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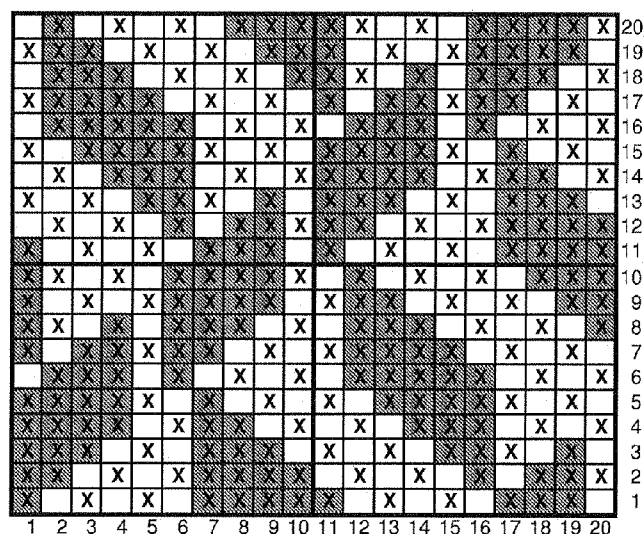


FIG. 1

(57) Abstract: The invention relates to a fibrous web including a fibrous construct having at least one formed surface feature, the surface feature including a topographical pattern reflective of a weave pattern in a fabric used in a papermaking machine having a through-air drying system, the fabric including a single layer of yarns arranged in a repeating weave pattern, said weave pattern including a plurality of warp yarns substantially oriented in a machine direction (MD) defining MD yarns, and a plurality of weft yarns substantially oriented in a cross machine direction (CD) defining CD yarns, the MD yarns each having at least one long float within the weave pattern, each long float being adjacent to at least one other long float of an MD yarn, the weave pattern being a plain weave apart from the long floats.

FIBROUS WEB FORMED ON A STRUCTURED FABRIC**BACKGROUND OF THE INVENTION****Cross Reference To Related Applications**

[0001] This is a continuation-in-part of U.S. patent application serial no. 12/847,519, entitled "STRUCTURED FABRIC", filed July 30, 2010, which is incorporated herein by reference.

1. Field of the Invention

[0002] The present invention relates generally to papermaking, and relates more specifically to a fibrous web formed on a structured fabric employed in papermaking.

2. Description of the related art.

[0003] In a conventional papermaking process, a water slurry, or suspension, of cellulosic fibers (known as the paper "stock") is fed into a gap between two endless woven wires that travels between two or more rolls. At least one of the wires are often referred to as a "structured fabric" that provides a papermaking surface on the upper surface of its upper run which operates as a filter to separate the cellulosic fibers of the paper stock from the aqueous medium, thereby forming a wet paper web. The aqueous medium drains through mesh openings of the structured fabric, known as drainage holes, by gravity or vacuum located on the lower surface of the upper run (i.e., the "machine side") of the fabric.

[0004] After leaving the forming section, the paper web is transferred to a press section of the paper machine, where it is passed through the nips of one or more pairs of pressure rollers covered with another fabric, typically referred to as a "press felt." Pressure from the rollers removes additional moisture from the web; the moisture removal is often enhanced by the presence of a "batt" layer of the press felt. The paper is then transferred to a dryer section for further moisture removal. After drying, the paper is ready for secondary processing and packaging.

[0005] Typically, papermakers' fabrics are manufactured as endless belts by one of two basic weaving techniques. In the first of these techniques, fabrics are flat woven by a flat weaving process, with their ends being joined to form an endless belt by any one of a number of well-known joining methods, such as dismantling and reweaving the ends together (commonly known as splicing), or sewing on a pin-seamable flap or a special foldback on each end, then reweaving these into pin-seamable loops. A number of auto-joining machines are available, which for certain fabrics may be used to automate at least part of the joining process. In a flat woven papermakers' fabric, the warp yarns extend in the machine direction and the filling yarns extend in the cross machine direction.

[0006] In the second basic weaving technique, fabrics are woven directly in the form of a continuous belt with an endless weaving process. In the endless weaving process, the warp yarns extend in the cross machine direction and the filling yarns extend in the machine direction. Both weaving methods described hereinabove are well known in the art, and the term "endless belt" as used herein refers to belts made by either method.

[0007] Effective sheet and fiber support are important considerations in papermaking, especially for the forming section of the papermaking machine, where the wet web is initially formed. Additionally, the structured fabrics should exhibit good stability when they are run at high speeds on the papermaking machines, and preferably are highly permeable to reduce the amount of water retained in the web when it is transferred to the press section of the paper machine. In both tissue and fine paper applications (i.e., paper for use in quality printing, carbonizing, cigarettes, electrical condensers, and the like) the papermaking surface comprises a very finely woven or fine wire mesh structure.

[0008] In a conventional tissue forming machine, the sheet is formed flat. At the press section, 100% of the sheet is pressed and compacted to reach the necessary dryness and the sheet is further dried on a Yankee and hood section. The sheet is then creped and wound-up, thereby producing a flat sheet.

[0009] In an ATMOSTM system, a sheet is formed on a structured or molding fabric and the sheet is further sandwiched between the structured or molding fabric and a dewatering fabric. The sheet is dewatered through the dewatering fabric and opposite the molding fabric. The dewatering takes place with airflow and mechanical pressure. The mechanical pressure is created by a permeable belt and the direction of air flow is from the permeable belt to the dewatering fabric. This can occur when the sandwich passes through an extended pressure nip formed by a vacuum roll and the permeable belt. The sheet is then transferred to a Yankee by a press nip. Only about 25% of the sheet is slightly pressed by the Yankee while approximately 75% of the sheet remains unpressed for quality. The sheet is dried by a Yankee/Hood dryer arrangement and then dry creped. In the ATMOSTM system, one and the same structured fabric is used to carry the sheet from the headbox to the Yankee dryer. Using the ATMOSTM system, the sheet reaches between about 35 to 38% dryness after the ATMOSTM roll, which is almost the same dryness as a conventional press section. However, this advantageously occurs with almost 40 times lower nip pressure and without compacting and destroying sheet quality. Furthermore, a big advantage of the ATMOSTM system is that it utilizes a permeable belt which is highly tensioned, e.g., about 60 kN/m. This belt enhances the contact points and intimacy for maximum vacuum dewatering. Additionally, the belt nip is more than 20 times longer than a conventional press and utilizes airflow through the nip, which is not the case on a conventional press system.

[0010] Actual results from trials using an ATMOSTM system have shown that the caliper and bulk of the sheet is 30% higher than the conventional through-air drying (TAD) formed towel fabrics. Absorbency capacity is also 30% higher than with conventional TAD formed towel fabrics. The results are the same whether one uses 100% virgin pulp up to 100% recycled pulp. Sheets can be produced with basis weight ratios of between 14 to 40 g/m². The ATMOSTM system also provides excellent sheet transfer to the Yankee working at 33 to 37% dryness. A key aspect of the ATMOSTM system is that it forms the sheet on the molding fabric and the same molding fabric carries the sheet from the headbox to the Yankee dryer. This produces a sheet with a uniform and defined pore size for maximum absorbency capacity.

[0011] U.S. patent application Ser. No. 11/753,435 filed on May 24, 2007, the disclosure of which is hereby expressly incorporated by reference in its entirety, discloses a structured fabric for an ATMOSTM system. The fabric utilizes an at least three float warp and weft structure which, like the prior art fabrics, is symmetrical in form.

[0012] U.S. Pat. No. 5,429,686 to CHIU et al., the disclosure of which is hereby expressly incorporated by reference in its entirety, discloses structured forming fabrics which utilize a load-bearing layer and a sculptured layer. The fabrics utilize impression knuckles to imprint the sheet and increase its surface contour. This document, however, does not create pillows in the sheet for effective dewatering of TAD applications, nor does it teach using the disclosed fabrics on an ATMOSTM system and/or forming the pillows in the sheet while the sheet is relatively wet and utilizing a hi-tension press nip.

[0013] U.S. Pat. No. 6,237,644 to HAY et al., the disclosure of which is hereby expressly incorporated by reference in its entirety, discloses structured forming fabrics which utilize a lattice weave pattern of at least three yarns oriented in both warp and weft directions. The fabric

essentially produces shallow craters in distinct patterns. This document, however, does not teach using the disclosed fabrics on an ATMOS™ system.

[0014] What is needed in the art is an efficient effective single layer fabric weave pattern to be used in a papermaking machine.

SUMMARY OF THE INVENTION

In one aspect, the invention provides a fibrous web including a fibrous construct having at least one formed surface feature. The surface feature including a topographical pattern reflective of a weave pattern in a fabric used in a papermaking machine having a through-air drying system. The fabric including a single layer of yarns arranged in a repeating weave pattern, each weave pattern including a plurality of warp yarns substantially oriented in a machine direction (MD) defining MD yarns; and a plurality of weft yarns substantially oriented in a cross machine direction (CD) defining CD yarns. The MD yarns each having at least one long float within the weave pattern. Each long float being adjacent to at least one other long float of an MD yarn. The weave pattern being a plain weave apart from the long floats.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

[0016] Fig. 1 shows a repeating weave pattern having a square shape of a top side or paper facing side of an embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0017] Fig. 2 shows the weave pattern of the structured fabric of Fig. 1;

[0018] Fig. 3 shows a repeating weave pattern having a square shape of a top side or paper facing side of another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0019] Fig. 4 shows the weave pattern of the structured fabric of Fig. 3;

[0020] Fig. 5 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0021] Fig. 6 shows the weave pattern of the structured fabric of Fig. 5;

[0022] Fig. 7 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0023] Fig. 8 shows the weave pattern of the structured fabric of Fig. 7;

[0024] Fig. 9 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0025] Fig. 10 shows the weave pattern of the structured fabric of Fig. 9;

[0026] Fig. 11 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0027] Fig. 12 shows the weave pattern of the structured fabric of Fig. 11;

[0028] Fig. 13 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X'

indicating a location where a warp MD yarn passes over a weft CD yarn;

[0029] Fig. 14 shows the weave pattern of the structured fabric of Fig. 13;

[0030] Fig. 15 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0031] Fig. 16 shows the weave pattern of the structured fabric of Fig. 15;

[0032] Fig. 17 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0033] Fig. 18 shows the weave pattern of the structured fabric of Fig. 17;

[0034] Fig. 19 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0035] Fig. 20 shows the weave pattern of the structured fabric of Fig. 19;

[0036] Fig. 21 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0037] Fig. 22 shows the weave pattern of the structured fabric of Fig. 21;

[0038] Fig. 23 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0039] Fig. 24 shows the weave pattern of the structured fabric of Fig. 23;

[0040] Fig. 25 shows a repeating weave pattern having a square shape of a top side or paper

facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0041] Fig. 26 shows the weave pattern of the structured fabric of Fig. 25;

[0042] Fig. 27 shows a repeating weave pattern having a square shape of a top side or paper facing side of yet another embodiment of a structured fabric of the present invention, each 'X' indicating a location where a warp MD yarn passes over a weft CD yarn;

[0043] Fig. 28 shows the weave pattern of the structured fabric of Fig. 27;

[0044] Fig. 29 illustrates a schematic cross-sectional view of an embodiment of an ATMOSTM papermaking machine;

[0045] Fig. 30 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine;

[0046] Fig. 31 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine;

[0047] Fig. 32 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine;

[0048] Fig. 33 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine;

[0049] Fig. 34 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine;

[0050] Fig. 35 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine;

[0051] Fig. 36 illustrates a schematic cross-sectional view of another embodiment of an ATMOSTM papermaking machine; and

[0052] Fig. 37 is a schematic process flow diagram of a throughdrying process in accordance with this invention, illustrating an uncreped throughdrying process with only one throughdryer;

[0053] Fig. 38 is a schematic process flow diagram of a throughdrying process in accordance with this invention, illustrating an uncreped throughdrying process having two throughdryers in series; and

[0054] Fig. 39 shows another schematic view of an apparatus for practicing the present invention product and process.

[0055] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one embodiment of the invention, in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[0056] The particulars shown herein are by way of example and for purposes of illustrative discussion of the embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the present invention. In this regard, no attempt is made to show structural details of the present invention in more detail than is necessary for the fundamental understanding of the present invention, and the description is taken with the drawings making apparent to those skilled in the art how the forms of the present invention may be embodied in practice.

[0057] The present invention relates to a structured fabric for a papermaking machine, a former for manufacturing a paper web, and also to a former which utilizes the structured fabric, and in some embodiments a belt press, in a papermaking machine.

[0058] The present invention also relates to a twin wire former ATMOS™ system which utilizes the structured fabric which has good resistance to pressure and excessive tensile strain forces, and which can withstand wear/hydrolysis effects that are experienced in an ATMOS™ system. The system may also include a permeable belt for use in a high tension extended nip around a rotating roll or a stationary shoe and a dewatering fabric for the manufacture of premium tissue or towel grades. The fabric has key parameters which include permeability, weight, caliper, and certain compressibility.

[0059] The structured fabric of the present invention is illustrated in Figs. 1-28. Fig. 1 depicts a weave pattern 10 from a top pattern view of the web facing side of the fabric (i.e., a view of the papermaking surface). The numbers 1-20 shown on the bottom of the pattern identify the warp, machine direction (MD) yarns while the right side numbers 1-20 show the weft, cross-direction (CD) yarns. The symbol X illustrates a location where a warp yarn passes over a weft yarn and an empty box illustrates a location where a warp yarn passes under a weft yarn. As shown in Fig. 1, the areas that are shaded indicate long float warp yarns, which float over at least two weft yarns. The shaded areas form a MD float pattern, while the non-shaded areas represent a plain weave pattern. In a like manner the weave patterns of Figs. 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, and 27 illustrate other embodiments of the present invention.

[0060] Fig. 2 illustrates the weave pattern of the MD yarns relative to the CD yarns with the CD yarns being represented in each line as the numbers, with the line being the pattern of the MD yarn. Each line representing the MD yarn identified along the left side of the Fig. In a like manner Fig. 4 corresponds to Fig 3 and so on with the even numbered figures through Fig. 28, corresponding to the odd numbered figure that is numerically one less than the even numbered Fig.

[0061] The embodiments shown in Figs. 1-28 are illustrative of the invention and the invention is not limited to the weave patterns shown therein.

