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Canadian Intellectual Property Office
An agency of Industry Canada

CA 2634432 A1 2009/12/09

(21) 2 634 432

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2008/06/09

(41) Mise à la disp. pub./Open to Public Insp.: 2009/12/09

(51) Cl.Int./Int.Cl. *D21F 7/08* (2006.01), *D03D 1/00* (2006.01), *D03D 13/00* (2006.01), *D03D 15/00* (2006.01), *D03D 25/00* (2006.01), *D21F 1/10* (2006.01)

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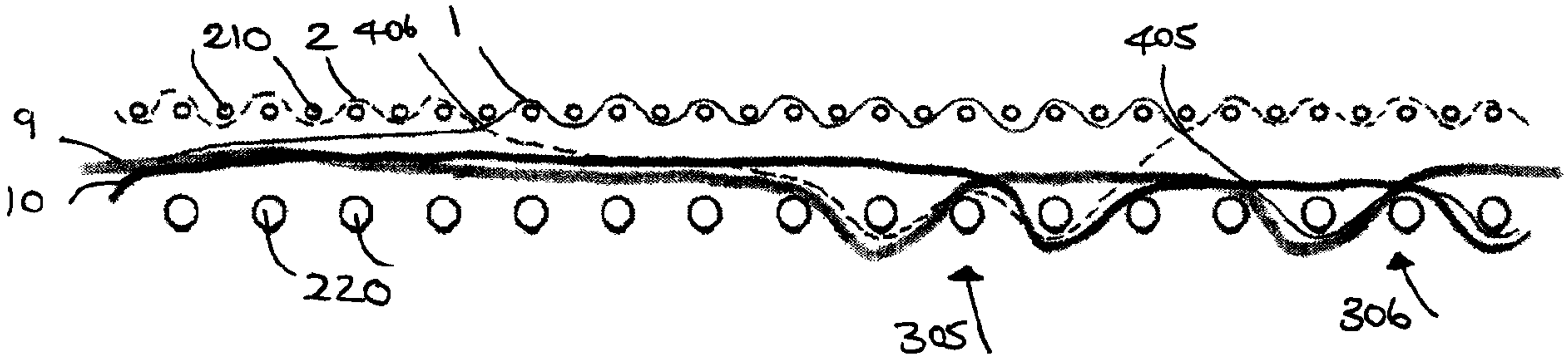
(54) Titre : TOILE A TEXTURE COMPOSITE A FIL DE CHAINE DE LIAGE INTRINSEQUE AVEC SUPPORT A HAUTE TENEUR EN FIBRES

(54) Title: HIGH FIBER SUPPORT INTRINSIC WARP TIED COMPOSITE FORMING FABRIC



HIGH FIBER SUPPORT INTRINSIC WARP TIED COMPOSITE FORMING FABRIC

FIELD OF THE INVENTION

This invention relates to industrial woven fabrics for filtration in formation of a cellulosic fibrous sheet, in particular to papermakers' forming fabrics, the fabrics providing high fiber support, and improved drainage properties. In particular, the invention relates to a warp-tied fabric, in which all the warp yarns of the sheet side comprise intrinsic binder pairs or triplets, and having a high ratio between the number of machine side warp yarns and the effective number of warp yarn paths in the sheet side.

BACKGROUND OF THE INVENTION

This invention relates to industrial woven fabrics for filtration in sheet formation in general. However, the invention has particular applicability to papermakers' forming fabrics, and will be discussed primarily below in relation to such fabrics, although equally applicable to many industrial filtration uses in which significant fabric design factors include fiber support, the relationship of the length of fibers in the initial stock to the space between consecutive yarns, and controls on drainage rates.

In modern papermaking processes as would be found for example in a twin wire gap or hybrid forming section, a highly aqueous stock comprising about 99% water and 1% papermaking solids is ejected from a headbox slice onto a moving forming fabric. The stock jet impinges the fabric over an impingement or forming shoe and is thereafter sandwiched by a second fabric and conveyed over various fabric support elements including blades and foils so as to agitate the stock and provide good sheet formation in the final paper product. This agitation is necessary in order to randomize the distribution and orientation of the papermaking fibers which, as has been established by measurement, on leaving the headbox and approaching the forming fabric prior to drainage are primarily aligned in the machine direction (MD). Agitation is also provided to avoid agglomeration of the fibers as flocs in the paper sheet.

Paper products evidencing uniform sheet formation are generally preferred for printing and like applications due to their more even ink absorption qualities and other properties such as the ratio of MD/CD (cross-machine direction) tensile strength. Other desirable physical properties of the paper product are also enhanced when sheet formation is uniform. The nascent paper web is delivered from the forming section with a fiber to water percentage ratio of about 25/75 to the press section where further water removal occurs by mechanical means. The web is conveyed on a series of press fabrics through several press nips where a portion of the water is removed into the fabrics by pressure. As it exits the press section, the now somewhat consolidated sheet will consist of about 45% fiber and 55% water. It is then passed into the dryer section where the remaining water is removed by evaporative means as the sheet is exposed to heat sources, for example by being conveyed in a serpentine manner over numerous heated dryer cylinders while supported on a series of dryer fabrics. As it exits the dryer section to be wound onto reels, the sheet will consist of about 97-99% papermaking fibers and about 1-3% water.

The purpose of the forming fabric is to allow the water in the papermaking stock to drain through openings in the fabric while retaining the cellulosic fibers on the paper side (PS) surface to consolidate and become the embryonic sheet that will be passed into the downstream press section for further water removal. Virgin papermaking fibers intended for printing, newsprint and similar grades of paper generally have fiber lengths in the order of from about 1 - 3 mm depending on their source (i.e. softwood or hardwood). Increasingly greater amounts of fiber are now being derived from recycle sources where newsprint, cardboard and similar paper products are re-pulped and the fibers thus obtained are either mixed with a quantity of virgin fiber or supplied directly to the papermaking process. The re-pulping process tends to break the fibers and shorten them. With the increasing use of recycled stock, together with the use of fillers, it becomes proportionately more difficult to support and retain the shortened fibers on the PS of the fabric due to the size of the mesh openings in the forming fabric. This problem is exacerbated by the fact that, as noted above, as the stock jet impinges the forming fabric, the stock fibers tend to be predominantly MD oriented. Depending on fabric design, the mesh openings in the fabric may be square (e.g. in a plain weave over/under design) or they may be rectangular with the long side of the opening oriented in either the MD or the CD. It is well known in the industry that forming fabrics woven to provide either a plain weave PS surface, or one with rectangular openings oriented in the CD will provide better support for the fibers than fabrics with MD oriented rectangular openings.

However, experiments by Beran demonstrated that cross machine direction support by the forming fabric yarns is more important than the machine direction support. Beran's Fiber Support Index formula, which he developed as a result of his experiments, gives a weighting of 2:1 in favour of the CD yarn support over MD yarns. This formula has been successfully applied by the paper industry for many years.

