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(54) **Forming fabrics**

(57) A forming fabric has a paperside warp layer and a machine side warp layer. The fabric comprises at least one set of machine side wefts and at least one set of weft triplets, the weft triplets together forming two continuous weft paths on the paperside. Only one external

member of the weft triplets interweaves with at least some paperside warps and at least some machine side warps.

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Description

[0001] The present invention relates to fabrics employed in web forming equipment, such as papermaking and non-woven web forming equipment. More particularly, the preferred fabrics of this invention are employed as forming fabrics in web forming equipment; most preferably in papermaking machines.

[0002] Paper is conventionally manufactured by conveying a paper furnish, usually consisting of an initial slurry of cellulosic fibres, on a forming fabric or between two forming fabrics in a forming section, the nascent sheet then being passed through a pressing section and ultimately through a drying section of a papermaking machine. In the case of standard tissue paper machines, the paper web is transferred from the press fabric to a Yankee dryer cylinder and then creped.

[0003] Papermachine clothing is essentially employed to carry the paper web through these various stages of the papermaking machine. In the forming section the fibrous furnish is wet-laid onto a moving forming wire and water is encouraged to drain from it by means of suction boxes and foils. The paper web is then transferred to a press fabric that conveys it through the pressing section, where it usually passes through a series of pressure nips formed by rotating cylindrical press rolls. Water is squeezed from the paper web and into the press fabric as the web and fabric pass through the nip together. In the final stage, the paper web is transferred either to a Yankee dryer, in the case of tissue paper manufacture, or to a set of dryer cylinders upon which, aided by the clamping action of the dryer fabric, the majority of the remaining water is evaporated.

[0004] So called "triple layer" papermachine fabrics are known in the art. These generally comprise paper side and machine side warp and weft yarn systems, which are bound together by binder yarns.

[0005] US 5,437,315 discloses a triple-layer fabric with binding weft yarns wherein the binding weft knuckle replaces the knuckle of the paper side weft yarn when the former weaves in the paper side fabric. The only embodiment disclosed in US 5,437,315 shows each binder making a single knuckle in the weave repeat of the paper side. This invention avoids blocking areas of the paper side fabric by not having paper side and binder weft knuckles lying adjacent to each other. However, because only a single paper side weft knuckle is replaced there is limited opportunity for the said paper side weft to provide a straight section of yarn, bound at both sides by interlacing with paper side warp yarns, with which to increase fabric cross-machine direction (CD) bending stiffness and thereby better control paper sheet profiles.

[0006] US 6,354,335 B1 discloses a triple layer fabric in which the paperside yarn system contains so called "substitute" wefts which replenish the yarn paths of two adjacent binder wefts at the points where they engage the machine side warps. These replenishing yarns weave with the paperside warps only and not with the

machine side warps. As with US 5,437,315, duplicate binder and paper side weft knuckles are avoided. However, due to the bind-substitute-bind combination there is, once again, limited opportunity for the matching substitute and binder wefts to provide a lengthy straight section of yarn, bound at both sides by interlacing with paper side warp yarns, with which to increase fabric CD bending stiffness and thereby better control paper sheet profiles.

[0007] The present invention has been made from a consideration of this problem.

[0008] According to the present invention there is provided a forming fabric having a paperside warp layer and a machine side warp layer, the fabric comprising at least one set of machine side wefts and at least one set of weft triplets, the weft triplets together forming two continuous weft paths on the paperside, wherein only one external member of said set of weft triplets interweaves with at least some paperside warps and at least some machine side warps.

[0009] A weft triplet is herein defined as a weft yarn belonging to a group of three weft yarns. Each weft triplet is either an external or central member of the group of three weft yarns wherein one external triplet member and the internal triplet member form one continuous paperside weft path and the internal triplet member and the remaining external triplet member form a second continuous weft path in the fabric paperside which lies adjacent the first continuous weft path of the triplets. The triplet group members are either interchanging top weft yarns, in which case they interlace with paper side warp yarns only, or they are interchanging binder wefts, in which case they interlace with both paper side and machine side (wear side) warp yarns at some stage in the weave repeat. In the fabrics of the invention it is preferred that at least some triplet groups have only one external member which binds to at least one warp yarn in the machine side fabric layer.

