

July 16, 1963

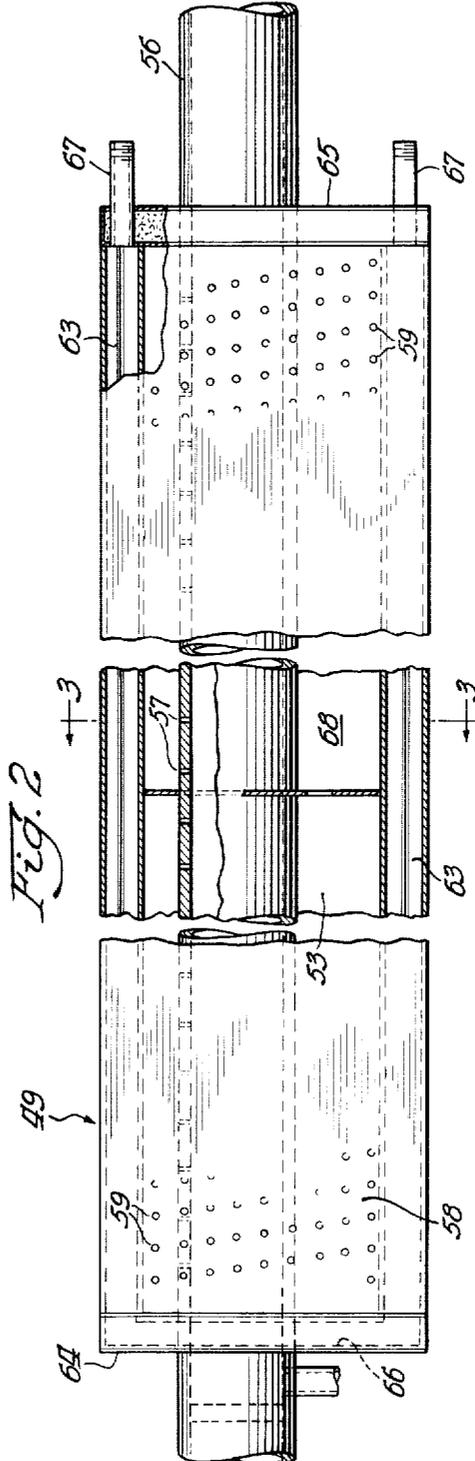
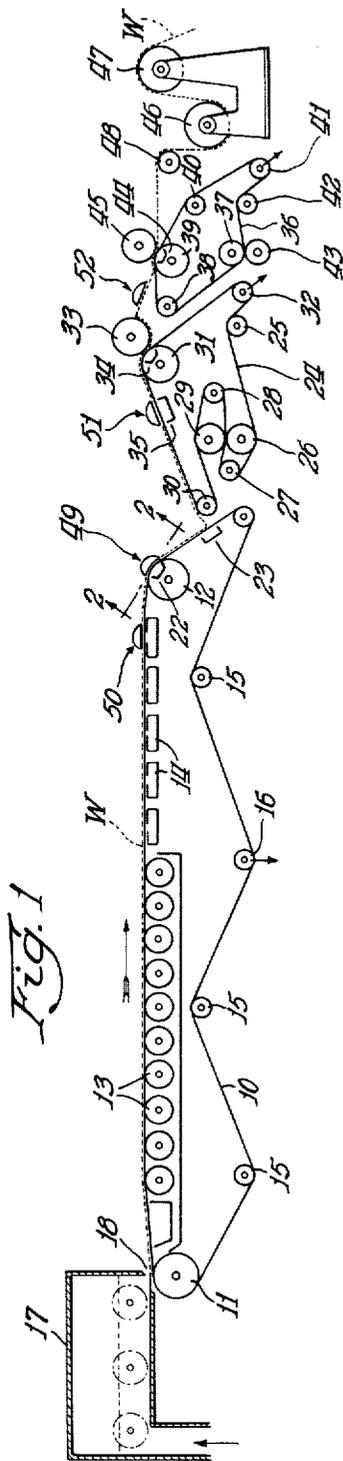
W. A. DICKENS ETAL

3,097,994

STEAMING DEVICE FOR A PAPERMAKING MACHINE

Filed Feb. 3, 1961

5 Sheets-Sheet 1



July 16, 1963

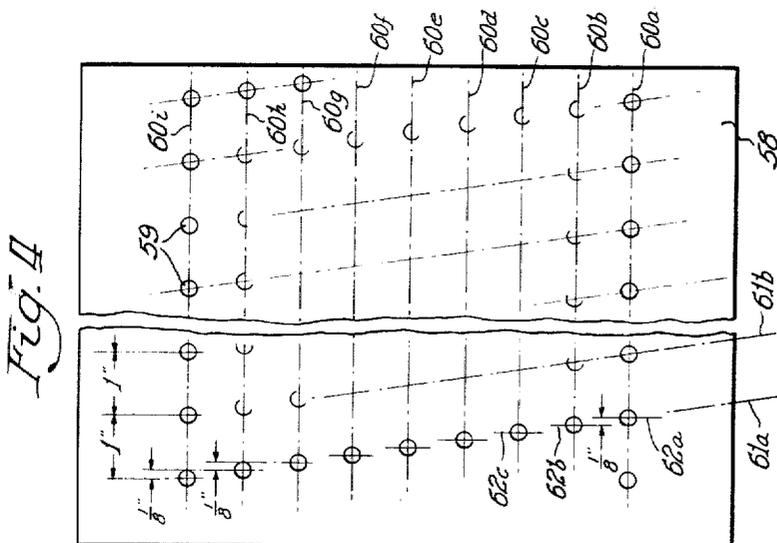
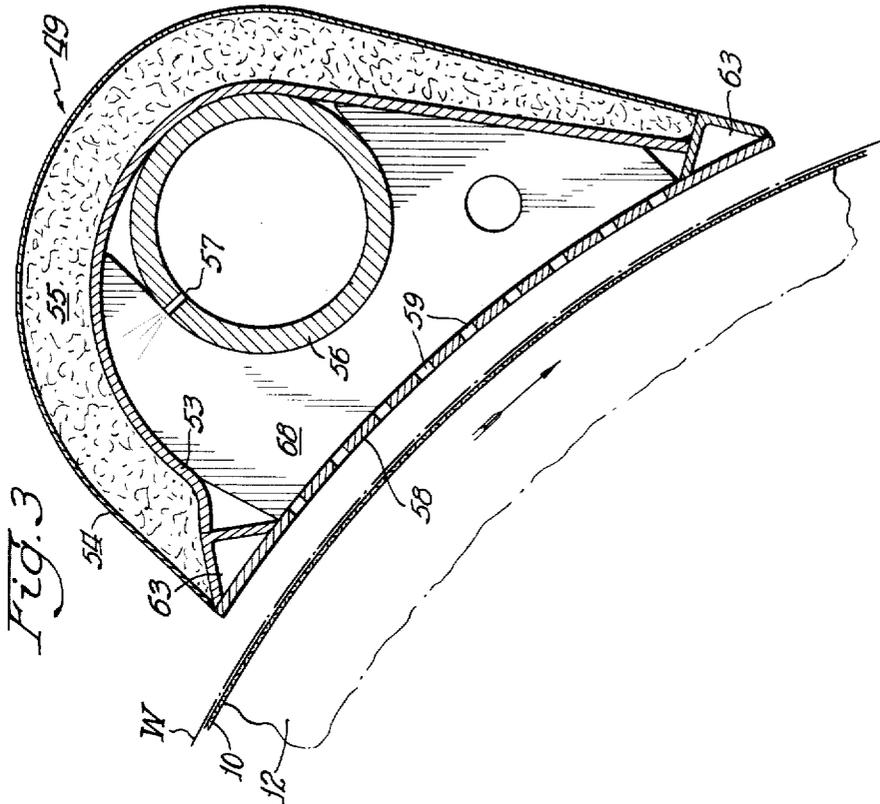
W. A. DICKENS ET AL

