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(54) **WEAR SIDE WEAVE PATTERN OF A COMPOSITE FORMING FABRIC**

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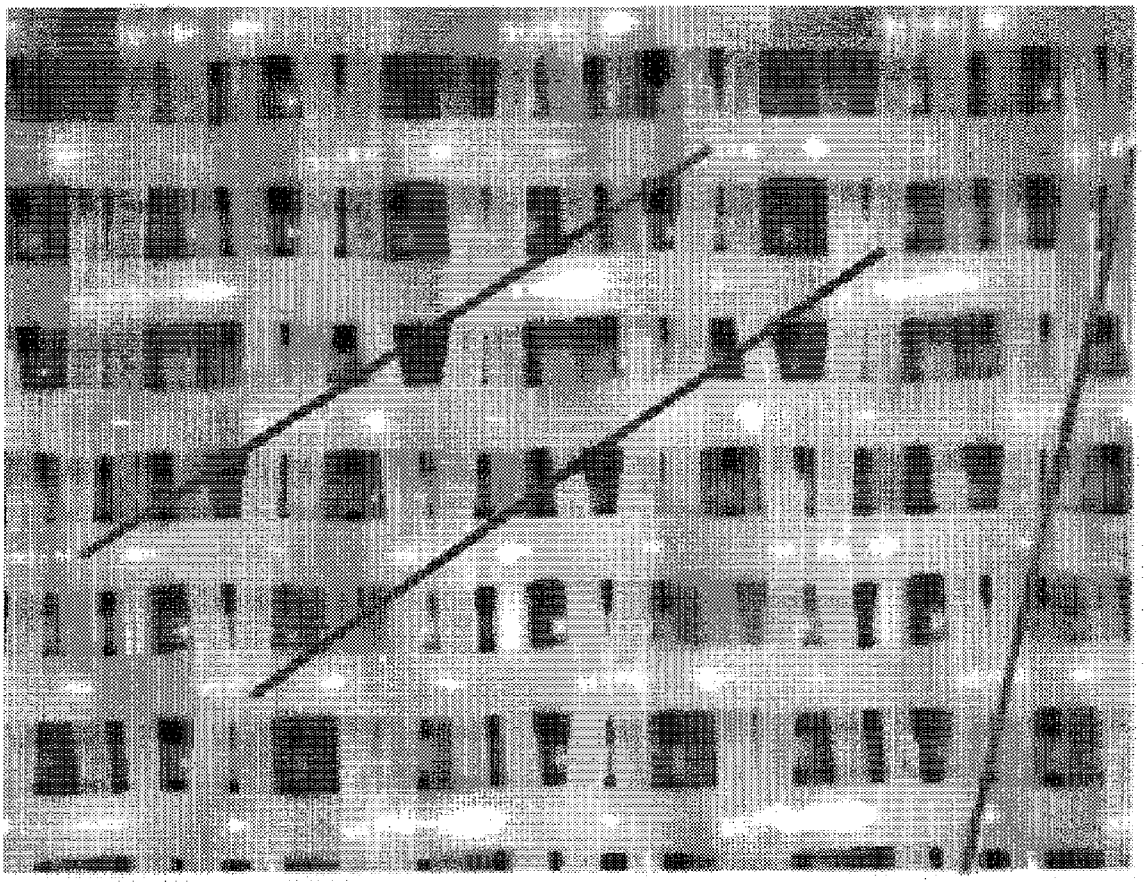
D03D 25/00 (2006.01)

(52) **U.S. Cl.** ..... **139/383 A**; 139/383 R

(57) **ABSTRACT**

A fabric for papermaking including a first layer side, a second layer side and at least one binder warp yarn pair. The first side layer, having a plurality of first weft yarns and a plurality of first warp yarns. The second side layer having a plurality of second weft yarns and a plurality of second warp yarns. The at least one binder warp yarn pair including a first binder warp yarn pair having a first binder warp yarn and a second binder warp yarn, the first side layer and the second side layer being bound by the first binder warp yarn pair. The first binder warp yarn and the second binder warp yarn exchanging the layer to which they are woven at exchange points. A knuckle is formed with the first binder warp yarn and an adjacent first warp yarn, a subsequent adjacent knuckle only being formed with the first binder warp yarn and an opposite adjacent first warp yarn.