[0062] The fabric of Figs. 1-28 illustrates a repeating weave pattern square of the fabric that encompasses twenty MD warp yarns (yarns 1-20 numbered along the bottom of each pattern) and twenty weft yarns (yarns 1-20 that are numbered along the right side of each pattern). There are long floats of the MD warp yarns over the weft yarns, with the long float being over at least two weft yarns, and in most patterns over at least three weft yarns. Although in some patterns the MD warp yarn float is over at least four or even over at least five weft yarns.

[0063] Where the MD warp yarns have there long float they are always adjacent to at least one other MD warp yarn that is also undergoing a long float. The float beginning and ending are offset in the MD by one weft yarn position. The contiguous adjacent MD warp yarns form an MD yarn float pattern, with at least one being present in each weave pattern 10. The MD yarn float patterns are replicated in weave pattern 10, and includes mirror-image or reflected MD yarn float patterns. The MD yarn float patterns can be symmetrical or asymmetrical. For example, in Fig. 1 there is one MD yarn float pattern having a float over five weft yarns that is only four MD yarns wide and there is another MD yarn float pattern having a float over five weft yarns that is five MD yarns wide. So, while the patterns are similar and are a reflection of each other, they are also asymmetrical.

[0064] Looking at Fig. 3, there are MD yarn float patterns that are mirror-images and are symmetrical. The MD yarns float over three weft yarns and are three MD yarns wide. In each case apart from the MD yarn float patterns the weave of the single layer fabric is a simple weave pattern. In many cases the plain weave pattern surrounds the MD yarn float patterns. In some weave patterns, such as those of Figs. 17 and 19, the simple weave patterns appear surrounded

by MD yarn float patterns.

[0065] The parameters of the structured fabric shown in Figs. 1-28 can have a mesh (number of warp yarns per inch) and a count (number of weft yarns per inch) of any amount. The single-layered fabric should have a high permeability value due to the nature of a single layer fabric and the way it is woven. Regarding yarn dimensions, the particular size of the yarns is typically governed by the mesh of the papermaking surface and the yarn size can be selected based upon the intended use. Fabrics employing these yarn sizes may be implemented with polyester yarns or with a combination of polyester and nylon yarns.

[0066] The structured fabric can also be treated and/or coated with an additional polymeric material that is applied by, e.g., deposition. The material can be added cross-linked during processing in order to enhance fabric stability, contamination resistance, drainage, wearability, improve heat and/or hydrolysis resistance and in order to reduce fabric surface tension. This aids in sheet release and/or reduced drive loads. The treatment/coating can be applied to impart/improve one or several of these properties of the fabric. As indicated previously, the topographical pattern in the paper web can be changed and manipulated by use of different single-layer weaves. Further enhancement of the pattern can be attained by adjustments to the specific fabric weave by changes to the yarn diameter, yarn counts, yarn types, yarn shapes, permeability, caliper and the addition of a treatment or coating etc. In addition, a printed design, such as a screen-printed design, of polymeric material can be applied to the fabric to enhance its ability to impart an aesthetic pattern into the web or to enhance the quality of the web. Finally, one or more surfaces of the fabric or molding belt can be subjected to sanding and/or abrading in order to enhance surface characteristics.

[0067] The characteristics of the individual yarns utilized in the fabric of the present invention can vary depending upon the desired properties of the final papermakers' fabric. For example, the materials comprising yarns employed in the fabric of the present invention may be those commonly used in papermakers' fabric. As such, the yarns may be formed of polypropylene, polyester, nylon, or the like. The skilled artisan should select a yarn material according to the particular application of the final fabric.

[0068] By way of non-limiting example, the structured fabric is a single-layered woven fabric which can withstand high pressures, heat, moisture concentrations, and which can achieve a high level of water removal and also mold or emboss the paper web. These characteristics provide a structured fabric appropriate for the Voith ATMOSTM papermaking process. The fabric preferably has a width stability and a suitable high permeability and preferably utilizes hydrolysis and/or temperature resistant materials, as discussed above. The fabric is preferably a woven fabric that can be installed on an ATMOSTM machine as a pre-joined and/or seamed continuous and/or endless belt. Alternatively, the structured fabric can be joined in the ATMOSTM machine using, e.g., a pin-seam arrangement or can otherwise be seamed on the machine.

[0069] The invention also provides for utilizing the structured fabric disclosed herein on a machine for making a fibrous web, e.g., tissue or hygiene paper web, etc., which can be, e.g., a twin wire + a permeable belt ATMOSTM system. Referring again to the drawings, and more particularly to Figs. 29-35, there is a fibrous web machine including a headbox 22 that discharges a fibrous slurry between a forming fabric 26 and a structured fabric 28 having a weave pattern 10. It should be understood that structured fabric 28 is an embodiment of the structured fabric discussed above in connection with Figs. 1-28. Rollers 30 and 32 direct fabric

26 in such a manner that tension is applied thereto, against slurry 24 and structured fabric 28. Structured fabric 28 is supported by forming roll 34 which rotates with a surface speed that matches the speed of structured fabric 28 and forming fabric 26. Structured fabric 28 has peaks and valleys as defined by weave pattern 10, which give a corresponding structure to web 38 formed thereon. Structured fabric 28 travels in a web direction, and as moisture is driven from the fibrous slurry, structured fibrous web 38 takes form. The moisture that leaves the slurry travels through forming fabric 26.

[0070] The fibrous slurry is formed into a web 38 with a structure that matches the shape of structured fabric 28. Forming fabric 26 is porous and allows moisture to escape during forming. Further, water is removed through dewatering fabric 82. The removal of moisture through fabric 82 does not cause compression of web 38 traveling on structured fabric 28.

[0071] Due to the formation of the web 38 with the structured fabric 28 the pockets of the fabric 28 are fully filled with fibers. Therefore, at the Yankee surface 52 the web 38 has a much higher contact area, up to approximately 100%, as compared to the prior art because the web 38 on the side contacting the Yankee surface 52 is almost flat.

[0072] Referring to Fig. 29, there is shown an embodiment of the process where a structured fibrous web 38 is formed. Structured fabric 28 carries a three dimensional structured fibrous web 38 to an advanced dewatering system 50, past vacuum box 67 and then to a position where the web is transferred to Yankee dryer 52 and hood section 54 for additional drying and creping before winding up on a reel (not shown).

[0073] A shoe press 56 is placed adjacent to structured fabric 28, holding fabric 28 in a position proximate Yankee dryer 52. Structured fibrous web 38 comes into contact with Yankee dryer 52 and transfers to a surface thereof, for further drying and subsequent creping.

[0074] A vacuum box 58 is placed adjacent to structured fabric 28 to achieve improved solids levels. Web 38, which is carried by structured fabric 28, contacts dewatering fabric 82 and proceeds toward vacuum roll 60. Vacuum roll 60 operates at a vacuum level of -0.2 to -0.8 bar with a preferred operating level of at least -0.4 bar. Hot air hood 62 is optionally fit over vacuum roll 60 to improve dewatering.

[0075] Optionally a steam box can be installed instead of the hood 62 supplying steam to the web 38. The steam box preferably has a sectionalized design to influence the moisture re-dryness cross profile of the web 38. The length of the vacuum zone inside the vacuum roll 60 can be from 200 mm to 2,500 mm, with a preferable length of 300 mm to 1,200 mm and an even more preferable length of between 400 mm to 800 mm. The solids level of web 38 leaving suction roll 60 is 25% to 55% depending on installed options. A vacuum box 67 and hot air supply 65 can be used to increase web 38 solids after vacuum roll 60 and prior to Yankee dryer 52. Wire turning roll 69 can also be a suction roll with a hot air supply hood. As discussed above, roll 56 includes a shoe press with a shoe width of 80 mm or higher, preferably 120 mm or higher, with a maximum peak pressure of less than 2.5 MPa. To create an even longer nip to facilitate the transfer of web 38 to Yankee dryer 52, web 38 carried on structured fabric 28 can be brought into contact with the surface of Yankee dryer 52 prior to the press nip associated with shoe press 56. Further, the contact can be maintained after structured fabric 28 travels beyond press 56.

[0076] Now, additionally referring to Fig. 30, there is shown yet another embodiment of the present invention, which is substantially similar to the invention illustrated in Fig. 29, except that instead of hot air hood 62, there is a belt press 64. Belt press 64 includes a permeable belt 66 capable of applying pressure to the machine side of structured fabric 28 that carries web 38 around vacuum roll 60. Fabric 66 of belt press 64 is also known as an extended nip press belt or

a link fabric, which can run at 60 KN/m fabric tension with a pressing length that is longer than the suction zone of roll 60.

[0077] Preferred embodiments of the fabric 66 and the required operation conditions are also described in PCT/EP2004/053688 and PCT/EP2005/050198 which are herewith incorporated by reference.

[0078] The above mentioned references are also fully applicable for dewatering fabrics 82 and press fabrics 66 described in the further embodiments.

[0079] Belt 66 is a specially designed extended nip press belt 66, made of, for example reinforced polyurethane and/or a spiral link fabric. Belt 66 also can have a woven construction. Such a woven construction is disclosed, e.g., in EP 1837439. Belt 66 is permeable thereby allowing air to flow there through to enhance the moisture removing capability of belt press 64. Moisture is drawn from web 38 through dewatering fabric 82 and into vacuum roll 60.

[0080] Referring to Fig. 31, there is shown another embodiment of the present invention which is substantially similar to the embodiment shown in Fig. 30 with the addition of hot air hood 68 placed inside of belt press 64 to enhance the dewatering capability of belt press 64 in conjunction with vacuum roll 60.

[0081] Referring to Fig. 32, there is shown yet another embodiment of the present invention, which is substantially similar to the embodiment shown in Fig. 30, but including a boost dryer 70 which encounters structured fabric 28. Web 38 is subjected to a hot surface of boost dryer 70, and structured web 38 rides around boost dryer 70 with another woven fabric 72 riding on top of structured fabric 28. On top of woven fabric 72 is a thermally conductive fabric 74, which is in contact with both woven fabric 72 and a cooling jacket 76 that applies cooling and pressure to all fabrics and web 38. The pressing process does not negatively impact web quality. The drying

rate of boost dryer 70 is above 400 kg/hr m² and preferably above 500 kg/hr m². The concept of boost dryer 70 is to provide sufficient pressure to hold web 38 against the hot surface of the dryer thus preventing blistering. Steam that is formed at the knuckle points of fabric 28 passes through fabric 28 and is condensed on fabric 72. Fabric 72 is cooled by fabric 74 that is in contact with cooling jacket 76, which reduces its temperature to well below that of the steam. Thus the steam is condensed to avoid a pressure build up to thereby avoid blistering of web 38. The condensed water is captured in woven fabric 72, which is dewatered by dewatering device 75. It has been shown that depending on the size of boost dryer 70, the need for vacuum roll 60 can be eliminated. Further, depending on the size of boost dryer 70, web 38 may be creped on the surface of boost dryer 70, thereby eliminating the need for Yankee dryer 52.

[0082] Referring to Fig. 33, there is shown yet another embodiment of the present invention substantially similar to the invention disclosed in Fig. 30 but with an addition of an air press 78, which is a four roll cluster press that is used with high temperature air and is referred to as a High Pressure Through Air Dryer (HPTAD) for additional web drying prior to the transfer of web 38 to Yankee dryer 52. Four-roll cluster press 78 includes a main roll, a vented roll, and two cap rolls. The purpose of this cluster press is to provide a sealed chamber that is capable of being pressurized. The pressure chamber contains high temperature air, for example, 150° C or higher and is at a significantly higher pressure than conventional TAD technology, for example, greater than 1.5 psi resulting in a much higher drying rate than a conventional TAD. The high-pressure hot air passes through an optional air dispersion fabric, through web 38 and fabric structured 28 into a vent roll. The air dispersion fabric may prevent web 38 from following one of the cap rolls. The air dispersion fabric is very open, having a permeability that equals or exceeds that of fabric structured 28. The drying rate of the HPTAD depends on the solids content of web 38 as it

enters the HPTAD. The preferred drying rate is at least 500 kg/hr m^2 , which is a rate of at least twice that of conventional TAD machines.

[0083] Advantages of the HPTAD process are in the areas of improved sheet dewatering without a significant loss in sheet quality and compactness in size and energy efficiency. Additionally, it enables higher pre-Yankee solids, which increase the speed potential of the invention. Further, the compact size of the HPTAD allows for easy retrofitting to an existing machine. The compact size of the HPTAD and the fact that it is a closed system means that it can be easily insulated and optimized as a unit to increase energy efficiency.

[0084] Referring to Fig. 34, there is shown another embodiment of the present invention. This is significantly similar to the embodiments shown in Figs. 30 and 33 except for the addition of a two-pass HPTAD 80. In this case, two vented rolls are used to double the dwell time of structured web 38 relative to the design shown in Fig. 33. An optional coarse mesh fabric may be used as in the previous embodiment. Hot pressurized air passes through web 38 carried on structured fabric 28 and onto the two vent rolls. It has been shown that depending on the configuration and size of the HPTAD, more than one HPTAD can be placed in series, which can eliminate the need for roll 60.

[0085] Referring to Fig. 35, a conventional twin wire former 90 may be used to replace the crescent former shown in previous examples. The forming roll can be either a solid or open roll. If an open roll is used, care must be taken to prevent significant dewatering through the structured fabric to avoid losing basis weight in the pillow areas. The outer forming fabric 93 can be either a standard forming fabric or one such as that disclosed in U.S. Pat. No. 6,237,644. The inner fabric 91 should be a structured fabric that is much coarser than the outer forming fabric 90. For example, inner fabric 91 may be similar to structured fabric 28. A vacuum roll 92 may be

needed to ensure that the web stays with structured fabric 91 and does not go with outer wire 90. Web 38 is transferred to structured fabric 28 using a vacuum device. The transfer can be a stationary vacuum shoe or a vacuum assisted rotating pick-up roll 94. The second structured fabric 28 is at least the same coarseness and preferably coarser than first structured fabric 91. The process from this point is the same as the process previously discussed in conjunction with Fig. 30. The registration of the web from the first structured fabric to the second structured fabric is not perfect, and as such some pillows will lose some basis weight during the expansion process, thereby losing some of the benefit of the present invention. However, this process option allows for running a differential speed transfer, which has been shown to improve some sheet properties. Any of the arrangements for removing water discussed above as may be used with the twin wire former arrangement and a conventional TAD.

