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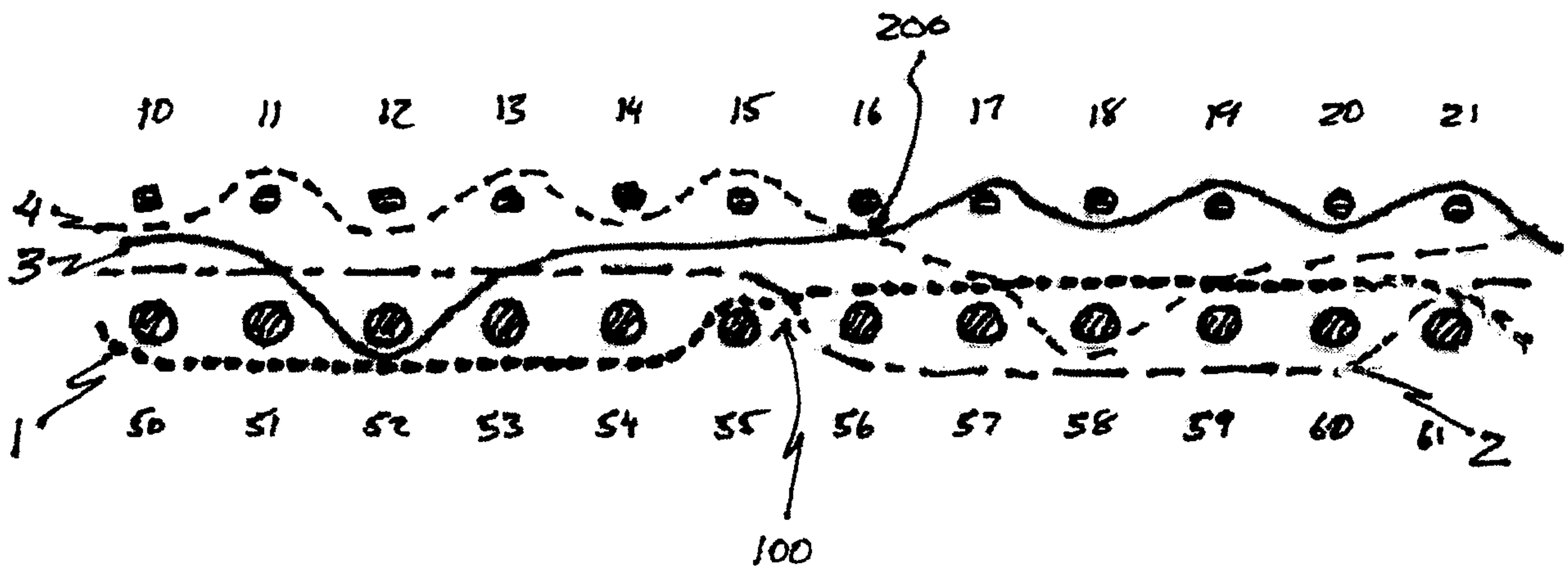
(54) Titre : TOILE SERVANT A LA FABRICATION DU PAPIER COMPRENANT DES PAIRES D'ECHANTILLONS DE FILS COMPLEMENTAIRES DU COTE MACHINE

(54) Title: PAPERMAKERS' FORMING FABRIC INCLUDING PAIRS OF MACHINE SIDE COMPLEMENTARY YARNS



(57) Abrégé/Abstract:
A multilayer woven industrial fabric comprises at least two layers of weft yarns interwoven with at least one system of warp yarns. At least some of the machine side (MS) weft yarns are arranged as complementary pairs of weft yarns, such that for each pair, the members follow mutually complementary paths, and exchange positions with each other so that, in the MS surface, the path of a pair of well yarns will appear to be that of a single yarn. The complementary pairs interweave only with the MS warp yarns and do not appear in the paper side. The unique MS well yarn arrangement increases both fabric stiffness and dimensional stability, and can be applied to any multi-layer fabric design which includes at least two layers of well yarns and one system of warp yarns.

ABSTRACT

A multilayer woven industrial fabric comprises at least two layers of weft yarns interwoven with at least one system of warp yarns. At least some of the machine side (MS) weft yarns are arranged as complementary pairs of weft yarns, such that for each pair, the members follow mutually complementary paths, and exchange positions with each other so that, in the MS surface, the path of a pair of weft yarns will appear to be that of a single yarn. The complementary pairs interweave only with the MS warp yarns and do not appear in the paper side. The unique MS weft yarn arrangement increases both fabric stiffness and dimensional stability, and can be applied to any multi-layer fabric design which includes at least two layers of weft yarns and one system of warp yarns.