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5 Sheets-Sheet 2



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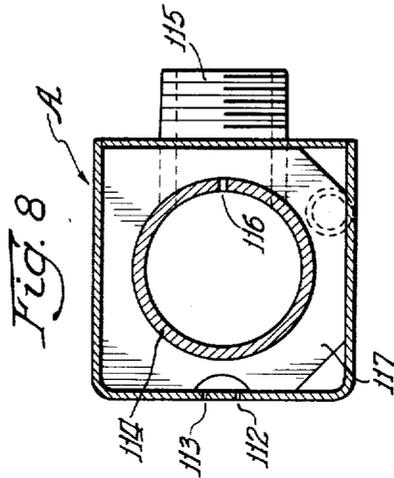
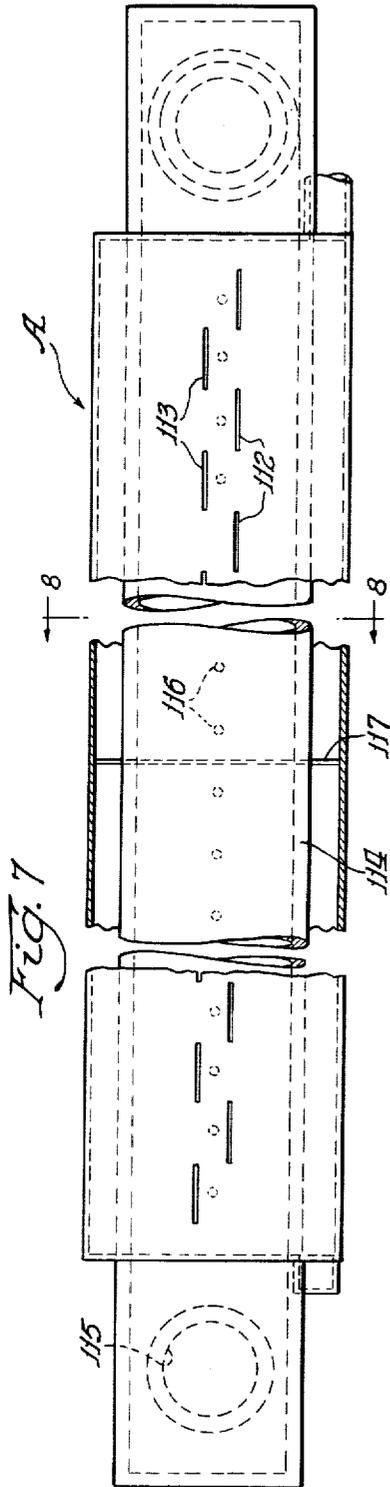
W. A. DICKENS ETAL

