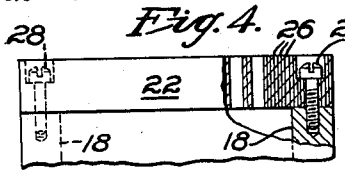


Fig. 5.

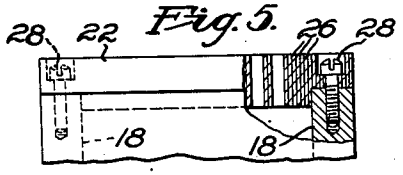


Fig. 6.

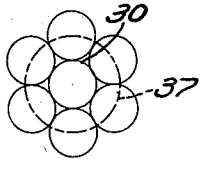
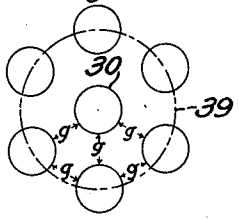


Fig. 7.



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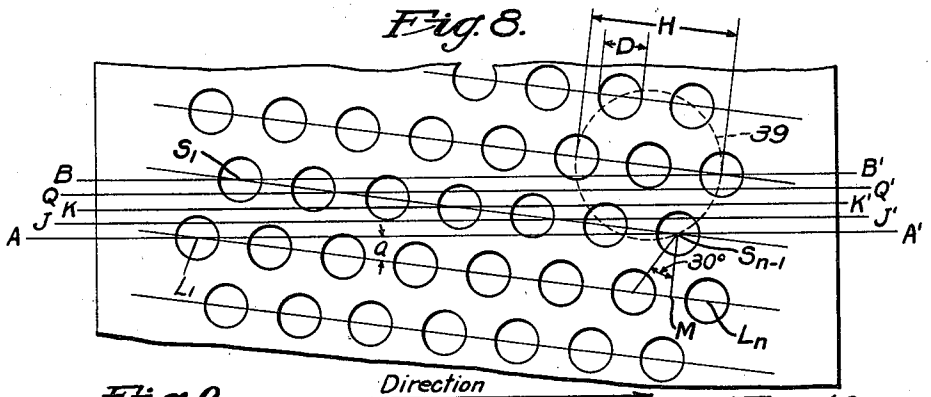
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May 26, 1936. J. S. SWAUGER 2,042,198

SUCTION BOX COVER

Filed April 28, 1934 2 Sheets-Sheet 2

Fig. 8.



Direction of Sheet Travel

Fig. 9.

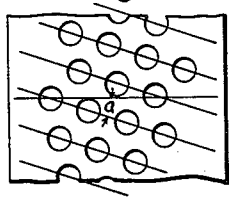


Fig. 10.

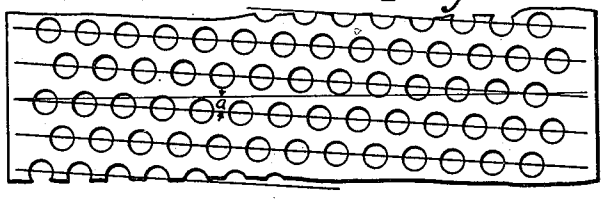


Fig. 11.

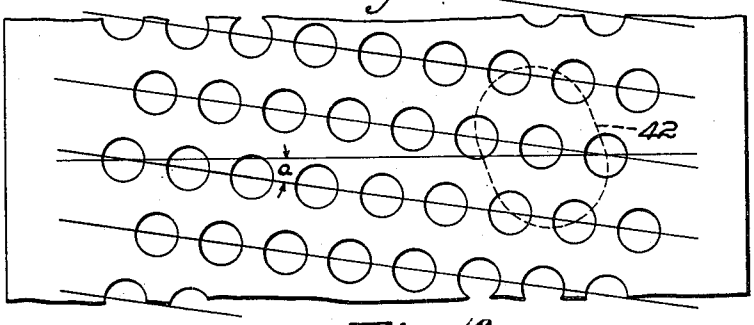


Fig. 12.