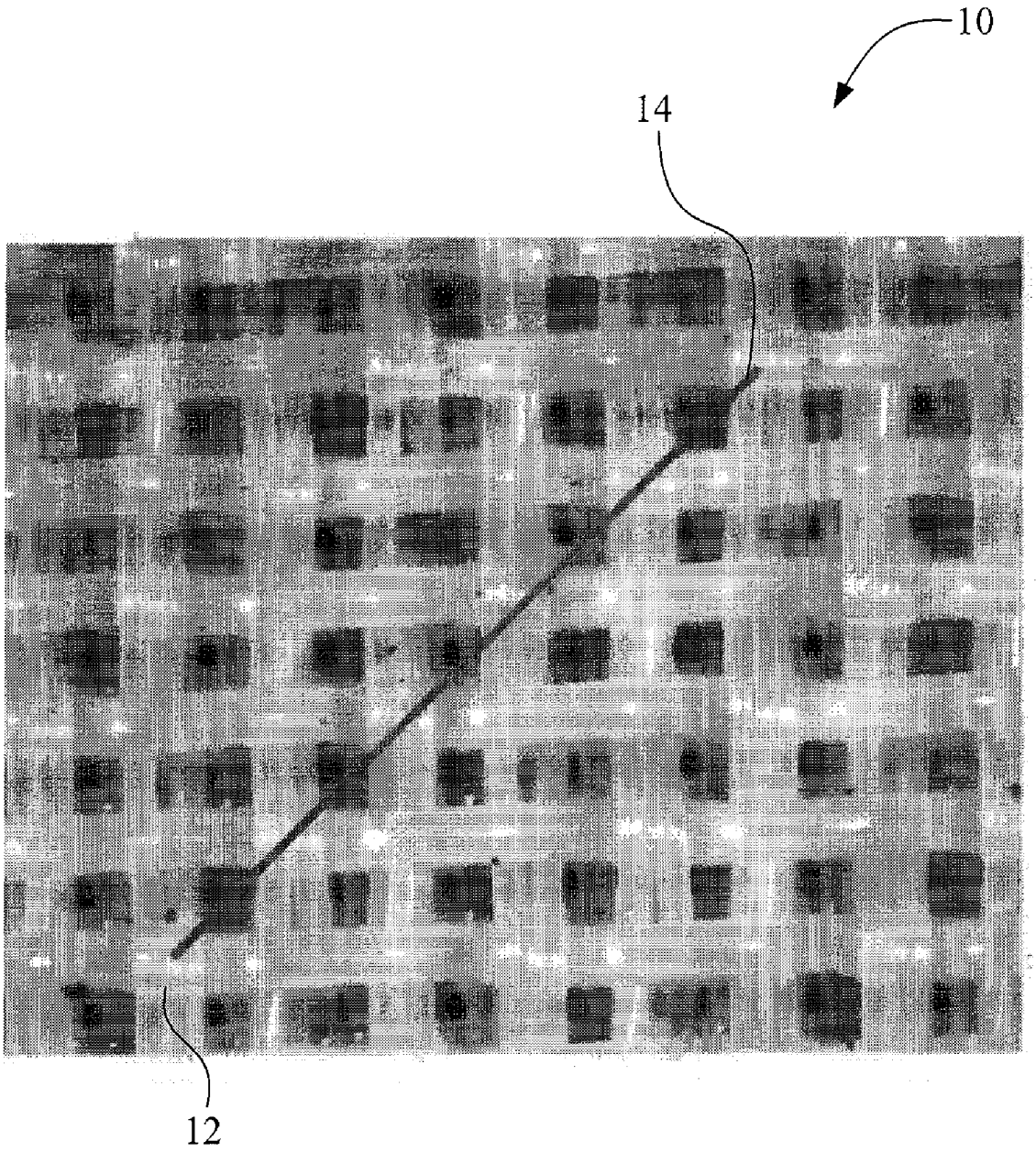


Fig. 1

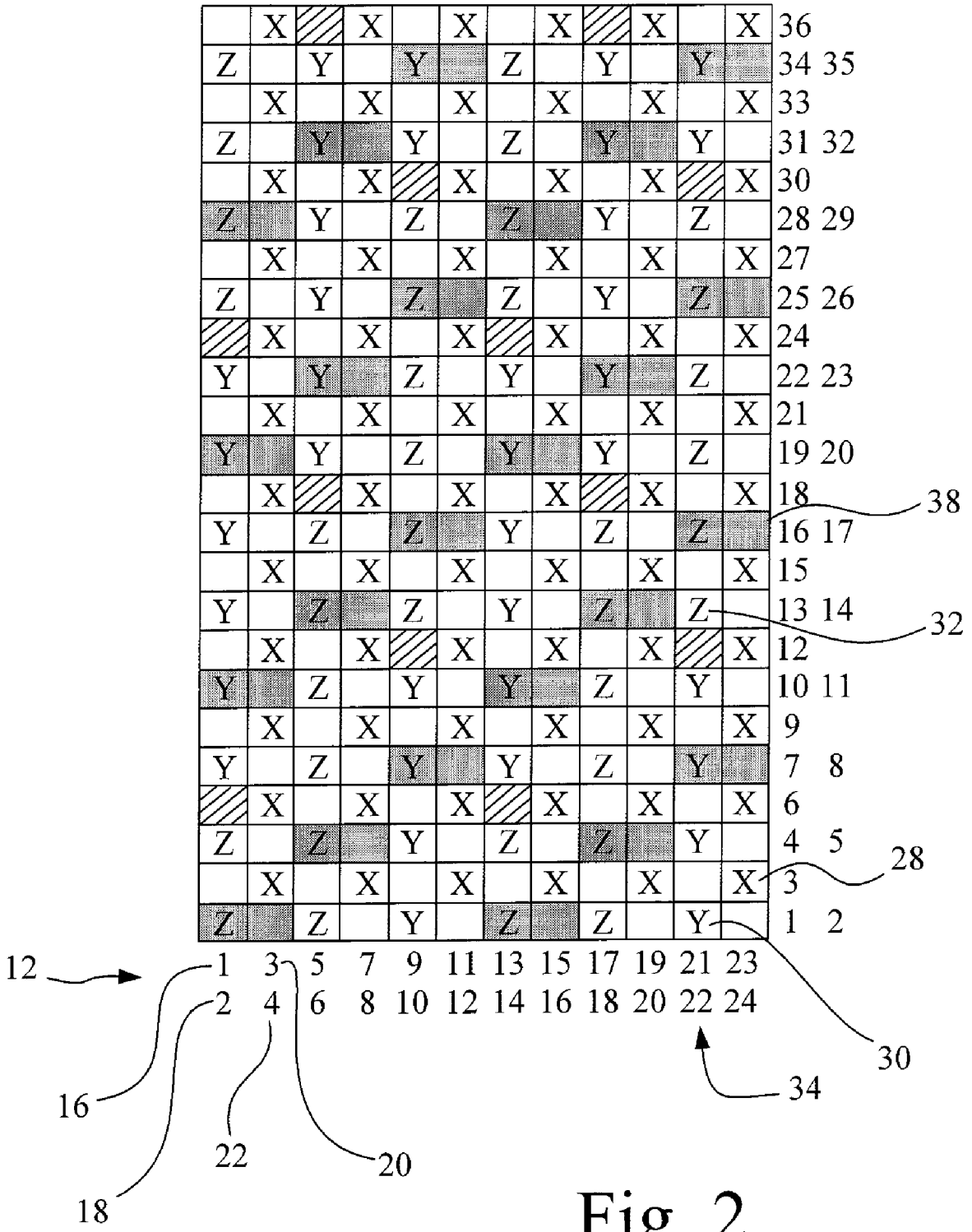


Fig. 2
PRIOR ART

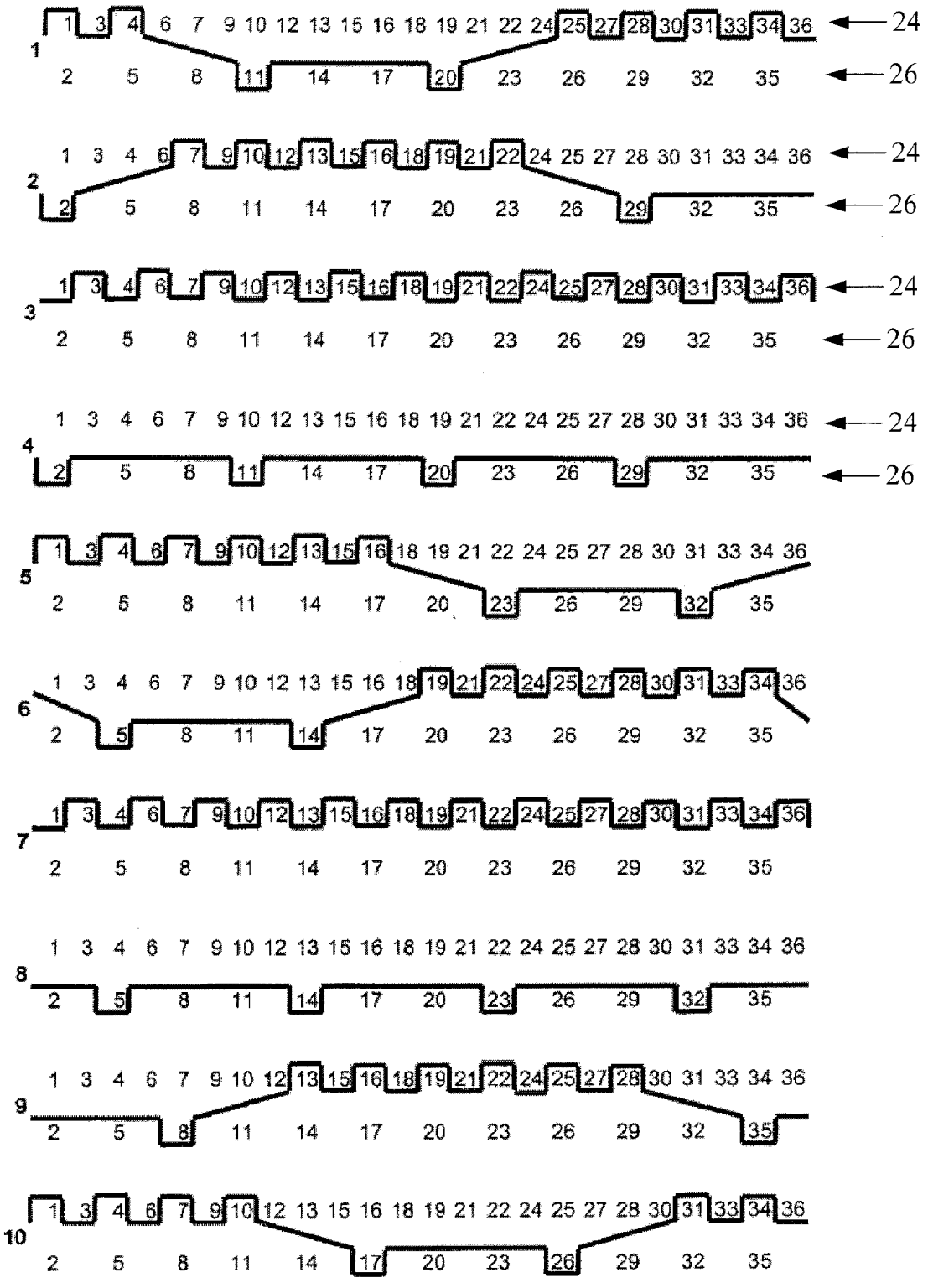

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Fig. 3A

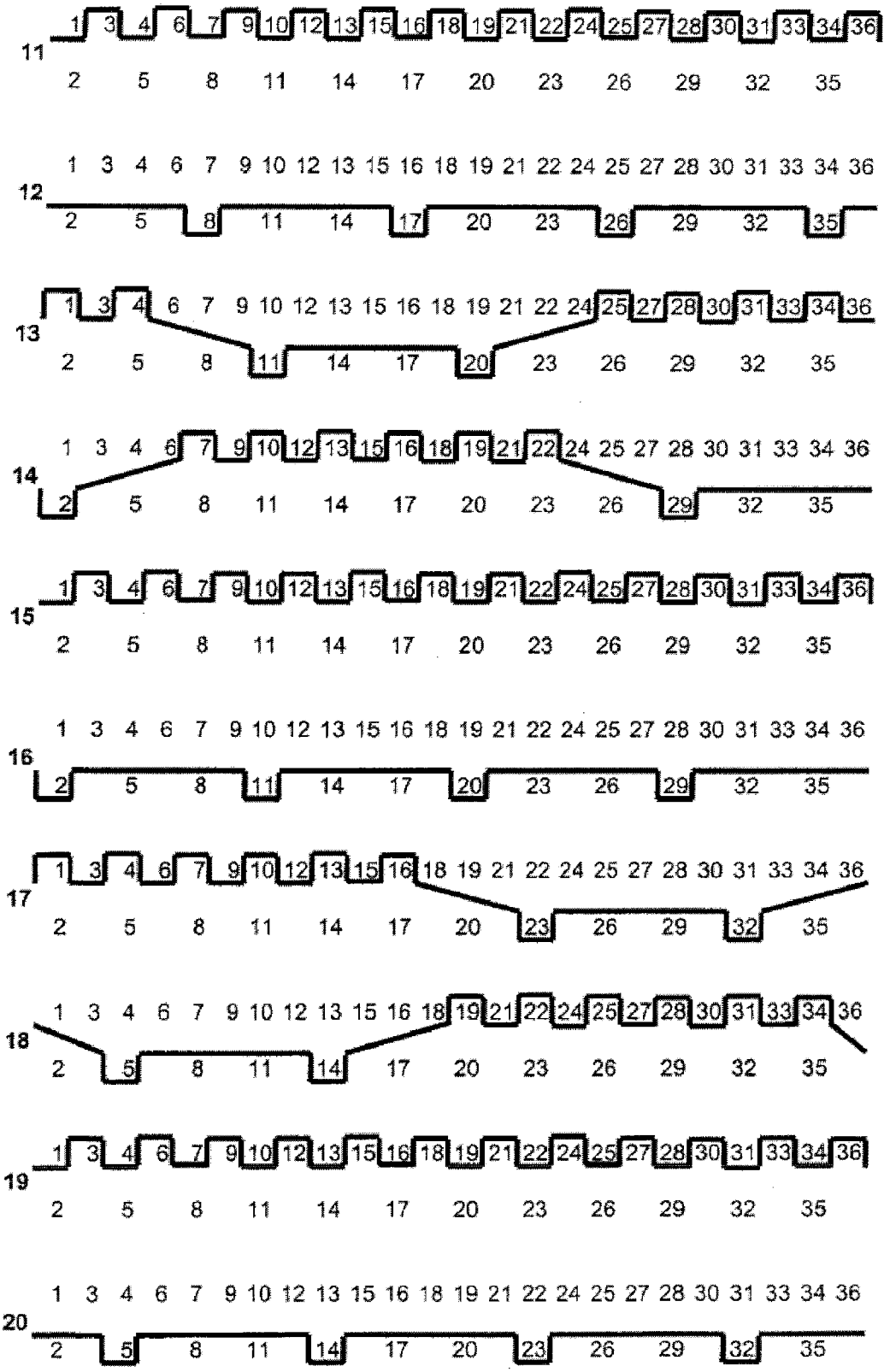
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Fig. 3B

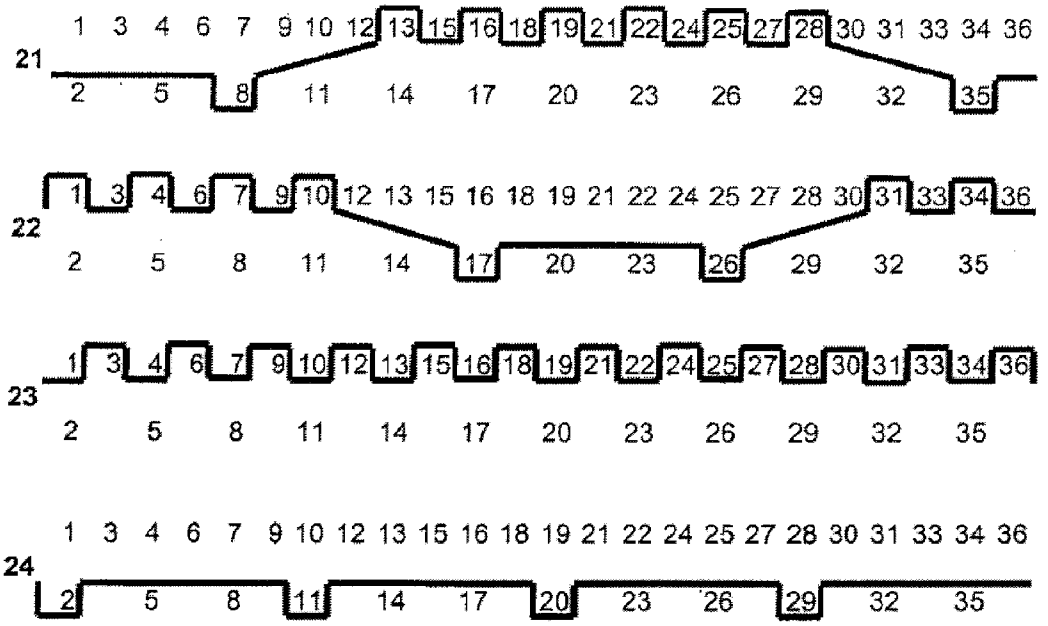
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Fig. 3C