Shapiro Cohen Ref. No. 01204P0544CA01

PAPERMAKERS' FORMING FABRIC INCLUDING PAIRS OF MACHINE SIDE COMPLEMENTARY YARNS

FIELD OF THE INVENTION

The present invention relates to fabrics intended for use in industrial filtration processes, and is particularly concerned with papermakers forming fabrics which are used to drain and form a paper web in the forming section of papermaking machines.

BACKGROUND OF THE INVENTION

In modern high speed papermaking processes, a highly aqueous stock consisting of about 99% water and 1% papermaking solids is ejected at high speed and precision onto an endless moving forming fabric. A nascent web, which will be self coherent and consist of about 25% papermaking solids by the end of the forming section, is formed as the stock is drained through the fabric. This web is then transferred from the forming fabric into the press section where, together with at least one press fabric, it passes through one or more nips where additional fluid is removed by mechanical means. The web is then transferred into the dryer section of the papermaking machine where much of the remaining moisture is removed by evaporative means, the web being supported on one or more dryer fabrics as it is heated, for example by being passed in serpentine fashion over a series of heated rotating drums. The finished sheet is then reeled into large rolls at the end of the papermaking machine, and further finishing processes may be applied.

Forming fabrics are critical to the quality of the paper product that is ultimately produced on the papermaking machine. In simplest terms, these fabrics are designed to allow fluid from the stock to drain through the fabric in a controlled manner, while providing uniform support to the papermaking solids. The fabrics must also be very robust and dimensionally stable so as to survive the environmental forces to which they are exposed. In addition, the fabrics should be as thin as is possible, so as to minimize internal void volume and water carrying capacity. Considerable efforts have been made by various manufacturers of papermaking fabrics to decrease the thickness (or caliper) of their fabrics so as to minimize this interior void volume while, at the same time, maximizing fiber support.

The papermaking surfaces of modern forming fabrics are finely woven structures formed using very small diameter monofilament yarns in order to provide this requisite support for the papermaking components while allowing adequate fluid drainage. On its own, a fine woven structure would generally not be usable in a high speed papermaking process as it would lack sufficient mechanical stability and stiffness while in operation, thus causing problems such as fabric creasing and poor fabric guiding. It would also be difficult to provide a seam of sufficient strength to reliably join the fabric ends while in use on the machine; other mechanical issues, especially relating to wear, would also occur due to the small yarn size and fabric structure employed. By comparison, coarse mesh fabrics which employ relatively larger diameter yarns generally provide adequate stability and wear life while sacrificing good formation. Selection of an appropriate fabric design, mesh and yarn size by the fabric manufacturer for a given application usually represents a balance between desirable papermaking qualities (e.g. formation and drainage) and the structural properties of the fabric (e.g. stiffness and caliper).

To minimize this trade-off between sheet support and fabric stability, a variety of fabric structures have been developed over time. A comprehensive listing and description of these structures is provided by R. Danby and J. Perrault in Weaves of Papermaking Wires and Forming Fabrics, Pulp & Paper Technical Association of Canada [PAPTAC] Data Sheet G-18, Revised July 2009, a copy of which is incorporated here by reference. This Data Sheet G-18 lists the following forming fabric structures as those which are in current use:

Single layer designs – fabrics woven using one warp yarn system and one weft yarn system.

Semi Duplex or Extra Support Single Layer designs – fabrics woven using one warp yarn system and two weft yarn systems in which the weft yarns are not located directly over each other.

Double layer or Duplex – fabrics woven using one warp yarn system and two weft yarn systems in which the weft yarns of the two systems are usually vertically stacked directly over one another.

Extra Support Double Layer – double layer fabrics with additional weft yarns woven into one layer, usually the top papermaking surface.

Triple Weft – fabrics woven using one warp yarn system and three systems of weft yarns in which the weft are usually stacked vertically one over the other.

Standard Triple layer – fabrics woven using two warp yarn systems and two weft yarn systems to provide two independent fabric structures (top and bottom) that are stitched together during weaving, in the majority of cases using an extra weft yarn system.

Triple Layer Sheet Support Binder (SSB) or Intrinsic Weft or Paired Binders – fabrics woven using two warp and two weft (CD) yarn systems, in which a selected number of the weft yarns are woven into the fabric as interchanging pairs of intrinsic binder yarns. In these arrangements, when one yarn of the pair is being woven into a first fabric surface, the second yarn of the pair is being woven into the second fabric surface. These yarns then exchange positions within one repeat of the weave thereby providing an unbroken, continuous repeat of the weave in both surfaces, and tie the two surfaces together.

