Dec. 1, 1964 H. H. HELLER ETAL 3,159,530

PAPERMAKING MACHINE

Filed June 23, 1960 3 Sheets-Sheet 1

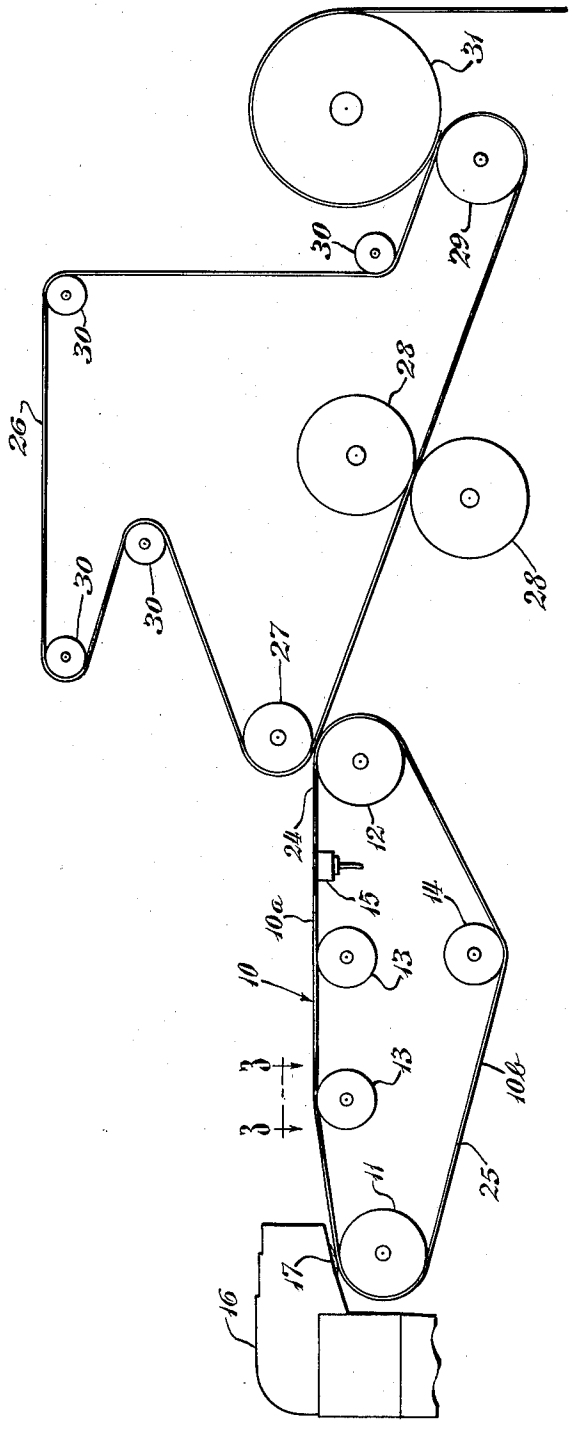

Fig. 1.