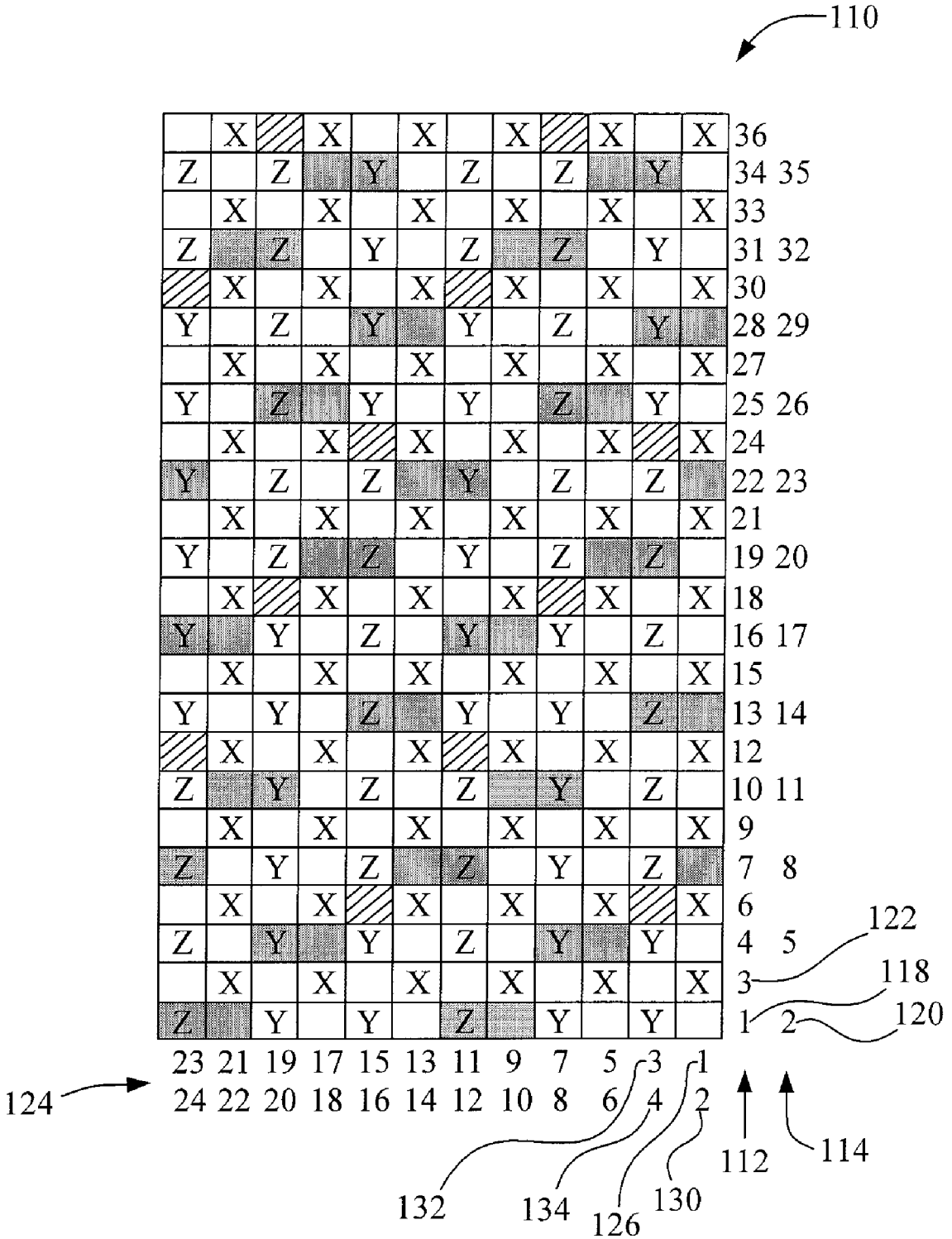
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Fig. 4

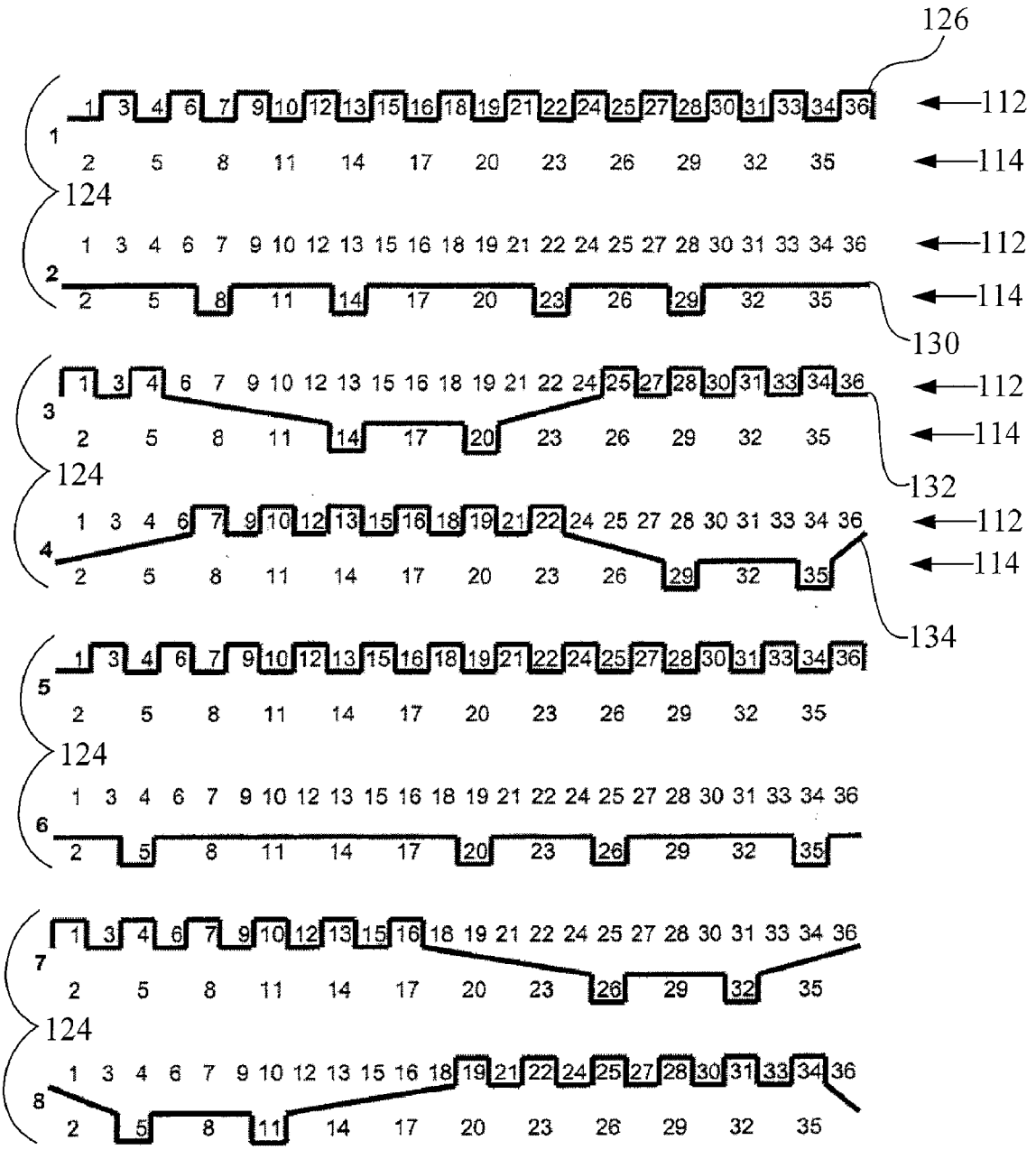

Fig. 5A

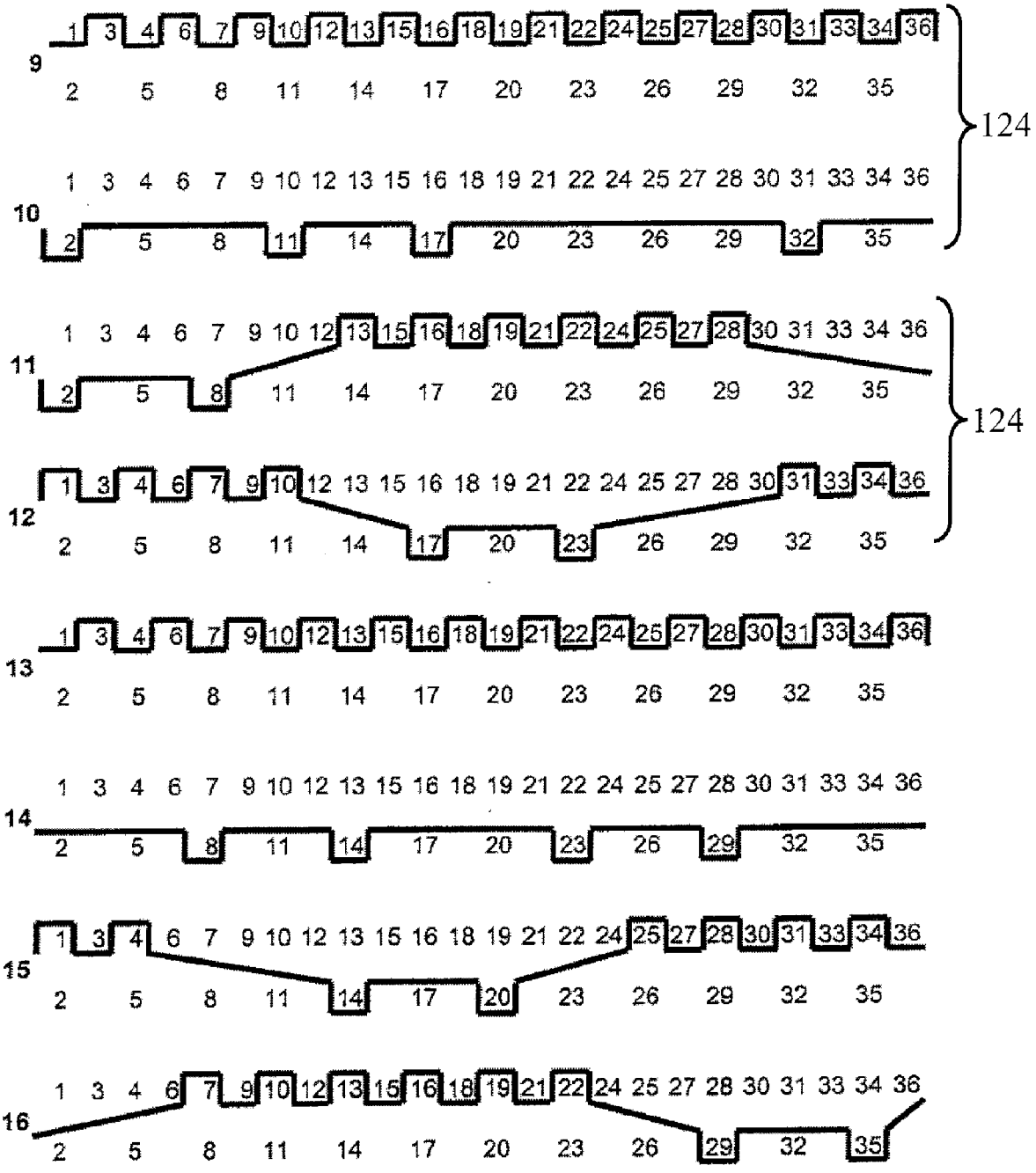
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Fig. 5B