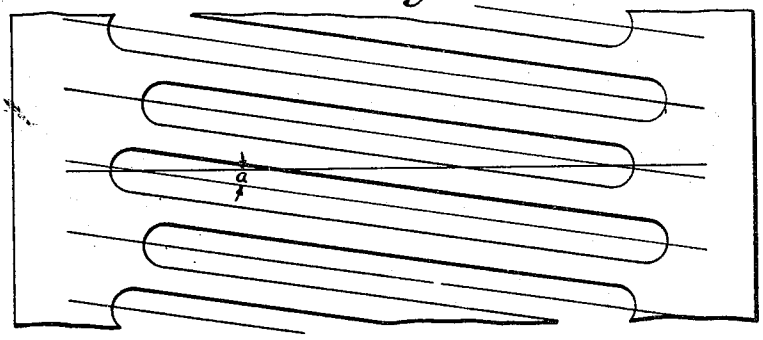
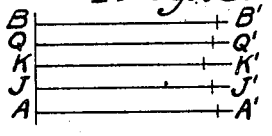


Fig. 13.



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Patented May 26, 1936

2,042,198

UNITED STATES PATENT OFFICE

2,042,198

SUCTION BOX COVER

John S. Swauger, Turtle Creek, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application April 28, 1934, Serial No. 722,825

9 Claims. (Cl. 92—51)

My invention relates to suction box covers utilized in paper making machines and it has particular relation to improvements in the positioning of the openings in and the construction of such covers.

In the art of paper manufacture, fibrous material pulp in a water-saturated state is, in the form of a web or sheet, fed upon a conveyor which carries it past one or more suction boxes, the function of which is to withdraw from the sheet a portion of the moisture prior to its delivery to compressive rolling mechanism. Each of these boxes, in which a partial vacuum is maintained, is provided with a cover adapted to directly contact the moving conveyor in a manner that suitable openings in the cover may transmit the negative box pressure to the pulp web and thereby extract the water therefrom. These covers have, both in the Fourdrinier and cylinder type machines now so extensively applied, presented rather serious operating difficulties.

Numerous attempts have been made to overcome these difficulties important among which has been an exceedingly high maintenance incident to the use of the conventional wooden cover. Within my knowledge, however, the matter of scientifically determining the most advantageous and satisfactory positioning of openings in the covers has in the past received far less attention than its importance from an operating standpoint justifies. My invention is directed to improvements in the construction of and a formulation of highly improved drilling plans for suction box covers which successfully overcome these and other operating difficulties.

One object of my invention is to eliminate streaking in the paper pulp stock by providing an opening-positioning arrangement which assures uniform moisture withdrawing effort along all lines of travel of the pulp sheet in its movement past the cover.

Another object of my invention is to combine the above-defined arrangement with the opening-distribution pattern which is the most effective as regards utilization of the drilled area in order that the moisture-withdrawing capacity of the cover may be maximum.

An additional object of my invention is to provide a hole drilling pattern incorporating the above advantageous combination which permits the drilling equipment set up therefor to be readily changed from one size of cover to another.

A further object of my invention is to provide a drilling pattern having the above desirable characteristics which is machinable by multi-spindle machine presses without complicated set-ups.

A still further object of my invention is to provide a form of cover construction possessing superior wear resisting and other long operating like qualities which in addition prolongs the life of the paper machine conveyor with which it is used.

My invention itself, together with additional objects and advantages, will best be understood through the following description of specific embodiments thereof when taken in conjunction with the accompanying drawings, in which

Figure 1 is a simplified diagrammatic representation of one form of paper-making machine with which the suction box covers of my invention are adapted to be utilized;

Fig. 2 is a top or plan view of the conveyor of the machine of Fig. 1 further showing the manner in which the suction boxes are associated therewith;

Fig. 3 is a top or plan view of a cover constructed in accordance with the teachings of my invention and adapted for use with one of the suction boxes of the machine of Figs. 1 and 2, or an equivalent;

Fig. 4 is a view in end elevation, partially in section, of the cover of Fig. 3;