[0010] One or more further triplet groups may be included in the fabric. For example triplet groups wherein all members bind to the wear side and/or triplet groups wherein only both external members bind to the wear side may also be included.

[0011] The triple layer fabrics of the invention are stable and have good cross machine direction (CD) bending stiffness with which to control sheet profiles as groups of three weft triplets incorporate two interchanging top wefts to thereby provide stiffening sections. Where two yarns interchange to form a single continuous paper side weft path the yarn not forming the paper side path may float between the paper side and wear side layers to provide a straight length of yarn with which to stiffen the fabric. This straight length of yarn or so called "stiffening section" is ideally bound at either end by interlacing with either two warp yarns in the paper side layer or with two warp yarns from the wear side layer.

[0012] Preferably the fabric of the present invention

has a 20 warp repeat or greater. Preferred examples of warp repeat sizes could also be 24 shaft, or greater. The machine side wefts may, for example, make a single binding with the machine side warps over a five warp repeat. However, other weaveside weave patterns can be used, for example six shaft repeat with single interlacing or an eight or ten shaft with multiple non-adjacent warp-weft interlacings.

[0013] In some embodiments of the invention the fabric preferably further comprises a further set of wefts which bind only with the paperside warps, ideally in a plain weave.

[0014] In order that the present invention may be more readily understood, specific embodiments thereof will now be described by way of illustration only with reference to the accompanying drawings in which:-

Fig. 1 is a series of warp cross-sectional diagrams showing the consecutive weft paths of a number of wefts in accordance with the embodiment shown in prior art US 5,437,315;

Fig. 2 is a series of warp cross sectional diagrams showing consecutive weft paths of a number of wefts in a first fabric in accordance with the present invention;

Fig. 3 is a series of warp cross sectional diagrams showing consecutive weft paths of a number of wefts in a second fabric in accordance with the present invention;

Fig. 4 is a series of warp cross sectional diagrams and tables showing all of the weft paths of a third fabric in accordance with the present invention.

[0015] Referring to Fig. 1 a fabric in accordance with US 5,437,315 has a twenty warp yarn repeat.

[0016] Each of the diagrams shown in Fig. 1 shows the twenty yarn warp repeat. There is a 1:1 paper side to wear side warp ratio, comprising machine side warps (1, 3, 5, 7, 9, 11, 13, 15, 17, 19) and paper side warps (2, 4, 6, 8, 10, 12, 14, 16, 18, 20).

[0017] The weft yarns fall into four categories. The first set of weft yarns, as exemplified by wefts B1,B2,B3 bind only with the machine side warps, the weave repeat being over five machine side or wear side yarns, binding with every fifth wear side warp yarn. Thus the fabric has a so-called five shaft back.

[0018] The second set of weft yarns, as exemplified by wefts T1,T2,T3 bind continuously only with the paper side warps, to form complete weave repeats in over-under fashion. Thus the fabric has a so-called plain weave face.

[0019] The remaining wefts form interchanging pairs for example yarns I1&I2. In each pair there is one binder and one interchanging top weft such that the binder re-

places the top weft when it moves into the paper side fabric surface. In pair I1&I2 the binder I2 replace the top weft I1 over warp 17 allowing the top weft I1 to float between the two fabric layers and under three adjacent top warps 15,17,19 to form a stiffening section bound at either end by warp 13 and 1 respectively. It can also be seen in interchanging pair I1&I2 that the binder member floats extensively between the upper and lower fabric layers before weaving into the said upper and lower fabric layers such that the fabric layers may be relatively loosely bound. This feature is different from the stiffening sections of yarns in the invention wherein the stiffening section of yarn is bound on either end by interlacing with warp in the same fabric layer. The loose binding of the prior art structure may contribute to high fabric thickness such that high void space may fill with water during sheet production only to rewet the sheet near the end of the forming zone such that the performance of the papermaking machine is impaired.