[0086] Referring to Fig. 36 there is illustrated another ATMOSTM system having many elements as discussed above. The ATMOSTM system of Fig 36, is further described in WO 2010/069695 having a priority date of December 19, 2008. Belt press 64 constitutes a first pressing zone where web 38 is pressed. Web 38 proceeds to a second pressing zone 65 where web 38 is pressed again.

[0087] Figs. 37-39 illustrate types of TAD systems, specifically those described in the patent record of Kimberly-Clark (See WO 2005/073461 A1) and Procter & Gamble (See WO 2009/069046 A1). Fig. 37 illustrates one of many papermaking processes to which the invention is applicable. Shown is an uncreped throughdried tissue process in which a twin wire former having a layered papermaking headbox 205 injects or deposits a stream of an aqueous suspension of papermaking fibers between two forming fabrics 206 and 207. Forming fabric 207 being the same as structured fabric 28, discussed above. Forming fabric 207 serves to support and carry

the newly-formed wet web 208 downstream in the process as the web is partially dewatered to an appropriate consistency, such as about 10% dry weight percent. As shown in this example, profiling of the web in accordance with this invention takes place at the point in the process where the exhaust gas recovery plenum 211 and the vacuum box(es) 210 are positioned.

Additional dewatering of the wet web can be carried out, such as by vacuum suction, using one or more steam boxes in conjunction with one or more vacuum suction boxes (not shown) while the wet web is supported by the forming fabric 207.

[0088] The wet web 208 is then transferred from the forming fabric 207 to a transfer fabric 213 traveling at a slower speed than the forming fabric 207 in order to impart increased MD stretch into the web. The transfer is carried out to avoid compression of the wet web, preferably with the assistance of a vacuum shoe 214. Although not shown, it is within the scope of this invention for the profiling to take place at any point while the web is supported by the transfer fabric as well as the forming fabric 207.

[0089] The web is then transferred from the transfer fabric 213 to the throughdrying fabric 220 with the aid of a vacuum transfer roll 215 or a vacuum transfer shoe. Transfer is preferably carried out with vacuum assistance to ensure deformation of the sheet to conform to the throughdrying fabric, thus yielding desired bulk, flexibility, CD stretch and appearance.

[0090] The vacuum shoe (negative pressure) can be supplemented or replaced by the use of positive pressure from the opposite side of the web to blow the web onto the next fabric in addition to or as a replacement for sucking it onto the next fabric with vacuum. Also, a vacuum roll or rolls can be used to replace the vacuum shoe(s).

[0091] While supported by the throughdrying fabric 220, the web is dried to a final consistency, typically about 94 percent or greater, by the throughdryer 225 and thereafter

transferred to a carrier fabric 230. The dried basesheet 227 is transported to the reel 235 using carrier fabric 230 and an optional carrier fabric 231. An optional pressurized turning roll 233 can be used to facilitate transfer of the web from carrier fabric 230 to fabric 231. Although not shown, reel calendering or subsequent off-line calendering can be used to improve the smoothness and softness of the basesheet.

[0092] The hot air used to dry the web while passing over the throughdryer is provided by a burner 240 and distributed over the surface of the throughdrying drum using a hood 241. The air is drawn through the web into the interior of the throughdrying drum via fan 243 which serves to circulate the air back to the burner. In order to avoid moisture build-up in the system, a portion of the spent air is vented 245, while a proportionate amount of fresh make-up air 247 is fed to the burner. The exhaust gas recycle stream 250 provides exhaust gas to the exhaust gas recovery plenum 211 operatively positioned in the vicinity of one or more vacuum suction boxes 210, such that exhaust gas fed to the exhaust gas recovery plenum is drawn through the web, through the papermaking fabric and into the vacuum box(es) in order to control the consistency profile the web. The humidity of the recycled exhaust gas can be about 0.15 pounds of water vapor or greater per pound of air, more specifically about 0.20 pounds of water vapor or greater per pound of air, and still more specifically about 0.25 pounds of water vapor or greater per pound of air.

[0093] Fig. 38 is a schematic process flow diagram of another throughdrying process in accordance with this invention, similar to that illustrated in Fig. 37, but in which two throughdryers are used in series to dry the web. The components of the second throughdryer are given the same reference numbers used for the first throughdryer, but distinguished with a "prime". When two throughdryers are used as shown, the exhaust gas from the first (primary) throughdryer is recycled to the exhaust gas recovery plenum 211 because of its relatively greater

heat value. As previously noted, if the throughdryers are operated in such a fashion that the relative heat value of the second throughdryer is greater than the first for the given application, the exhaust gas from the second throughdryer can be used for the recycle stream to the exhaust gas recovery plenum 211.

[0094] Optionally, exhaust gas from the second throughdryer can be used to heat and/or profile the dewatered web by providing an exhaust gas recycle stream 255 which, as shown, is directed to exhaust gas recovery plenum 256 opposite vacuum roll or shoe 257. Any of the web-contacting or sheet-contacting rolls in the vicinity of vacuum roll or shoe 257 are also suitable locations for introducing the exhaust gas for purposes of profiling in accordance with this invention should these rolls be equipped with vacuum. As an alternative (not shown), a vacuum box can be placed within the loop of fabric 213 and the plenum 256 can be placed operatively opposite this vacuum box to profile the web.

[0095] As described supra, one fibrous structure useful in achieving the fibrous structure paper product of the present invention is the through-air-dried (TAD), differential density structure described in U.S. Pat. No. 4,528,239. Such a structure may be formed according to the nonlimiting embodiment of the apparatus exemplified in Fig. 39. The apparatus 300 includes a head box 310, a Fourdrinier section 320 comprising a Fourdrinier wire 322, a press section 330 comprising a TAD carrier fabric 332, which is the same as structured fabric 28 discussed above and a Yankee Dryer 340.

[0096] In one embodiment, it is possible to operate the papermaking machine such that there is a differential velocity between the TAD carrier fabric 332 and the Fourdrinier wire 322 to provide increased fibers in the pillow regions of the fibrous web. The Fourdrinier wire 322 may even run at a higher speed than the TAD carrier fabric 332.

[0097] As described supra, it is found that some consumers prefer a relatively bulky product as compared to a relatively cushiony product. It is surprisingly found that in addition to the process/additive changes described supra, in some embodiments during the transfer of the slurry from the Fourdrinier wire to the TAD carrier fabric, if the speed of the Fourdrinier wire and the speed of the TAD carrier fabric are approximately equal, or if the Fourdrinier wire is operating at a relatively slower speed than the TAD carrier fabric, then a relatively high amount of fibers are distributed in the walls of the formed features compared to the formed features of the prior art and a relatively bulky product may be achieved. In other embodiments, the speed of the Fourdrinier wire is from about 0% to about -6% of the TAD carrier fabric (wire-to-press draw of from about 0% to about -6%). One of skill in the art will appreciate that a resin coated belt may be used instead of a TAD carrier fabric.

[0098] While this invention has been described with respect to at least one embodiment, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. A fibrous web, comprising:
 - a fibrous construct having at least one formed surface feature, said surface feature including a topographical pattern reflective of a weave pattern in a fabric used in a papermaking machine having a through air drying (TAD) system, the fabric including:
 - a single layer of yarns arranged in a repeating weave pattern, each said weave pattern including:
 - a plurality of warp yarns substantially oriented in a machine direction (MD) defining MD yarns; and
 - a plurality of weft yarns substantially oriented in a cross machine direction (CD) defining CD yarns, said MD yarns each having at least one long float within said weave pattern, each said long float being adjacent at least one other long float of an MD yarn, said weave pattern being a plain weave apart from said long floats.
2. The fibrous web of claim 1, wherein within said weave pattern said long floats that are adjacent to each other form at least one MD float pattern within said weave pattern.
3. The fibrous web of claim 2, wherein within said weave pattern said at least one MD float pattern is a plurality of MD float patterns.
4. The fibrous web of claim 3, wherein within said weave pattern said plurality of MD float patterns are each one of identical and mirror imaged.

5. The fibrous web of claim 4, wherein within said weave pattern each of said plurality of MD float patterns are surrounded with said plain weave.

6. The fibrous web of claim 4, wherein within said weave pattern each of said plurality of MD float patterns touch each other forming a continuous MD float pattern with said plain weave defining the balance of said weave pattern.

7. The fibrous web of claim 1, wherein within said weave pattern each said long float floats across at least 3 CD yarns.

8. The fibrous web of claim 7, wherein within said weave pattern each said long float floats across at least 4 CD yarns.

9. The fibrous web of claim 8, wherein within said weave pattern each said long float floats across at least 5 CD yarns.

10. The fibrous web of claim 1, wherein the papermaking machine having a TAD system includes:

a dewatering fabric, a fibrous web is dewatered through the dewatering fabric, the dewatering fabric and said fabric being on opposite sides of the fibrous web; and

a permeable belt in contact with a portion of the fabric, there being an airflow in a direction such that the airflow first passes through said permeable belt, then said fabric, then the fibrous web, then said dewatering fabric.

11. A fibrous web obtainable by a process in a papermaking machine having a through-air dryer, the process comprising the steps of:

discharging a fibrous slurry between a forming fabric and a structured fabric; and

removing moisture from said fibrous slurry through at least one of said forming fabric and said structured fabric to thereby form the fibrous web, said structured fabric being a single layer structured fabric of yarns arranged in a repeating weave pattern, a fibrous web being formed between said forming fabric and said structured fabric, each said weave pattern including:

a plurality of warp yarns substantially oriented in a machine direction (MD) defining MD yarns; and

a plurality of weft yarns substantially oriented in a cross machine direction (CD) defining CD yarns, each of said MD yarns having at least one long float within said weave pattern, each said long float being adjacent at least one other long float of an MD yarn, said weave pattern being a plain weave apart from said long floats.

12. The process of claim 11, wherein within said weave pattern said long floats that are adjacent to each other form at least one MD float pattern within said weave pattern.

13. The process of claim 12, wherein within said weave pattern said at least one MD float pattern is a plurality of MD float patterns.

14. The process of claim 13, wherein within said weave pattern said plurality of MD float patterns are each one of identical and mirror imaged.

15. The process of claim 14, wherein within said weave pattern each of said plurality of MD float patterns are surrounded with said plain weave.

16. The process of claim 14, wherein within said weave pattern each of said plurality of MD float patterns touch each other forming a continuous MD float pattern with said plain weave defining the balance of said weave pattern.

17. The process of claim 11, wherein within said weave pattern each said long float floats across at least 3 CD yarns.

18. The process of claim 11, wherein the papermaking machine includes a permeable belt in contact with a portion of said single layer structured fabric, the fibrous web being between said single layer structured fabric and said forming fabric, there being an airflow in a direction such that the airflow first passes through said permeable belt, then said single layer structured fabric, then the fibrous web, then said forming fabric.

19. A fibrous web obtainable by a process in a papermaking machine having a through – air dryer, the process comprising the steps of:

discharging a fibrous slurry between a forming fabric and a structured fabric; and

removing moisture from said fibrous slurry through at least one of said forming fabric

and said structured fabric to thereby form the fibrous web, the fibrous web having at least one surface feature, said surface feature including a topographical pattern reflective of a weave pattern in said structured fabric used in a papermaking machine, said structured fabric including a single layer of yarns arranged in a repeating weave pattern, each said weave pattern including:

a plurality of warp yarns substantially oriented in a machine direction

(MD) defining MD yarns; and

a plurality of weft yarns substantially oriented in a cross machine direction

(CD) defining CD yarns, said MD yarns each having at least one long float within said weave pattern, each said long float being adjacent at least one other long float of an MD yarn, said weave pattern being a plain weave apart from said long floats.

20. The process of claim 19, wherein within said weave pattern said long floats that are adjacent to each other form at least one MD float pattern within said weave pattern.

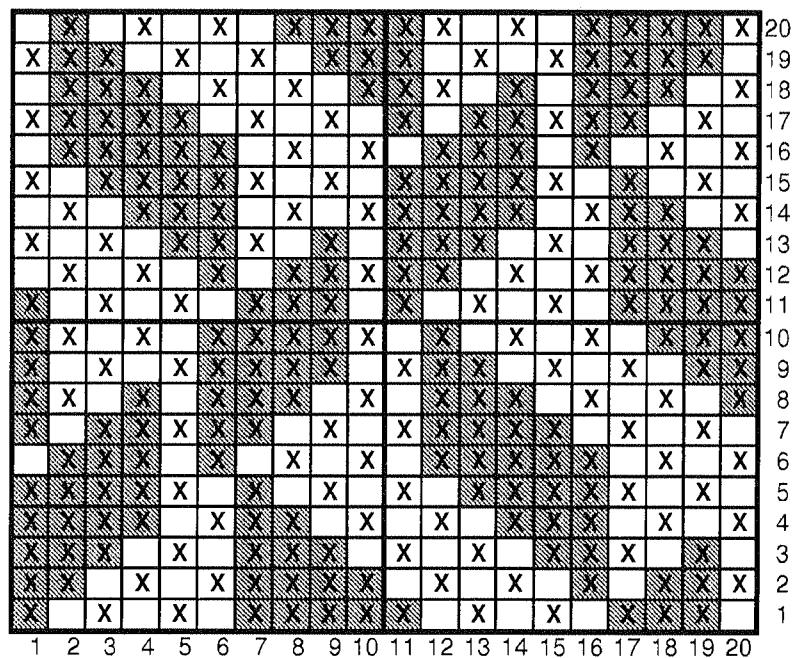
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FIG. 1

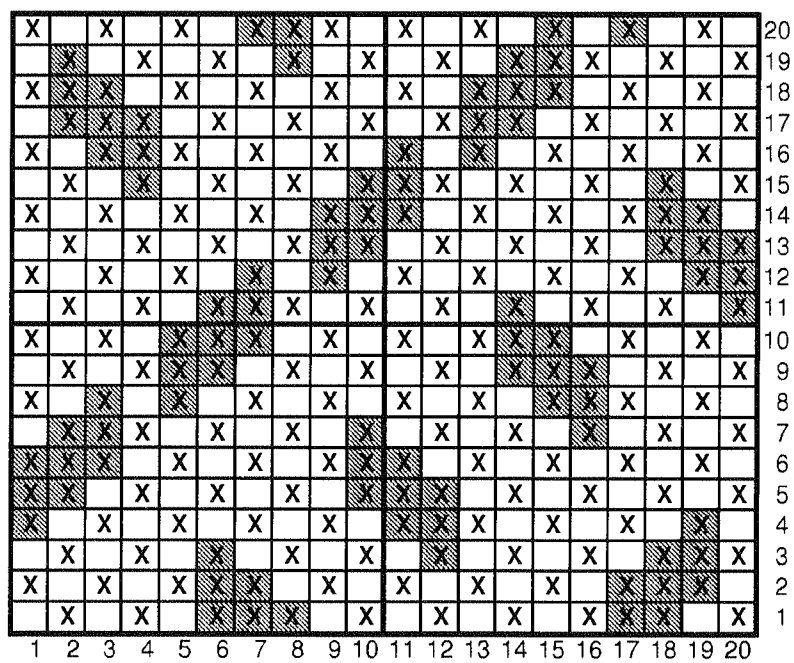
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FIG. 3