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PAPERMAKING MACHINE

Filed June 23, 1960 3 Sheets-Sheet 2

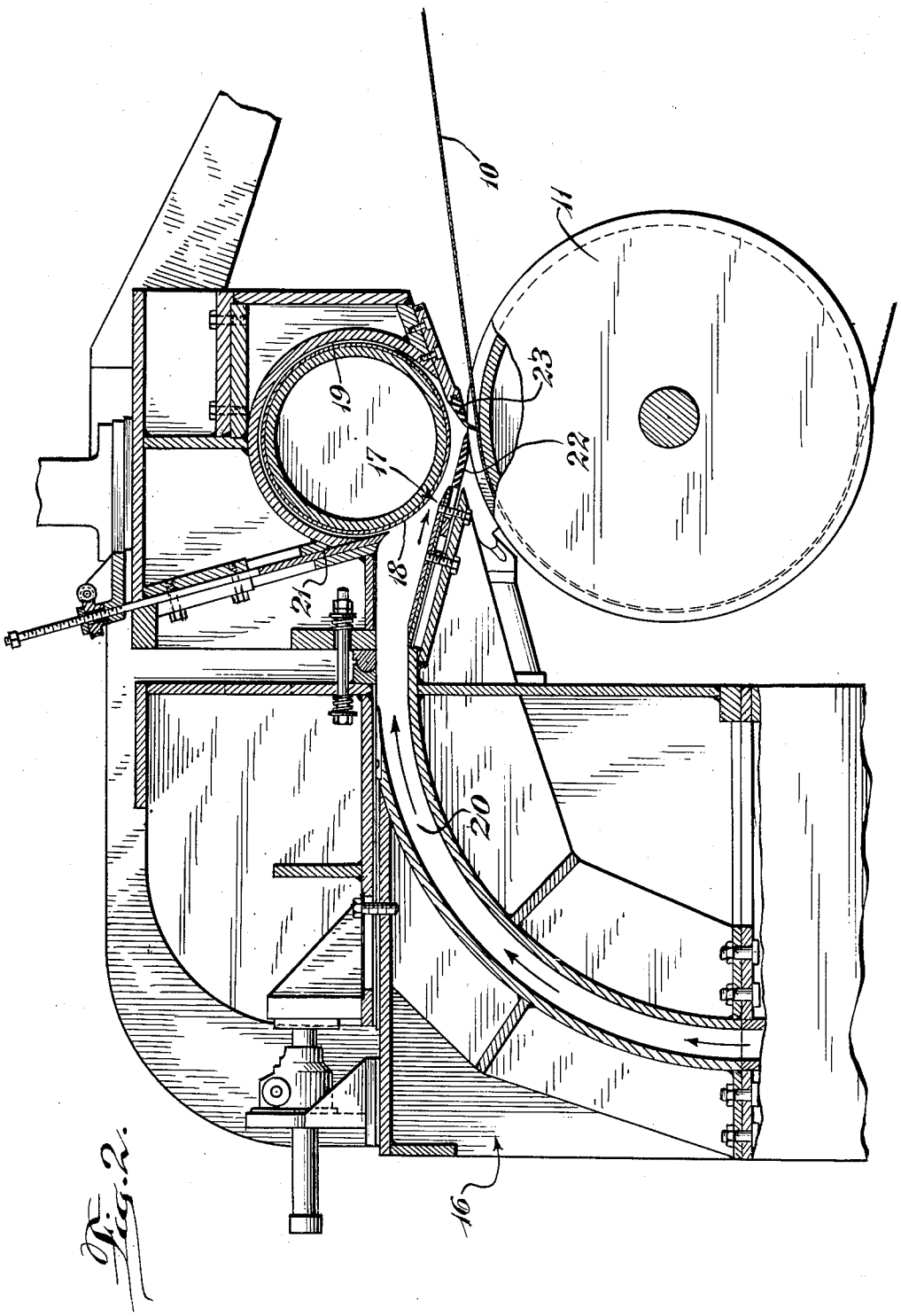

Fig. 2.

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PAPERMAKING MACHINE

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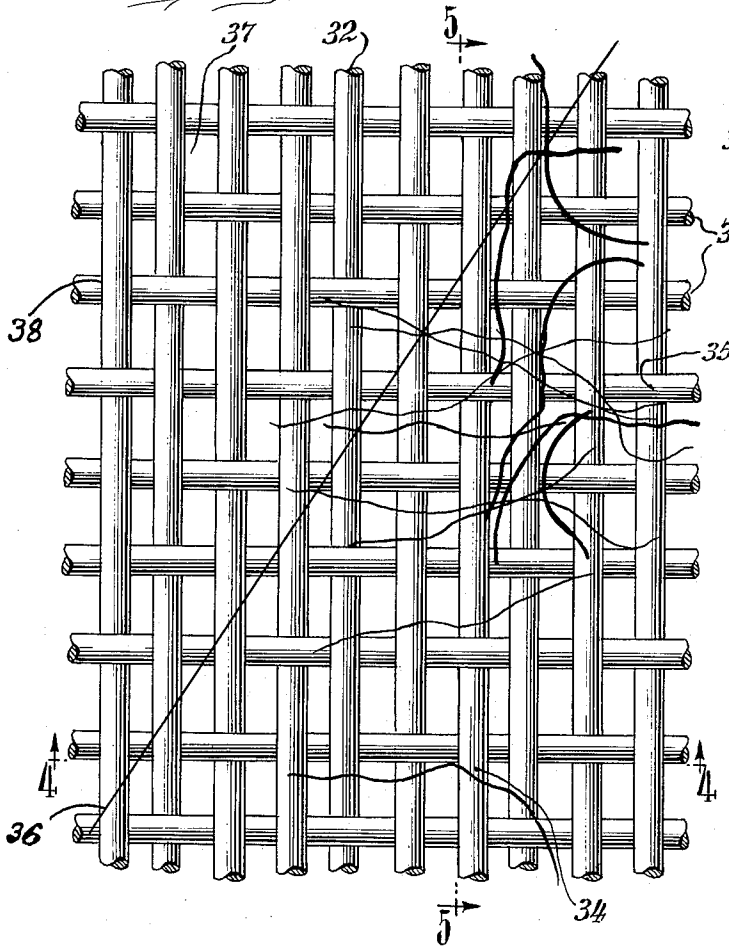
Fig. 3.