Fig. 5 is a similar end elevational view of a slightly different form of cover;

Figs. 6 and 7 are representations of the basic honeycomb pattern from which the opening positioning plan possessed by the cover illustrated in Fig. 3 is made up;

Fig. 8 is an enlarged representation of a section of the drilled area comprised by a cover comparable to that represented in Fig. 3;

Fig. 9 is a similar sectional representation of a shorter or narrower cover incorporating my improved drilling plan;

Fig. 10 is a similar representation of a cover having a longer or wider drilled area;

Fig. 11 is a top plan view of a section of cover in which the openings are located in accordance with a modified form of my improved drilling plan;

Fig. 12 is a similar representation of a slotted opening type of cover having the advantageous characteristics inherent in the other opening arrangements of my invention; and

Fig. 13 is a pictorial representation of the comparative summations of chord lengths intercepted by a plurality of spaced axes drawn in the direction of pulp sheet travel through the drilled area of the cover of Fig. 8.

Referring to the drawings, and particularly to Figs. 1 and 2 thereof, the paper making machine there depicted in simplified form is of the well known Fourdrinier type comprising an endless conveyor screen or wire 10 upon one end of which there is fed, from pulp making equipment generally indicated at 12, a sheet or web 14 of fibrous pulp in a water saturated state. In its movement around the main or end rolls 16, at least one of which serves as a driver, the conveyor carries the web of pulp over a series of "table" rolls 17, through which a portion of the moisture drains by gravity and then past a plurality of suction boxes 18, each of which serves to extract from the web a portion of the remaining moisture to thereby place it in a proper state of dryness for reception by sheet-rolling and other equipment generally indicated at 20.

Each of the boxes 18 is connected with a conduit system 21 in which there is maintained a partial vacuum and is provided with a cover 22 positioned to bear against the under side of the screen conveyor 10. Each of the covers has a plurality of openings through which the reduced pressure inside of the box is communicated through the conveyor screen to the web of pulp 14 through which the atmospheric pressure acting upon the upper side thereof causes the moisture to be forced downwardly into the box below.

Preferably, I form each of the covers 22 from a laminated resinous material built up of superimposed layers of fibrous sheet impregnated with a synthetic binder, such as a phenolic condensate, which may be hardened by proper curing. Such a material eliminates the difficulties incident to the use of those materials used in the past, among which wood has predominated, and gives much longer life between resurfacings than does wood. More important still, the low coefficient of friction of such a laminated resinous material, especially when water is present, results in increased life of the screen or other type of conveyor. Power consumption is, therefore, also reduced.

Since the laminated resinous material does not warp appreciably there is no difficulty in maintaining a plane surface and the highly restricted percentage of moisture which it is capable of absorbing is found to cause practically no swelling of the fibres. Furthermore, there is no tendency for hills and valleys to form in the exposed surface, since there are no hard and soft spots such as are found in the grain of wood. The strength of the material makes it possible to use closer spacing in drilling the openings in the cover and thus a greater part of the water can be removed than is possible with conventional wooden covers.

In constructing the cover, it has been found of great advantage to build up, as shown in Figs. 3, 4 and 5, the material to be drilled from a plurality of resinous material laminations 26 which are placed perpendicular to the plane of the working surface. Each of these laminations is in the form of a thin sheet of fibrous material which has been impregnated with a synthetic resin such, for example, as the before mentioned phenolic condensate, and partially cured. The requisite number of these sheets having been cut to the proper size and placed side by side, the entire assemblage is placed in a press where both heat and pressure are applied to complete the curing of the resin and consolidate the laminations into a unitary mass. This consolidation having been completed, the top or working surface of the cover is machined and the edges properly trimmed. The openings are then made by drilling in accordance with the improved drilling plan of my invention which will be explained presently, and the working surface is further smoothed by a grinding operation.