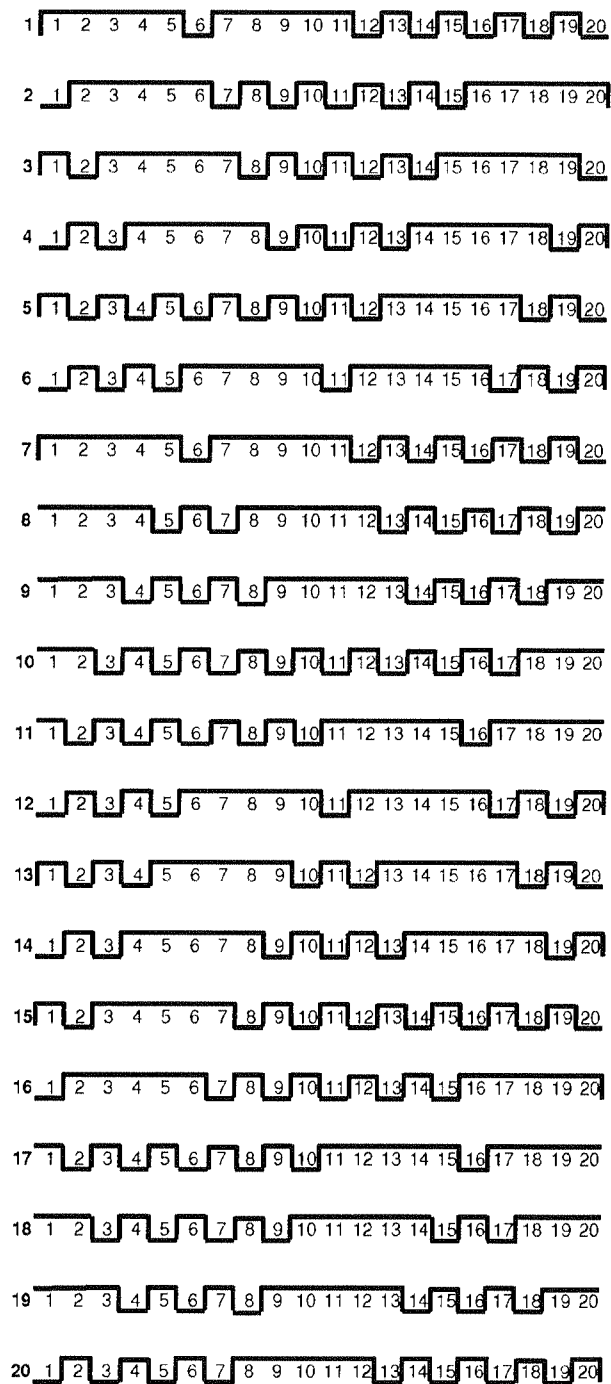


FIG. 2

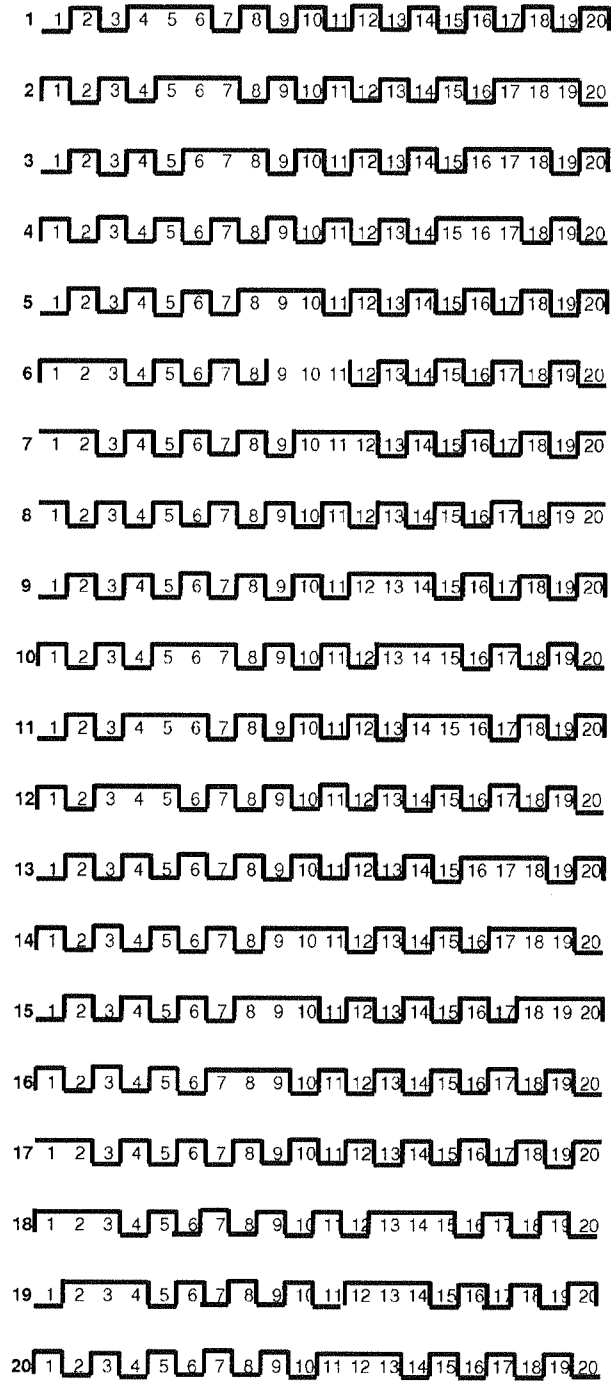

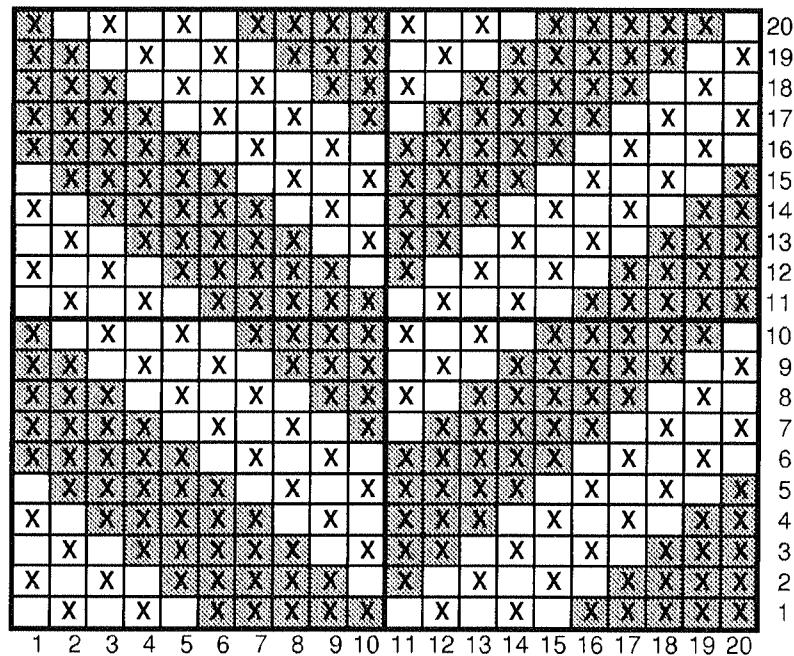

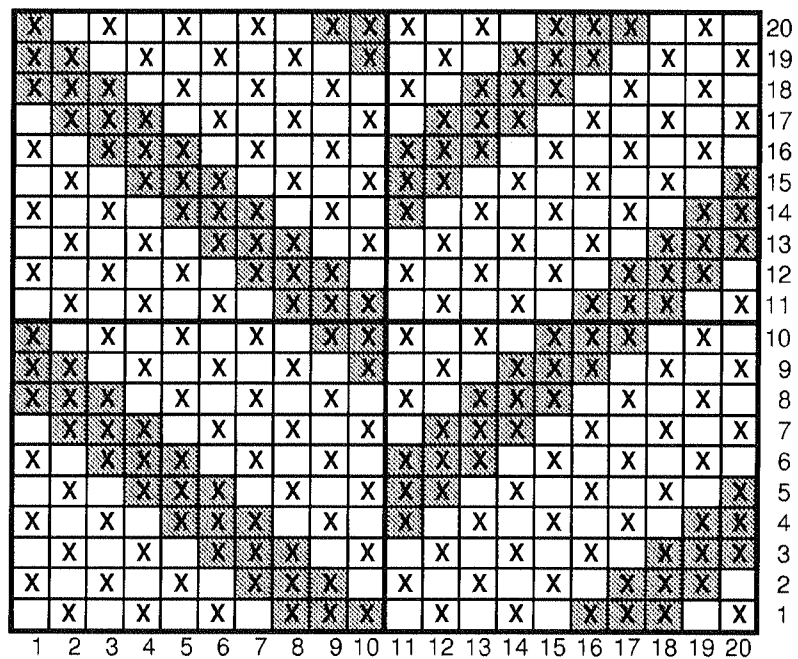


FIG. 4

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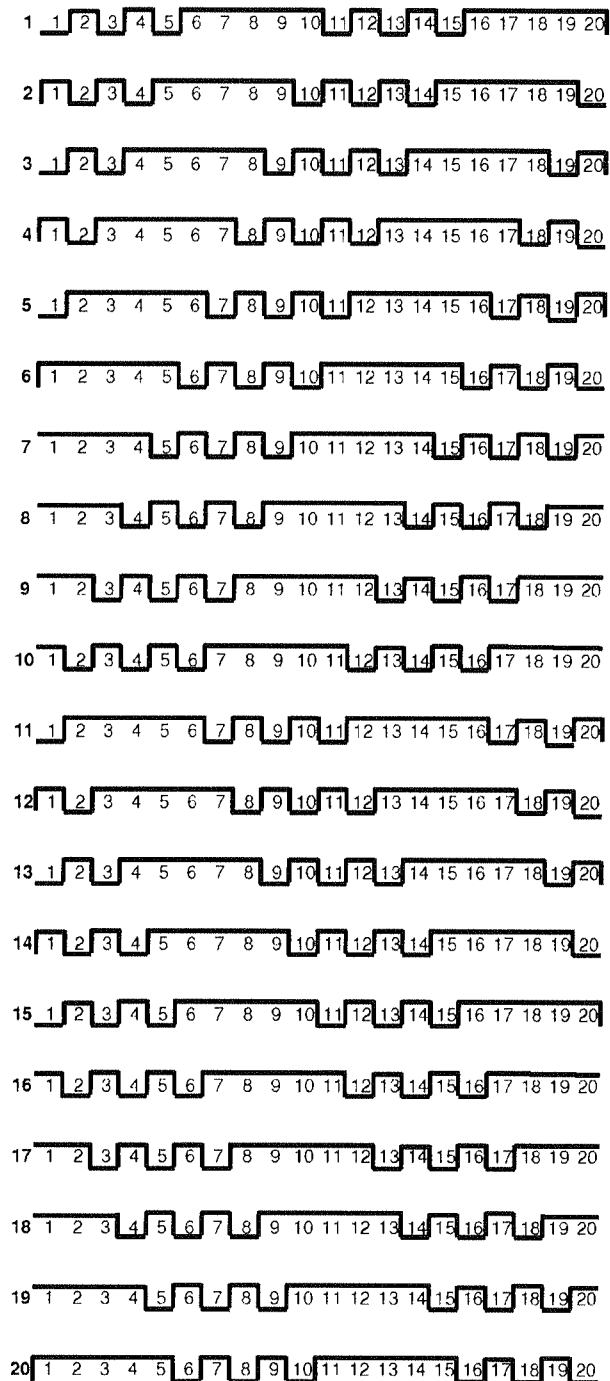