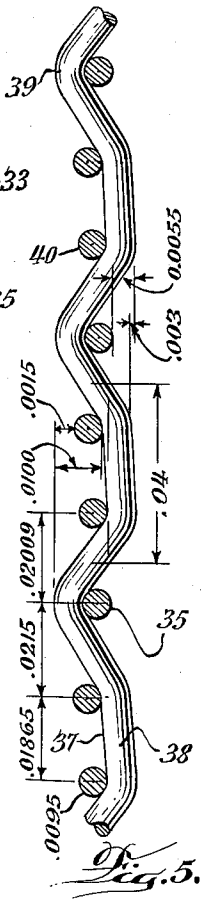


Fig. 5.

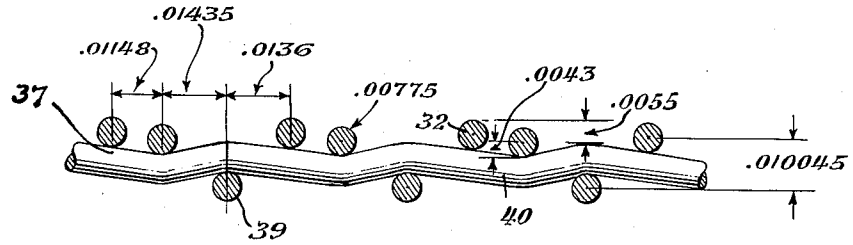


Fig. 4.

United States Patent Office

3,159,530

Patented Dec. 1, 1964

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3,159,530

PAPERMAKING MACHINE

Harold H. Heller, Appleton, and John B. Graham, Neenah, Wis., assignors to Kimberly-Clark Corporation, Neenah, Wis., a corporation of Delaware

Filed June 23, 1960, Ser. No. 38,291
4 Claims. (Cl. 162—348)

The invention relates to papermaking machines and methods and more particularly to such machines and methods utilizing Fourdrinier wires or cloths.

In a conventional Fourdrinier papermaking machine, the paper stock is deposited on the Fourdrinier wire or cloth as it moves, in looped form, about various supporting rolls. The paper fibers tend to align themselves in the direction of movement of the stock onto the wire, and the net result is that more of the fibers extend lengthwise of the wire and the paper web formed thereon than crosswise, so that the paper has a greater strength in the machine direction than in the cross direction.

It is an object of the present invention to provide an improved method and apparatus for increasing the cross direction strength of the paper and, more particularly, it is an object to provide an improved Fourdrinier cloth or wire which may be substituted in place of the conventional cloth or wire for attaining this result.

Various types of wire cloths have, in the past, been used on such machines. One of the conventional types has a so-called plain weave in which shute or cross wires are passed over and under alternate warp wires, and the ends of the cloth are bonded together as by soldering, so as to form a loop of the cloth in which the warp wires extend longitudinally of the loop.

Another type of Fourdrinier wire cloth is one having a twill weave. In this type, the warp wires each pass over one and under two shute wires to make relatively long knuckles extending diagonally across the cloth. The side of the cloth having the long knuckles constitutes the inner surface of the cloth in contact with the various supporting rolls.

It is another object of the invention to utilize such a wire of the twill type in such a manner that the cross direction strength of the resulting paper is increased.