This described "on edge" construction is especially desirable as it assures a surface of absolutely uniform composition throughout and thereby eliminates all tendency to wear unequally. In actual operation, it has been found that covers of this type function satisfactorily without attention of any kind for periods in excess of 100 days, at the expiration of which a re-surfacing operation may be repeated to again place the cover in proper condition for another operating period of similar length. Wood covers previously used in the same application had to be re-surfaced every four or seven days.

The completed cover 22 may be secured to the suction box 18 in any suitable manner as by the use of attaching screws illustrated at 28 in Figs. 3, 4, and 5. If desired, the portions of the cover edge which contact the box sides may be machined down to provide the construction shown in Fig. 5 in which the main body portion of the cover is of greater thickness than are the edge portions.

Attention may now be directed to my improved opening-location or drilling plan which is applicable to suction box covers not only of the desired synthetic resinous material construction but also to covers made from wood, metal or any other suitable substance. In the past, as previously pointed out, little attention has been given to such drilling plans and in all cases within my knowledge, no adequate consideration has been given to the effecting of a substantially uniform moisture withdrawing effort along all lines of travel of the pulp sheet across the box cover. As a result, particularly in the cases of thin or colored stock, streaking of the pulp sheet has resulted, this being due to the uneven water withdrawing effort to which different points in the pulp web are subjected. The improved drilling plan of my invention effectively overcomes this disadvantage and possesses additional advantages to be made evident presently.

It is now well recognized that the maximum number of uniformly spaced openings of a given size may be made within a given area when these openings are laid out in the form of a honeycomb pattern, in which pattern at any point removed from the edge of the drilled area, one opening is at the center of a "base" circle which passes through the centers of six other openings symmetrically located about the one first named. The reason that this most economical distribution results from the honeycomb pattern is illustrated by the showing of Fig. 6 in which there is depicted a central circular opening 30 surrounded by six other openings of the same diameter. It will be observed that all adjacent sets of these openings touch each other and that the centers of the outer six lie along the circumference of a base circle 37, the center of which is coincident with the center of opening 30. The resulting space between the openings when so arranged is reduced to an absolute minimum.

As the base circle 37 is enlarged to some greater dimension as indicated at 38 in Fig. 7, the six openings lying along its circumference are moved radially outward from the center opening 30 with the result that the spacing indicated, in Fig. 7

at *g*, between adjacent openings lying along the base circle and also between the central opening and each of these outer openings is uniform. This uniformity results in the most economical utilization of the drilled area, and for this reason, the honeycomb pattern has been extensively adopted for the positioning of the openings in suction box covers. It is, consequently, the pattern that I prefer to utilize in my improved drilling plan. Thus it will be observed that the pattern represented in Fig. 3 is of this honeycomb type, one of the large number of base circles comprised thereby being indicated at 39.

Instead of orienting this honeycomb pattern so that the parallel rows of openings comprised thereby coincide with the direction of travel of the pulp sheet which is moved over the suction box cover, as has been done in the past, I shift the axes of these rows of openings from the direction of sheet travel by an accurately predetermined angle, indicated at *a* in Fig. 8. I have discovered that when such a shift is properly made, all lines of travel of the pulp web across the box cover will be subjected to moisture-removing suction from the box for substantially uniform times and that the streaking effects heretofore experienced may thereby be completely eliminated.

This uniformity results from the fact that the degree of negative pressure exerted upon the sheet by all openings in the cover is, of course, the same, so that the quantity of moisture removed from the sheet is substantially a direct function of the amount of time that a given point in the sheet is subjected to this reduced pressure. Since all points in the sheet travel at the same rate over the box cover, this time is directly proportional to the summation of chord interceptions of the cover openings over which each point in the sheet is moved by the machine conveyor. Consequently, by providing a drilling plan in which the chord interceptions are substantially uniform along all lines of sheet travel, the desired uniformity of moisture removal across the entire width of the sheet may be effectively achieved.