[0020] Referring now to Fig. 2 a partial representation of fabric in accordance with the invention has a twenty warp yarn repeat. Each of the diagrams shown in Fig. 2 shows the twenty yarn warp repeat. There is a 1:1 paper side to wear side warp ratio, comprising machine side warps (1, 3, 5, 7, 9, 11, 13, 15, 17, 19) and paperside warps (2, 4, 6, 8, 10, 12, 14, 16,18,20).

[0021] The weft yarns fall into three categories. The first set of weft yarns, as exemplified by wefts B1,B2... B6 bind only with the machine side warps, the weave repeat being over five machine side or wear side yarns, binding with every fifth wear side warp yarn. Thus the fabric has a so-called five shaft back.

[0022] The second set of weft yarns, as exemplified by wefts IT1,IT2 bind only with the paper side warps in the paper side fabric where they interchange positions to form complete weave repeats in over-under fashion. Thus the fabric has a so-called plain weave face. However, although yarns IT1,IT2 provide one continuous weft path of plain weave, the next continuous weft path of plain weave is provided by interchanging top weft IT2 co-operating with interchanging binder IB1 such that weft triplet group 1 contains yarns IT1,IT2, & IB1 which between them provide two adjacent and continuous paths of plain weave in the paper side fabric.

[0023] Reference will only be made to weft triplet group WTG1 as the other triplet groups utilise the same technique and have similar features to group WTG1. In each triplet group, as demonstrated in group WTG1, there are two adjacent interchanging top wefts IT1, IT2 which between them complete a continuous path of plain weave. There is thereby provided a stiffening section of three warps duration (16,18, &20) by yarn IT1. Yarn IT2 provides two stiffening sections from warps 10 to 16 and from warps 20 to 6 respectively. The stiffening sections of IT2 are interrupted at paper side warp 8 as yarn IT2 must reappear in the top fabric to replace the binder yarn IB1. As is shown one of the two external members of each group is a binder which, because it

must appear in the machine side (wear side) layer at some stage, can only give an incomplete weave in the paper side. Thus the central member of each group, which in Fig. 2 is always a top weft, is used to complete the paper side weft path partly filled by the binder. Unlike the fabric of US 5,437,315 it is possible in the invention for interchanging binders and interchanging top wefts to both contribute to the paper side weave in the same region. IT2 must interlace with warp 18 to complete a path of plain weave with IT1. However, adjacent to IT2, the binder IB1 forms a plain weave pattern with warps 12,14,16,18,20 thus the binder does not replace the top weft where it weaves in the paper side. The binder IB1 is itself replaced by the top weft IT2 at warp 8 when the binder IB1 moves to the wear side fabric to bind with warp 7.

[0024] It is noted that the Fig. 2 fabric has a 1:1 effective paperside to wearside weft ratio. It is further noted that "reversing" of adjacent triplet groups is possible in that one outer triplet of each triplet group will be an interchanging binder yarn which may be inserted as the first yarn in the group or as the last yarn in the group. Reversing is a technique used in the weaving of fabrics to break up twill patterns. Such patterns manifest themselves in the paper formed in the fabric and are considered to be undesirable.

[0025] It is further noted that in Fig. 2 the wear side knuckle of the binder yarns are locked in position by the action of adjacent wear side warp and weft interlacings. For example IB1 binds on warp 7 where it is locked in place on one side by the action of adjacent weft B1 with warp 9 and on the other side by the action of weft B2 with warp 5. However, it is not a necessity of the invention that the binder knuckles are so locked on the fabric wear side and any suitable position may be chosen for the binder knuckle in the wear side fabric.

[0026] Referring to Fig. 3 a partial representation of a second triple layer fabric in accordance with the invention has a twenty warp yarn repeat.