Triple Layer "Warp Tie" – fabrics that are woven using two weft yarn systems and two warp yarn systems in which at least a portion of the warp yarns are woven as interchanging pairs so that, as one yarn of the pair is woven into the first fabric surface, the other is woven into the second. In certain designs, some of the warp yarns of each of the two systems will be interwoven exclusively with weft yarns of one of either the first or second systems of weft yarns.

Triple Layer (WISS) Warp Integrated Sheet Support Binders – fabrics woven using two weft yarn systems and two warp (MD) yarn systems in which all (100%) of the warp yarns are woven as interchanging pairs so that, as one yarn of the pair is being woven into the first surface, the other yarn of the pair is woven into the second. In these fabrics, all of the warp yarns function to bind the surfaces together as well as to contribute to the woven structure of those surfaces.

The features of the present invention can advantageously be applied to each of the above described fabric structures, with the exception of single layer and so-called triple weft fabrics.

A characteristic common to the fabric structures for which the present invention is applicable is that they include at least two layers or systems of weft yarns. This feature allows for each of the two fabric surfaces to be woven to differing fabric designs using differing materials. The fabric surfaces are tied together using binder yarns which are part of the weave design in the manner described above. These fabrics are capable of providing high levels of fiber support and good mechanical stability and wear life.

DISCUSSION OF THE PRIOR ART

As previously noted, the forming fabric is installed on the papermaking machine as a continuous belt which is driven through the forming section at high speeds. Accordingly, the fabric must possess good mechanical stability, in particular cross-machine direction (or CD) stability, in order to survive the rigors of the forming section environment. This problem has been recognized and addressed by various means in the past.

For example, one means of increasing CD fabric stability is to add additional weft yarns to the structure to create a triple weft fabric. Such fabrics are described in US 4,379,735 (MacBean), US 4,941,514 (Taipale), US 5,164,249 (Tyler et al.), and US 5,169,709 (Fleischer). Other similar structures are known and used. However, a problem associated with triple weft structures is that they are relatively thick, which increases fabric caliper and void volume. This increased thickness in comparison to other fabric designs adversely affects vacuum efficiency, and the water carried by these fabrics may also spot the sheet.

US 6,902,652 (Martin) discloses a warp tie forming fabric with additional cross-machine direction (CD) packing yarns and paired intrinsic warp binder yarns. The CD packing yarns are additional weft yarns that are inserted between adjacent machine side (MS) weft yarns in the fabric weave. The packing yarns reduce the void volume on the machine side of the fabric without significantly disrupting the air permeability or increasing fabric caliper. The placement of the packing yarns also adds to the CD stability and seam strength of the fabric and reduces the lateral movement of the MS weft yarns.

US 6,810,917 (Stone) discloses a forming fabric the PS and MS layers of which are interconnected by pairs of MS intrinsic weft binder yarns. Each of the binder yarn pair members in sequence interlaces with a portion of the MS warp yarns so as to complete an unbroken weft path in the MS weave pattern, and to provide an internal MS float. Each of the binder yarn pair members also interweaves with a PS warp yarn so as to bind the PS and MS layers together.

It would therefore be advantageous to provide a forming fabric which offers the benefits of increased mechanical stability and CD stiffness in comparison with the known fabrics, without consequential disadvantages of undue increase in caliper or adverse effects on drainage or wear resistance, by improved weave patterns which are applicable as modifications to a wide variety of fabric structures.

SUMMARY OF THE INVENTION

As used herein, the term "complementary yarns" refers to two or more yarns which are interwoven in a fabric so as to form a pattern equivalent to that followed by a single yarn in one repeat of the fabric weave. Each member of a pair of complementary yarns alternates positions with the other member of that pair at exchange points as they interweave such that, as one yarn ceases interweaving on one surface it is replaced by the next which continues the weave pattern in that surface. The complementary yarns continue to exchange positions across the entire length or width of the pattern so as to form an unbroken yarn path in one surface of the fabric. Complementary yarns consist of at least two yarns and may be warp or weft yarns; in the fabrics of the present invention, the complementary yarns are pairs of weft yarns. Complementary yarns do not function as binder yarns which tie two fabric layers together by interweaving with yarns from both layers.

The present invention is based on the discovery that it is possible to use, in the machine side layer of fabrics including at least two systems of weft yarns, pairs of machine side layer weft yarns arranged as pairs of complementary yarns to complete the MS fabric weave structure. In other words, the members of each weft yarn pair co-operate together by alternating with each other between interweaving with the MS warp yarns and being carried in the interior of the fabric, to form the weave pattern of the MS and effectively double the number of weft on the MS surface. This doubles the yarn mass in the MS layer and increases certain of the mechanical properties of the fabric, including stiffness, stability and wear resistance.