Nevertheless, drainage must occur in order to leave a fiber matt on the forming fabric surface. With machine speed increases this drainage has to occur much faster than was previously the case. The area in the top surface, which is available for drainage, is expressed in forming fabric terms as top surface drainage area. The top surface drainage area is a plan view of open areas of the fabric through which water drains. This open area is usually expressed as a percentage opening of the top surface.

The smaller the top surface open area, the higher the differential pressure which is required to obtain the same volume of drainage in a given distance, i.e. if the differential pressure is not increased, a lower volume of water will be drained.

The area for drainage in the top surface is calculated using the MD space between CD yarns and the CD space between the MD yarns. Based on Beran's experiments, showing that CD support is very important as is the MD spacing between the CD yarns, as this is the span between CD yarn supports for the MD oriented fibers, the MD spacing between CD yarns is thus more important than the CD spacing between MD yarns.

The MD space between CD yarns is known as the "maximum frame length". With the decrease in fiber length, it is advantageous for fiber support to reduce the maximum frame length so far as possible, without adversely affecting other properties of the fabric. In particular, any reduction in the maximum frame length will close up the top surface drainage area, unless the CD space between the MD yarns is correspondingly increased.

It is also known that a finer mesh, woven using very small monofilament yarns in both the MD (warp) and CD (weft) can provide a forming fabric with a very fine, smooth papermaking surface with the smallest holes possible. Monofilament yarn sizes in the range of about 0.10 to about 0.15mm diameter are currently being used to weave the PS of some forming fabrics. These very small yarns enable the manufacturer to minimize the hole size (referred to as the "frame opening") to the greatest extent possible. However, at papermaking speeds in excess of 1000 m/min, the stability of these finely woven textiles may become problematic. It is also difficult to provide a strong and reliable woven seam that will not fail under the high tensile loads imposed on the fabric. Still further, it is also very time consuming and expensive to produce high mesh forming fabrics with very small frame openings due to the number of weft yarns per unit length (referred to as the "knocking") that must be inserted into the fabric surface.

In conventional Triple Layer weaving, having a plain weave on the PS, the MD and CD yarns stay in the same plane. Experience has shown that during weaving there are physical limitations as to how many CD (weft) yarns can be inserted into the plane before it becomes fully crowded. Overcrowding occurs when the total diameter of the warp and weft yarns is greater than the space that is available. In manufacturing terms, this is known as the crowd factor, i.e. 100% crowd is reached when there is no more room for either warp or weft yarns in, for example, one inch of MD length. If extra weft yarns are forced into the fabric during weaving, either the yarns or the weave pattern will become distorted.

For these reasons, manufacturers of papermakers' forming fabrics strive to minimize the MD frame length in their products while maximizing fiber support. For examples, fabrics constructed in accordance with the claims of US 5,826,627 (Seabrook et al.) are woven with about 100 weft yarns per inch of fabric length on the PS in order to achieve a very fine but open papermaking surface to provide the necessary fiber support and drainage openings. However, this is inefficient as a weft yarn must be "shot" across the fabric width each time one is inserted, thus slowing production. Further, at high weft yarn densities such as these, a minimum frame length is reached because there must be enough room between each successive weft to accommodate a warp yarn that is interwoven around each weft. The only way to reduce frame length in fabrics woven to such patterns is to reduce the diameter of either, or both, the warp and weft. However, a practical lower limit on these yarn sizes will be reached, by reason of the need to maintain certain minimum limits of physical fabric properties.

It is therefore desirable to achieve a fabric design which will efficiently allow for a high degree of support for the papermaking fibers while providing for as small a frame opening as possible; which can be woven efficiently; which provides for both a stable textile product capable of running at modern papermaking speeds; and which can be reliably seamed.

It has been found that using groups of warp yarns, i.e. pairs or triplets, as intrinsic binder yarns, such that when one warp is weaving in the PS, the second warp yarn of the pair is (or second and third warp yarns of triplets are) either passing through the center or weaving into the machine side (MS) surface. This means that for each pair, or each group of triplets, there is a single combined warp yarn path in the PS; while for each of the individual members of the warp pairs or warp triplets that make up the PS there is not a continuous run, but instead, the warp path of each yarn is broken up into short plain weave sections between long floats through the center before the yarn ties into the MS layer and thus ties the PS and MS layers together. These long floats relieve the crowding conditions of a continuous plain weave, discussed above, while allowing a greater number of CD yarns to be woven into the structure than would be otherwise possible. It also means that the CD distance between MD knuckles in the PS surface is double, which opens up the PS drainage area, while maintaining the high fiber support from the close MD distance between CD knuckles.

In particular, it has been found that where the PS weave pattern is provided by only groups (pairs or triplets) of intrinsic binder warp yarns, but the MS weave pattern also includes dedicated MS warp yarns which remain in the MS layer, these desirable characteristics discussed above are further ensured by providing for the ratio of the MS warp paths to the PS warp paths to be at least 1.5: 1, taking the combined warp path of each pair, or each group of triplets, to be a single path. It has further been found to be particularly advantageous in the weave patterns of the invention for the dedicated MS warp yarns to interweave with the MS weft only at locations where the warp yarns from the intrinsic binder warp yarns interweave with an MS weft. This can be achieved, for example, by the dedicated MS warp yarns interweaving in turn with a group of successive MS wefts with which an intrinsic binder warp yarn interweaves to form a double warp knuckle on those MS weft; or by two dedicated MS warp yarns interweaving with a single MS weft with which an intrinsic binder warp yarn interweaves to form a single knuckle.

This novel warp yarn arrangement allows for the formation of CD oriented rectangular openings in the PS of the fabric to increase papermaking fiber support, while the higher MS:PS warp ratio tends to close up the MS surface of the fabrics, thus retarding drainage and providing improvements in paper formation.

The invention therefore seeks to provide an industrial woven fabric for filtration in formation of a fibrous cellulosic sheet, the fabric having a sheet side layer with a sheet side surface and a machine side layer with a machine side surface, the fabric being woven to an overall repeating weave pattern and comprising

(i) sheet side weft yarns;

(ii) machine side weft yarns;

(iii) a first set of warp yarns comprising only intrinsic binder warp yarns; and

(iv) a second set of warp yarns comprising machine side layer warp yarns, contributing only to the machine side layer

wherein

(a) the intrinsic binder warp yarns are selected from groups comprising only pairs and groups comprising only triplets and each group occupies a single combined path in the sheet side surface; and

(b) in each repeat of the overall repeating weave pattern, there are at least two machine side layer warp yarns, and a warp yarn path ratio of numbers of machine side layer warp yarns to warp paths of the first set of warp yarns is at least 1.5:1.

In particular, the fabric may be a composite papermakers' forming fabric, in which case the fibrous cellulosic sheet will comprise a paper sheet, and the sheet side layer and surface of the fabric would be referred to respectively as the paper side (PS) layer and the PS surface.