[0027] Each of the diagrams shown in Fig. 3 shows the twenty warp repeat. There is a 1:1 paper side to wear side warp ratio, comprising machine side warps (1, 3, 5, 7, 9, 11, 13, 15, 17, 19) and paper side warps (2, 4, 6, 8, 10, 12, 14, 16, 18, 20).

[0028] Unlike Fig. 2 the weft yarns shown in Fig. 3 fall into four categories as, in addition to back weft, interchanging top weft, and interchanging binder weft, there are provided top wefts which each make a complete paper side weft path. The first set of weft yarns, as exemplified by wefts B1,B2,B3 bind only with the machine side warps, the weave repeat being over five machine side or wear side yarns, binding with every fifth wear side warp yarn. Thus the fabric has a so-called five shaft back.

[0029] The second set of weft yarns, as exemplified by wefts IT1,IT2 bind only with the paper side warps in the paper side fabric where they interchange positions to form complete weave repeats in over-under fashion.

Thus the fabric has a so-called plain weave face. However, although yarns IT1,IT2 provide one continuous weft path of plain weave, the next continuous weft path of plain weave is provided by interchanging top weft IT2 co-operating with interchanging binder IB1 such that weft triplet group WTG1A contains yarns IT1,IT2, & IB1 which between them provide two adjacent and continuous paths of plain weave in the paper side fabric.

[0030] In the triplet group shown at WTG1A, there are two adjacent interchanging top wefts IT1 and IT2 which between them complete a continuous path of plain weave. There is thereby provided a stiffening section of 5 warps duration (4,2, 20,18,&16) by yarn IT1. Yarn IT2 provides two stiffening sections from warps 6 to 4 and from warps 10 to 16 respectively. The stiffening sections of IT2 are interrupted at paper side warp 8 as yarn IT2 must reappear in the top fabric to replace the binder yarn IB1 as it descends to bind with wear side warp 7. As is shown one external member of each group is a binder which, because it has to appear in the wear side layer at some stage, can only give an incomplete weave in the paper side. Thus the central member of each group, which is always a top weft in Fig. 3, is used to complete the paper side weft path partly filled by the binder.

[0031] It is noted that the Fig. 3 fabric has a 2:1 effective paper side to wear side weft ratio. It is further noted that "reversing" of adjacent triplet groups occurs in that the number of weft knuckles made in the paper side by the adjacent yarns IT1,IT2, & IB1 in group 1A are 3,3,& 4 respectively whereas in group WTG2A it is reversed such that yarns IT3,IT4, & IB2 make 4,3,&3 paper side knuckles respectively. It would also be possible to insert IB2 prior to IT3 and IT4 to achieve a reversing effect although the respective interlacings of all yarns would require adjustment.

[0032] In Fig. 3, as with Fig. 2, the wear side knuckle of the binder yarns are locked in position by the action of adjacent wear side warp and weft interlacings. As with Fig. 2 it is not a necessity of the invention that the binder knuckles are so locked on the fabric wear side and any suitable position may be chosen for the binder knuckle in the wear side fabric.

[0033] Returning to Fig. 2 it can be seen that the central members of each triplet group contribute only 1 weft knuckle to the adjacent weft paths e.g. IT2 in group WTG1 provides a knuckle on warp 18 to complete the first path with IT1 and IT2 also provides a knuckle on warp 8 to complete the second path with IB1. Thus IT2 provided relatively long stiffening sections when compared to the central members in Fig. 3 where, because of contributing an additional weft knuckle to one adjacent path, one stiffening section is shortened in length.

[0034] Referring to Fig. 4 a full representation of a further triple layer fabric in accordance with the invention has a twenty warp repeat.

[0035] Each of the diagrams shown in Fig. 4 shows the twenty warp repeat. There is a 1:1 paper side to wear side warp ratio, comprising machine side warps

(1, 3, 5, 7, 9, 11, 13, 15, 17, 19) and paper side warps (2, 4, 6, 8, 10, 12, 14, 16, 18, 20).