Doubling the number of weft yarns in the MS layer, without reducing the size of those yarns, will increase the caliper or thickness of the resulting fabric. Over time, forming fabric manufacturers have strived to reduce fabric caliper so as to minimize the water carrying capacity of the fabric. Thin fabrics carry less water and are less prone to marking the sheet when the fabric passes around rolls at high speed in the papermaking process, causing water retained in the interior voids of the fabric to be released and spray onto the sheet.

In the fabrics of the present invention, it is possible to decrease the size of the MS weft yarns in comparison to those which have been previously used in similar designs which are not so constructed and thereby to decrease fabric caliper without sacrificing the abrasion resistance of the fabric. This is because the number of weft yarns used in the fabrics of the present invention is double that which would be used in comparable designs.

In the fabrics of this invention, the MS weft yarns do not interweave with any of warp yarns forming the PS layer, but instead remain in the MS layer where they interweave solely with the MS warp. Because the complementary weft pair members do not interweave with any PS yarns, the fabric structure can be tied into any selected PS weave by means of either intrinsic weft binder yarns in the manner described by Seabrook et al. in US 5,826,627, or intrinsic warp binder yarns in the manner described by Danby et al. in US 7,426,944.

The invention therefore seeks to provide a multilayer woven industrial fabric, having a paper side layer and a machine side layer, comprising at least one set of warp yarns interwoven with at least one set of paper side layer weft yarns and a set of machine side layer weft yarns in a repeating weave pattern wherein all the machine side layer weft yarns comprise complementary pairs, each pair comprising a first member and a second member, which alternate with each other at exchange points to interweave with selected warp yarns in the machine side layer such that for each complementary pair

(i) the first and second members of the pair appear only in the machine side layer of the fabric; and

(ii) when the first member of the pair appears in the machine side layer of the fabric, the second member of the pair is carried within the fabric.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of one repeat of the weave of a triple layer sheet support binder forming fabric taken along the weft yarns, in a first embodiment of the invention;

Figure 2 is a weave diagram of the fabric of Figure 1;

Figure 3 is a photograph of the MS of a fabric woven according to the weave pattern of Figure 2;

Figure 4 is a photograph showing an enlarged view of one repeat of the fabric of Figure 3; and

Figure 5 is a cross-sectional view of one repeat of the weave of a triple layer warp integrated sheet support binder forming fabric, taken along the warp yarns, in a second embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 shows a representation of one repeat of the weave pattern of a first embodiment of a fabric according to the invention. In this Figure, the PS warp yarns are identified by numerals 10 – 21 and the MS warp are identified by numerals 50 - 61. The PS weft, which are intrinsic weft binder yarns, are identified by numerals 3 and 4 while the paired MS weft, which are complementary weft yarns, are identified by numerals 1 and 2. The weave diagram of this fabric is shown in Figure 2.

Figure 1 is a cross section taken across the warp yarns of a fabric of the invention. The fabric includes two layers of warp yarns, and in a similar manner to the fabrics of US 5,826,627, the PS weft yarns are comprised in part of pairs of intrinsic weft binder yarns such as 3 and 4 in Figure 1. These yarns are interwoven with a portion of the PS warp yarns 10-21 so as to form part of the PS surface of the fabric. The weft yarns exchange positions at exchange point 200 so that, beginning from the left side of Figure 1, weft yarn 4 forms a plain weave on the PS of the fabric passing under warp yarn 10, over 11, under 12, over 13, under 14 and over warp yarn 15. Weft yarn 4 then exchanges position with weft yarn 3 and passes down into the MS layer of the fabric to interweave beneath MS warp yarn 58, thus binding the MS and PS fabric layers together. Weft yarn 4 then passes through the centre plane of the fabric to cross weft yarn 3 after (to the right of) warp yarn 21 and repeat the same pattern. Also beginning at the left, weft yarn 3 floats between the PS and MS layers beneath warp yarns 10 and 11, and above warp yarns 50 and 51. Weft yarn 3 then passes beneath warp yarn 52 thereby binding the PS layer of warp yarns 10-21 to the MS layer of warp yarns 50-61. Weft yarn 3 then floats over warp yarns 53, 54, 55 and 56 to exchange positions with weft yarn 4 at exchange point 200.