FIG. 6

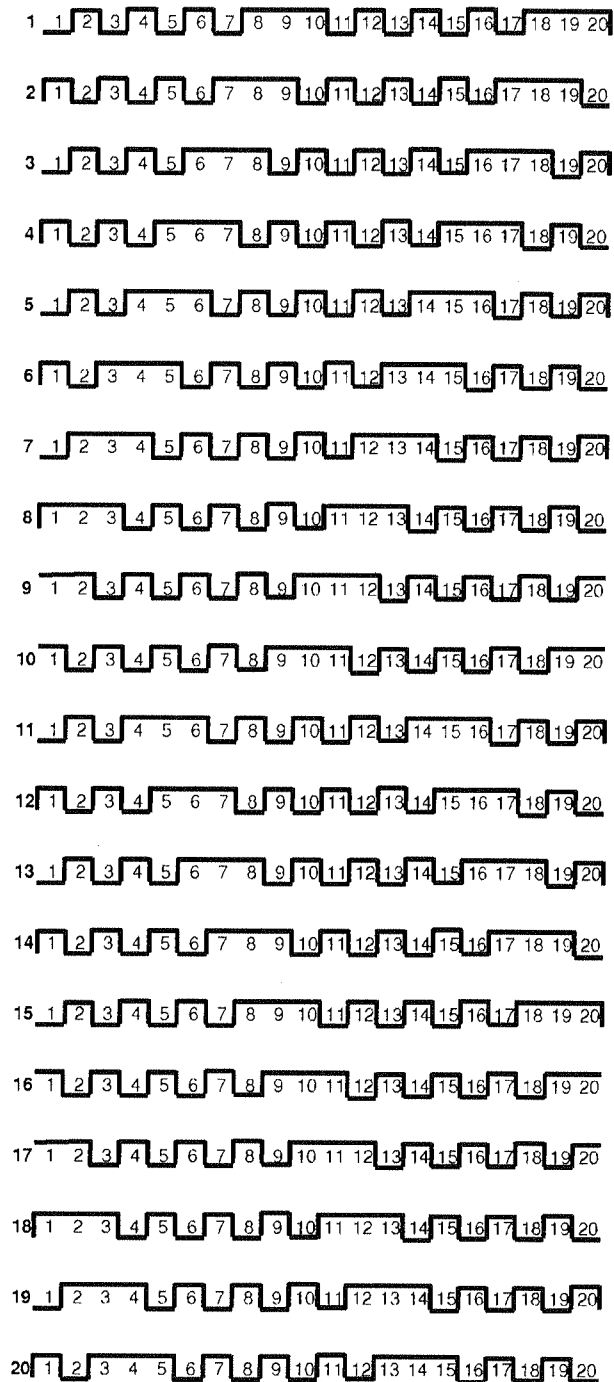


FIG. 8

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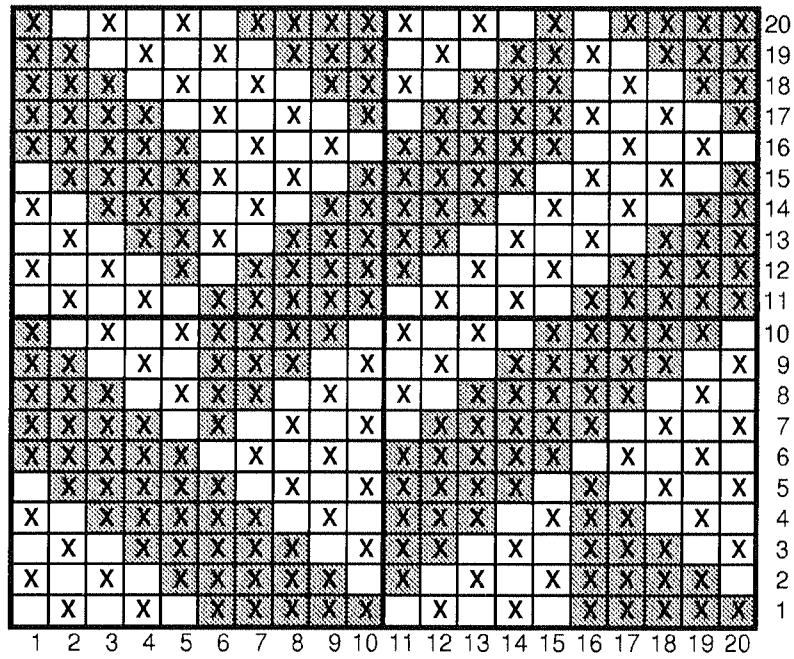


FIG. 9

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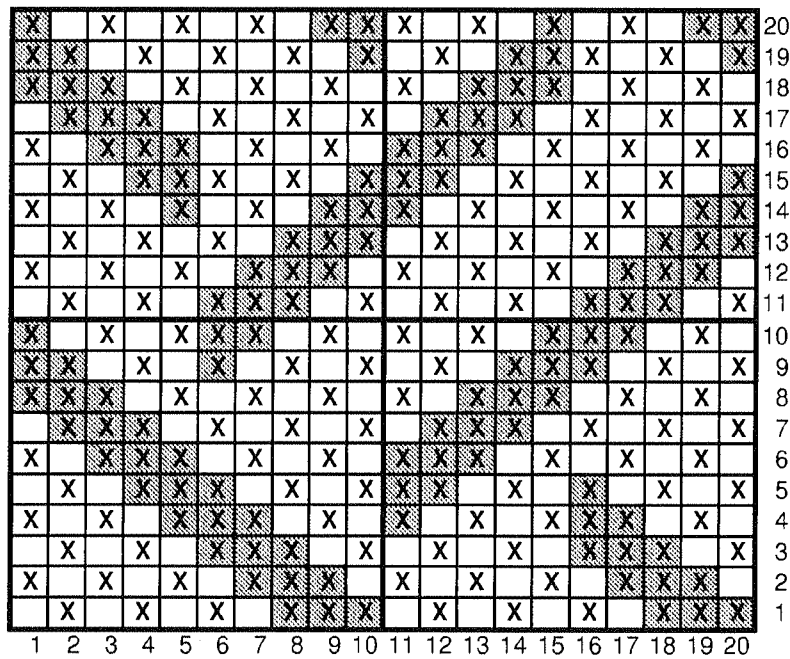


FIG. 11

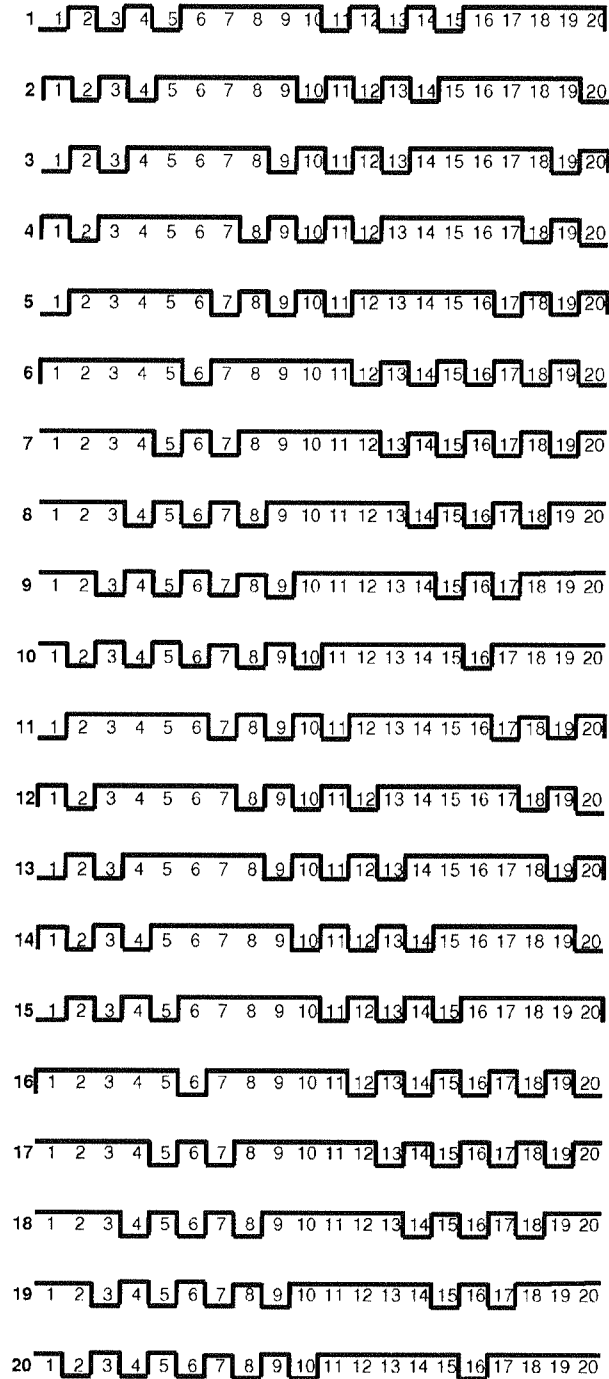


FIG. 10

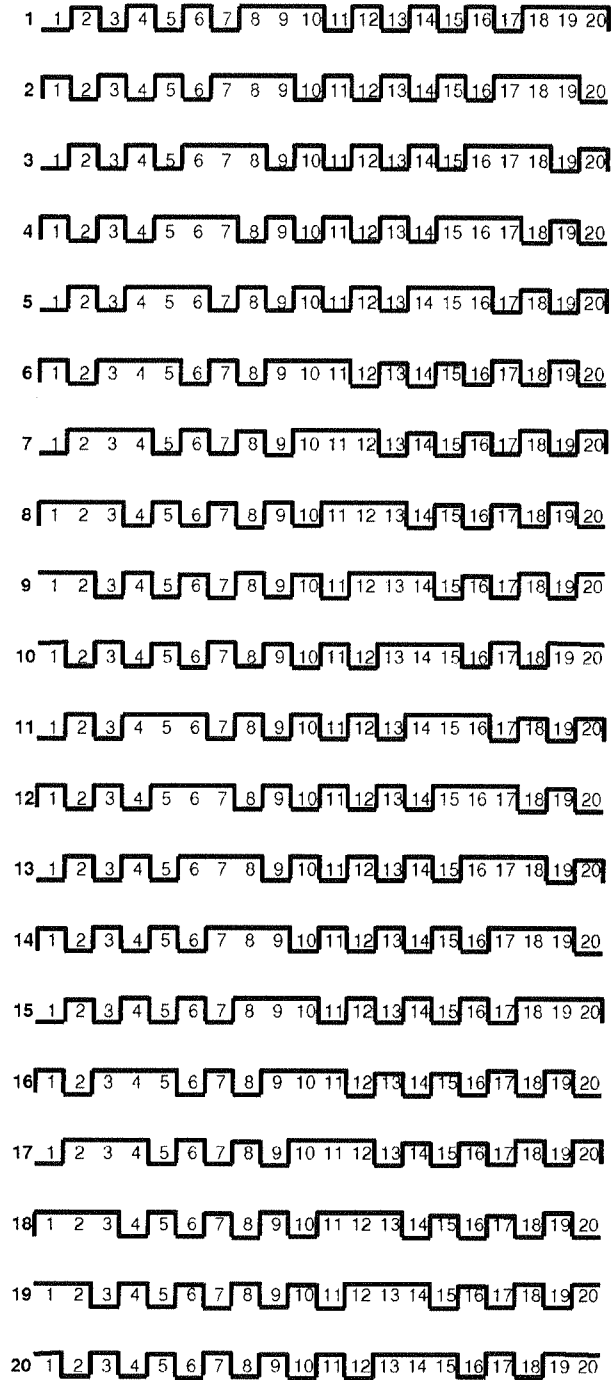


FIG. 12

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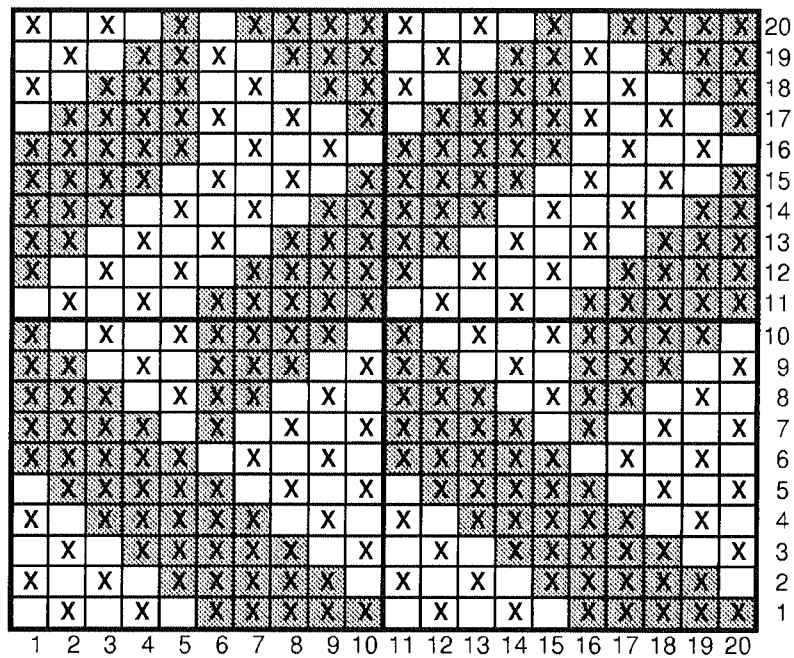


FIG. 13

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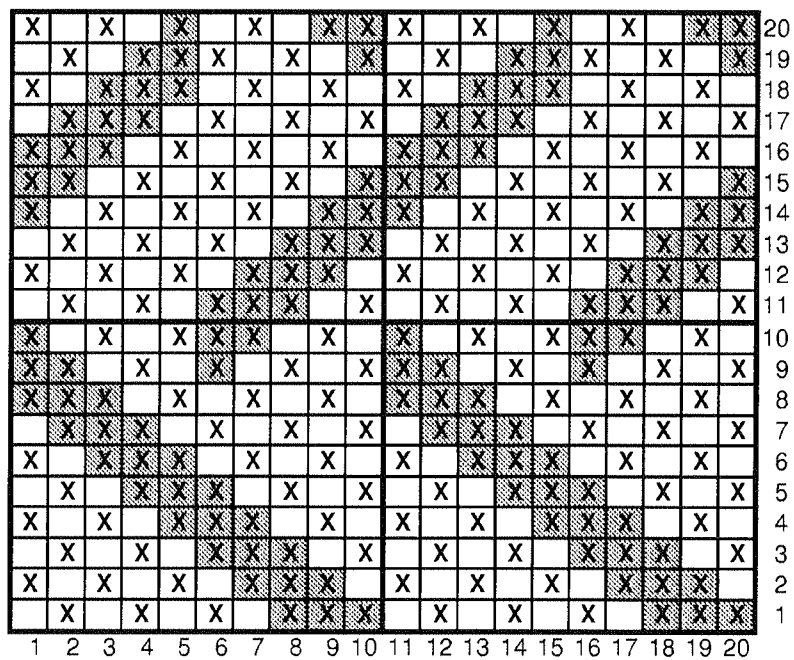