Referring now to Fig. 8, I have there represented a section of a suction box cover having positioned therein a plurality of circular openings, of diameter D, located in accordance with the improved drilling plan of my invention which preferably utilizes the basic honeycomb pattern illustrated in Fig. 7, there being indicated at 39 one of the several base circles of diameter H which may be drawn through the openings of this pattern. It will be observed that the axes of the parallel rows of openings comprised by this pattern, two of which are identified as S_1S_{n-1} and L_1L_n, are displaced from the direction of pulp sheet travel, parallel to which the represented line AA' is drawn, by the before mentioned angle *a*.

I have discovered that best results are obtained when the pattern is made up of the illustrated alternate long and short rows, each of which long rows has one more opening than does each of the short rows. In Fig. 8 each of these long rows is shown as comprising eight openings and each of the short rows seven. In the showing of Fig. 3, these long and short rows have nine and eight openings, respectively.

An examination of the patterns of Figs. 3 and 8 will reveal that were these rows of openings to be positioned directionally coincident with the line of travel of the pulp sheet, as has been the practice in past suction box cover constructions, a point along the width of the pulp sheet which passed over the central line of one of the rows would be subjected to moisture removing suction for the maximum period of time. Departure from this point in either direction of sheet width then would cause the length of suction time to be progressively decreased. In fact when the shift reached a line of travel located midway between adjacent rows, no moisture removing suction whatever could be effected. This most extreme contrast applies to the generous opening spacing illustrated in Fig. 8, the order of which is consistent with maintaining cover material between openings sufficient to stand handling during manufacture and to properly stand up in service. The result is, of course, the before mentioned disadvantageous streaking in the pulp sheet.

However, by so shifting the axes of the opening rows that a line, as for example AA', drawn in parallel to the direction of the sheet travel through the center of the first opening L_1 in one of the long rows will pass through the center of the last opening S_{n-1} in one of the adjacent short rows, the length of time to which the pulp in the sheet is subjected to moisture-removing suction may be made substantially uniform along all lines of its travel past the cover. While other displacement angles effect improvement over the prior practice, the one just defined is found to produce the best results and hence it is the one which I prefer to employ.

To demonstrate the substantialness of the uniformity of moisture removing suction which it produces, I have indicated in Fig. 13, the summations of the chords intercepted across the circular openings by a plurality of spaced axes drawn through the drilled area of the box cover of Fig. 8 parallel to the direction of sheet travel. It will be observed that as a shift from axis AA' to axis JJ' is made, this summation but slightly decreases, and that a further shift to axis KK', which it will be observed is located midway between the first openings L_1 and S_1 of a long and a short row, results in only a small further reduction in chord interception summation. This summation again increases as a shift to axis QQ' is made and again attains its maximum value at axis BB' which occupies a position exactly comparable to that of axis AA'.

It may be pointed out that as the diameter of the base circle 39 of the opening pattern is reduced and the spacing between the adjacent openings correspondingly decreased, the departure from the chord summation uniformity decreases below that illustrated in Fig. 13, it practically disappearing as the spacing between the openings approaches zero. Likewise, as the pattern base circle is made larger to increase the opening spacing, it is found that the departure from the uniformity of chord summation may slightly increase beyond that depicted in Fig. 13. In all cases, however, the departure is restricted within rather narrow limits, it never exceeding a few percent. As compared with the exceedingly high values which have been common in drilled suction boxes of the prior art, the improvement afforded by the plan of my invention is indeed substantial.

As an aid to determining the magnitude of the angle of pattern shift designated at *a* in Fig. 8, a relatively simple trigonometric formula may be derived from the expression of this angle in terms of the number of holes comprised by the parallel rows of openings in the pattern. To derive this formula, there is first erected from the

center of the opening S_{n-1} in the drilled area representation of Fig. 8 a line which is perpendicular to the axis L_1L_n, which line intersects the axis at point M to form a right-angle triangle of which angle a forms a part. By setting up an equation which expresses the tangent, for example, of this angle in terms of the lengths of two of the triangle sides, the desired equation results. Thus:

$$\tan a=\frac{MS_{n-1}}{L_1M}=\frac{.5H\ (\cos 30°)}{.5H(n-1.5)}=\frac{.866}{(n-1.5)}$$

From which:

$$\text{angle } a=\tan^{-1}\frac{.866}{(n-1.5)}$$

where "n"=the number of openings in each of the long rows.