3,097,994

STEAMING DEVICE FOR A PAPERMAKING MACHINE

Filed Feb. 3, 1961

5 Sheets-Sheet 4



July 16, 1963

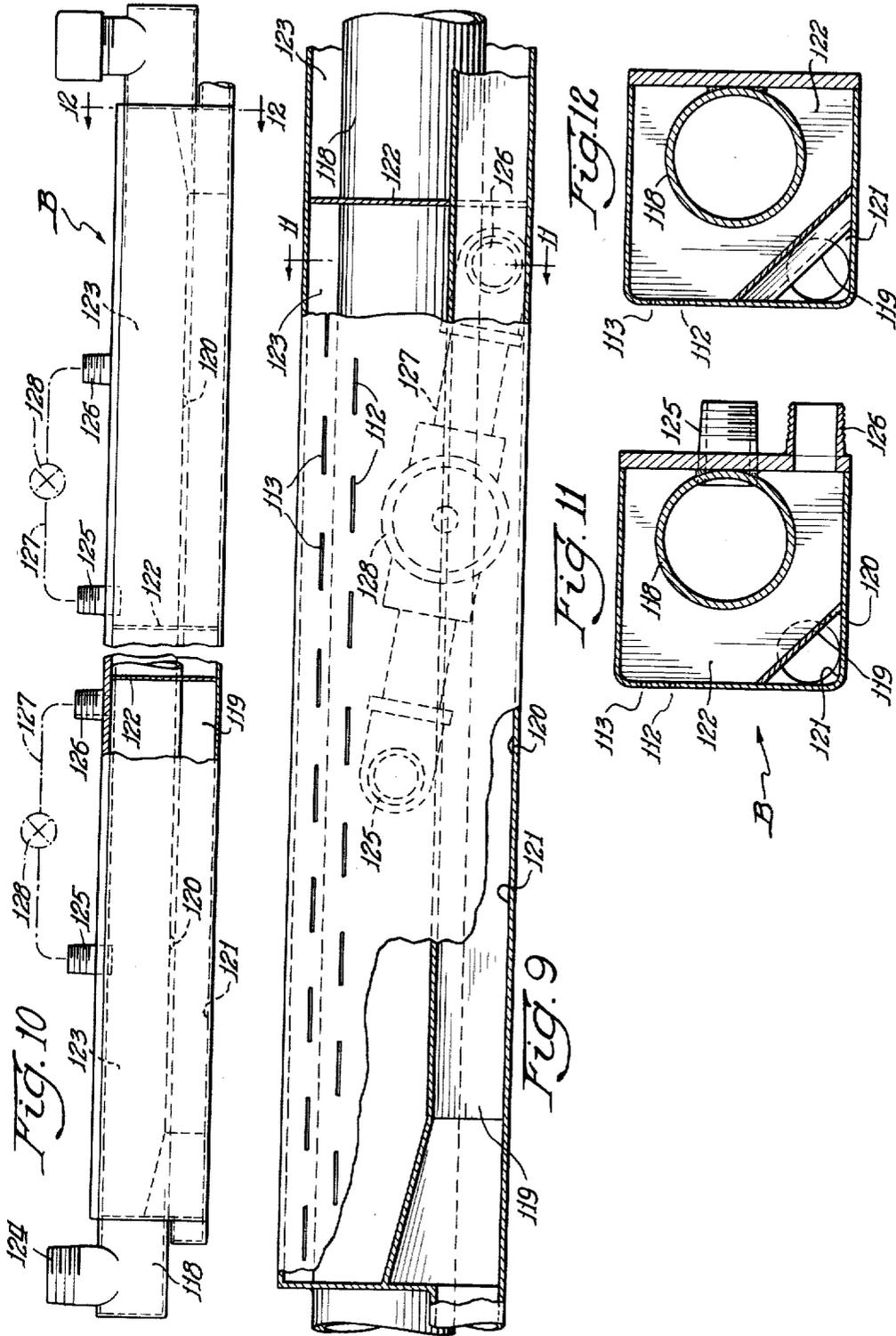
W. A. DICKENS ETAL

3,097,994

STEAMING DEVICE FOR A PAPERMAKING MACHINE

Filed Feb. 3, 1961

5 Sheets-Sheet 5



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3,097,994

STEAMING DEVICE FOR A PAPERMAKING MACHINE

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 Filed Feb. 3, 1961, Ser. No. 86,920
 6 Claims. (Cl. 162-297)

The invention relates to machines for making fibrous webs and, more particularly, to papermaking machines. Still more particularly, the invention relates to improved dewatering devices for and methods for dewatering wet fibrous webs, such as paper webs.

Dewatering of fibrous webs in such machines commonly occurs as the result of natural drainage through the fabric on which the web is formed; and auxiliary devices are provided for increased dewatering, such as rotatable table rolls supporting the fabric and vacuum boxes under the fabric downstream of the place of deposit of the fibrous web, and pressure rolls effective on felts carrying the web positioned in the machines prior the steam heated web drier drum or drums.

It is an object of the present invention to provide mechanism and method for increasing the dewatering effect of various of these auxiliary devices and, more particularly, to provide steam chests, showers or shrouds for applying steam on to the web simultaneously with passage of the web over vacuum boxes or prior to the passage of the web between pressure rolls, so that the web is dewatered to a greater extent when it is presented to the drying section of the machine.

It is a more particular object to provide such chests, showers or shrouds supplied with superheated steam and which are so constructed and are so located that steam jets are discharged from them onto the web with sufficient velocity that the jets penetrate the air blanket on the web and in effect scrub off the air from the web so that superheated steam substantially undiluted with air is applied onto the web. It is contemplated also that the steam jets shall be so spaced that the steam is supplied substantially uniformly to the web.

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 diagrammatic illustration of a papermaking machine including steam shrouds according to the invention, each of which has a perforated plate for jetting steam onto the web;

FIG. 2 is a view on an enlarged scale of a steam shroud in the papermaking machine, taken on line 2-2 of FIG. 1;

FIG. 3 is a sectional view on a still further enlarged scale taken on line 3-3 of FIG. 2;

FIG. 4 is a view of the perforated plate of the steam shroud;

FIG. 5 is a schematic illustration of another type of papermaking machine including a steam shower according to the teachings of the invention and including a plurality of shower sections;

FIG. 6 is an end view on an enlarged scale of the steam shower in the machine illustrated in FIG. 5;

FIG. 7 is a side view of one of the sections of the steam shower illustrated in FIG. 6;

FIG. 8 is a sectional view taken on line 8-8 of FIG. 7;

FIG. 9 is a side view of another of the sections of the steam shower illustrated in FIG. 6;

FIG. 10 is a top view on a reduced scale of the steam shower section illustrated in FIG. 9;

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FIG. 11 is a sectional view taken on line 11-11 of FIG. 9; and

FIG. 12 is a sectional view on an enlarged scale taken on line 12-12 of FIG. 10.

Referring now to the drawings, the illustrated Fourdrinier type papermaking machine shown in FIG. 1 is of a type generally used for paper of conventional weights, such as book paper, bond paper, onionskin paper, filter paper, newsprint, wall paper base, etc. The machine may be seen to comprise a Fourdrinier wire or fabric 10 which is trained over a breast roll 11 and a couch roll 12. A plurality of table rolls 13 and a plurality of vacuum boxes 14 are provided beneath the upper pass of the wire 10. A plurality of idler and guide rolls 15 and a stretch roll 16 are provided for the lower pass of the wire 10. Force is applied on the stretch roll 16 in accordance with conventional practice for maintaining the wire 10 taut about the rolls about which the wire is trained.

A paper stock headbox 17 of conventional type is provided at one end of the upper pass of the wire 10 and has an outlet 18 for jetting the stock onto the wire 10.

The couch roll 12 is of a conventional open construction, and a suction gland 22 is provided within the roll. A suction box 23 is provided within the wire 10 below the couch roll 12.