Briefly, the invention contemplates that the twill type of wire shall be reversed so that its side with the long knuckles is the papermaking side of the wire and, furthermore, that the wire shall be turned through an angle, such as 90°, so that the long knuckles of the warp wires are at an angle, such as 90°, with respect to the machine direction. Sections of the wire may be fastened together in order to form a wire or cloth that has the long knuckles extending substantially transversely of the direction of stock flow onto the wire or alternately, as will be understood, the wire may be woven in such a manner initially. It has been found that the stock fibers issuing onto a Fourdrinier wire or cloth tend to align themselves and to lie in the deepest valleys or depressions in the papermaking side of the wire, and if these valleys or depressions, which extend alongside of the long knuckles, are disposed transversely of the wire or cloth, more of the fibers extend transversely than otherwise, the sheet is more uniform, and the cross direction strength of the finished paper is materially increased.

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

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FIG. 1 is a diagrammatic side elevational view of a papermaking machine embodying the principles of the invention and including a Fourdrinier wire and a felt both supported by means of rolls, a stock head box for discharging paper stock onto the wire and a drier drum for paper web;

FIG. 2 is a partial sectional view of the head box;

FIG. 3 is a plan view on an enlarged scale of the Fourdrinier wire taken substantially from line 3—3 of FIG. 1 and showing a plurality of fibers deposited from the head box onto the wire;

FIG. 4 is a sectional view taken on line 4—4 of FIG. 3; and

FIG. 5 is a sectional view taken on line 5—5 of FIG. 3.

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

Referring now to the drawings, the illustrated papermaking machine may be seen to comprise an endless belt 10 in the form of a Fourdrinier wire or cloth, positioned about a breast roll 11, a couch roll 12, table rolls 13, and a guide roll 14. A vacuum box 15 is positioned beneath the wire and in contact with it. A head box 16, having a slice 17, is positioned above the wire 10.

The head box 16 may be of any suitable type, but, as illustrated, comprises a stock turbulizing driven roll 18 disposed in a cylindrical cavity 19. A stock inlet conduit 20 is connected to the cavity 19. A throttle plate 21 is adjustably positioned adjacent the roll 18. The slice 17 is provided by means of an apron plate 22 and a lip 23. The wire 10 extends around the breast roll 11 and in contact with the lip 23.

The wire 10 is made up of a plurality of segments, such as the two segments 10*a* and 10*b*. The segments 10*a* and 10*b* are bonded together at ends 24 and 25, so that the wire is in the form of a complete loop.

A felt 26 in the form of a loop extends around a plurality of relatively large diameter rolls 27, 28 and 29 and a plurality of smaller rolls 30. The roll 27 is in the vicinity of the couch roll 12, and the roll 29 is adjacent a steam heated drier drum 31. A second roll 28 is positioned adjacent the first roll 28 so as to form a press for the felt 26 between the rolls 28.

Each of the segments 10*a* and 10*b* is made up of a series of parallel warp filaments or wires 32 and a series of parallel shute filaments or wires 33 (see FIG. 3). The Fourdrinier wire is made with a twill weave in which each of the warp wires 32 passes over two shute wires 33 and under a third shute wire so as to provide relatively high long warp knuckles or crests 34. The shute wires each have relatively low knuckles or crests 35 beneath which the warp wires pass. In accordance with usual weaving practices for twill wires, the long knuckles 34 of succeeding warp wides bridge adjacent consecutive pairs of the shute wires 33 and succeeding warp wires 32 pass underneath succeeding adjacent shute wires 33, so that the long knuckles extend along a diagonal, for example, the diagonal 36. The terms "warp" and "shute" have been used in connection with the illustrated wire cloth in the usual sense, namely, in accordance with the manner in which such cloths are usually woven, with the warp

wires extending longitudinally of the loom and being therefore crimped to a greater extent than the shute wires.

A wire, such as that illustrated, is generally used in a papermaking machine in a continuous piece, with the two ends of the wire being bonded together. In this case, the warp wires 32 extend in the machine direction and are, in effect, complete loops; and the shute wires 33 extend crosswise of the machine. The long knuckles 34 are on the inside, so that they ride over the suction box 15 and the various rolls.