[0036] As with Fig. 3 weft yarns in Fig. 4 fall into four categories as, in addition to back weft, interchanging top weft, and interchanging binder weft, there are provided top wefts which each make a complete paper side weft path. The first set of weft yarns, as exemplified by wefts B1,B2,B3....B30 bind only with the machine side warps, the weave repeat being over five machine side or wear side yarns, binding with every fifth wear side warp yarn. Thus the fabric has a so-called five shaft back.

[0037] The second set of weft yarns, as exemplified by wefts IT1,IT2.....IT20 bind only with the paper side warps in the paper side fabric where they interchange positions to form complete weave repeats in over-under fashion. Thus the fabric has a so-called plain weave face. However, although yarns such as IT1,IT2 provide one continuous weft path of plain weave, the next continuous weft path of plain weave is provided by interchanging top weft IT1 co-operating with interchanging binder IB1 such that weft triplet group WTG1B contains yarns IT1,IT2, & IB1 which between them provide two adjacent and continuous paths of plain weave in the paper side fabric.

[0038] In the triplet group shown at WTG1B, there are two adjacent interchanging top wefts IT1, IT2 which between them complete a continuous path of plain weave. There is thereby provided a stiffening section of 5 warps duration (15,17,19,1,3) by yarn IT2. Yarn IT1 provides two stiffening sections from warp 3 to 5 and from warp 13 to 15 respectively. The stiffening sections of IT1 are interrupted at paper side warps 7,9, &11 as yarn IT1 must reappear in the top fabric to replace the binder yarn IB1 as it descends to bind with wear side warp 10. As is shown in group 1B one external member of each triplet group is a binder which, because it has to appear in the wear side layer at some stage, can only give an incomplete weave in the paper side. Thus the central member of each triplet group, which is always a top weft in Fig. 4, is used to complete the paper side weft path partly filled by the binder.

[0039] It is noted that the Fig. 4 fabric has a 4:3 effective paper side to wear side weft ratio. It is further noted that no "reversing" of adjacent triplet groups occurs in that the number of weft knuckles and the functions of the external members of adjacent groups do not vary. However, this is not a requirement of the invention and both such features may be varied in fabric according to the invention.

[0040] In Fig. 4, the wear side knuckle of the binder yarns are locked in position by the action of adjacent wear side warp and weft interlacings. As with the prior embodiments it is not a necessity of the invention that the binder knuckles are so locked on the fabric wear side and any suitable position, or positions for multiple interlacings, may be chosen for the binder knuckle(s) in the wear side fabric.

[0041] It is to be understood that the above described

embodiments are by way of illustration only. Many modifications and variations are possible.

[0042] Although all embodiments show each triplet group to contain two interchanging top wefts and one interchanging binder, it is possible to make embodiments of the invention wherein one or more of the triplet groups utilise either three interchanging binder wefts and/or two interchanging binders with a central interchanging top weft.

[0043] Various "effective" paperside to wearside weft ratios can be used 1:1, 2:1, 4:3 as shown but also others, for example, 3:2, 3:1 and so forth. The selected "effective" paperside to wearside weft ratio is a trade off between optimising the fabric paperside properties and optimising the fabric wearside properties.

[0044] Similarly the ratio of warp in the paperside and wearside fabrics may be chosen from the group including 1:1, 2:1, 3:1, 3:2, 4:3.

[0045] In all the disclosed embodiments the external binders have a single wearside knuckle each. This is not an essential feature of the invention. The wearside binding frequency may be the same for the binder in each set of triplets or at least one triplet may have a binder with a different number of wearside interlacing from the other triplets.

[0046] Similarly paperside interlacing frequency and type of interlacings may vary for the interchanging top weft yarns in at least one triplet set compared to another within the same fabric.

[0047] The material chosen for the triplet members may be the same or different for the respective functional (i.e. central or external) triplet members to allow optimising of properties such as paperside surface smoothness, or binding integrity of the fabric.