The fabrics of the invention have a fiber support index value, calculated pursuant to Beran's Fiber Support Index, of at least 100 and preferably up to at least 140, most preferably 150. The sheet side drainage area is less than 45%, preferably 30% to 45%, most preferably 30% to 32%. The fabrics of the invention have a drainage area in a notional central plane between the sheet side layer and the machine side layer of less than 40%, preferably less than 30%, most preferably less than 20%. The frame count is between 3000/in^2 and 6000/in^2, preferably between 3300/in^2 and 4500/in^2, and the frames preferably have a greater dimension in the CD than in the MD, the dimension in the MD being less than 0.25mm, preferably less than 0.2mm, and most preferably less than 0.1mm.

The MS warp yarns are preferably at least equal in size to the intrinsic binder warp yarns, preferably larger. The intrinsic binder warp yarns can have any cross-sectional configuration, but are preferably circular. The yarns of the fabrics of the invention can be constructed of any material known in the art, and weave designs for the sheet side layer and the machine side layer can be selected from various weave patterns known in the art.

Examples of the fabrics of the invention were woven, and compared with a control fabric woven according to US 5,826,627 to Seabrook et al. (identified in Table 1 below as "Control"), and a similar fabric having an increased weft yarn count (Fabric 2 in Table 1). Fabrics 3 and 4 in Table 1 are two fabrics of the invention, as discussed further below.

Example

Fabric	Control	Fabric 2	Fabric 3	Fabric 4
	Seabrook et al			
Weave	Plain Weave	Plain Weave	Plain Weave	Plain Weave
Yarn Count (1/in.)				
Paper Side MD X CMD	74 x 90	74 x 110	37 x 90	37 x 110
Yarn Diameters (mm)				
Paper Side MD	0.13	0.13	0.13	0.13
Paper Side CMD	0.14	0.14	0.14	0.14
Surface Characteristics				
Drainage Area	31.3%	24.5%	40.9%	31.9%
Frames Count	6660 /in.^{2}	8140 /in.^{2}	3330 /in.^{2}	4070 /in.^{2}
Fibre Support Index (F.S.I)	169	196	145	171
Maximum MD Frame Length	0.142 mm	0.091 mm	0.142 mm	0.091 mm
Frames (Drainage Orifice)				
Frame Count/sq inch	6660 /in.^{2}	8140 /in.^{2}	3330 /in.^{2}	4070 /in.^{2}
Frame Length (mm)	0.142	0.091	0.142	0.091
Frame Width (mm)	0.213	0.213	0.556	0.556
Frame Area (mm^2)	0.030	0.019	0.079	0.051

The Control fabric was woven as a conventional plain weave, having a PS surface of 74 (MD) x 90 (CD) using diameters 74 of 0.13mm x 90 of 0.14 mm. The PS surface drainage area was 31.3%, the drainage frames per square inch were 6660/in^2 ; the Beran Fiber Support Index was 169 and the maximum MD frame length was 0.142mm.

Fabric 2 – In this sample the fabric was woven as a plain weave, and the yarn diameters that were used were the same as for the Control fabric. However, the CD weft count was increased to 110 in order to give greater CD support to the MD oriented fibers. This had the desired effect of reducing the maximum MD frame length down to 0.091 mm and increasing the Beran Fiber Support Index up to 196, at the same time as increasing the frame count to 8140/in^2. However, the drainage area was reduced from 31.3% to 24.5% (a 21.7% reduction). This considerable reduction thus would reduce the volume of water drained through a fabric, if the same differential pressure was maintained.

Fabric 3 – In this fabric of the invention, all the warps appearing in the PS were paired as intrinsic binder warp yarns, resulting in only half of the number of MD knuckles being in the plain weave surface. The CD component of each frame thereby increased to 0.556 mm from 0.213mm, increasing the drainage area to 40.9% from 31.3%, using the same yarn diameters as in the Control fabric. The maximum MD frame length of 0.142mm was the same as in the

Control fabric, but the frame count dropped down from 6660/in^2 to 3330/in^2. The fewer MD yarns thus resulted in larger frames than in the Control fabric, but at the same time the FSI dropped from 169 to 145 because of the reduced MD support.

Fabric 4 – In this second fabric of the invention, the more open structure of Fabric #3 was maintained, but the number of CD weft yarns was increased to 110, i.e. the same as in Fabric #2, and using the same diameter yarns. However, by reason of the use of the warp yarn pairs, Fabric #4 had a 31.9% drainage area, i.e. closely the same as in the Control fabric, but much more open than in Fabric #2. The maximum MD frame length was still 0.091mm, the Beran FSI went up to 171 and the frame count rose to 4070/in^2 compared to 3330/in^2 for Fabric #3 and 6660/in^2 for the Control fabric.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the drawings, in which

Fig. 1 is a weave diagram of an embodiment of the invention;

Fig. 2 is a cross-sectional view of the embodiment of Figure 1, showing warp profiles of selected yarns;

Fig. 3 is a weave diagram of an embodiment of the invention;

Fig. 4 is a cross-sectional view of the embodiment of Figure 3, showing warp profiles of selected yarns;

Fig. 5 is a weave diagram of an embodiment of the invention;

Fig. 6 is a cross-sectional view of the embodiment of Figure 51, showing warp profiles of selected yarns;

Fig. 7 is a weave diagram of an embodiment of the invention; and

Fig. 8 is a cross-sectional view of the embodiment of Figure 7, showing warp profiles of selected yarns.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to Figures 1, 3, 5 and 7, each of these shows a weave diagram of an embodiment of the invention; whereas each of Figures 2, 4, 6 and 8 show warp profiles corresponding to these four weave diagrams respectively.

In each of these four weave diagrams, warp yarns 100 are shown running vertically on the page, numbered across the top of the diagram individually as 1 to 24 in each of the 24-shed patterns shown in Figures 1, 3 and 7, and as 1 to 16 in the 16-shed pattern shown in Figure 5. The weft yarns 200, comprising PS wefts 210 and MS wefts 220, are shown running horizontally across the page, numbered down the left side of the diagram individually as 1 to 24 (Figure 1), 1 to 36 (Figure 3), 1 to 48 (Figure 5) and 1 to 36 (Figure 7).

Referring to Figure 2, PS wefts 210 and MS wefts 220 are shown in cross-section, interwoven with intrinsic binder warp yarns 1 and 2, and dedicated MS warp yarns 13 and 14, in a 24 shed pattern. In a first segment, warp yarn 1 interweaves with PS wefts 210 in a plain weave pattern, while warp yarn 2 interweaves with the MS wefts 220 to form a double knuckle 301, together with first MS warp yarn 13 and then MS warp yarn 14. After warp yarns 1 and 2 exchange positions at exchange point 401, in a second segment, warp yarn 2 interweaves with PS wefts 210 in a continuation of the plain weave pattern, while warp yarn 1 interweaves with the MS wefts 220 to form a double knuckle 302, together with first MS warp yarn 13 and then MS warp yarn 14. Thereafter, warp yarns 1 and 2 again exchange positions at exchange point 402 to repeat the pattern.