In the present invention, the other side of the wire, namely, that having the long knuckles 34, is used as the papermaking side. In addition, the wire has been turned through 90°, so that the long warp knuckles 34 extend crosswise of the machine. The shute wires 33 extend in the machine direction, so that these, in effect, are fastened together at the points 24 and 25 so as to form complete loops.

Although cloths of many different dimensions may be used, just as an example, the cloth 10 in one particular embodiment, as shown in FIGS. 3, 4 and 5, had the following dimensions:

The cloth may be 70 x 52 twill weave in which there are 70 warp wires 32 and 52 shute wires to the inch. The diameter of the warp wires 32 may be .00775 inch, and the diameter of the shute wires may be .0095 inch. The size of the openings, looking directly down on the cloth from the top as seen in FIG. 3, may thus be about .0065 inch x .0097 inch. In the machine direction, the distance between adjacent warp wires would thus be about .0065 inch; while, in the cross direction, the distance between adjacent shute wires would be about .0097 inch. Looking at FIG. 4, the warp knuckles 34 were about .0055 inch higher than the shute knuckles 35. The long warp knuckles 34, furthermore, had a substantial length of about .04 inch taken at the same level at the top of the shute knuckles 35. The warp wires 32 were bent substantially more than the shute wires 33. The warp wires 32 had a variation of about .0100 inch between their lowermost and uppermost surfaces taking measurement on the same side of the wire 10, and the shute wires had a corresponding variation of only .0043 inch. There is also a variaiton in height of about 0.003 inch between alternate warp wires taken at any given section of the type shown in FIG. 4 caused by eccentricities of weaving. For this reason, the difference in height between the tops of the warp wires and the tops of the shute wires shown in both FIG. 5 and FIG. 4 as being 0.0055 inch represents an average difference.

In operation, stock flows through the channel 20 and out onto the wire 10 through the slice between the apron plate 22 and the lip 23. A part of the stock that passes through the slice is that propelled around within the cylindrical cavity 19 by the driven roll 18, and turbulence and dynamic energy are thus added to the stock prior to its passage onto the wire 10.

Water drains through the Fourdrinier wire 10, and drainage is increased and facilitated, in accordance with conventional practice, by the table rolls 13 and the suction box 15 to form the paper web W. The paper web W is transferred from the wire 10 onto the felt 26 beneath the roll 27 and has water expressed from it by the press rolls 28. The felt 26 not only carries the paper web, but it also has the function of extracting water from it, as is well known. The paper web W is transferred from the felt at the roll 29 onto the drier drum 31, and the latter dries the web still further. Incidentally, the felt section and the drier section of the machine may have the usual variations all of which are well known in the art.

The fibers in the stock as they discharge through the slice between the apron plate 22 and lip 23, having substantially no inertia, tend to become aligned with the streamlines in the stock which are in the machine direction, that is, in the direction of movement of the wire 10 and movement of stock through the slice. In this connection, it may be mentioned that the velocity of the stock as it is spouted onto the wire 10 through the slice is preferably maintained about the same as the velocity of the wire 10.

Although the wire 10, as a whole, has a number of different open areas and channels between wires through which the water drains from the fibers deposited on the wire (note illustrations of the fibers in FIG. 3), since the wire is made up of the many warp and shute wires; nevertheless, the largest area drainage channels 37 of the wire are alongside of the long warp knuckles 34 opening into the valleys 38. Each channel 37 extends at an acute angle with respect to the general plane of the wire 10, is formed by a hump or knuckle of a wire 32 extending over and on top of a pair of wires 33, and is bounded on its ends by wires 33 under which the particular wire 32 passes to form the hump. Since the wires 33 are spaced farther apart than the wires 32, not only are the openings between adjacent wires 32 and 33 longer in the direction transverse of wire movement, looking directly down on the cloth as seen in FIG. 3, but these slantwise extending channels 37 are elongated and have a relatively large cross sectional area due to this fact. Naturally, the fibers tend to move along with and become aligned with the water draining from the wire through the largest area channels. Thus, although most of the fibers initially lie in the machine direction, some of them, such as those shown darkest in FIG. 3, are turned, as they tend to flow with the water through the valleys 38 which are alongside of the transversely extending long knuckles 34, and are thus transverse of the wire 10. Therefore, although most of the fibers drape themselves over the long knuckles 34 and remain in the machine direction, more than the usual number of fibers are made to extend crosswise of the web W, and they increase the cross direction strength of the web. Ordinary paper has the very greatest part of its strength in the machine direction and much less strength in the cross direction, and utilizing the long knuckles 34 with the relatively large area water drainage channels 37 extending in the transverse direction of the wire 10 sidewardly and underneath the knuckles 34 assures that the cross direction strength of the paper web is increased, since more of the fibers are turned to extend in the cross direction.