Claims

1. A fabric having a paperside warp layer and a machine side warp layer, the fabric comprising at least one set of machine side wefts and at least one set of weft triplets, the weft triplets together forming two continuous weft paths on the paperside, wherein only one member of said set of weft triplets interweaves with at least some paperside warps and at least some machine side warps.
2. A fabric as claimed in claim 1, wherein the fabric has a 20 warp repeat or greater.
3. A fabric as claimed in claim 2, wherein the fabric has a 20 warp repeat.
4. A fabric as claimed in claim 2, wherein the fabric has a 24 warp repeat.
5. A fabric as claimed in claim 1, wherein the machine side wefts make a single interlacing with the ma-

chine side warps over a 5 shaft or 6 shaft repeat.

6. A fabric as claimed in one of the preceding claims, wherein the machine side warps make multiple non-adjacent interlacings with the machine side wefts over an eight or ten shaft repeat. 5
7. A fabric as claimed in one of the preceding claims, wherein the fabric further comprises a further set of wefts which bind only with the paperside warps. 10
8. A fabric as claimed in one of the preceding claims, wherein the further set of wefts bind with the paperside warps in a plain weave. 15
9. A fabric as claimed in one of the preceding claims, wherein the two members of said triplet set which do not interweave with at least some paperside warps provide stiffening sections. 20
10. A fabric as claimed in one of the preceding claims, wherein the stiffening sections extend under at least two paperside warp yarns.
11. A fabric as claimed in one of the preceding claims, wherein the fabric includes at least one further triplet set comprising two interchanging binder yarns and one interchanging top weft member. 25
12. A fabric as claimed in one of the preceding claims, wherein the fabric includes at least one further triplet set comprising three interchanging binder yarns. 30
13. A fabric as claimed in one of the preceding claims, wherein the paperside weave comprises a plain weave, a twill weave or a sateen weave. 35
14. The use of a fabric as claimed in any preceding claim as a forming fabric. 40

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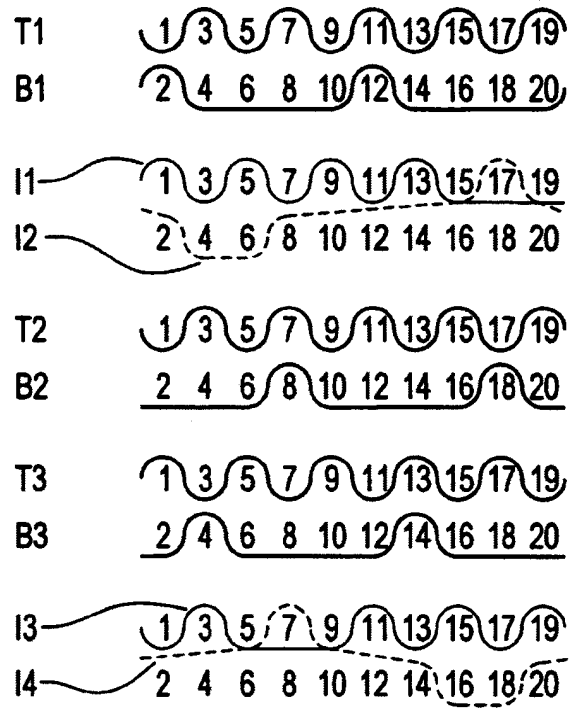