The Fourdrinier machine includes a felt section comprising a loop of felt 24 disposed about the rolls 25, 26, 27, 28, 29, 30, 31 and 32. The rolls 25, 27, 28 and 30 are idler and guide rolls, and the roll 32 is a stretch roll on which force is applied for maintaining the felt loop in taut condition. The rolls 26 and 29 are wringer rolls through which the felt passes under pressure. The roll 31 is a press roll, and a mating roll 33 is provided to have a press nip with the roll 31. The roll 31 is of a conventional open construction and has a suction gland 34 within it. A suction box 35 is provided for the felt 24 between the rolls 30 and 31. The felt section comprises another loop of felt 36. The felt 36 travels around rolls 37, 38, 39, 40, 41 and 42. The rolls 38, 40 and 42 are idler and guide rolls, and the roll 41 is a stretch roll. The roll 37 is a wringer roll, and a mating wringer roll 43 is provided to have a nip with the roll 37 for passing the felt 36 therebetween. The roll 39 is of conventional open construction, and a suction gland 44 is provided within the roll. The roll 39 constitutes a press roll and a mating press roll 45 is provided to have a press nip with the roll 39.

A drier section of any suitable type follows the felt section and may comprise, for example, a plurality of serially arranged heated drier drums, such as the two drums 46 and 47 which are illustrated. A carrier roll 48 is provided ahead of the drum 46.

It will be understood that the particular felt section illustrated, including the felts 24 and 36 and the rolls about which these felts pass, may be replaced by other conventional felt sections. In the illustrated felt section, the rolls 31 and 39 having the vacuum glands 34 and 44 therein are perforate rolls, but if desired these rolls may be replaced by solid rolls or with rolls having blind drillings in the peripheral surfaces, without such vacuum glands. The rolls 33 and 45 are preferably solid rolls.

It has been found, according to the invention, that the moisture content of web W is substantially reduced at the time of application to the drier section if a steam applying mechanism, such as a shroud, is used to previously apply steam onto the web W prior to the final pressing step, if one is used. The steam functions to reduce the viscosity of the water in the web so that more water is expressed from the web at one or more of the various dewatering positions. These positions may, for example, be in the felt section or in the wire section. An exemplary dewatering position in the felt section is a press nip,

such as between the press rolls 31 and 33 or between the press rolls 39 and 45. An exemplary dewatering position in the wire section is over a vacuum box, such as over one of the vacuum boxes 14 or over the vacuum gland 22. The steam shrouds may be used with or without an associated vacuum box or gland but are preferably used for best results with a vacuum box or gland when the shroud applied steam onto the web while on the wire.

Steam shrouds 49, 50, 51 or 52 may be utilized. The shroud 49 located over the couch roll 12, which is of perforated construction and has the vacuum gland 22 therein, has proved particularly effective. The shroud 49 (FIG. 3) comprises an inner housing 53 of relatively thick material and an outer housing 54 of relatively thin material. Insulation 55 is provided between the two housings. A steam supply pipe 56 is fixed within the shroud substantially at the center of the housing 53, and the pipe 56 is provided with a plurality of spaced discharge orifices 57 directed upwardly toward the adjacent side of the housing 53. The impervious portions of the pipe 56 are thus the lowest portions of the pipe so that the pipe can retain condensate within it which may be withdrawn from it at the ends of the pipe.

A rounded plate 58, provided with a plurality of openings 59 therethrough, is fixed at the open ends of the housings 53 and 54. As illustrated in FIG. 4, these openings are disposed in a plurality of rows extending longitudinally of the shroud 49, which are located on longitudinal center lines 60a and 60b to 60i. The openings 59 are also disposed in rows extending transversely and slightly slantwise of the shroud 49, being disposed on the center lines 61a, 61b, 61c, etc. In the particular embodiment of steam shroud illustrated, the center lines 60a and 60b to 60i are about $1\frac{1}{16}$ inch apart, and the center lines 61a, 61b, etc., are about one inch apart. Due to the fact that the rows 61a and 61b, etc., are slanted with respect to the longitudinal axes of the shroud, the openings 59 are located on transversely extending center lines 62a, 62b, 62c, etc., that are relatively closely spaced, such as $\frac{1}{8}$ inch.

The openings 59 may have a diameter of $\frac{1}{4}$ inch, for example, and the plate 58 is curved about substantially the same center as that of the couch roll 12, so that the plate 58 is substantially equally distant from the surface of the roll. The steam shroud 49 is so located that its perforated plate 58 is disposed quite close to the web W and the surface of the roll 12, such as $\frac{3}{4}$ inch, for example.

The shroud 49 may be provided with steam conduits 63 on its opposite edges. The shroud has ends 64 and 65, and as shown in FIG. 2, conduits 63 are joined by a passage 66 in the end 64 to form a continuous loop for the passage of steam and removal of condensate. Steam supply and return pipes 67 for the conduits 63 extend through the end 65, and the pipe 56 also extends through the end 65, as shown.

In operation, steam preferably superheated steam, is supplied to the pipe 56. The steam passes and expands through the orifices 57 of the pipe 56 into the cavity 68 provided by the inner housing 53 and the plate 58, and the steam is jetted from the cavity 68 through the openings 59 onto the web W passing over the roll 12. The steam thus jetted on the web W condenses within the web so as to liberate the heat of condensation, and the steam thus has a substantial heating effect on the web, although it does release a relatively slight amount of water in the web in condensing. The steam in heating the web reduces the viscosity of the water within the web so that more of it is expressed from the web by the associated dewatering devices which are the gland 22, the press rolls 31 and 33, and the press rolls 39 and 45, than would be the case without the shroud. The rate of water removal at a given moisture content of the web at either the gland 22 or between the sets of press rolls is thus greater, and the web W is thus supplied to the driers 46 and 47 at

substantially reduced moisture contents, than would be the case if the shroud were not used. It should be noted that the gland 22 in the roll 12 is located directly beneath the steam shroud 49, and the gland thus tends to draw the steam through the web W to saturate the web and cause the steam to condense in the web, and the gland functions also to draw out the reduced viscosity water in the web and dewater the web.