The wire cloth is somewhat analogous in its construction and action, with respect to the stock, to a perforated sheet of metal having spaced upwardly extending arches punched in it in parallel rows and providing transversely extending openings at the sides of the arches. The stock would be spouted onto the sheet transversely of the arches at a low angle with respect to the plane of the sheet. The water would not be able to flow through the sides of the arches perpendicularly to the sheet, but necessarily would have to flow nearly parallel to the sheet through the transverse openings and under the arches. The upstanding long knuckles 34 in the actual wire cloth are analogous to the upwardly extending arches in the sheet above referred to. In both cases, the water would flow at various angles less than 90° with the average plane, and the liquid would turn and flow sidewise, laying down the fibers and turning some of them from the direction of stock flow into the transverse valleys between the arches or knuckles. Many of the fibers, on the other hand, that are not completely turned into the valleys, would drape themselves over the arches or long knuckles. A perforated sheet as above mentioned is disclosed in detail and is claimed in a co-pending application on "Papermaking Machine," Serial No. 110,982, filed May 18, 1961, by Harold H. Heller, one of the inventors of the present application.

A multitude of upstanding protuberances extending in the machine direction, such as would exist if the long knuckles 34 extended in the machine direction rather

than in the cross direction or if the shute knuckles 35 extending in the machine direction were higher than the warp knuckles 34, would be expected to cause perforations in the sheet extending in the machine direction and a resultant weakening of the sheet in the cross direction. Due to the fact that the long warp knuckles 34 extending transversely of the wire 10 are higher than the shute knuckles 35 and due to the fact that the knuckles 34 are longer than the shute knuckles 35 and the openings in the wire 10 are longer transverse of wire movement than in the direction of wire movement, the fibers extending along with the streamlines of the stock in the machine direction tend to drape over the long knuckles and form a uniform sheet without such perforations. The lack of perforations formed by any high knuckles extending in the machine direction, in addition to a changing in direction of some of the fibers due to the transverse drainage channels 37 opening into the transverse valleys 38, cause the sheet to be stronger transversely.

The Fourdrinier wire cloth with high long knuckles running crosswise of the wire has been found particularly advantageous for use with light weight sheets, such as, for example, sheets of 6 to 10 pounds per ream of 2880 square feet (uncreped) suitable for use as creped facial tissue. With heavier weight sheets, it will be understood that there is not as great a tendency for wire knuckles, particularly those extending in the machine direction, to protrude and make perforations. Utilizing the improved wire cloth, the stock may be made to flow with as low or as great a velocity as desired. A satisfactory sheet may be formed with as little as 10 to 20 feet per minute stock velocity. The squareness of the sheet, that is, its relatively high strength in the cross direction as compared to its strength in the machine direction, is particularly due to the fact that the stock fibers tend to line up in valleys in the wire which in this case extend in the cross direction. Incidentally, as the stock settles on the wire, it is the last small movement or flow of fibers that actually places the fibers crosswise of the sheet due to the relatively large amount of water flowing from the stock through the relatively large channels 37 opening into the valleys 38. Therefore, more of the fibers adjacent the wire are turned transversely than on the top to the sheet.

The wire, having the relatively large area channels 37 extending transversely drains faster than it would if the channels were extending in the machine direction, since the stock is spouted on the wire in the machine direction, and this attribute of the wire cloth helps to assure a more square sheet and also assures that there is substantially no rolling of the fibers when they are deposited on the wire. A softer paper sheet is also obtained utilizing the invention.