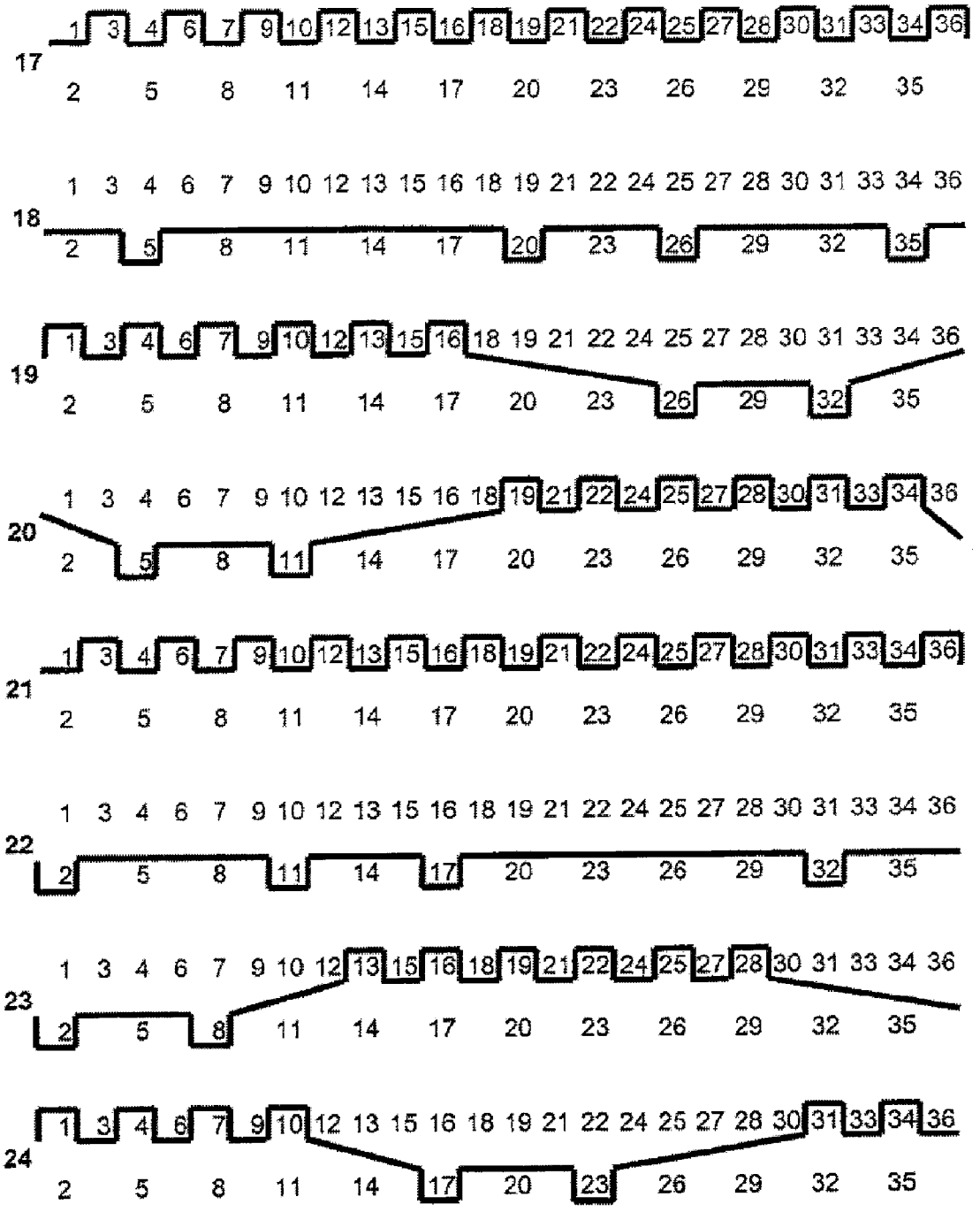
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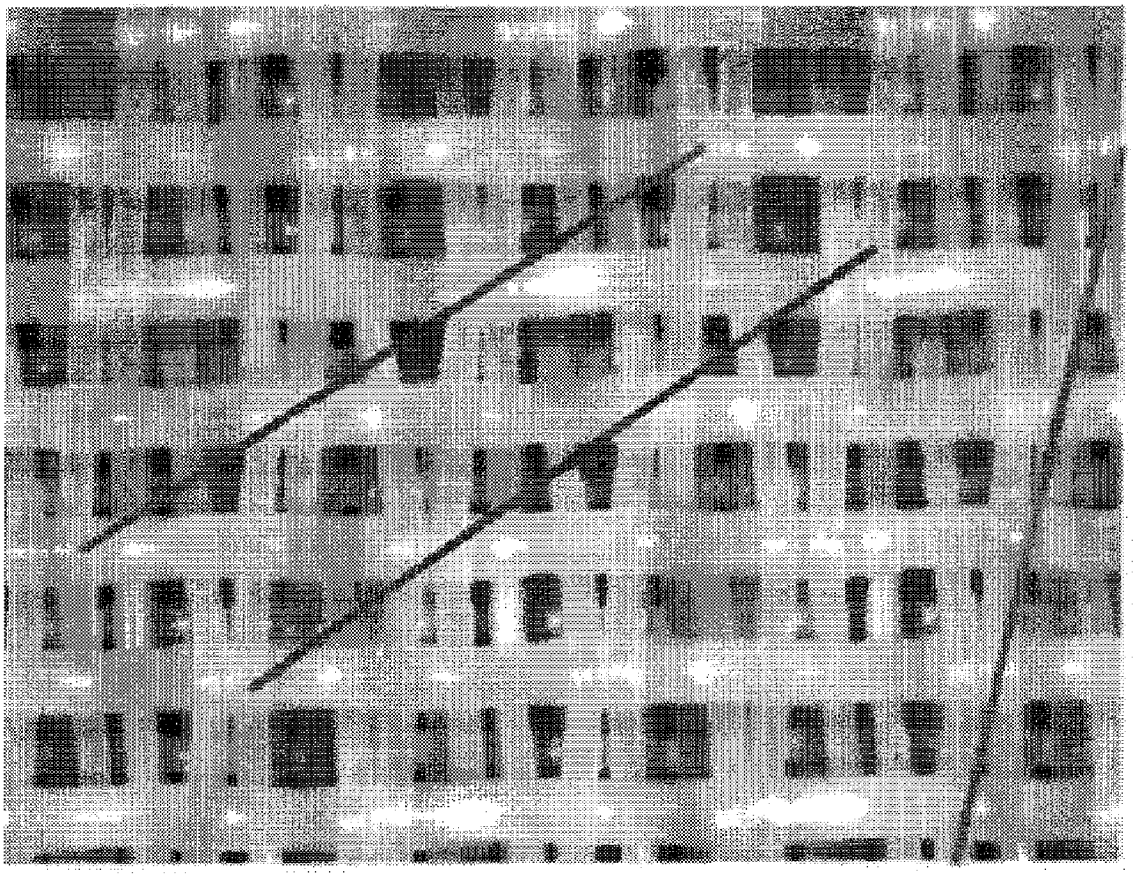
Fig. 5C



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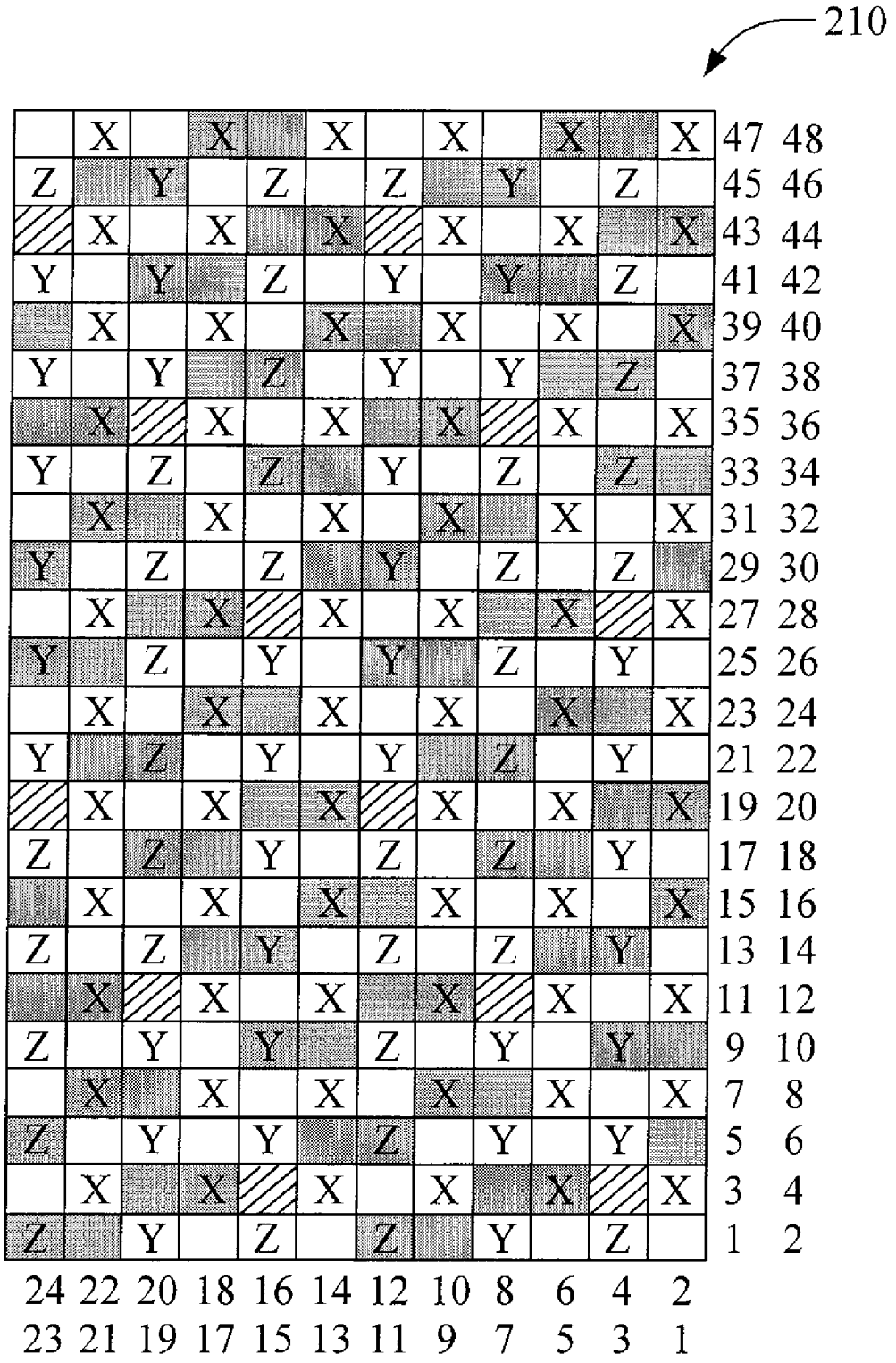
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Fig. 7