Steam is also supplied to one of the pipes 67 to circulate through the conduits 63 and functions to heat the leading and following edges of the shroud to minimize water drip from the shroud. The insulation 55 functions to allow the housing 53 to remain substantially at the temperature of the steam, so that there is little condensation in the housing 53 and thus little water drip from this source. It will be understood that other means may be utilized for maintaining the housing 53 at an elevated temperature, such as electric heaters, for example. If desired, the conduits 63 need not be used, particularly if steam containing 40 to 50° of superheat, such as steam at 260 to 270 degrees F. (at 3 p.s.i. gage) is supplied to the shroud which in itself tends to minimize water drip from the shroud.

An important feature of the invention lies in the characteristics of the steam issuing from the openings 59 which are such that the steam has a high penetrating effect suffice to pierce the blanket of air between the shroud 49 and the web W and which are such that the steam issues as jets from the openings 59 and actually impinges as jets on the web W. We obtain these improved characteristics by properly setting the steam pressure in the cavity 68, which determines the velocity of the steam discharging through the openings 59, and properly determining the size of the openings 59 along with the distance of the plate 58 from the surface of the roll 12. The steam with these characteristics in effect scrubs the air off the web W and thus actually reaches the web W in the nascent form of the steam without any substantial cooling by or intermixture with the air and without any substantial condensation in the air. The spacing of the plate 58 from the surface of the roll 12 and from the web W thereon and the velocity of the steam passing through the openings 59 are such that the steam passes from the plate 58 to the web W in a very short time so that no substantial condensation of the steam takes place in the blanket of air surrounding the roll 12 and almost the full thermal value of the steam is available to heat the web W on condensation of the steam to reduce the viscosity of the water in the web.

In order for this improved heating effect of the web W to occur due to steam application onto the web from the shroud 49, the velocity of the steam as it passes through the openings 59 shall preferably be greater than 10 feet per second. The velocity of the steam through the openings 59, however, as is apparent, must be kept below a velocity at which the steam will rip the web W from the wire 10 over the roll 12 or will otherwise disturb the formation of the web. Such a typical high steam velocity could be on the order of 600 feet per second. The latter value, of course, varies greatly with the type of web being made and, in particular, with the length of the fibers used in the web and the thickness of the web. Fifty feet per second has proved to be a desirable steam velocity from the openings 59 in producing the above mentioned conventional weight papers, such as book-paper; and, at this velocity, about 90 percent of the full B.t.u. value of the steam appears as sensible heat in the web.

The sizes of the openings 59 shall preferably range between $\frac{1}{16}$ inch to $\frac{3}{8}$ inch, and a satisfactory practical size has been found to be $\frac{1}{4}$ inch. The distance of the plate 58 from the surface of the roll 12 shall preferably be less than 4 to 8 times the diameter of the orifices 59. A jet of gas issuing from an opening, such as an opening 59, into another gaseous medium will not entrain an appreci-

able amount of the latter medium until the jet has travelled a distance equivalent to about 4 times the diameter of the jet at the point of issuance from the opening, and hence the distance between the plate 58 and surface of the roll 12 may well be 4 times the diameter of the openings 59. Between 4 and 8 diameter spacing, there is a small amount of entrainment of the second gaseous medium within the jet, but not enough to be seriously objectionable; but above a spacing of 8 diameters, the entrainment becomes substantial and more objectionable. Therefore, it is desirable to maintain a spacing distance which is less than 8 times the opening diameters. A satisfactory practical operating distance between the plate 58 and the surface of the roll 12 has been found to be between ½ inch and 2 inches. Separations of less than ½ inch between the plate 58 and roll 12 may not be too practical due to the possibility of some of the paper web or spray contacting the plate 58 and thus being scraped off the wire 10 and wadding up and collecting between the shroud and roll. One inch has been found, in particular, to be a very satisfactory spacing of the plate 58 and the roll 12, and at the minimum velocity of 10 feet per second through the openings 59, the time of travel of the steam from the plate 58 to the surface of the roll 12 is about .008 second. At a two-inch separation with this same velocity, the steam jetting onto the roll 12 is at the roll surface within about .017 second. These short travel times do not allow substantial intermixture of the steam with the air surrounding the roll 12 and assures that most of the steam is not condensed until it contacts the web W.

The spacing of the openings 59 is not critical, but they should be disposed in such patterns that the web W is uniformly treated by the steam jets. The openings 59 may, as an example, be spaced on the centers above mentioned, and approximate distance of one inch between openings is considered quite satisfactory. In lieu of the openings 59, slots might instead be provided in the plate 58, such as will be described in connection with another embodiment of the invention, for also uniformly covering the web W with steam. The slots may be of any practical length, but their width should be within the ¼" to ⅜" dimension noted above.

The degree of vacuum that exists in the vacuum gland 22 is not at all critical; it may vary from 0 inch to 23 inches of mercury as a practical matter. The degree of vacuum is utilized in actual cases is determined principally by other operating criteria such as the weight of the web W, vacuum pump capacity and the amount of wire marking that is acceptable. Although the use of the vacuum gland 22 is desirable beneath the shroud 49, it is not absolutely necessary and may be dispensed with.

The steam shroud 49 located over the couch roll 12 has been found particularly satisfactory for webs having a basis weight of 30 pounds (bone dry weight) per 3300 square feet or heavier. For these webs, the steam shroud 49 is preferably used with the vacuum gland 22. The press rolls 31 and 33 and the press rolls 39 and 45, in addition to the vacuum gland 22, function to dewater the web; and the web W at the higher temperatures provided by the steam has a higher rate of water removal at a given moisture content by each of these dewatering means than would be the case without the steam application. The net result is a sheet of lower moisture content presented to the drier section.

In lieu of, or in addition to the steam shroud 49, the steam shroud 50 may be utilized. The shroud 50 is positioned over a vacuum box 14 and is identical with the shroud 49 except that the corresponding perforated plate 58 is flat, rather than being curved to correspond with the curvature of a couch roll. The shroud 50 is effective on the upper pass of the Fourdrinier wire 10 as is the shroud 49. If desired, the shroud 50 may be duplicated so that there are a plurality of shrouds 50 between the rolls 13 and the roll 12. Any one or more

of the vacuum boxes 14 beneath shrouds 50 may be dispensed with if desired; however, their use is preferred, particularly for the heavier weight webs (above 30 pounds per 3300 square feet).