As an additional advantage, the paper formed on the cloth of the invention does not tend to interlock to a great extent with the cloth, and it may be easily couched or picked up from the cloth onto the felt. This is true, it is believed, because the fibers in general drape across the relatively high transverse knuckles rather than extend alongside of such knuckles, if the knuckles instead extended in the machine direction, for example.

The wire cloth of the invention may be expected to have a long life in actual usage due to the fact that the warp wires 32, which extend transversely of the machine and which are under a relatively low tension and are not flexed to speak of, are in contact with and run over the vacuum box 15 and the rolls 11, 12, 13, and 14. On the inner side of the cloth 10, the warp knuckles 39 are higher than the shute knuckles 40, and hence the warp knuckles actually contact and run over the rolls and vacuum box. In the actual wire embodiment illustrated, the knuckles of the warp wires 32 on the inner side of the cloth 10 are about .0015 inch higher than the knuckles of the shute wires 33 (see FIG. 5). This operation may be contrasted with the conventional use of the wire cloth

in which the warp wires 32 are in contact with the rolls and vacuum box, are run in the machine direction, and are under the tension of the cloth to maintain it tautly looped around the rolls 11, 12, 13 and 14.

The knuckles 34 passing under the lip 23 assure that there is a minimum of plugging of fibers beneath the lip. The knuckles 34, since they are raised and extend transversely, tend to catch the fibers and pull them from underneath the lip 23.

Although a twill wire has been illustrated in which the high warp knuckles 34 extend only over two shute wires 33, it will be apparent that a more open wire with faster drainage and a greater disposition to align the fibers transversely of the wire may be obtained by causing the warp knuckles to extend over three or more shute wires. More openness of the wire may also be obtained if the difference in height between the high knuckles 34 and the low knuckles 35 is increased, such as, by bending the warp wires 32 to a greater extent and maintaining the shute wires 33 more straight. Increasing the spacing of the warp and shute wires will also give more openness to the cloth as will a decrease of wire size, but less support is thereby given a sheet.

It is to be understood that the invention is not to be limited to the specific constructions, arrangements, methods and devices shown and described, except only insofar as the following 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. An endless foraminous belt for a Fourdrinier type papermaking machine having an outer surface on which paper stock may be deposited for drainage to form a paper web, said belt comprising spaced longitudinal filaments extending lengthwise of the belt and spaced transverse filaments extending crosswise of the belt which are interwoven together, each transverse filament passing alternately over a plurality of longitudinal filaments on said outer belt surface and then under a less number of longitudinal filaments, said filaments being so crimped that said transverse filaments have crests on said outer belt surface that are higher than crests of the longitudinal filaments on said outer belt surface.

2. An endless foraminous belt for a Fourdrinier type papermaking machine having an outer surface on which paper stock may be deposited for drainage to form a paper web, said belt comprising spaced longitudinal filaments extending lengthwise of the belt and spaced transverse filaments extending crosswise of the belt which are interwoven together, each transverse filament passing alternately over a plurality of longitudinal filaments on said outer belt surface and then under a single longitudinal filament, succeeding transverse filaments respectively extending under succeeding longitudinal filaments so that crests of said transverse filaments extend diagonally across the belt on said outer belt surface, said filaments being so crimped that the crests of said transverse filaments on said outer belt surface are higher than crests of said longitudinal filaments on said outer belt surface.

3. And endless foraminous belt as set forth in claim 2, said longitudinal filaments being spaced farther apart than said transverse filaments.

4. An endless foraminous belt for a Fourdrinier type papermaking machine having an outer surface on which paper stock may be deposited for drainage to form a paper web, said belt comprising spaced longitudinal wires extending lengthwise of the belt and spaced transverse wires extending crosswise of the belt which are interwoven together, each transverse wire passing alternately over a plurality of longitudinal wires on said outer belt surface and then under a single longitudinal wire, succeeding transverse wires respectively extending under succeeding longitudinal wires so that crests of said trans-

verse wires extend diagonally across the belt on said outer belt surface, said transverse wires being permanently crimped to a greater extent than said longitudinal wires so that the crests of said transverse wires are higher by about .005 inch than crests of said longitudinal wires on said outer belt surface.