FIG. 15

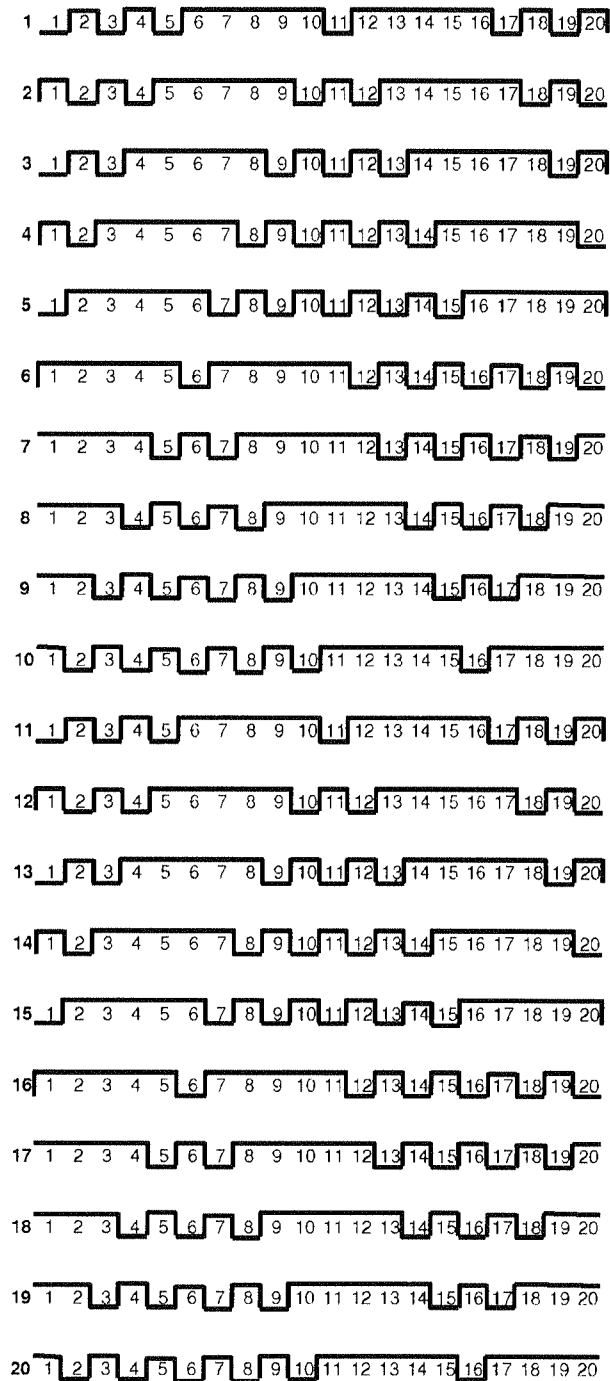


FIG. 14

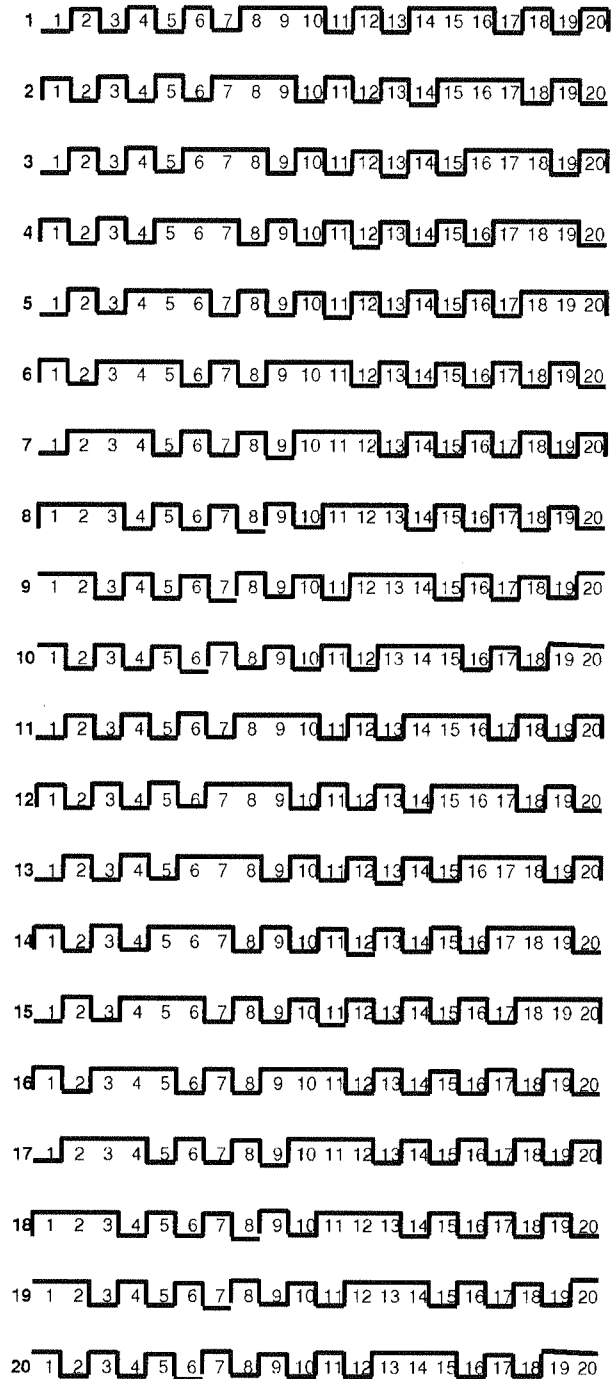
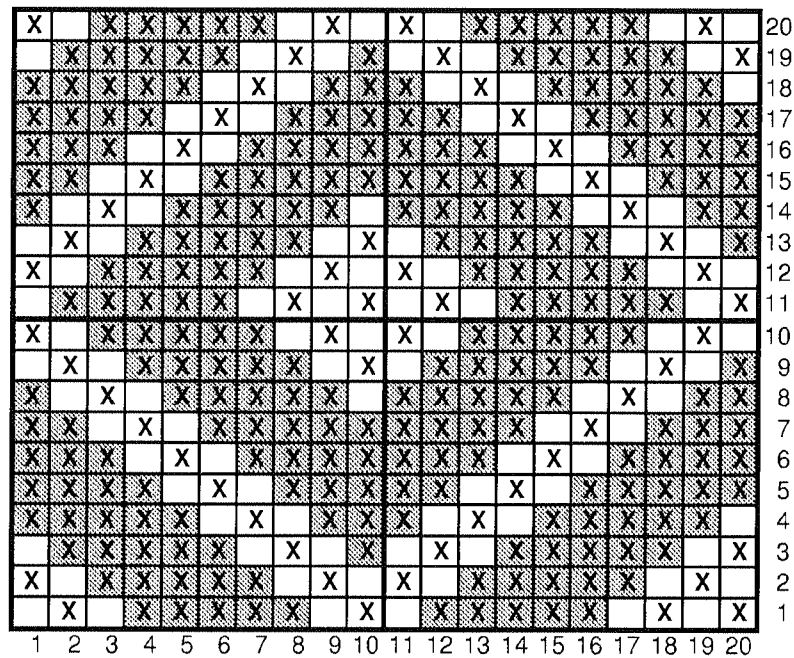
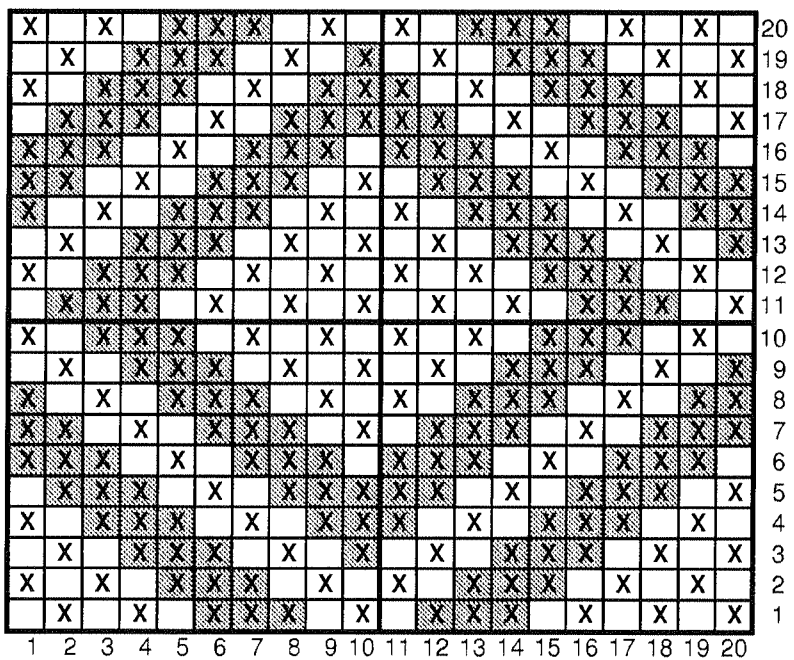


FIG. 16

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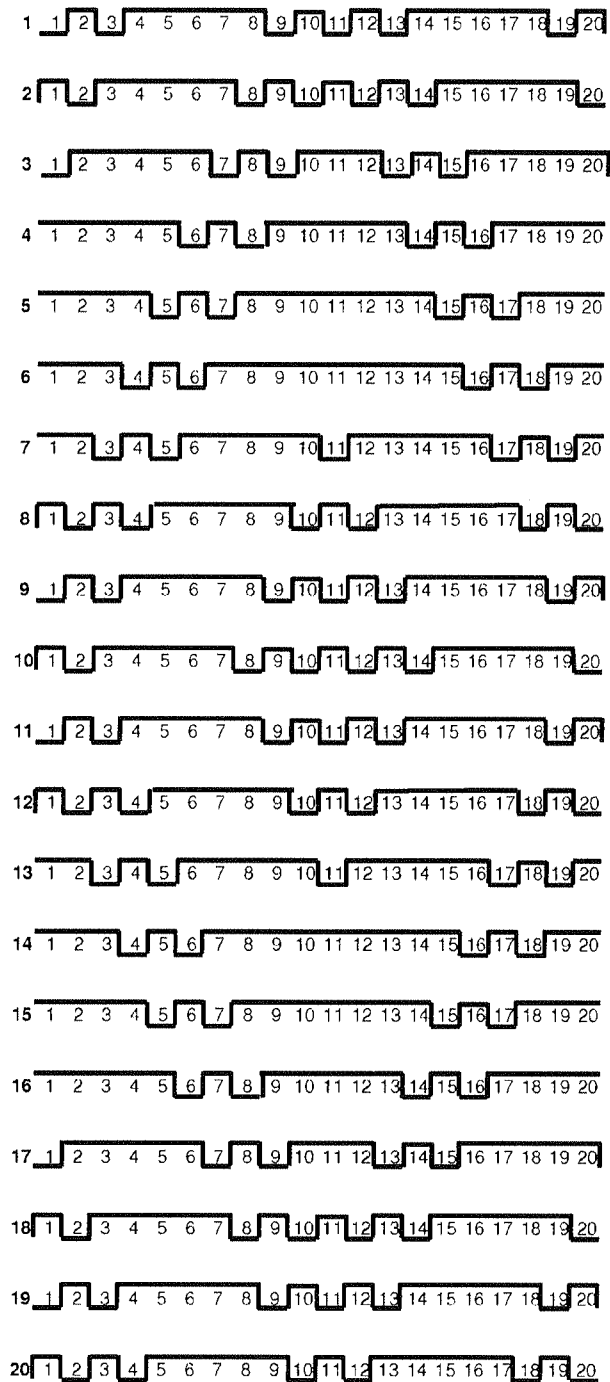