Applying this formula to the drilled area representation of Fig. 8 the proper value of the angle a is found to be 7.6°. Similarly applying the formula to the representation of Fig. 9 in which the number of openings in each of the long rows is 4, the proper value of the angle a for the drilling pattern there represented is found to be 19.1°. Similarly, in the pattern represented in Fig. 10 in which the number of openings in each of the low rows is 14, the proper value of the angle a for that pattern is found to be 3.95°.

It will thus be observed that as the number of openings in the rows of cover openings is decreased, the displacement angle a must be correspondingly increased to assure that an axis drawn in the direction of said travel through the first opening in the long row will pass through the last opening in an adjacent short row, and vice versa. An increase in the number of openings in each row has the opposite effect and requires that the angle of displacement be correspondingly reduced.

When the illustrated honeycomb pattern is utilized as illustrated in Figs. 3, 8, 9, and 10, a change in the size of the box cover to be drilled thus necessitates only that the orientation of the opening pattern be shifted and in no way varies the spacing between adjacent holes in the pattern or changes their relation with respect to each other. Consequently, for a given base circle and hole diameter combination, a single drilling template may be utilized to allocate the holes in covers of various dimensions. The axis of this template may be appropriately shifted to produce in the drilled pattern the value of angle a calculated by the previously stated formula. From the standpoint of manufacture, therefore, the drilling plan above described is exceedingly satisfactory and economical. This characteristic, combined with the superior operating performance features of the completed covers already discussed, causes the plan to possess great practical merit and utility.

The desirability of alternating long and short rows of openings through the drilled area has been explained. When the axes of the opening rows are displaced from the line of travel of the pulp sheet by the small angle a it is necessary, to effect such alternation, that certain small areas along the edge of the drilled pattern be left blank. While the magnitude of these areas is in the majority of cases insufficient to constitute a practical objection, in some situations it may be desired to eliminate it and in such cases this may be done by utilizing the modified pattern depicted in Fig. 11.

In this pattern, it will be seen that the end holes in the rows of openings lie along lines which are parallel to the edges of the box cover. To effect this relation, it is, however, necessary that the basic honeycomb pattern be slightly departed from in allocating the openings. Thus, instead of comprising six openings surrounding a common central opening and uniformly spaced therefrom, the pattern of Fig. 11 has the corresponding six openings located on an ellipse 42. This results in a somewhat shorter spacing between the holes in the same row than there is between the adjacent openings of adjacent rows and therefore requires a somewhat more difficult set-up of the drilling equipment than does the basic honeycomb pattern earlier explained. However, the summations of chord interceptions along all lines of travel of the pulp sheet over the cover are substantially uniform so that in operation results equal to those of the first explained modification are obtainable.

In certain applications of suction box covers to cylindrical type paper making machines, it is permissible to dispense with the series of circular openings and substitute in their stead a plurality of parallel positioned slots such as are depicted in Fig. 12. By making these slots in such manner that they are alternately long and short, and include areas comparable to those included by the long and short rows of openings in the before described cover drilling plans, the advantageous results of uniform moisture removal effort along all lines of travel of pulp sheet may also be achieved in this type of construction.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the scope of the appended claims.

I claim as my invention:

1. In a paper-making machine having a suction box adapted to withdraw moisture from a sheet of pulp as it is conveyed through the machine, the combination of a cover for said box having a plurality of openings positioned in uniformly spaced parallel rows which are so displaced from the direction of travel of the sheet that a line drawn parallel to said direction through the center of the first opening in any given row will pass through the center of the last opening in an adjacent row, there being "n" openings each in alternate of said rows and "n—1" openings in each of the remaining of said rows.