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MERVIN STEIN, *Primary Examiner.*

RICHARD D. NEVIUS, RUSSELL C. MADER, DONALD W. PARKER, *Examiners.*

UNITED STATES PATENT OFFICE

Certificate of Correction

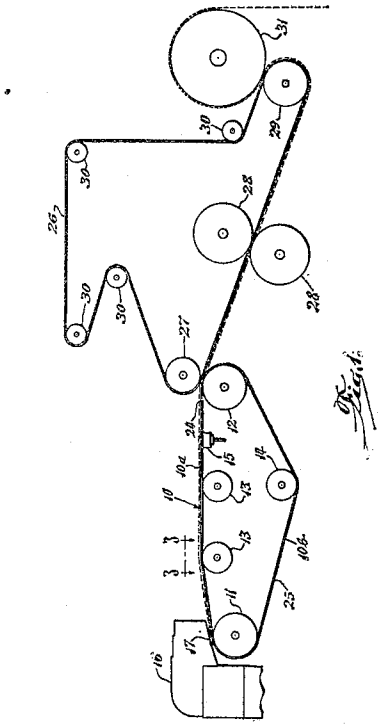
Patent No. 3,159,530 December 1, 1964

Harold H. Heller et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the drawings, Sheets 1, 2 and 3 should appear as shown below instead of as in the patent:

Dec. 1, 1964 H. H. HELLER ETAL 3,159,530
PAPERMAKING MACHINE
Filed June 23, 1960 3 Sheets-Sheet 1



Dec. 1, 1964 H. H. HELLER ETAL 3,159,530
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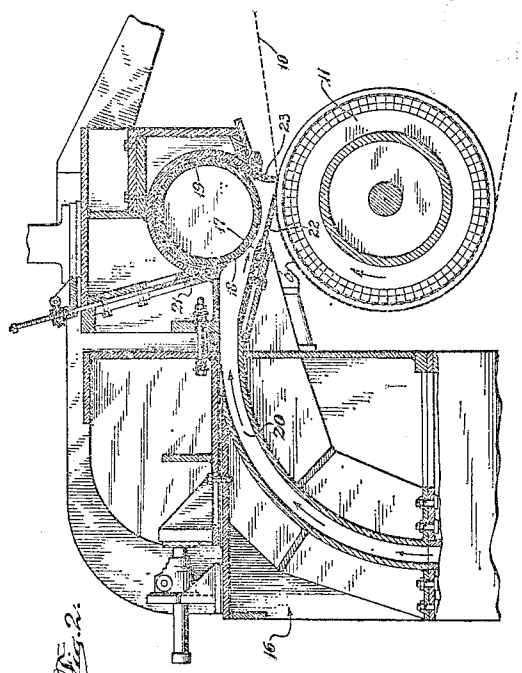

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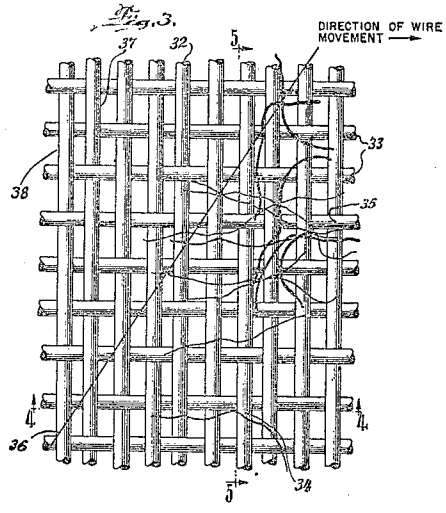
Fig. 3.



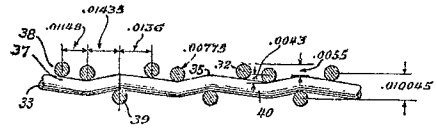


Fig. 4.

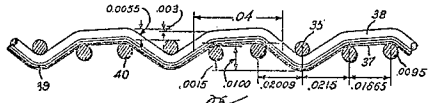


Fig. 5.

column 2, line 58, for "wides" read—wires—.

Signed and sealed this 11th day of May 1965.

[SEAL]

Attest:

ERNEST W. SWIDER,
Attesting Officer

EDWARD J. BRENNER,
Commissioner of Patents.