FIG. 18

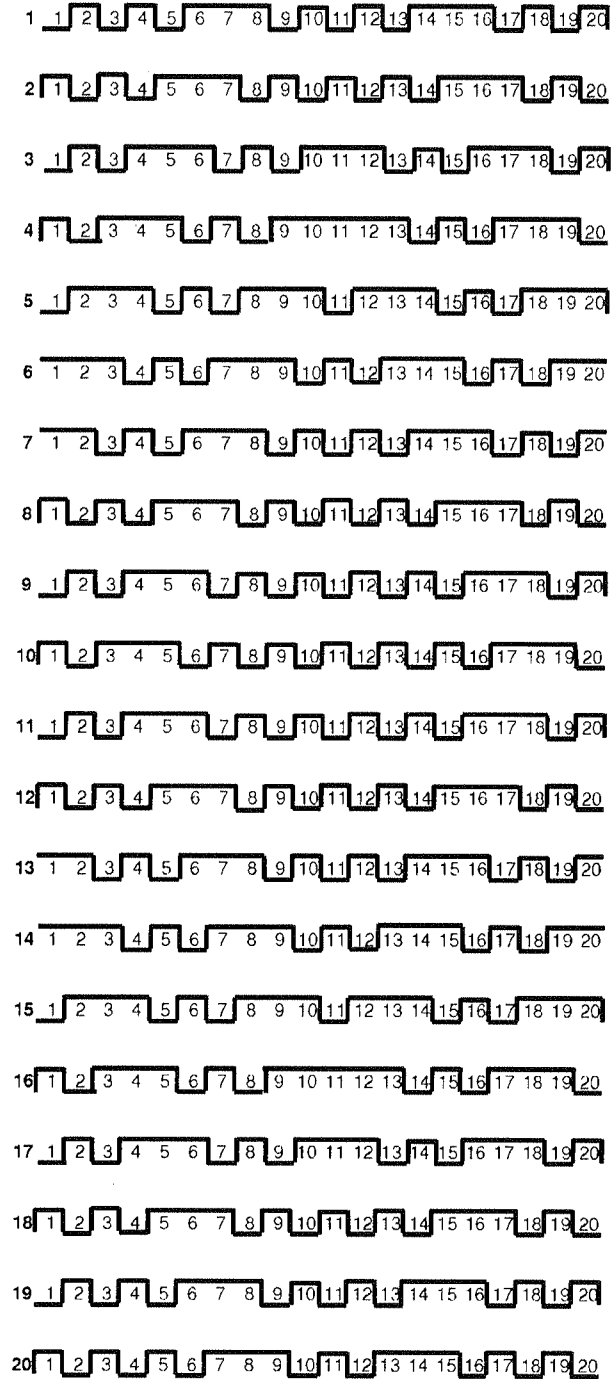


FIG. 20

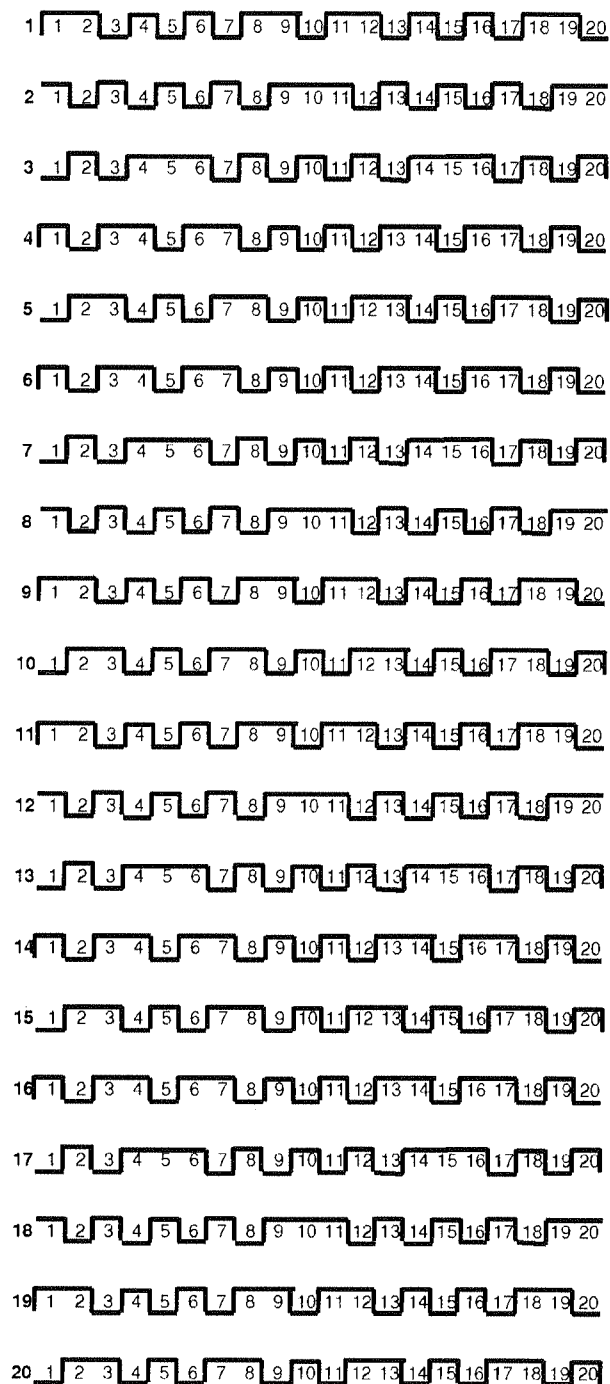


FIG. 22

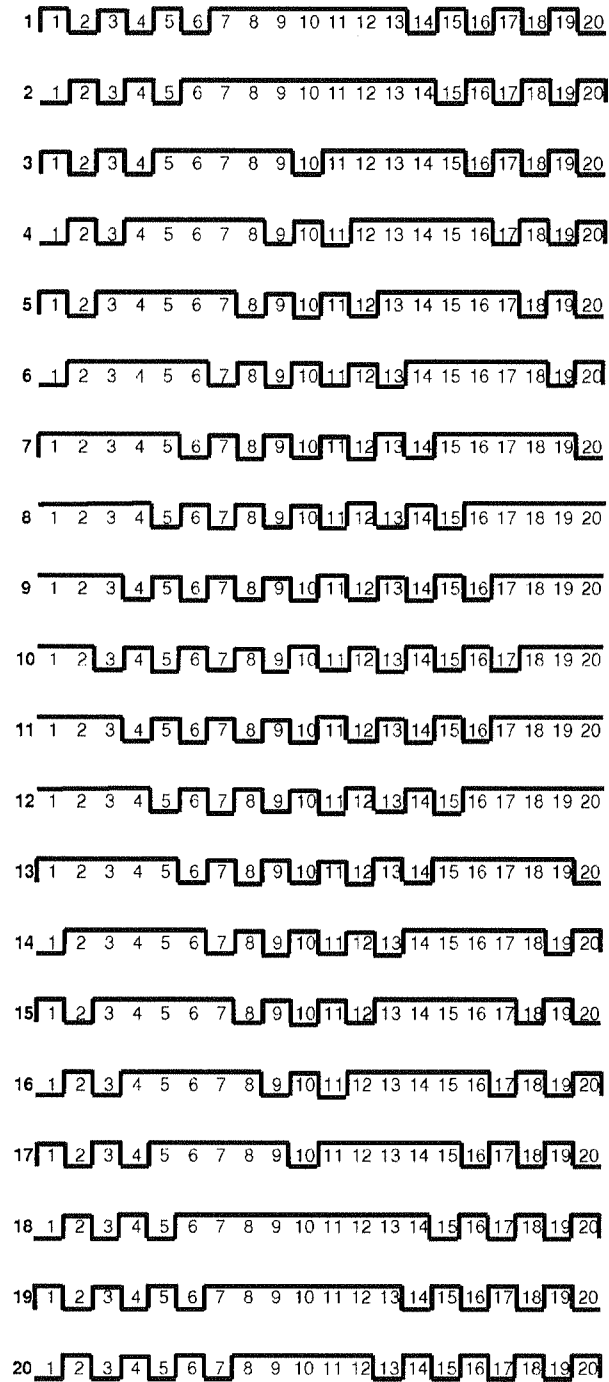


FIG. 24

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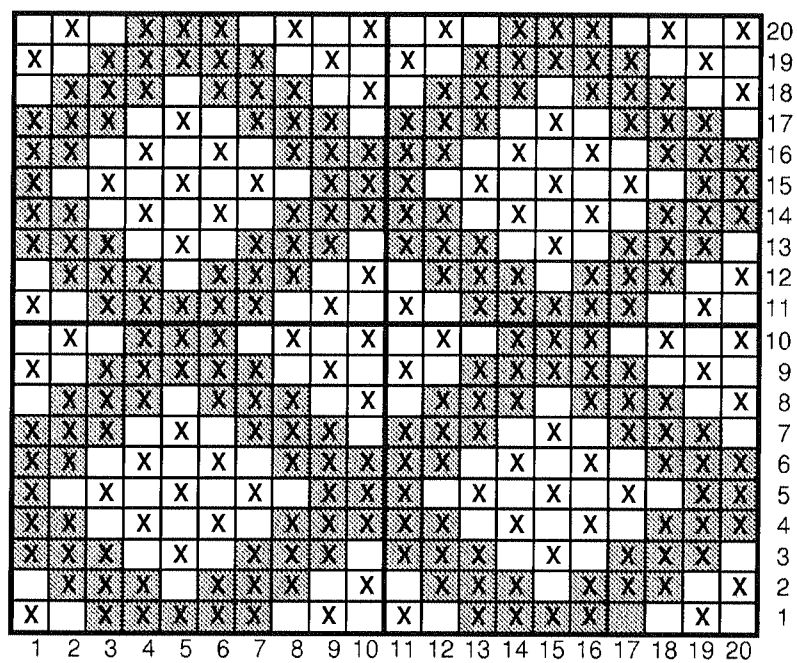


FIG. 25

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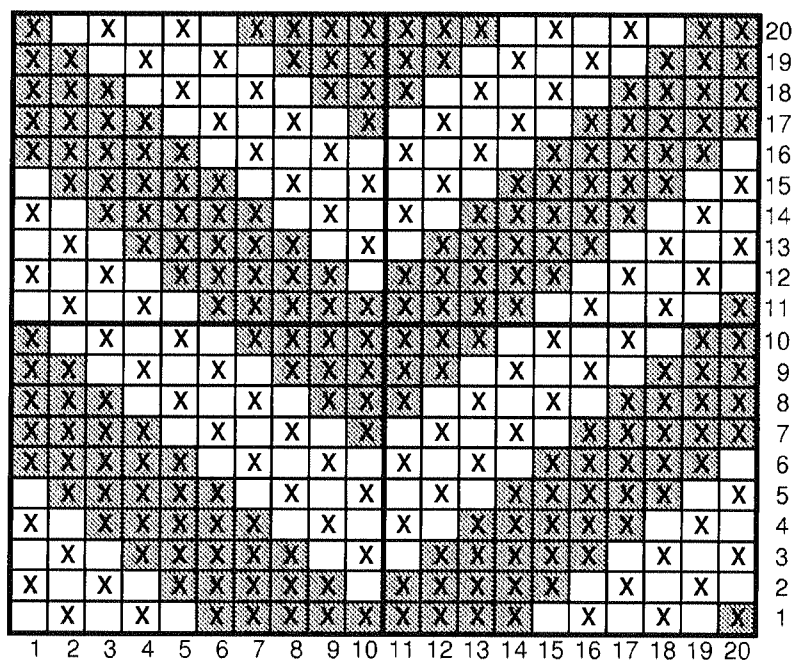