Referring to Figure 4, again PS wefts 210 and MS wefts 220 are shown in cross-section, interwoven with intrinsic binder warp yarns 1 and 2, and dedicated MS warp yarns 13 and 14, in a 24 shed pattern. In a first segment, warp yarn 1 interweaves with PS wefts 210 in a plain weave pattern, in a longer run on the PS than in Figure 2, while warp yarn 2 interweaves with the MS wefts 220 to form a double knuckle 303, together with first MS warp yarn 13 and then MS warp yarn 14, and then remains in the centre plane of the fabric, until warp yarns 1 and 2 exchange positions at exchange point 403. Thereafter, in a second segment, warp yarn 2 interweaves with PS wefts 210 in a continuation of the plain weave pattern, again in a longer run on the PS than in Figure 2, while warp yarn 1 interweaves with the MS wefts 220 to form a double knuckle 304, together with first MS warp yarn 13 and then MS warp yarn 14, and then remains in the centre plane of the fabric, until warp yarns 1 and 2 again exchange positions at exchange point 404 to repeat the pattern.

Referring to Figure 6, PS wefts 210 and MS wefts 220 are shown in cross-section, interwoven with intrinsic binder warp yarns 1 and 2, and dedicated MS warp yarns 9 and 10, in a 16 shed pattern. In a first segment, shown in the centre of this figure as a complete segment, warp yarn 1 interweaves with PS wefts 210 in a plain weave pattern, while warp yarn 2 is carried in the centre plane, and then interweaves with the MS wefts 220 to form a double knuckle 305, first with MS warp yarn 9 and then with MS warp yarn 10, before exchanging positions with warp yarn 1 at exchange point 405. Thereafter, in a second segment, shown at the right and left of the figure, warp yarn 2 interweaves with PS wefts 210 in a continuation of the plain weave pattern, while warp yarn 1 interweaves with the MS wefts 220 to form a double knuckle 306, together with first MS warp yarn 9 and then MS warp yarn 10, and then remains in the centre plane of the fabric until exchanging positions with warp yarn 2 at exchange point 406 to repeat the pattern.

Referring to Figure 8, PS wefts 210 and MS wefts 220 are shown in cross-section, interwoven with intrinsic binder warp yarns 1 and 2, and dedicated MS warp yarns 9 and 10, in a 24 shed pattern, in which each of warp yarns 1 and 2 alternate in providing a plain weave in the PS, and each interweaves with the MS wefts 220 at a single knuckle 307, but together with both of MS warps 9 and 10, remaining in the centre plane for long internal floats between exchange points 407 and 408.

In the fabrics of the invention, as discussed above, the intrinsic binder warp yarns can be provided as pairs or as triplets, but in each case, in each repeat of the weave pattern, each of the warp yarns of the pair or group of triplets will in turn interweave with the sheet side weft yarns to contribute to the sheet side pattern, while the remaining warp yarn or yarns will in turn form internal floats in the centre plane of the fabric, between the sheet side and machine side layers, and interweave with selected MS weft yarns. Thus in all cases, each group of either two or three intrinsic binder warp yarns will form a single combined warp path in the sheet side of the fabric, which when compared with the number of dedicated MS warp yarns in the same repeat of the overall weave pattern will identify the warp yarn path ratio, which for the fabrics of the invention is at least 1.5:1 (MS:PS ratio).

Further, in the fabrics of the invention, it can be seen from the figures that the segments, as identified above, and separated by the yarn exchange points of the intrinsic binder warp yarns, can be equal or unequal; thus the number of MS weft yarns between each adjacent pair of exchange points in one repeat of the overall fabric weave pattern can be equal or unequal, thus maximizing the options which can be selected for the MS weave patterns, such as MS weft float lengths, depending on the specific intended end use for the fabric.

Claims:

1. An industrial woven fabric for filtration in formation of a fibrous cellulosic sheet, the fabric having a sheet side layer with a sheet side surface and a machine side layer with a machine side surface, the fabric being woven to an overall repeating weave pattern and comprising

(i) sheet side weft yarns;

(ii) machine side weft yarns;

(iii) a first set of warp yarns comprising only intrinsic binder warp yarns; and

(iv) a second set of warp yarns comprising machine side layer warp yarns, contributing only to the machine side layer

wherein

(a) the intrinsic binder warp yarns are selected from groups comprising only pairs and groups comprising only triplets and each group occupies a single combined path in the sheet side surface; and

(b) in each repeat of the overall repeating weave pattern, there are at least two machine side layer warp yarns, and a warp yarn path ratio of numbers of machine side layer warp yarns to warp paths of the first set of warp yarns is at least 1.5:1.

2. An industrial woven fabric according to Claim 1, wherein the fabric is a composite papermakers' forming fabric, the fibrous cellulosic sheet comprises a paper sheet, and the sheet side comprises a paper side.

3. A fabric according to Claim 1 or Claim 2, wherein the fabric has a fiber support index calculated pursuant to Beran's Fiber Support Index of at least 100.

4. A fabric according to Claim 3, wherein the fabric has a fiber support index of at least 140.

5. A fabric according to Claim 4, wherein the fabric has a fiber support index of at least 150.

6. A fabric according to any one of Claims 1 to 5, wherein the sheet side surface has a drainage area of less than 45%.

7. A fabric according to Claim 6, wherein the drainage area is between 30% and 45%.

8. A fabric according to Claim 7, wherein the drainage area is between 30% and 32%.

9. A fabric according to any one of Claims 1 to 8, having a frame count between $3000/in^2$ and $6000/in^2$.

10. A fabric according to Claim 9, having a frame count between $3300/in^2$ and $4500/in^2$.

11. A fabric according to any one of Claims 1 to 10, wherein the sheet side surface comprises frames having a greater dimension in a cross-machine direction than in a machine direction of the fabric.

12. A fabric according to Claim 11, wherein the frame dimension in the machine direction is less than 0.25mm.

13. A fabric according to Claim 12, wherein the frame dimension in the machine direction is less than 0.2mm.

14. A fabric according to Claim 13, wherein the frame dimension in the machine direction is less than 0.15mm.

15. A fabric according to Claim 14, wherein the frame dimension in the machine direction is less than 0.1mm.

16. A fabric according to any one of Claims 1 to 15, wherein each machine side layer warp yarn has a cross-sectional area which is substantially equal to a cross-sectional area of each intrinsic binder warp yarn.

17. A fabric according to any one of Claims 1 to 15, wherein each machine side layer warp yarn has a cross-sectional area which is greater than a cross-sectional area of each intrinsic binder warp yarn.

18. A fabric according to any one of Claims 1 to 17, wherein the warp yarns of the first set each have a substantially circular cross-section and a diameter of between 0.08 mm and 0.25 mm.

19. A fabric according to Claim 18, wherein the warp yarns of the first set have a diameter of substantially .13 mm.

20. A fabric according to any one of Claims 1 to 18, wherein each yarn of any of the first set of warp yarns, the second set of warp yarns, the sheet side weft yarns and the machine side weft yarns has a cross-sectional configuration selected from circular, ovate, elliptical, rectangular and square.

21. A fabric according to any one of Claims 1 to 20, wherein the machine side warp yarns each have a substantially circular cross-section and a diameter of between 0.08 mm and 0.3 mm.