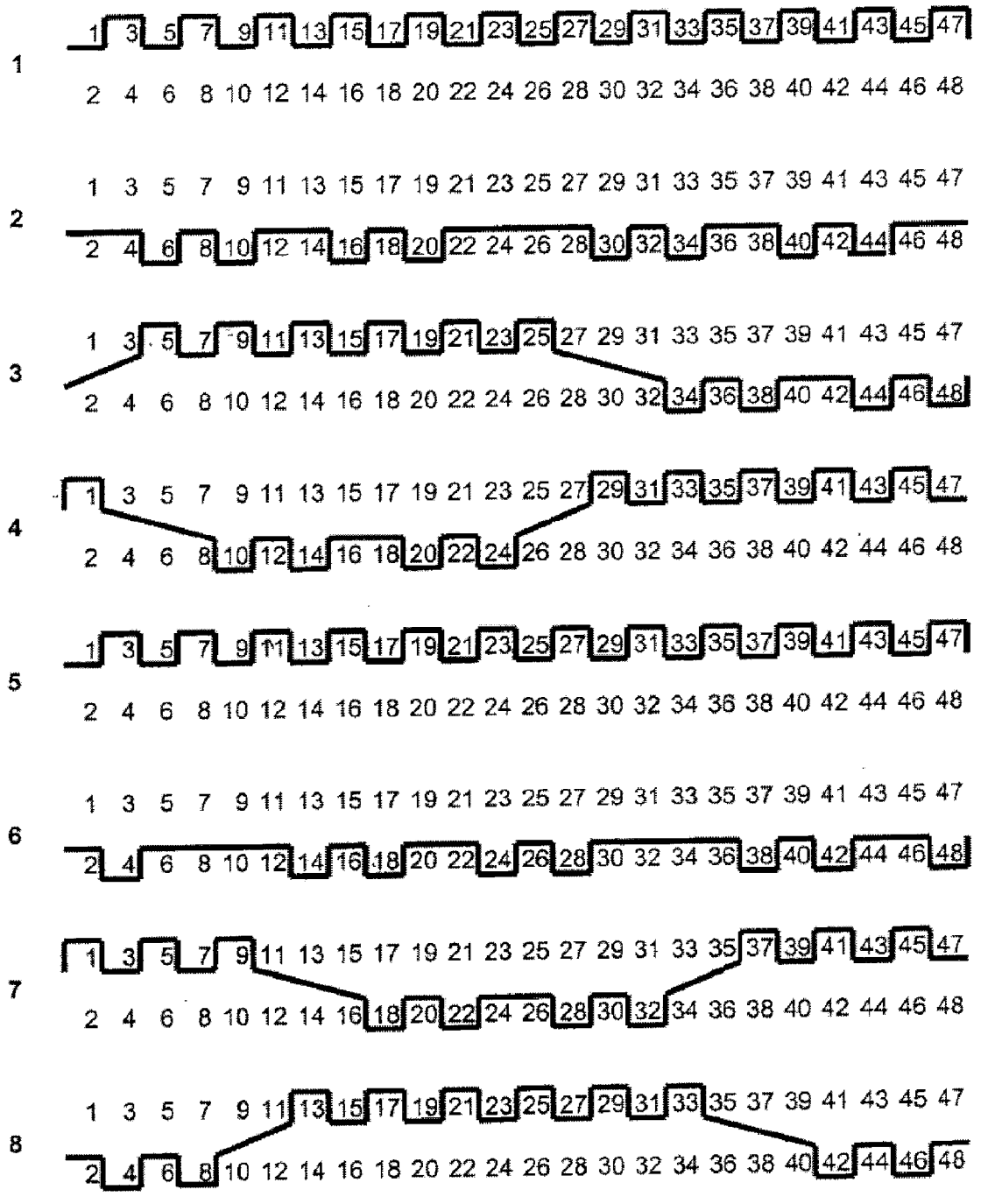
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Fig. 8A

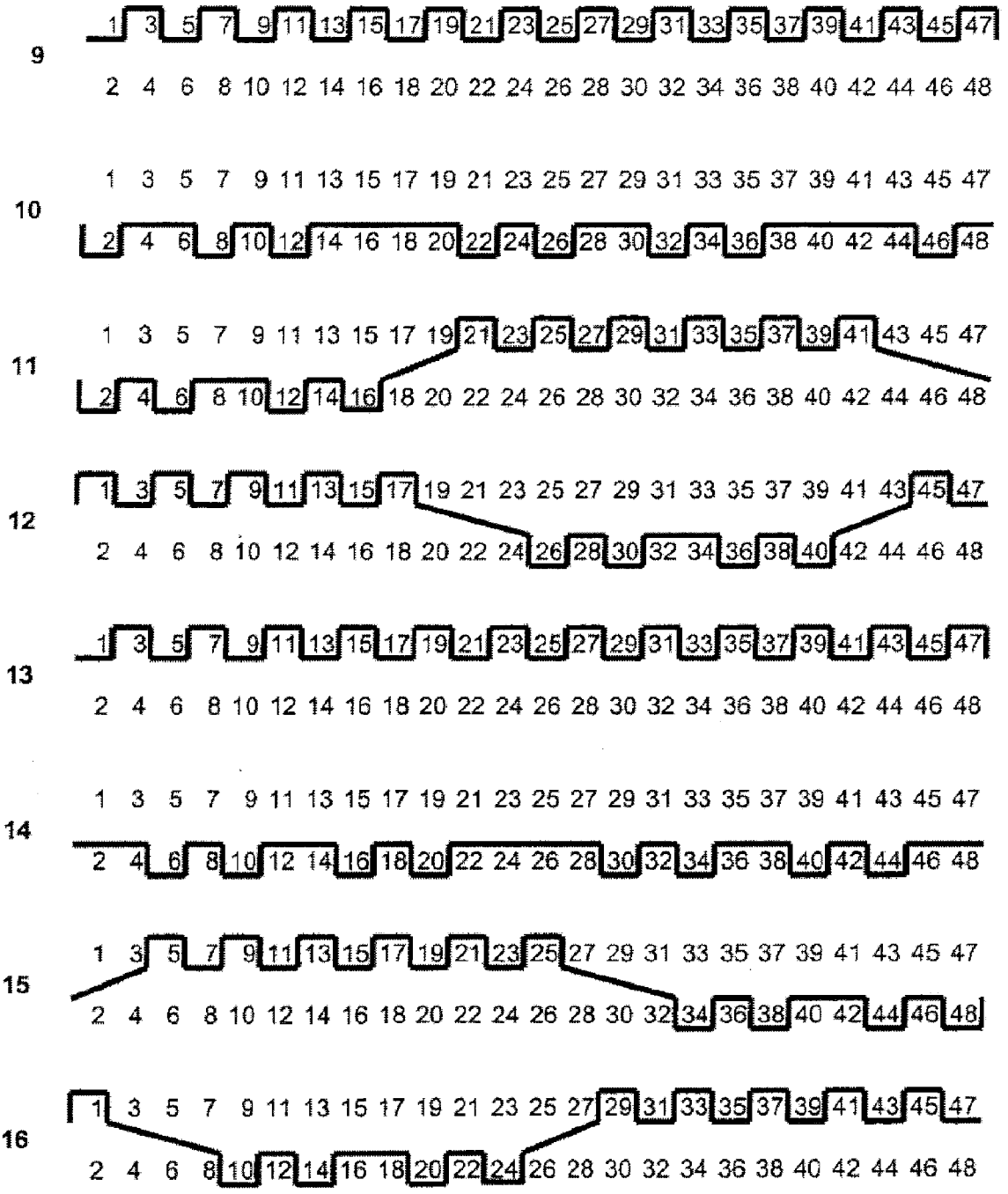
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Fig. 8B

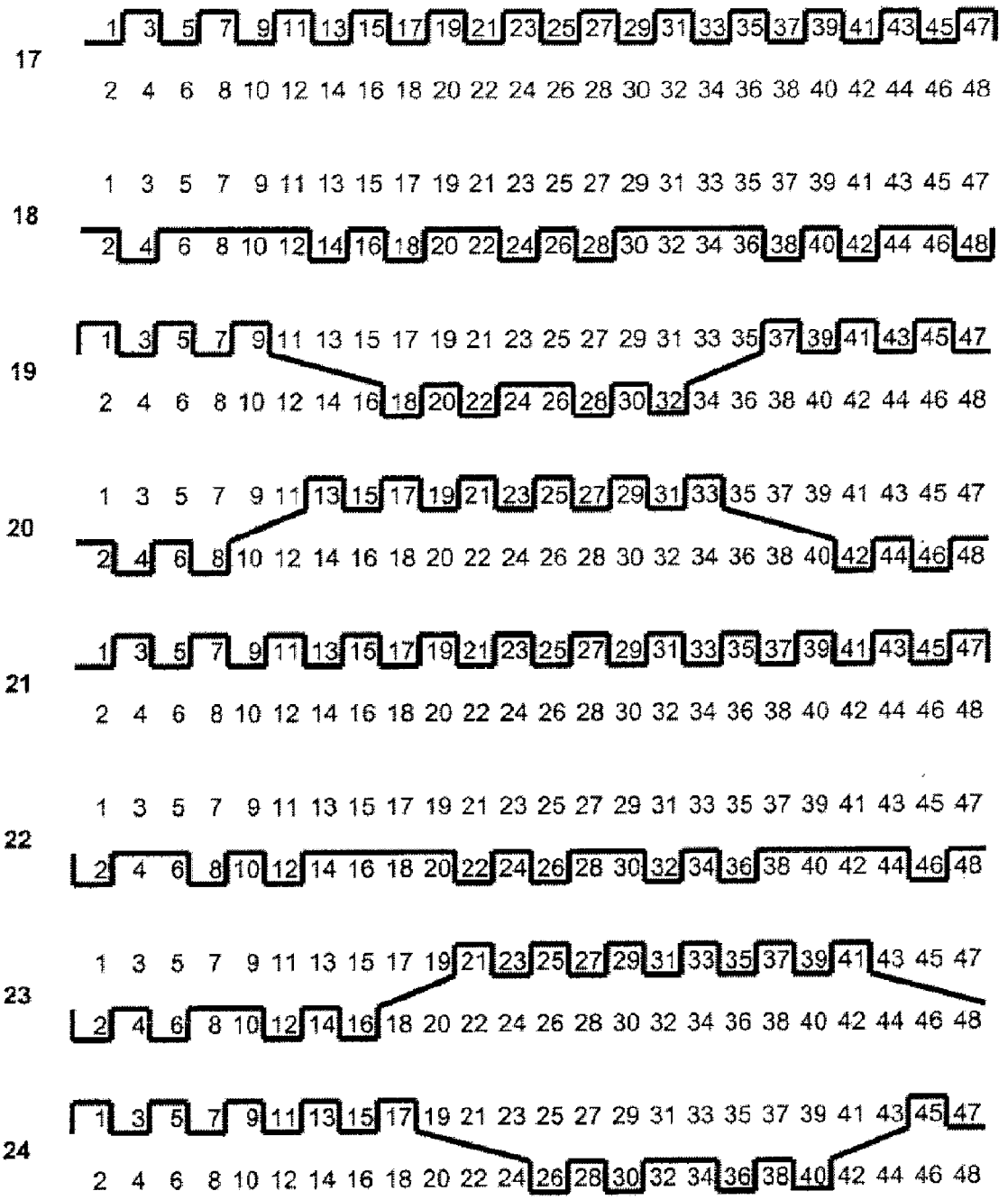
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Fig. 8C