FIG. 27

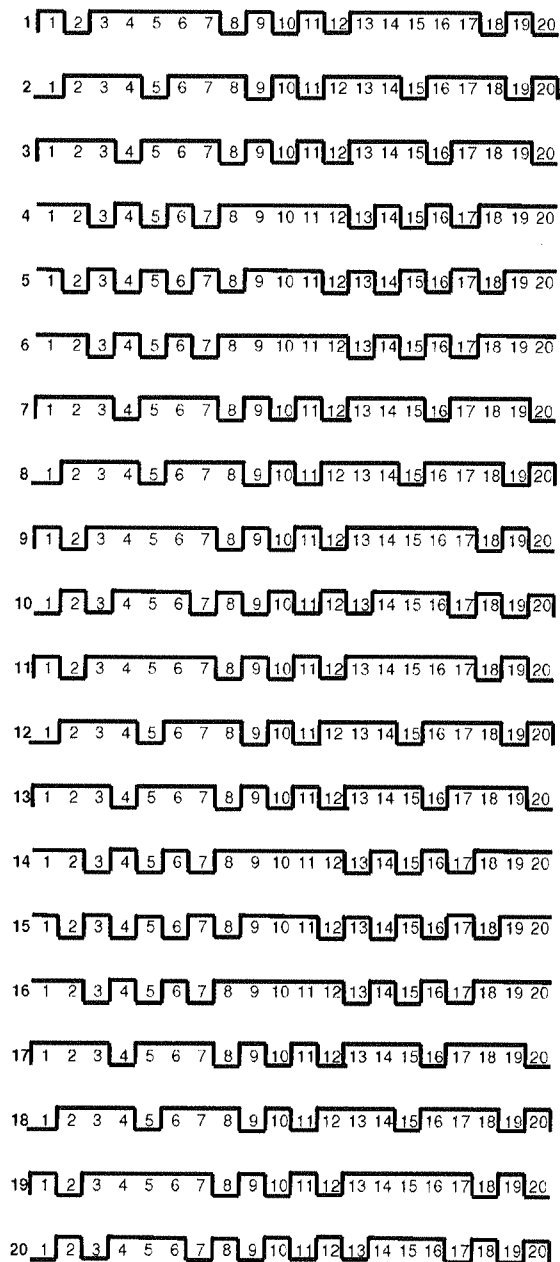


FIG. 26

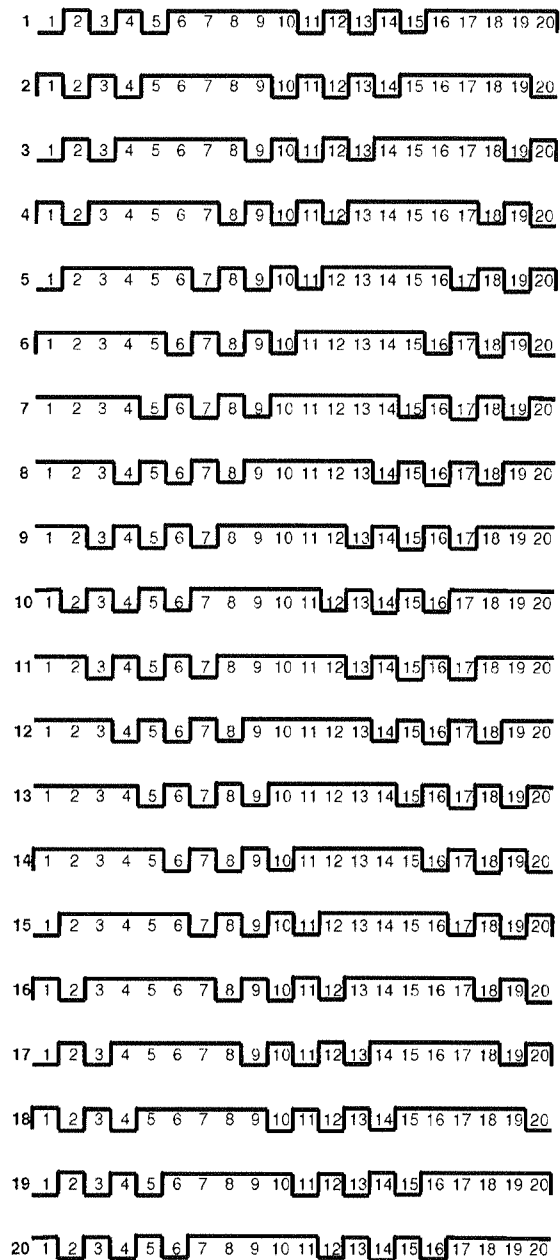


FIG. 28

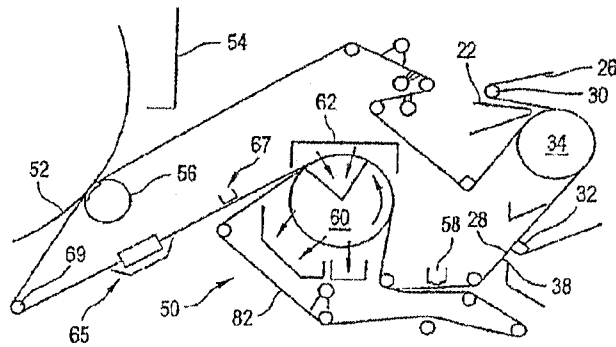


FIG. 29

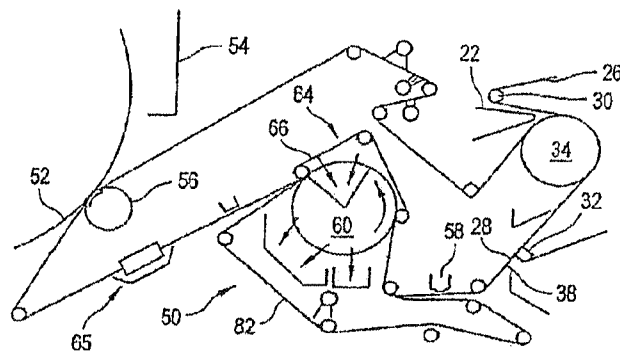


FIG. 30

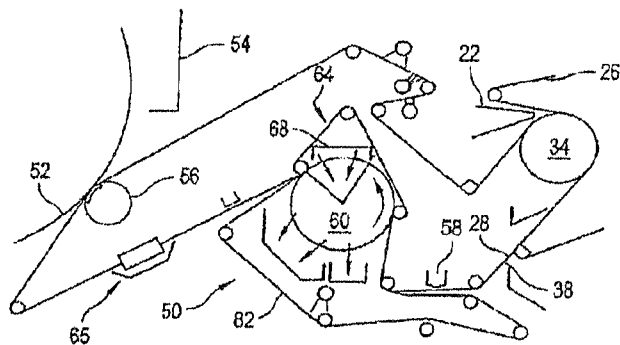


FIG. 31

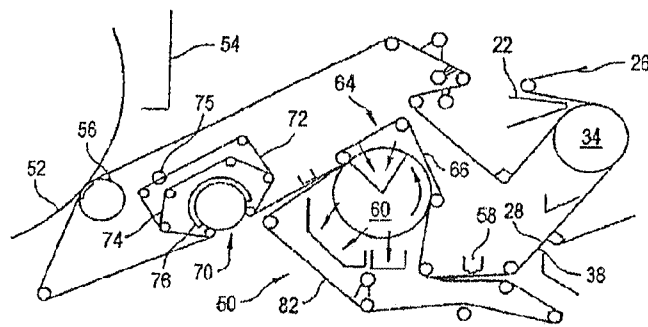


FIG. 32

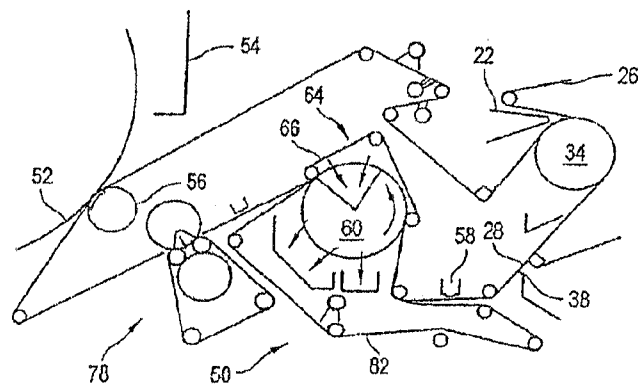


FIG. 33

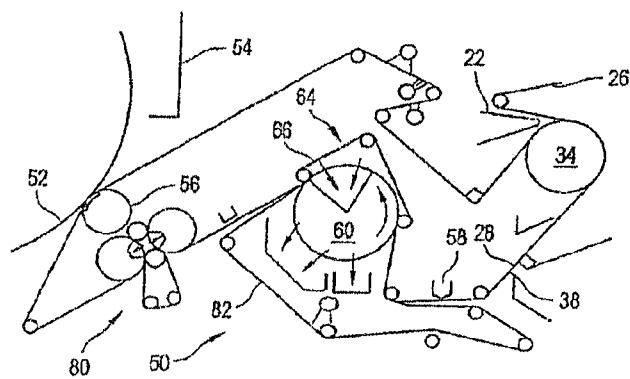


FIG. 34

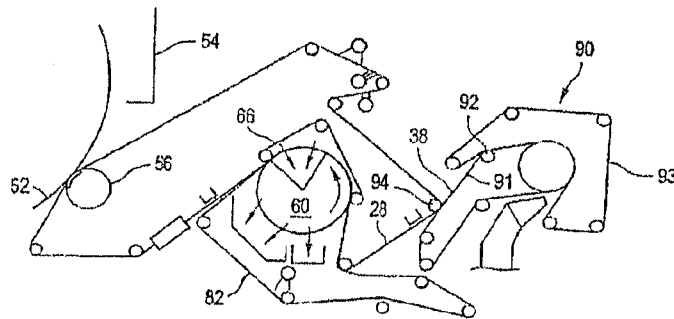


FIG. 35

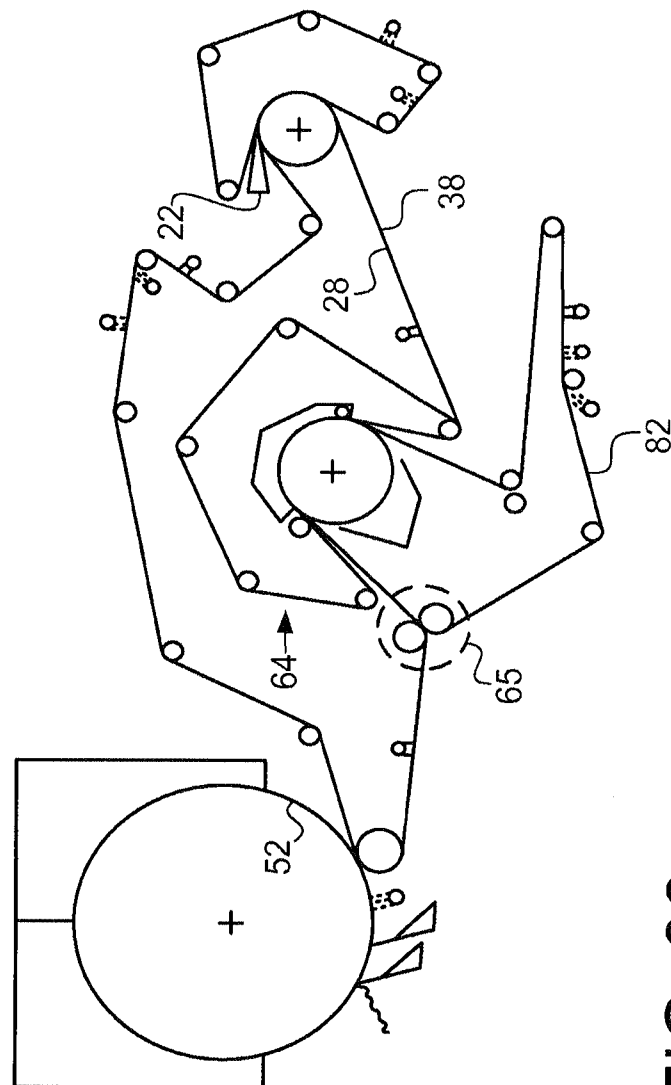


FIG. 36

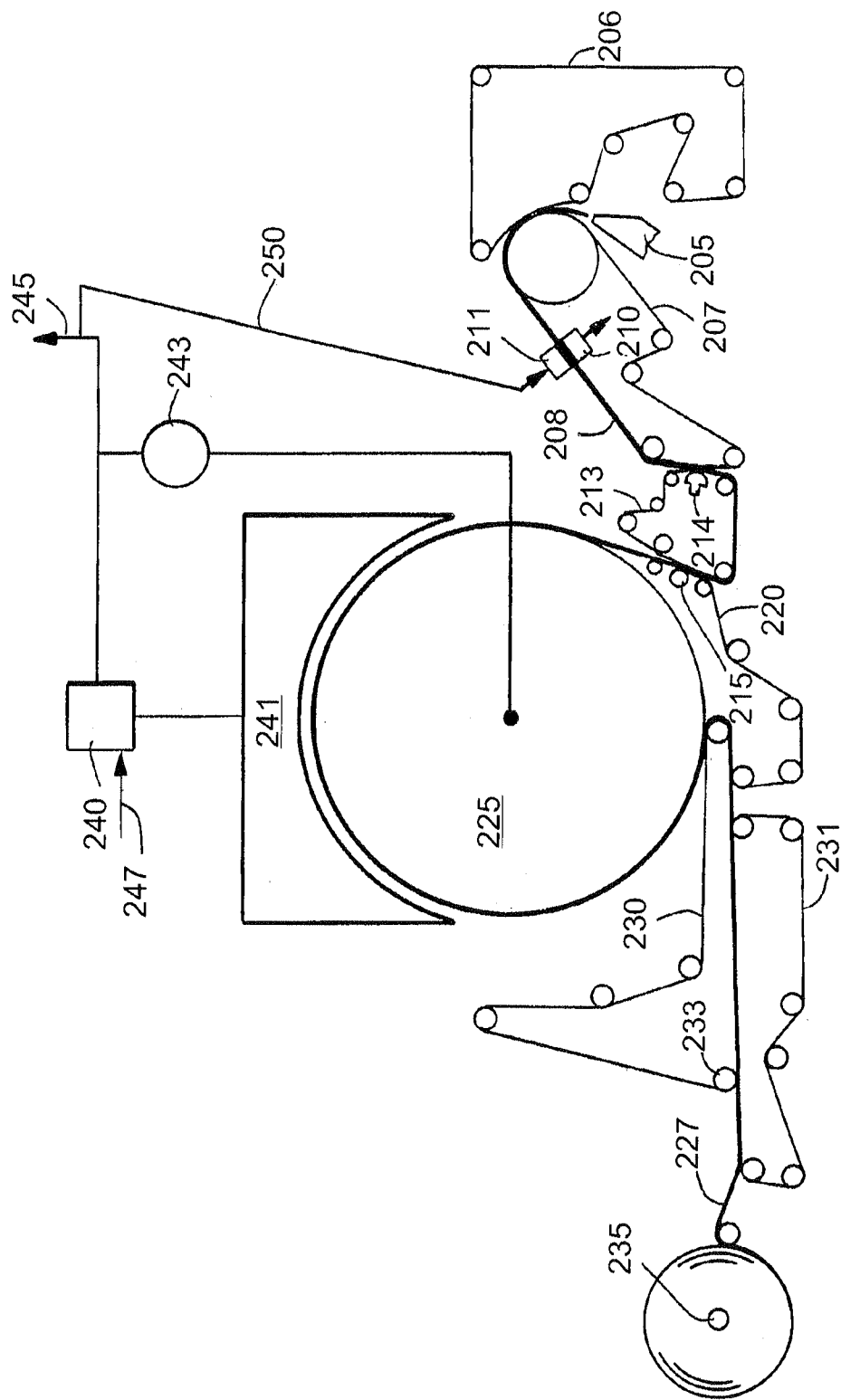


FIG. 37

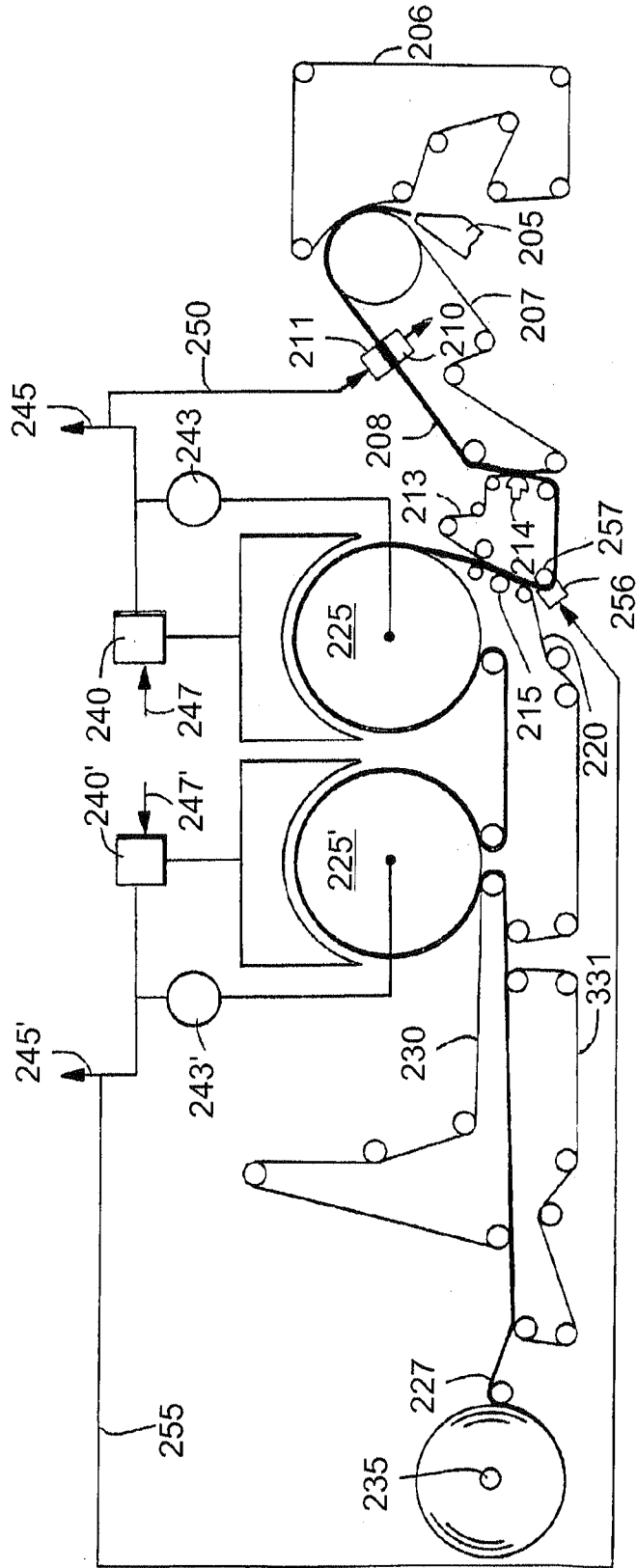


FIG. 38

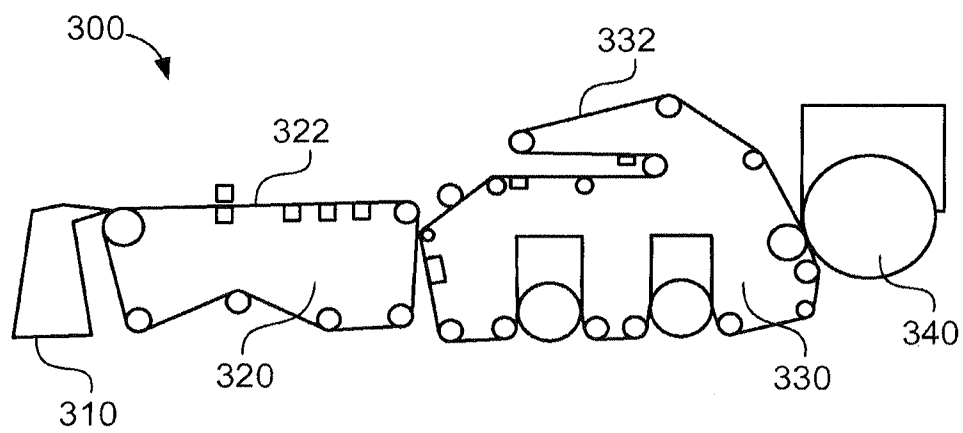


FIG. 39

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2011/063101

A. CLASSIFICATION OF SUBJECT MATTER

INV. D21F1/00 D21F11/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 191 609 A (TROKHAN PAUL D [US]) 4 March 1980 (1980-03-04) column 1, lines 8-15 column 4, line 46 - column 8, line 18 column 12, line 25 - column 14, line 60 figures 1,6-20	1-20
X	US 2007/175534 A1 (BARRETT REX [US] ET AL) 2 August 2007 (2007-08-02) paragraphs [0001], [0036] - [0043], [0045], [0047] - [0050] figures 1-3,5,6 ----- -/-	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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INTERNATIONAL SEARCH REPORT

International application No

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