Fig.1

Prior Art

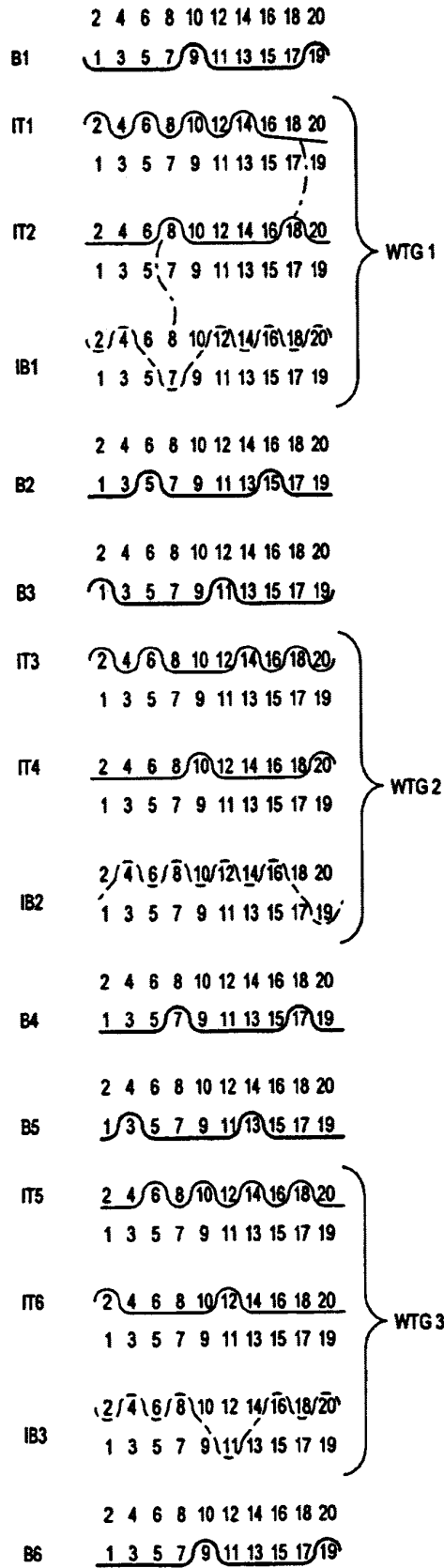


Fig.2

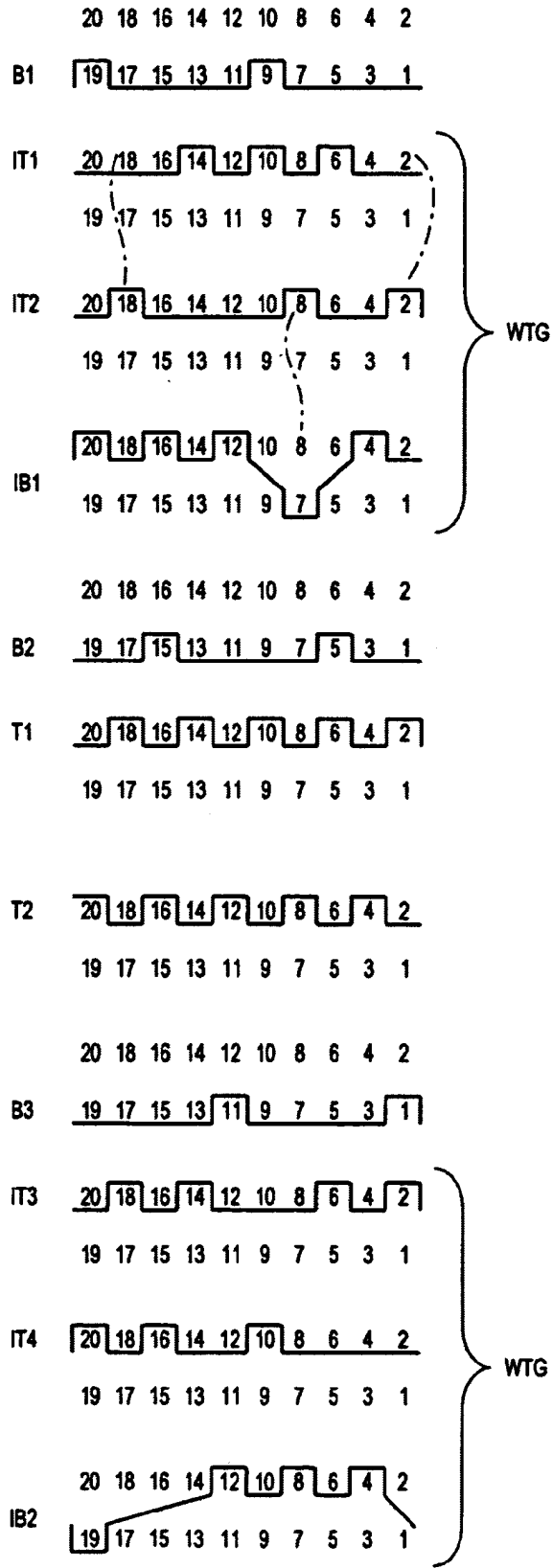