The steam shroud 51 may be used in addition to, or in lieu of, the shrouds 49 and 50. The shroud 51 is identical in construction with the shroud 50 and is effective to apply steam onto the web W carried by the felt 24. The shroud 51 may be used with or without the vacuum box 35 positioned beneath it; however, the vacuum box 35 slightly increases the effectiveness of the shroud in heating the web W. The shroud 52 may be used in lieu of or in addition to any of the shrouds 49, 50 and 51. The shroud 52 is identical with the shrouds 50 and 51, but the shroud 52 is positioned on the web W alone, as the web passes from the press roll 33 onto the felt 36. For increasing the effect of either of the shrouds 51 and 52, either of these shrouds may be duplicated. In these cases, a plurality of shrouds 51 will be effective on the web on the felt 24 and a plurality of shrouds 52 will be effective on the web between the rolls 33 and 39. Multiple treatment is especially effective for heavier webs or to achieve the highest degree of moisture removal prior to entry of the web into the drying section.

It should be noted that there is a substantial distance between the shroud 51 and the press rolls 31 and 33 (and between the shroud 52 and press rolls 39 and 45), so that there is a substantial soaking time for the steam after its application to the web by the shroud until the pressing by the following press rolls. A soaking time of about 0.1 second is desirable for the conventional papers above mentioned and the steam shroud is therefore located a foot or more ahead of the following press rolls, this distance, of course, being dependent on machine speed. In a particular case, at 900 feet per minute web speed, it is well to separate the steam shroud and the nip of the following press rolls by about 1.5 feet. This soaking time allows the heat caused by the steam condensation, which occurs particularly on the top surface of the web, to distribute itself throughout the web.

All of the shrouds 50, 51 and 52 operate in substantially the same manner as the shroud 49 to increase the temperature of the web W. If vacuum boxes are used beneath the shrouds 50 and 51, these operate in the same manner as the vacuum gland 22; however, the vacuum box 35, since it is positioned beneath the felt 24, is not nearly as effective to dewater the web W and to draw steam into the web W as the other vacuum boxes, since the felt 24 is relatively impervious as compared to the wire 10.

Experience indicates, in general, that the basis weight of the paper web determines the best position for the steam shroud. If the paper is relatively heavy (above 30 pounds per 3300 square feet), it has been found desirable to locate the steam shroud over the forming wire 10 and preferably use a vacuum box beneath the steam shroud. The advantages of applying the steam over the wire for such webs lies in the fact that the lower viscosity water in the web is expressed by a plurality of devices including the vacuum box 23 that is positioned at the point of departure of the web from the wire as well as the main press rolls 31 and 33 and rolls 39 and 45. Particularly with respect to the relatively heavy webs made on the type of machine illustrated in FIG. 1, using shroud 51 or shroud 52, it is important that there should be a substantial soaking time between the point of application of the steam and the following press rolls and hence a space is preferably provided between the chests 51 and 52 and the rolls 33 and 45 respectively.

For slightly higher weight webs (such as 25 to 30 pounds per 3300 square feet), it is preferred that the place of application of the steam be in the felt section, using the shrouds 51 or 52, prior to one or more of the press roll nips. Steam application in the felt section is preferred in this case, since the lighter weight webs do

not have the ability to retain the heat imparted to them by the shrouds as long as webs of heavier weight and since the efficiency of couch steam shroud heating is less for these lighter weight webs. Vacuum boxes may or may not be used. Even though steam application to the web in the press section does not present as dry a sheet to the press rolls as does steam application over the couch roll 12, for example, the advantage of having the web at a higher temperature at the nip of the press rolls, for these lighter weight webs, outweighs the factor of presenting the sheet with less water to the press rolls.

Incidentally, the residence time between the place of steam application and the press nip in this case should preferably amount to approximately 0.1 second.

Papers of tissue weights (about 4.5 to 12 or 15 pounds per 2880 square feet, bone dry, uncreped, drier basis weight) are, in general, made on Yankee type papermaking machines in which a single large diameter heated drier is used for the paper in lieu of quite a number of smaller diameter driers such as the driers 46 and 47. In this case, it has been found desirable to locate the steam application mechanism quite close to the Yankee drier. Incidentally, much heavier weights of webs may also be made on Yankee type machines, but the web speeds are very materially less.

FIGS. 5 and 6 may be referred to for a showing of a tissue making machine of the Yankee type. This machine comprises a Fourdrinier wire 80 disposed over a breast roll 81, a couch roll 82, a plurality of table rolls 83, idler and guide rolls 84 and a stretch roll 85.

The felt section of the tissue making machine comprises a felt 93 in the form of a loop disposed about a pickup roll 94 having a nip with the roll 82, a pressure roll 95, a main press roll 96, a stretch roll 97 and idler and guide rolls 98. The machine includes a Yankee drier drum 99 and the pressure roll 95 has a nip with the drum 99, with the felt 93 passing through the nip. A doctor blade 100 is provided in web scraping relation with the drum 99. Suitable cleaning devices are provided for the felt 93, including conventional showers 101 and Uhle boxes 102. In the event it is desired to produce an uncreped sheet, such as a machine glazed sheet, in this case, the doctor blade 100 is dispensed with.

A bottom felt 103 in the form of a loop is provided and extends around a main press roll 104, a wringer roll 105, a stretch roll 106 and idler and guide rolls 107. The press roll 104 has a nip with the roll 96, and the two felts 103 and 93 pass through the nip. A wringer roll 108 is provided having a nip with the roll 105, and the felt 103 passes through the nip. Suitable cleaning devices are provided for the felt 103 including a shower 101 and a Uhle box 102. The rolls 104 and 95 are preferably of open construction and vacuum glands 109 and 110 are provided within the rolls opposite the nips of these rolls with the roll 96 and the drum 99, respectively.

A steam shower 111 is provided for the web W' just prior to its passage from the felt 93 to the drier drum 99. The steam shower 111 comprises (see FIG. 6) a plurality of stacked square pipes A and B. Each of the pipes A is supplied with steam for applying such steam uniformly across the deckle of the web W'. Each of the pipes B is also supplied with steam, and provisions are made for varying the steam output across the deckle of the web W' for each of these pipes.