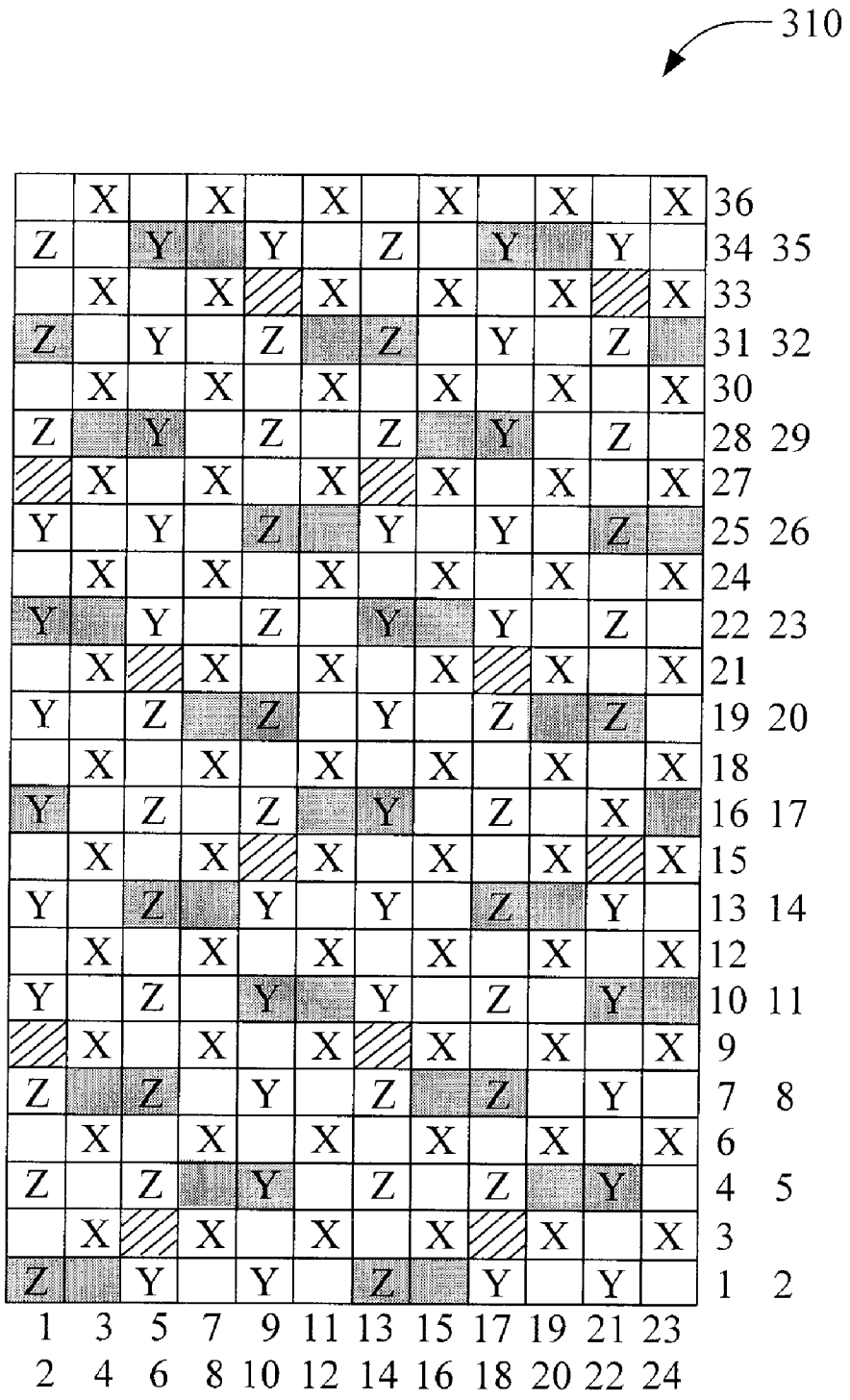
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Fig. 9

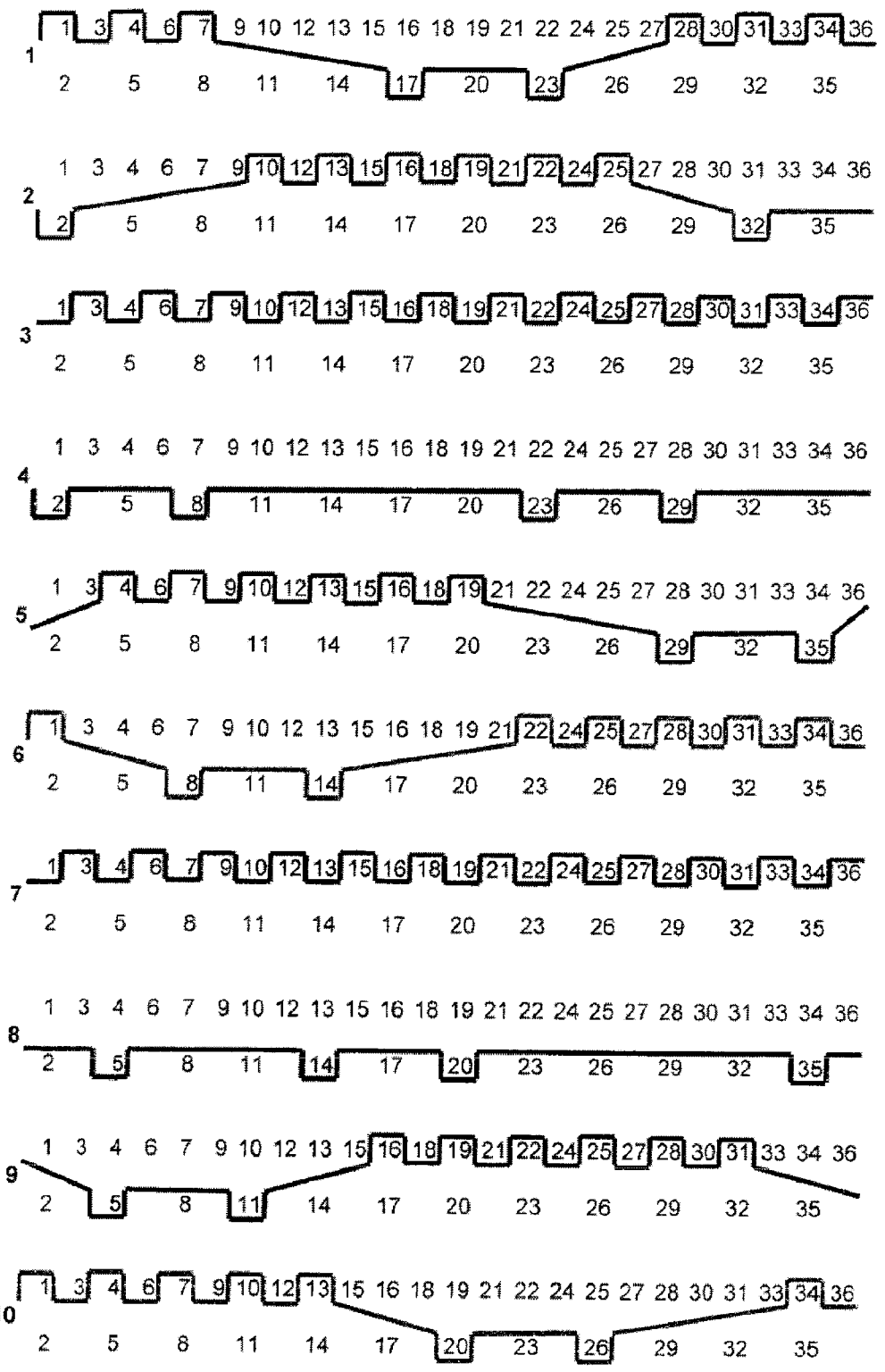
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Fig. 10A