2. In a paper-making machine having a suction box adapted to withdraw moisture from a sheet of pulp as it is conveyed through the machine, the combination of a cover for said box having a plurality of openings positioned in uniformly spaced parallel rows in alternate of which there are "n" openings each and in the remaining of which there are "n—1" openings each, the direction of said rows being such that a line drawn parallel to the direction of travel of the sheet through the center of the first opening in any given row will pass through the center of the last opening in an adjacent row, the effect of the above-defined arrangement being to cause the summations of chord lengths intercepted in the openings by all lines drawn parallel to said direction of travel through the pattern area to be substantially uniform.

3. In a paper making machine comprising a conveyor, having moisture-passing properties, adapted to support a sheet of moisture-laden pulp and a suction box adapted to draw through

the conveyor moisture from the sheet as it is moved past the box, the combination of a cover for said box made up of a plurality of resinous material laminations positioned perpendicular to the cover working surface and consolidated into a unitary mass by heat and pressure, said box being positioned to contact the under side of a sheet-carrying portion of the conveyor and having therein a plurality of circular openings so located with respect to the direction of sheet travel as to effect a substantially uniform removal of moisture from the sheet along all lines of travel thereof.

4. In a paper-making machine comprising a conveyor adapted to support a sheet of moisture-laden pulp and a suction box adapted to withdraw moisture from the sheet as it is moved past the box, the combination of a cover for said box made up from a plurality of resinous material laminations positioned perpendicular to the cover working surface and consolidated into a unitary mass by heat and pressure, said cover having a plurality of openings of uniform diameter positioned to form a honeycomb pattern the parallel rows of openings comprised by which are directionally displaced from the direction of sheet travel by an angle which results in an exertion on the sheet of a substantially uniform moisture-withdrawing force along all lines of travel thereof across the cover.

5. In a paper-making machine comprising a conveyor adapted to support a sheet of moisture-laden pulp and a suction box adapted to withdraw moisture from the sheet as it is moved therepast, the combination of a cover for said box made up from a plurality of resinous material laminations positioned perpendicular to the cover working surface and consolidated into a unitary mass by heat and pressure, said cover having therein a plurality of openings positioned to form a honeycomb pattern the parallel rows of openings comprised by which are directionally displaced from the direction of sheet travel by an angle which is a function of the number of openings in said rows and which results in an exertion on the sheet of a substantially uniform moisture-withdrawing force along all lines of travel of the sheet across the cover.

6. In a paper-making machine having a suction box adapted to withdraw moisture from a sheet of pulp as it is conveyed through the machine, the combination of a cover for said box made up from a plurality of resinous material laminations positioned perpendicular to the cover working surface and consolidated into a unitary mass by heat and pressure, said cover having a plurality of openings positioned in uniformly spaced parallel row in alternate of which there are "n" openings each and in the remaining of which there are "n—1" openings each, the direction of said rows being such that a line drawn parallel to the direction of travel of the sheet through the center of the first opening in any given row will pass through the center of the last opening in an adjacent row.

7. A suction box cover, adapted to cooperate with a moving sheet of moisture-laden material, having a plurality of openings positioned in uniformly spaced parallel rows in alternate of which there are "n" openings each and in the remaining of which there are "n—1" openings each, the direction of said rows being such that a line drawn parallel to the direction of travel of the sheets through the center of the first opening in any given row will pass through the center of the last opening in an adjacent row.

8. A suction box cover, adapted to cooperate with a moving sheet of moisture-laden material, having a plurality of openings positioned in uniformly spaced parallel rows in alternate of which are "n" openings each and in the remaining of which there are "n—1" openings each, the direction of said rows being displaced from the direction of travel of the sheet by an angle which in degrees is substantially equal to that expressed by the relation:

$$\tan^{-1}\frac{.866}{(n-1.5)}$$

9. A suction box cover, adapted to cooperate with a moving sheet of moisture-laden material, having therein a plurality of uniformly spaced parallel slots which are so displaced from the direction of travel of said sheet that a line drawn parallel to said direction through the leading end of any given slot will pass through the lagging end of an adjacent slot, alternate of said slots being longer than are the remaining.

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