22. A fabric according to any one of Claims 1 to 21, wherein the sheet side weft yarns each have a substantially circular cross-section and a diameter of between 0.08 mm and 0.3 mm.

23. A fabric according to any one of Claims 1 to 22, wherein the machine side weft yarns each have a substantially circular cross-section and a diameter of between 0.1 mm and 0.5 mm.

24. A fabric according to any one of Claims 1 to 23, wherein each warp yarn of any of the first set and the second set are monofilaments constructed of a polymer selected from polyethylene terephthalate, polyethylene naphthalate, and a blend of polyethylene terephthalate and polyethylene naphthalate.

25. A fabric according to any one of Claims 1 to 24, wherein the machine side warp yarns are monofilaments constructed of a material selected from a nylon, a polymer selected from

polybutylene terephthalate, polytrimethylene terephthalate, polyethylene terephthalate, polyethylene naphthalate, and a blend of polyethylene terephthalate and polyethylene naphthalate.

26. A fabric according to Claim 24, wherein the nylon is selected from nylon 6, nylon 6/6, nylon 6/10 and nylon 6/12.

27. A fabric according to any one of Claims 1 to 26, wherein the weft yarns are monofilaments constructed of a material selected from a nylon, a polymer selected from polybutylene terephthalate, polytrimethylene terephthalate, polyethylene terephthalate, polyethylene naphthalate, and a blend of polyethylene terephthalate and polyethylene naphthalate.

28. A fabric according to Claim 27, wherein the nylon is selected from nylon 6, nylon 6/6, nylon 6/10 and nylon 6/12.

29. A fabric according to any one of Claims 1 to 28, wherein the fabric has a drainage area in a notional central plane between the sheet side layer and the machine side layer of less than 40%.

30. A fabric according to Claim 29, wherein the drainage area in the notional central plane is less than 30%.

31. A fabric according to Claim 30, wherein the drainage area in the notional central plane is less than 20%.

32. A fabric according to any one of Claims 1 to 31, woven using two beams.

33. A fabric according to any one of Claims 1 to 31, woven using three beams.

34. A fabric according to any one of Claims 1 to 31 woven according to an overall weave pattern requiring a shed number selected from 8, 12, 16 and 24.

35. A fabric according to any one of Claims 1 to 34, wherein the sheet side weave design is selected from the group consisting of a plain weave, a 2/1 twill, a 2/1 satin, a 3/1 twill, a 3/1 satin, and a design selected from 2x2, 3x3, 3x6 and 4x8.

36. A fabric according to any one of Claims 1 to 34, wherein the MS weave design is selected from a plain weave, a twill and a satin weave.

37. A fabric according to Claim 36, wherein the MS weave design is selected from a 3x3, 4x4, 5x5, 6x6 and 6x12 design.

38. A fabric according to Claim 37, wherein the MS weave design is selected from a 3x3 twill, a 6-shed broken twill, a 9x9 twill or an N x 2N design in which N is the number of warp yarns and 2N is the number of weft yarns in one repeat of the overall weave pattern.

39. A fabric according to any one of Claims 1 to 38, wherein the intrinsic binder warp yarns are pairs, and the single combined path of each pair of the intrinsic binder warp yarns comprises two segments separated by yarn exchange points, and the number of MS weft yarns beneath each adjacent pair of yarn exchange points in one repeat of the overall fabric weave pattern is equal.

40. A fabric according to any one of Claims 1 to 38, wherein the intrinsic binder warp yarns are pairs, and the single combined path of each pair of the intrinsic binder warp yarns comprises two segments separated by yarn exchange points, and the number of MS weft yarns beneath each adjacent pair of yarn exchange points in one repeat of the overall fabric weave pattern is unequal.

41. A fabric according to any one of Claims 1 to 38, wherein the intrinsic binder warp yarns are triplets, and the single combined path of each pair of the intrinsic binder warp yarns comprises three segments separated by yarn exchange points, and the number of MS weft yarns beneath each adjacent pair of yarn exchange points in one repeat of the overall fabric weave pattern is equal.

42. A fabric according to any one of Claims 1 to 38, wherein the intrinsic binder warp yarns are triplets, and the single combined path of each pair of the intrinsic binder warp yarns comprises three segments separated by yarn exchange points, and the number of MS weft yarns beneath each adjacent pair of yarn exchange points in one repeat of the overall fabric weave pattern is unequal.

Figure 1:

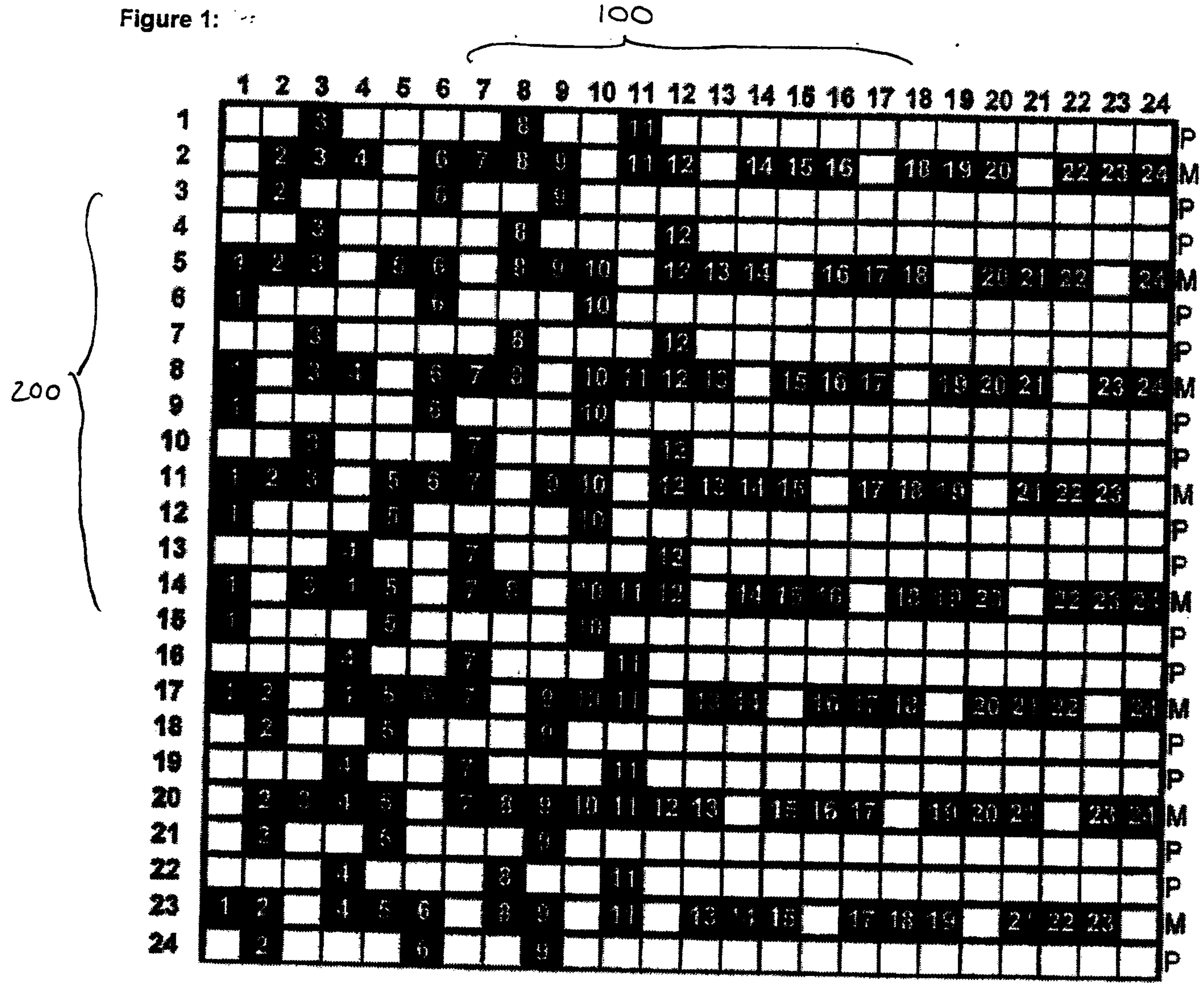


Figure 2:

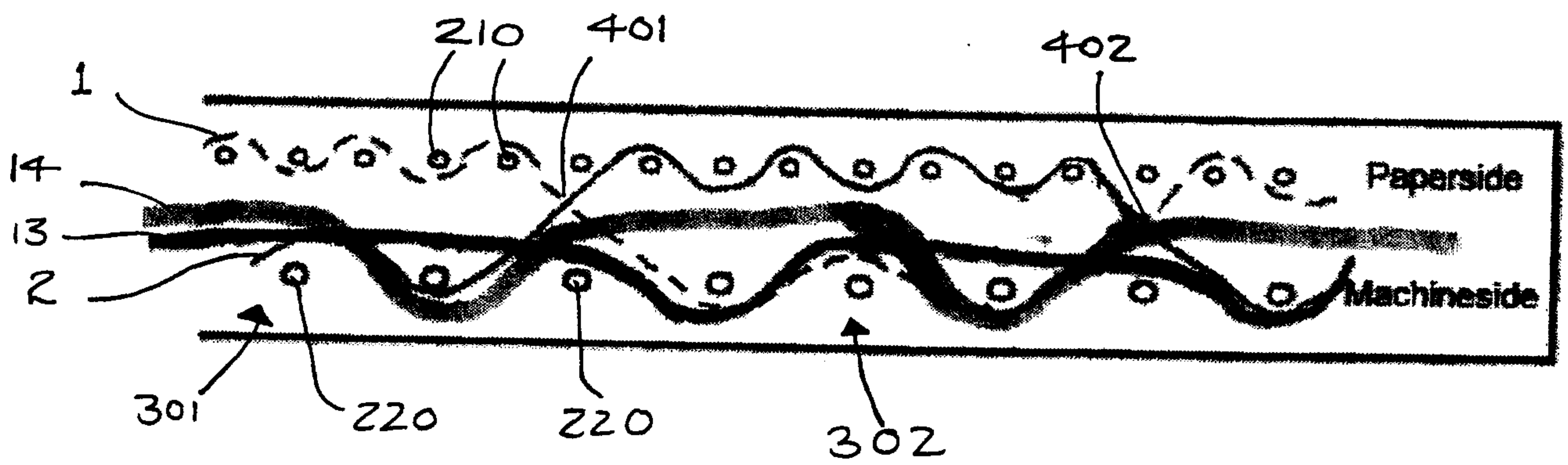


Figure 3:

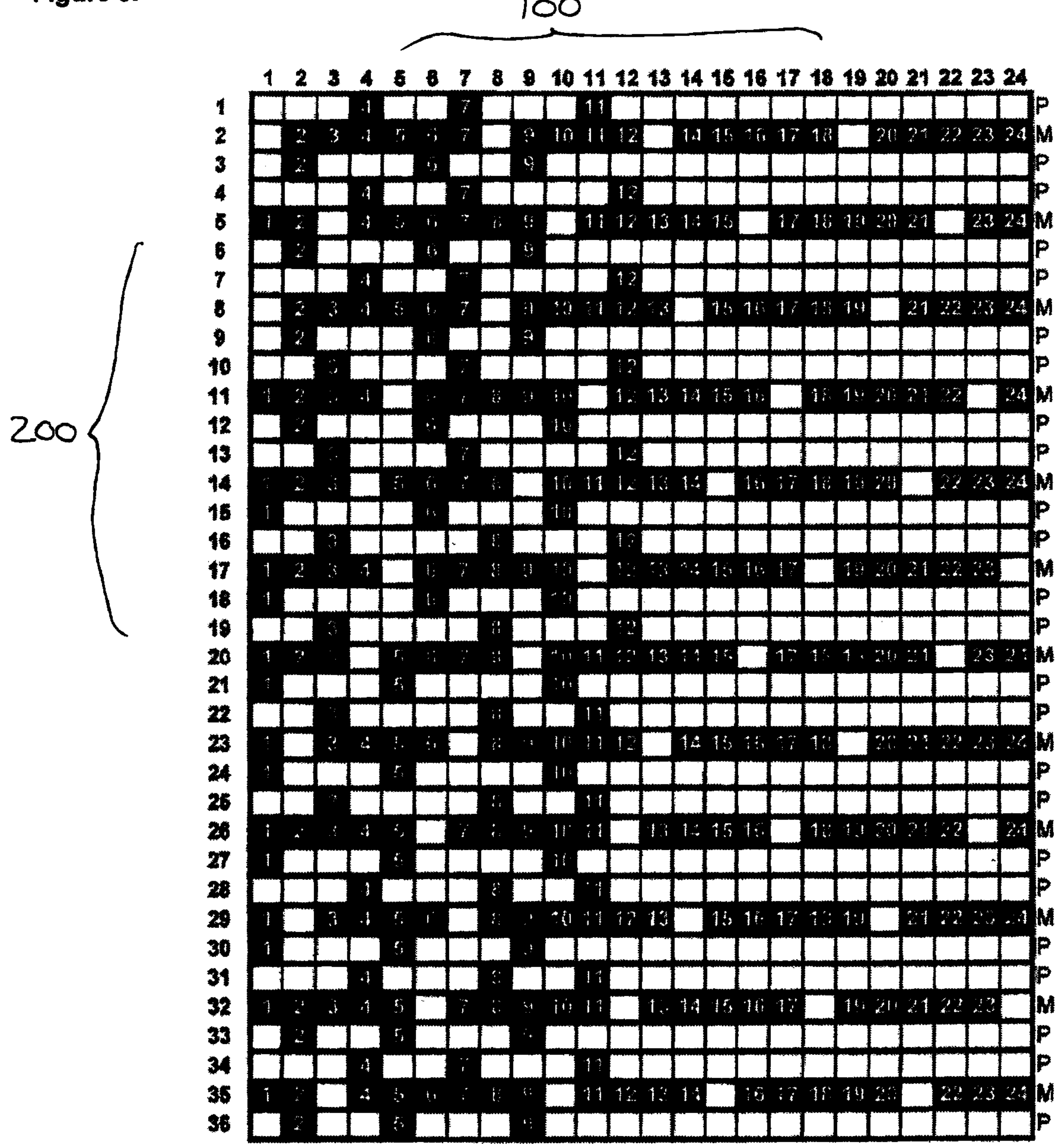


Figure 4:

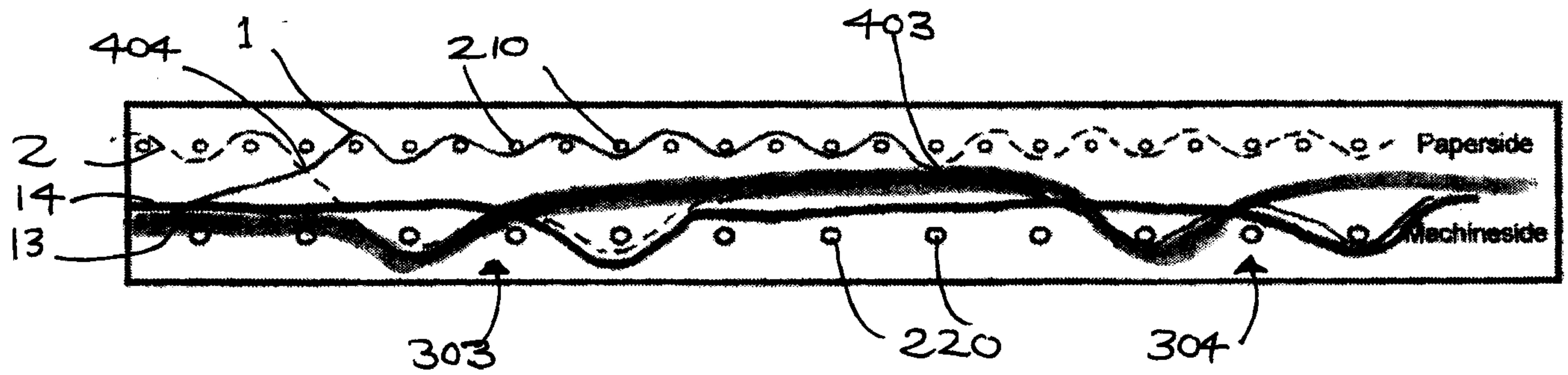
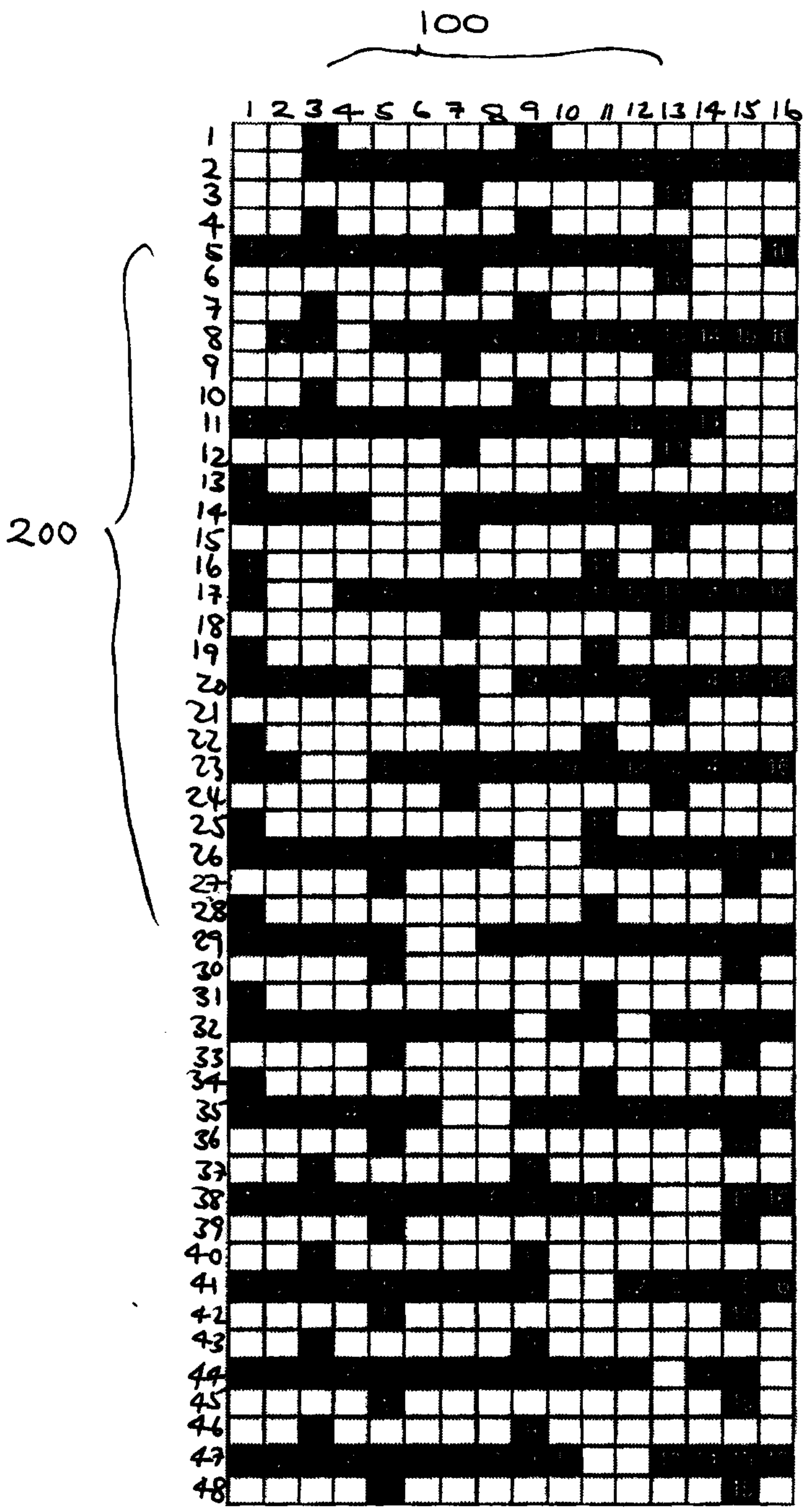


Figure 5:



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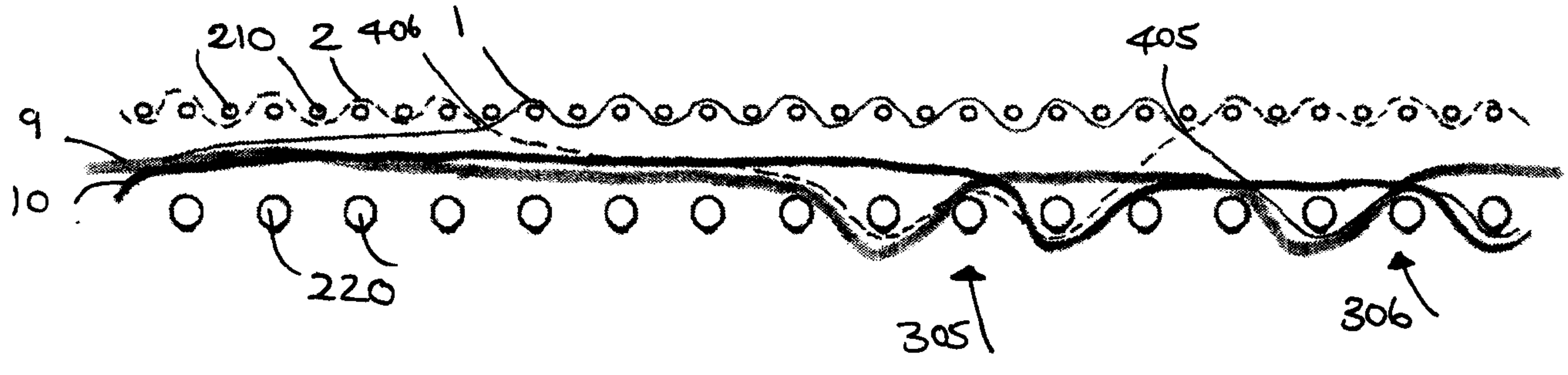


Figure 7:

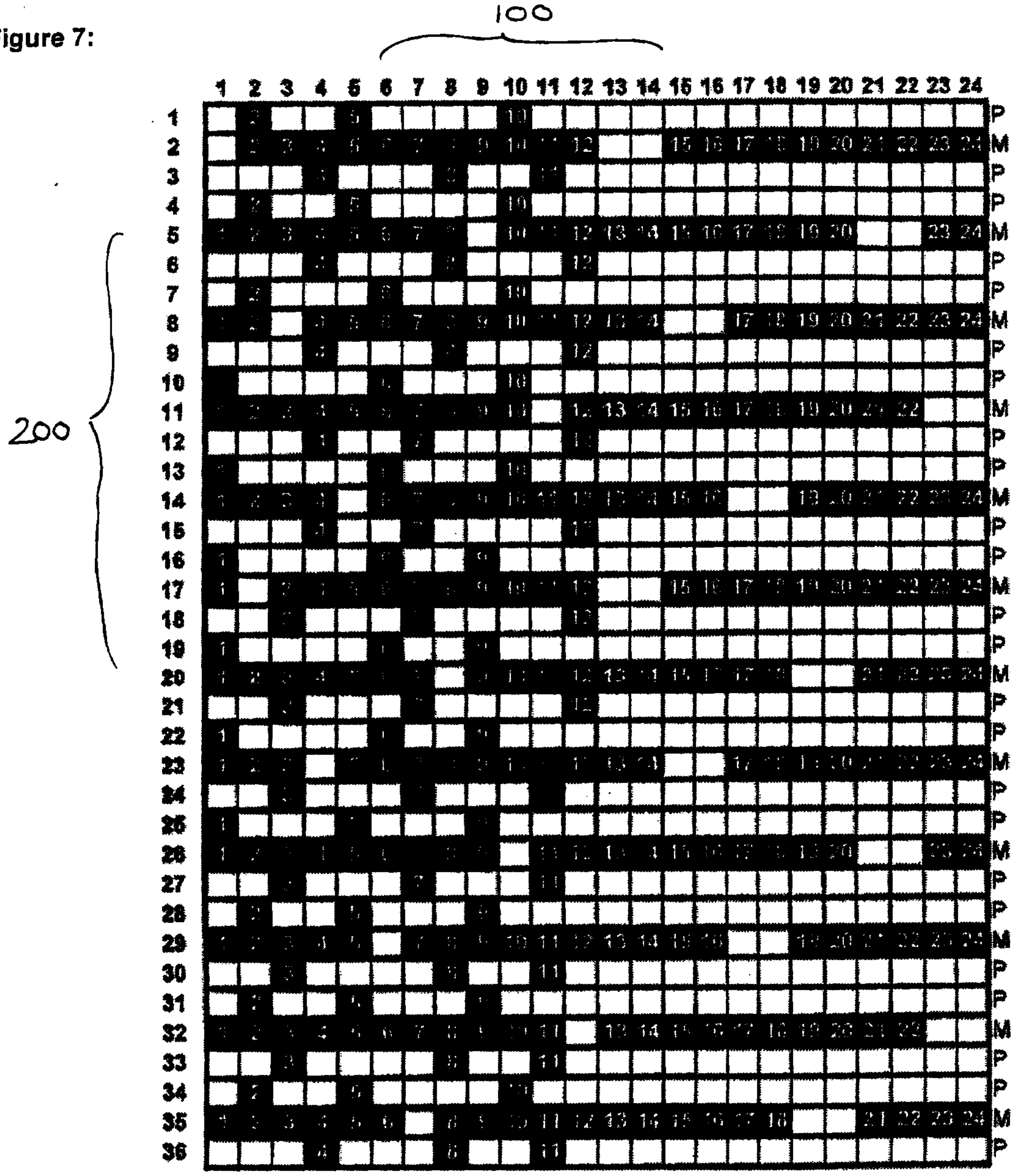
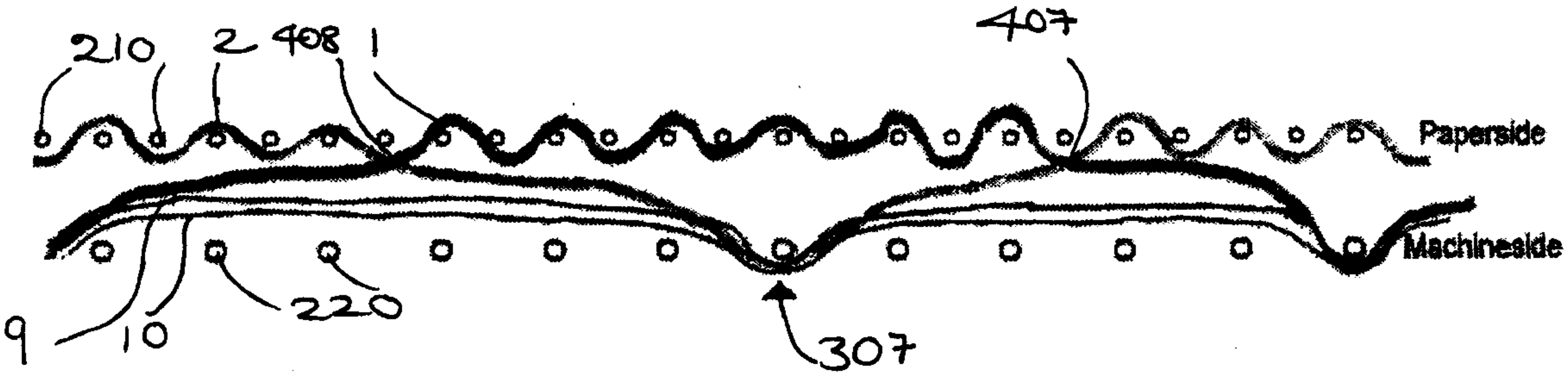


Figure 8:



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