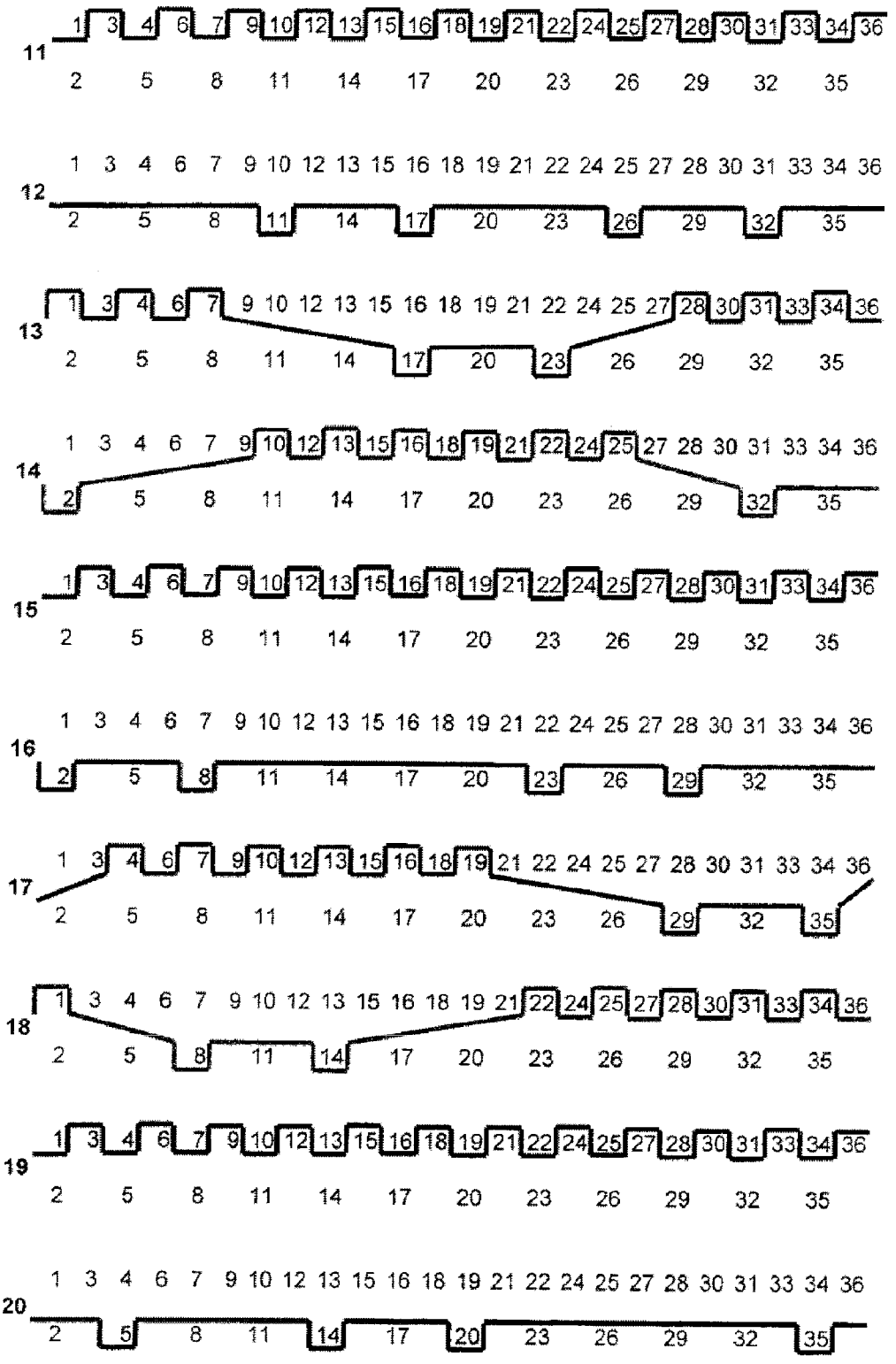
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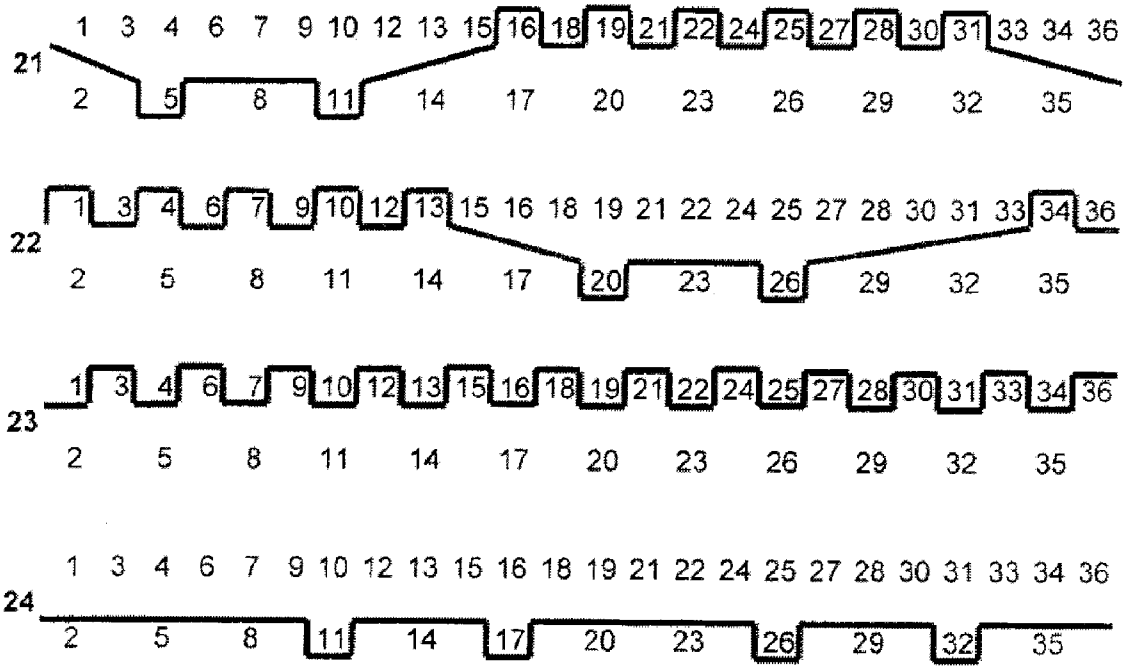
Fig. 10B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2 5 8 11 14 17 20 23 26 29 32 35

Fig. 10C

WEAR SIDE WEAVE PATTERN OF A COMPOSITE FORMING FABRIC

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to compound papermaking fabrics. More specifically, the present invention relates to forming fabrics used in the forming section of a papermaking machine.

[0003] 2. Description of the Related Art

[0004] In the art of papermaking, multiple steps occur from the introduction of a pulp slurry to the output of a finished paper product. The initial introduction of the slurry is at the portion of a papermaking machine known as the wet end. Here, the slurry, or fiber suspension, is initially dewatered when the slurry is introduced onto a moving forming fabric, in the forming section of the papermaking machine. Varying amounts of water is removed from the slurry through the forming fabric, resulting in the formation of a fibrous web on the surface of the forming fabric.

[0005] Forming fabrics address not only the dewatering of the slurry, but also the sheet formation, and therefore the sheet quality, resulting from the formation of the fibrous web. More specifically, the forming fabric must simultaneously control the rate of drainage while preventing fiber and other solid components contained in the slurry from passing through the fabric with the water. The role of the forming fabric also includes conveyance of the fibrous web to the press section of the papermaking machine.

[0006] Additionally, if the drainage occurs to rapidly or too slowly, the quality of the fibrous web is reduced, and overall machine production efficiency is reduced. Controlling drainage by way of fabric void volume is one of the fabric design criteria.

[0007] Forming fabrics have been produced to meet the needs and requirements of the various papermaking machines for the various paper grades being manufactured. As the needs arises to increase production speed of the papermaking machines and the quality of the paper being produced, the need for improved paper machine clothing allowing for increase production rates and improved quality resulted.

[0008] A twill pattern in woven fabrics is where a fabric is woven with a pattern of diagonal ribs. The twill is typically made by passing the weft threads over one warp thread and then under two or more warp threads. In this manner, in a twill weave, each warp or filling yarn floats across two or more filling or warp yarns with a progression of interlacings by one to the right or left, which forms a distinct diagonal line, or wale. A float is defined as the portion of yarn that crosses over two or more yarns from the opposite direction.

[0009] Twill weaves are generally designated as a fraction or ratio, for example 2:1, where the numerator indicates the number of harnesses that are raised, and the denominator indicates the number of harnesses that are lowered.

[0010] A straight twill used in forming fabrics is well known, for example, in FIG. **1** a fabric **10** has a straight twill pattern **14**. This fabric is prone to guide poorly and can lead to curling of the fabric edges. The twill pattern **14** can also "strike through," or cause marking, and can cause drainage, or hydraulic marks on the web being formed on the fabric. Additionally, twill patterns also have the possibility of creating holes on the back of the fabric that are too large, resulting in drainage marks.

[0011] U.S. Pat. No. 5,152,326 (Vöhringer '326) discloses a composite forming fabric having pairs of fabric borne warp binder yarns. However, Vöhringer '326 does not prevent diagonal marking of the web caused by the diagonals present in the weave pattern, and unbroken diagonals are not addressed.

[0012] U.S. Pat. No. 5,544,678 (Barrett '678) discloses different float lengths achieved by using additional or intrinsic binders.

[0013] WO 2004/085740 to Ward discloses the use of varying the warp or weft ratios between the top and bottom layers in order to break up the twill pattern. This break up of the twill pattern occurs only on the paper side surface of the fabric.

SUMMARY OF THE INVENTION

[0014] Accordingly, the present invention is for a fabric used in papermaking, and more particularly, as a forming fabric. In the preferred embodiment, the fabric is a composite multi-layer forming fabric whereby the diagonal twill is broken up on the wear side of the fabric. Also in a preferred embodiment, the warp paths are moved left and right alternatively, disturbing the twill-type pattern.

[0015] One method of breaking up the twill line is to overlap adjacent warp pairs. By offsetting an adjacent warp pair, a gap in the diagonal is created.

[0016] Another method of breaking up the twill line involves the use of four different floats on each warp yarn of three separate lengths. Fabric born binders are used. In contrast, Barrett '678 discloses at least two lengths of float and additional or intrinsic binder.

[0017] In the first methods of breaking up the twill line, the warp pairs stay together.

[0018] In another embodiment of the present invention, all of the warp yarn pairs change pairing to the left and to the right. There can also be a 2:1 weft ratio or a 1:1 weft ratio.

[0019] For example, a fabric for papermaking can have a first side layer, the first side layer having a plurality of first weft yarns and a plurality of first warp yarns; a second side layer, the second side layer having a plurality of second weft yarns and a plurality of second warp yarns; at least one binder warp yarn pair; wherein the first side layer and the second side layer are bound by the binder warp yarn pair; wherein the binder warp yarn pair is an exchange warp pair that exchanges at exchange points; wherein the binder warp yarn pair is woven in binder warp pair yarn groups in a repeating pattern; and wherein each repeating pattern of the binder warp yarn group forms a broken twill pattern.

[0020] Still further, the fabric has a first binder warp yarn pair having a first warp yarn and a second warp yarn; wherein between a first exchange point and a second exchange point of the first warp binder yarn pair, the first warp yarn forming a knuckle on the first side layer, the first side layer knuckle of the first warp yarn adjacent to one of the second warp yarn and an adjacent first side layer first warp yarns. In this manner, one of the binder pairs yarns is moving from its' own pair to the warp yarn on the left or right side of it, in an alternating fashion. This breaks up the twill pattern, and gives the appearance that one of the warp pair yarns is floating from left to right

[0021] It is also understood that there are no limitations to the paper grades or former types where this invention can be applied. It is also understood that the fabric can be woven utilizing either two or three warp beams.

[0022] These and other features and advantages of this invention are described in or are apparent from the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] 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:

[0024] The preferred embodiments of the present inventions will be described in detail, with reference to the following figures, wherein:

[0025] FIG. **1** is a plan view of the prior art;

[0026] FIG. **2** is a weave pattern of a prior art fabric having paired bottom warps;

[0027] FIGS. **3**A-**3**C show the individual weave pattern for each warp yarn of FIG. **2**;

[0028] FIG. **4** shows a weave pattern for a fabric having a 2:1 weft ratio arrangement according to an embodiment of the present invention;

[0029] FIGS. **5**A-**5**C show the individual weave pattern for each warp yarn of FIG. **4**;

[0030] FIG. **6** shows a plan view of the fabric of FIG. **4**;

[0031] FIG. **7** shows a weave pattern for a fabric having a 1:1 weft ratio arrangement according to another embodiment of the present invention;

[0032] FIGS. **8**A-**8**C show the individual weave pattern for each warp yarn of FIG. **7**.