Fig.3

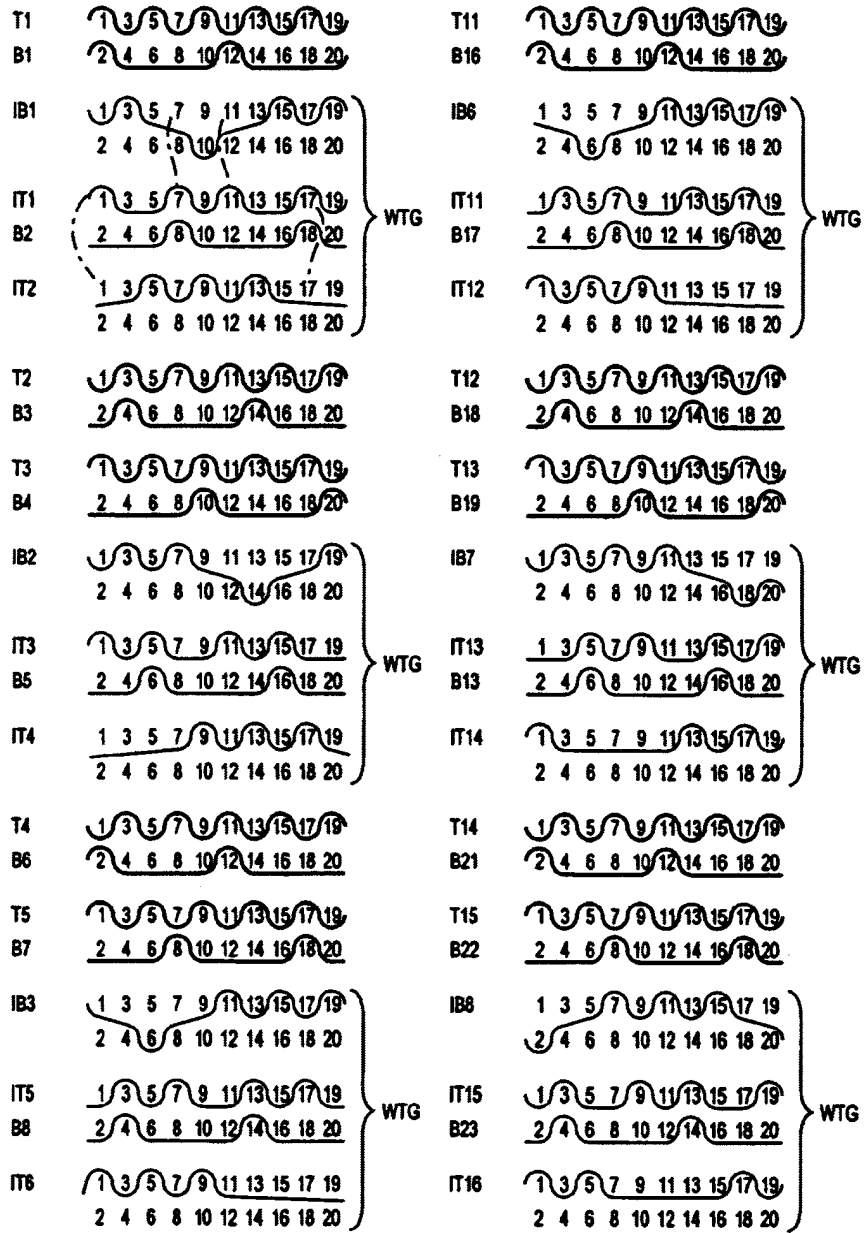


Fig.4

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