Each of the pipes A is provided with steam discharge slots 112 and 113 arranged in staggered relation (see FIGS. 7 and 8) so as to cover the entire deckle of the web W' with steam. A steam supply conduit 114 having a steam inlet 115 extends through each of the pipes A and is provided with a plurality of spaced steam discharge ports 116 within the pipe A. A plurality of baffles 117 are provided within the pipe A for holding the conduit 114 properly positioned within the pipe.

Each of the pipes B (see FIGS. 9 to 12) has steam discharge slots 112 and 113 in its surface facing the web

W' and felt 93, and a steam supply conduit 118 extends through the pipe B. A longitudinally extending partition 119 having small vent or drain ports 120 in an edge thereof extends through the pipe B and closes off a lower corner of the pipe except for the communication provided by the ports 120. The partition 119 forms a longitudinally extending drain conduit 121 in the pipe B which may discharge any condensed steam from its ends. A plurality of transversely extending baffles or partitions 122 are provided within the pipe B dividing the pipe into a plurality of separate chambers 123.

The conduit 118 is provided with a steam inlet 124 on an end and is provided with a plurality of outlet nipples 125 extending through a side of the pipe B to the exterior of the pipe B, one of such nipples 125 being provided for each of the chambers 123. Each of the chambers 123 is also provided with an inlet nipple 126 extending through a wall of the pipe B, and a conduit 127 with a valve 128 in it is provided for connecting each of the nipples 125 with one of the nipples 126.

The steam shower 111 in operation discharges steam through the slots 112 and 113 onto the web W' so as to heat the web just prior to passage of the web through the nip of the pressure roll 95 and drier drum 99, and the roll 95 and drum 99 express water from the web in a manner similar to the main press rolls in the papermaking machine first described. The same conditions apply to the pipes A and B and to the slots 112 and 113 as apply to the plate 58 and the orifices 59 in the prior described embodiments, insofar as the spacing between the orifices and slots and the paper web, the width of the slots (corresponding to the diameter of the orifices 59), and the velocities of the steam through the slots and ports are concerned; and, in fact, it is possible to substitute the steam shower 111 for the shrouds 49, 50, 51 and 52 and vice versa, if desired, or to use the slots 112 and 113 in lieu of the orifices 59 in the perforated steam discharge plates of the shrouds 49, 50, 51 and 52.

The dewatering effect of the steam shower 109 may be changed for various longitudinal strips of paper web across the deckle of the machine by suitably adjusting the valves 128. If there is too much drying on one particular part of the deckle, then the valve 128 for that chamber 123 from which the steam is issued for that part of the deckle may be closed to a greater extent, for example.

If desired, a steam applying mechanism, such as the shroud 135, may be utilized on the web W' carried by the felt 93. The shroud 135 is positioned a short distance ahead of the press rolls 96 and 104 and functions in the same manner as the shroud 51 in the FIG. 1 embodiment.

It has been found that the steam shower 111, which is located relatively close to the pressure roll 95 or to both the pressure rolls 95 and 131, if the latter is used, is very effective for relatively light webs, such as tissue, having a basis weight, for example, of about 7.5 pounds per 2880 square feet. In Yankee papermaking machines for lightweight webs, such as is disclosed in FIG. 5, the place of heaviest pressure application on the web is in the nip of the Yankee drier drum 99 and a pressure roll having a nip with the drier drum; and, therefore, the best place of application of the steam in such a machine is just prior to this nip. Since the web is relatively lightweight, it would retain little, if any, heat of condensation applied from a shroud or shower to the web at the wet end of the machine and hence the wet end is not considered the preferred place for applying the steam. Although tissue weight sheets have been principally referred to in connection with the machine illustrated in FIG. 5, which sheets are generally on the order of approximately 7.5 pounds per 2880 square feet (uncreped, bone dry, drier basis weight), this machine together with the shower 111 may also be used on other basis weight webs that may, if desired, be produced with a Yankee drier, such as machine glazed sheets of 15 to 100 pounds per

2880 square feet. On these very heavy sheets, the machine would be run at a relatively slow speed. The machine is also useful using the shower 111 on very light sheets such as tissue of 3.5 pounds per 2880 square feet, for example.

The various pipes A and B are simply cumulative in their action. A single pipe may not supply the desired quantity of steam to the web W'; and, therefore a plurality of such pipes are preferably provided. Although five pipes A and two pipes B are shown in FIG. 6, it will be obvious that the numbers of these various pipes may be increased or decreased as desired, depending on the desired drying effect, speed of operation, and weight of the tissue web. In general, for the light basis weight webs just mentioned, the closer the shower 111 is positioned to the nip of the pressure roll 95 and the drum 99, the more effective the shower is. A spacing of a foot between the shower and the nip has been found effective. It will be understood that the steam penetrates a lightweight sheet faster than a heavier sheet and the relatively long steam soaking time is not required. Soaking time of about 0.02 second is desirable for the lightweight webs just mentioned as contrasted to 0.1 second for the heavier weight sheets previously mentioned in connection with the FIG. 1 machine. The steam shower 111, however, may be moved farther from the nip, such as to 5 feet away, for example, and the shower will still be effective. For lightweight sheets, vacuum glands or boxes are not required (but may be provided) beneath the felt 93 and aligned with one or more of the pipes A and B to help the steam jetted onto the web W' to penetrate the web.

It will be obvious that although cross deckle control of drying is shown only in connection with the shower 111, the same type of cross deckle control could be provided in connection with any of the steam shrouds 49, 50, 51, 52 and 135.

Although no particular exhaust systems have been illustrated or described in connection with the various steam shrouds and showers of the invention, it will be understood that any suitable condensed steam fog exhaust systems may be used. These exhaust systems are particularly desirable in connection with shrouds 51 and 52 and shower 111, because there are no effective vacuum glands or boxes used beneath these shrouds and shower. It will also be understood, in view of the fact that the illustrated papermaking machines are illustrated only schematically, that other conventional parts of such machines not illustrated are intended to be used, such conventional parts including, for example, a hood surrounding the Yankee drier drum 99 and directing heated air on the outer surface of the drum 99 and particularly on the web carried by the drum.

The steam shrouds and showers of the invention advantageously increase the drying effect in a papermaking machine for either heavy or lightweight webs. Therefore, it is possible to produce heavier base sheets on machines that were intended for lighter base sheets, using the steam shroud or showers, or, if the base sheet is kept the same, then such a machine may be used at increased speeds due to the increased drying that is obtained.