[0033] FIG. **9** shows a weave pattern for a fabric according to another embodiment of the present invention; and

[0034] FIGS. **10**A-**10**C show the individual weave pattern for each warp yarn of FIG. **9**.

[0035] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate embodiments of the invention and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[0036] FIGS. **1**, **2** and **3**A-**3**C show the prior art. In FIG. **1**, a plan view of the wear side of a papermaking forming fabric **10** having paired bottom warps **12**, and shows a diagonal twill **14**.

[0037] In FIG. **2**, the weave pattern for fabric **10** of the prior art having paired bottom warps **12** is shown. FIGS. **3**A-**3**C show the individual weave patterns for each warp yarn of FIG. **2**. Alternate columns of FIG. **2** represent warp yarns that are binder warp yarn pairs **12**. For example, warp yarns marked **16** and **18** are a binder warp yarn pair **12**. Warp yarns **20** and **22** are only associated with either a top fabric **24** or a bottom fabric **26**. Warps marked with an X **28** indicate that a top knuckle is formed. Boxes marked with a Y **30** and Z **32** are binder warp yarn pairs **34**. The cross-hatched boxes **36** indicate where a warp exchange occurs between the binder yarns **30** and **32** of binder warp yarn pair **34**. The gray boxes **38** are where bottom knuckles occur. In a warp pair group **34**, when a binder warp yarn Y **30** occurs in a white box, the binder warp yarn Y **30** is forming a top knuckle. When a binder warp yarn Y **30** is in a gray box **38**, the corresponding binder warp yarn Z **32** is forming a bottom knuckle.

[0038] The same is true of a warp pair group **34**, when a binder warp yarn Z **32** occurs in a white box, the binder warp yarn Z **32** is forming a top knuckle. When a binder warp yarn Z **32** is in a gray box **38**, the corresponding binder warp yarn Y **30** is forming a bottom knuckle.

[0039] FIG. **4** shows a weave pattern for a fabric **110** having a 2:1 weft ratio arrangement according to the present invention FIGS. **5**A-**5**C show the individual weave pattern for each warp yarn of FIG. **4**; and FIG. **6** shows a plan view of the fabric of FIG. **4**, with a broken twill pattern.

[0040] FIGS. **5**A-**5**C depict a cross-sectional view of a triple layer fabric **110** having a 2:1 weft ratio according to the present invention, fabricated on a two beam loom. FIG. **4** depicts the forming side plan view of the same fabric **110**.

[0041] A first weft system **112** is shown above a second weft system **114**. Each weft system **112** and **114** is made up of a plurality of yarns **118**, **120**, **122**. First weft yarn **118** has a first yarn diameter, second weft yarn **120** has a second yarn diameter, and third weft yarn **122** has a third yarn diameter. The first, second and third yarn diameters **118**, **120**, **122** can be the same or different.

[0042] First weft system **112** and second weft systems **114** are bound together by a plurality of warp systems **124**. FIGS. **5**A-**5**C show six warp systems **124** in a repeating pattern. Each warp system **124** has at least one warp yarn (illustrated in the example as having 2 warp yarns per warp system, such as yarns **1** and **2**), and each warp yarn system is woven as shown in FIGS. **5**A-**5**C.

[0043] The weft and warp yarn materials include, but are not limited to mono filament yarns, synthetic or polyester mono filament yarns, twisted mono filament yarns, twisted synthetic or twisted polyester or twisted polyamide mono filament yarns, twisted multi-filament yarns, twisted synthetic or twisted polyester multi-filament yarns, and others. Various yarn profiles can be employed, including but not limited to yarns having a circular cross sectional shape with one or more diameters, or other cross sectional shapes, for example, non-round cross sectional shapes such as oval, or a polygonal cross sectional shapes, for example diamond, square, pentagonal, hexagonal, septagonal, octagonal, and so forth, or any other shape that the yarns may be fabricated into.

[0044] First warp yarn **126** binds the top or first weft system **112**. Second warp yarn **130** binds second weft system **114**. Warp yarns **132** and **134** form what is called an exchange warp. An exchange warp is, for example, when one member of a pair of warp yarns **132** and **134** is weaving with first weft system **112**, and the other member of the pair of warp yarns **132** and **134** is weaving with second weft system **114**. Stated differently, an exchange warp allows for one warp yarn of a pair of warp yarns to weave in alternate fashion such that when the warp yarn **132** is weaving with first weft system **132**, the warp yarn **134** is not weaving with first weft system **112**, and both the warp yarn **132** and warp yarn **134** are not weaving with the same weft system at the same time.

[0045] In the present invention, while depicting a plurality of warp systems **124**, some yarns of the warp systems form exchange warp pairs and some of the warp systems do not form exchange warp pairs. For example, the first warp yarn **126** and warp yarn **130** form the first warp system **128**, which is not an exchange warp pair. In contrast, warp yarn **132** and warp yarn **134** do form an exchange warp pair. Accordingly, when warp yarn **132** crosses warp yarn **134** an exchange warp is formed.

[0046] FIG. **4** depicts the forming side plan view of the triple layer fabric **110** having a 2:1 weft ratio of the present invention. In this example, it can be readily seen that warp yarns **132** and **134** form a warp system, and therefore a warp pair that forms an exchange warp. The warp yarn systems are independent from one another and each have a mesh density that is independent. In FIG. **4** the 'X' notation marks where a knuckle is formed by a warp yarn that is woven exclusively with a weft yarn closest to the forming side. The 'Y' indicates where a knuckle is formed by a warp yarn that is woven with weft yarns on both the forming and the wear side of the fabric. The 'Z' indicates where a knuckle is formed on the paper side of the fabric by another warp yarn and exchanges it's weaving between the weft yarns of both the paper side and wear side of fabric **10**. The shaded boxes indicate where a knuckle is formed by a warp yarn that is woven exclusively with the weft yarns on the wear side of the fabric **10**. The cross-slashed boxes indicate where warp yarns exchange the layer of weft yarns each warp yarn is individually woven with. Since the invention is directed to triple layer of fabric, the side shown is the paper side with the wear side being on opposite side as indicated in FIG. **4**.

[0047] The warp yarns can have different diameters, for example warp yarns **126**, **130**, **132** and **134** can each have a different diameter. The warp yarns and the weft yarns can include monofilament yarns and twisted pair yarns.

[0048] This pattern repeats throughout the forming side plan view. Accordingly, the views in FIGS. **4** and **5**A-**5**C show a pattern. That is repeated every 36 weft yarns in the machine direction and every 12 warp yarns in the cross-machine direction, resulting in a broken twill pattern.

[0049] FIGS. **7** and **8**A-C depict a cross-sectional view of a triple layer fabric **210** having a 1:1 weft ratio according to another embodiment of the present invention. FIG. **7** depicts the forming or paper side plan view of the triple layer fabric. As in FIGS. **4** and **5**A-**5**C, the second set of warp yarns form an exchange warp pair. The difference is that the warp yarns have a different weave pattern.

[0050] FIGS. **8**A-**8**C depict a cross-sectional view of a triple layer fabric having a 1:1 weft ratio. Twenty-four warp yarns and forty-eight weft yarns are shown with the designations of the boxes of FIG. **7** being the same as for FIG. **4**.

[0051] FIGS. **9** and **10**A-C depict a cross-sectional view of a triple layer fabric **310** according to another embodiment of the present invention. FIG. **9** depicts the forming or paper side plan view of the triple layer fabric. The first, third, fifth, seventh, ninth and eleventh set of warp yarns each form an exchange warp pair. The warp yarns again have a different weave pattern from those described above.

[0052] FIGS. **10**A-C depict a cross-sectional view of the fabric illustrated in FIG. **9**. Twenty-four warp yarns and thirty-six weft yarns are shown with the designations of the boxes of FIG. **9** being the same as those for FIGS. **4** and **7** as described above.

[0053] On at least one side of the fabric, knuckles are formed by the weaving of a binder warp yarn with alternating adjacent non-binder warp yarns. This causes the knuckles to alternate back and forth as can be seen by the shaded blocks of FIGS. **4**, **7** and **9**. This is in contrast to the prior art as illustrate in FIG. **2** where the knuckles do not alternate. This pattern continues as the yarns of the binder warp yarn pair exchange their weaving with the first and second layers of the fabric. As can be seen in the figures in some cases no more than four knuckles are formed in this manner between exchange points. In other patterns of the present invention no more than two knuckles are formed between exchange points.

[0054] The invention as it has been described can be fabricated on a three beam loom. Likewise, the triple layer fabric of the present invention can also be fabricated on a four beam loom. Use of four beams could result in similar fabrics, with the addition of at least one of a top only warp, a bottom only warp, a bottom warp that binds at the second weft system, and a top pair that bind with the second weft system.

[0055] 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 fabric for papermaking, comprising:

a first side layer, having a plurality of first weft yarns and a plurality of first warp yarns;

a second side layer having a plurality of second weft yarns and a plurality of second warp yarns; and

at least one binder warp yarn pair including a first binder warp yarn pair having a first binder warp yarn and a second binder warp yarn, the first side layer and the second side layer being bound by the first binder warp yarn pair, the first binder warp yarn and the second binder warp yarn exchanging the layer to which they are woven at exchange points, a knuckle being formed with the first binder warp yarn and an adjacent first warp yarn, a subsequent adjacent knuckle only being formed with the first binder warp yarn and an opposite adjacent first warp yarn.

2. The fabric for papermaking of claim **1**, wherein no more than four knuckles are formed between exchange points on the first layer along the binder warp yarn pair.

3. The fabric for papermaking of claim **1**, wherein no more than two knuckles are formed between exchange points on the first layer along the binder warp yarn pair.

4. The fabric for papermaking of claim **1**, wherein the knuckle is a first knuckle, the subsequent adjacent knuckle is a second knuckle, the second knuckle being the last knuckle prior to an exchange point, after the exchange point the second binder yarn forms a third knuckle with the adjacent first warp yarn.

5. The fabric for papermaking of claim **4**, wherein the second binder yarn forms a fourth knuckle with the opposite adjacent warp yarn.

6. The fabric for papermaking of claim **5**, wherein on the first layer side the at least one binder warp pair only has alternating knuckles in a repeating pattern.

7. The fabric for papermaking of claim **1**, wherein at least one of the plurality of first weft yarns and the plurality of second weft yarns include a first yarn having a first diameter a second yarn having a second diameter and a third yarn having a third diameter.

8. The fabric for papermaking of claim **7**, wherein at least one of the plurality of first warp yarns, the plurality of second warp yarns and the at least one binder warp yarn pair include

a warp yarn having a diameter different than the first diameter, the second diameter and the third diameter.

9. The fabric for papermaking of claim **1**, wherein the warp yarn and the weft yarns include at least one of a monofilament yarn and a twisted pair yarn.

10. The fabric for papermaking of claim **1**, wherein the fabric is fabricated using a loom having at least three warp beams.

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