As a particular example of the increased papermaking speeds obtainable, a particular papermaking machine of the type shown in FIG. 5 produced, without the application of steam by means of shrouds or showers, a tissue sheet of 7.5 pounds per 2880 square feet (bone dry, drier basis weight) at 2600 feet per minute, with the speed of the machine being limited by the drying capacity of the drum 99 and its associated air impingement hood. The addition of a steam shower 111 using three pipes A (without any pipes B), applying 7000 pounds of superheated steam per hour at a temperature of 350 degrees Fahrenheit to the web W', allowed an increase in the machine speed of 400 feet per minute to a speed of 3000 feet per minute.

As another example of the effectiveness of the inven-

tion, utilization of a steam shroud 49 over the couch roll 12 in a FIG. 1 form of paper machine with the application of 315 pounds of steam per hour per deckle foot to a web W with a basis weight of 30 pounds per 3300 square feet (bone dry basis weight) at 900 feet per minute reduced the moisture content of the sheet after the press nip defined by rolls 39 and 45 from a value of 1.89 pounds of water per pound of bone dry fiber which prevailed without the use of steam to a value of 1.64 pounds of water per pound of bone dry fiber. This substantial reduction in the moisture content of the sheet before subsequent drying obviously considerably increased the production potential of the machine. Adding additional steam to the same web W by a shroud 51 at a flow rate of 315 pounds per hour per deckle foot further reduced the water content of the sheet after the nip defined by press rolls 39 and 45 to a value of 1.53 pounds of water per pound of bone dry fiber.

As another advantage of operating the steam shroud 49 and/or 50, 51 and 52 in the FIG. 1 type of paper machine, it has been found that the tendency of fibers of the sheet to pick out and remain on the drier 46 as the sheet travels around the drier 46 is substantially reduced because of the materially reduced sheet moisture content present at the drier 46. It has also been found that the drier 46 may be operated at a higher surface temperature without causing such fiber pick out from the sheet when the aforementioned shrouds are utilized.

An additional advantage in using the steam shower 111 or the steam chest 135 in the FIG. 5 form of machine is that a heavier basis weight sheet may be applied to the cylinder 99 which is operated at a given surface temperature without experiencing a blistering of the sheet from the surface of the drier drum 99 immediately after the pressure roll 95. This is due to the fact that a drier sheet is a more porous sheet and the water vapor that is generated at the very surface of the drier will escape more easily through the porous sheet without causing the sheet to blister or otherwise separate from the surface of drier 99. Similarly, for a given basis weight sheet, when using the shower or shroud, a higher drier surface temperature, which increases drying rate, may be used with the drier 99 without blistering the sheet from the drier.

It is to be understood that the invention is not to be limited to the specific methods, 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.

We claim:

1. In web forming apparatus of the type in which a fibrous web of wet stock is formed on a moving fabric and is transferred to a drier section, a steam chest having a patterned array of steam discharge openings in a side thereof facing the web arranged in such a regular pattern to uniformly cover the web with steam, the smallest dimension of each of said openings being $\frac{1}{16}$ inch to $\frac{3}{8}$ inch and said side being spaced from said web 2 inches or less, and means for supplying steam at such a pressure to said chest that it is discharged through said openings on to said web at a velocity greater than 10 feet per second and less than 600 feet per second.

2. In web forming apparatus of the type in which a web of wet stock is formed on a moving fabric and is transferred to a rotatable drier drum, a steam chest having a side facing the web with openings approximately one inch apart formed in said side in such a regular pattern to uniformly cover the web with steam, said openings having a diameter between $\frac{1}{16}$ inch and $\frac{3}{8}$ inch and said side being spaced from said web between $\frac{1}{2}$ inch and 1 inch, means for supplying steam at such a pressure to said chest that steam is jetted through said openings at a velocity greater than 10 feet per second and less than 600 feet per second.

3. In web forming apparatus of the type in which a web

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of relatively wet stock is moved over various supporting belts to a rotatable drier drum, a pair of main press rolls effective on one of said belts and on the web thereon for dewatering the web between the rolls, a steam chest having a plurality of openings in a side thereof facing the web at a place prior to said press rolls so as to discharge steam on to the web to decrease the viscosity of the water in the web and facilitate dewatering of the web by the press rolls, said openings being arranged in a regular pattern so as to uniformly cover the web with steam said openings having a diameter between $\frac{1}{16}$ inch and $\frac{3}{8}$ inch and said side being spaced from said web less than 4 times the diameter of said openings, and means for supplying steam to said chest so that it issues from said openings at a velocity greater than 10 feet per second and less than 600 feet per second.

4. In web forming apparatus of the type in which a web of wet stock is formed on a moving fabric and is transferred to a rotatable drier drum, a steam chest having a side facing the web with openings about one inch apart formed in said side in such a regular pattern to uniformly cover the web with steam, said openings having a diameter of about $\frac{1}{4}$ inch and said side being spaced from said web about $\frac{3}{4}$ inch, and means for supplying steam at such a pressure to said chest that steam is jetted through said openings at a velocity between 10 and 600 feet per second.

5. In web forming apparatus of the type in which a fibrous web of wet stock is formed on a moving fabric and is transferred to a drier section, means providing a patterned array of steam discharge openings facing the web and arranged in such a regular pattern to uniformly cover the web with steam, the smallest dimension of each of said opening being $\frac{1}{16}$ inch to $\frac{3}{8}$ inch and said openings being

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spaced from said web two inches or less, and means for supplying steam at such a pressure to said openings that it is discharge through said openings onto said web at a velocity greater than 10 feet per second and less than 600 feet per second.

6. In web forming apparatus of the type in which a fibrous web of wet stock is formed on a moving fabric and is transferred to a drier section, a steam chest positioned above and adjacent the web and comprising a plate portion above, adjacent and facing the web and having a patterned array of openings formed in the plate for jetting steam through the openings onto the web and a housing enclosing the side of the plate portion remote from the web, a pipe extending longitudinally through said housing and having a plurality of discharge openings for directing steam toward a face of said housing which is remote from said plate portion and being impervious in portions thereof facing said plate portion, said impervious portions being in the lowest portions of the pipe so as to retain condensate in the pipe, and means for supplying steam to said pipe.

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