In Figure 1, the paths in the fabric of the pairs of complementary MS weft yarns 1 and 2 are also clearly seen. These yarns interweave only with the MS warp yarns, i.e. yarns 50-61. Starting from the left side of Figure 1, weft yarn 1 passes under MS warp 50, 51, 52, 53 and 54, then over warp yarn 55 where it exchanges positions with weft yarn 2 at exchange point 100. It then floats between the MS and PS layers over warp yarns 56, 57, 58, 59 60 and 61, at which point it exchanges positions with weft yarn 2 to repeat the pattern. Starting again from the left side of Figure 1, weft yarn 2 floats over warp yarns 50, 51, 52, 53, 54 and 55, then exchanges position with weft yarn 1 to pass under MS warp yarns 56, 57, 58, 59 and 60 at which point it exchanges positions with weft yarn 1 as it passes over MS warp yarn 61. The two weft yarns exchange positions at exchange point 100 and at both the left and right sides of the Figure where the pattern repeats.

As can be seen from Figure 1, the complementary weft yarns 1 and 2 together combine to interweave only with the MS warp yarns, i.e. warp yarns 50-61, according to an under 5/over 1 pattern. It can be appreciated that the long floats of these two weft on the MS of the fabric will contribute to the wear resistance of the MS surface. The arrangement also doubles the number of weft yarns in this layer.

It is not necessary that the MS weft pair members 1 and 2 be of the same size, shape or material constitution as the PS weft yarns 3 and 4. The weft yarns 1 and 2 can be larger or smaller than the weft 3 and 4; in certain instances, for example where fabric caliper is particularly important, it may be advantageous to downsize these weft yarns so that they contribute less to the fabric thickness. It may also be advantageous to use weft yarns formed from one of the various polyamides and blends thereof so as to maximize the wear life of the fabric; yarns formed from a blend of polyester and thermoplastic polyurethane such as described in US 5,169,711 or US 5,502,120 may also be beneficial.

The weave diagram of a fabric woven to provide the MS weft arrangement illustrated in Figure 1 is provided in Figure 2. Figures 3 and 4 are photographs of the MS surface of a sample fabric woven according to the weave diagram shown in Figure 2. The properties of the sample fabric are provided in Table 1 below. For comparison purposes, a similar fabric was woven according to US 5,826,627, using the same materials as the experimental fabric, and tested.

Table 1:

Property	Experimental Fabric	Comparison Fabric
PS Mesh & Knocking (/in.)	73 x 79	74 x 83
MS Mesh & Knocking (/in.)	73 x 53	74 x 55
PS MD Strand Diameter & Type	0.13mm WL-066	0.13mm WL-066
PS CD Strand Diameter & Type	0.14mm AW137	0.13mm AW137
Tie Strand Diameter & Type	0.14mm AW137	0.13mm AW137
MS Mesh & Knocking (/in.)	73 x 53	74 x 55
MS MD Strand Diameter & Type	0.21mm WL-066	0.21mm WL-066
MS CD Strand Diameter & Type	0.26mm WP-807	0.25mm AW145/171
Heatsetting Tension (p.l.i.)	45	55
Heatsetting Temperature (°F)	365	380
Fabric Properties: Experimental / Comparison		
Length Increase (%)	3.8	5.1
Width Decrease (%)	8.0	8.0
Elastic Modulus (p.l.i.)	8850	8100
Lateral Contraction (% p.l.i.)	0.0052	0.0056
Air Permeability (on loom) (cfm/ft^2)	380	475
Caliper (in.)	0.043	0.0331
PS Crimp Differential (in.)	-0.0010	-0.0008
MS Crimp Differential	-0.0081	-0.0051
As Woven Caliper (in.)	0.0435	n/a
Total as woven Knocking (/in.)	220	170
Stiffness (MD/CD/Total)	10.7 / 9.6 / 20.3	3.9 / 4.0 / 7.9

In Table 1 above, the PS & MS Mesh and Knocking are measured in the fabric following heatsetting at the tensions and temperatures indicated. Yarn sizes and processing conditions are as shown.

The data in Table 1 shows that Elastic Modulus of the experimental fabric is 10% higher than the comparison fabric that does not include the intrinsic MS weft yarns (8850 vs. 8100). This increase is likely due to the straighter path of the warp yarns in the fabric as a result of the yarn arrangement of the MS weft pair members. However, this increase in modulus is significant and was an unexpected benefit of the invention. However, the main benefit of the invention, that of increased fabric stiffness, is apparent from the data shown. The machine direction (MD) stiffness increased by 174% from 3.9 to 10.7 and the CD stiffness increased by 140% from 4.0 in the comparison fabric to 9.6 in the experimental which indicates that this fabric, which in almost all aspects is identical to the comparison fabric with the exception of the use of the complementary weft pairs in the MS, should be much stiffer when used on the papermaking machine. This should prevent or reduce problems such as creasing and similar issues associated with the dimensional stability of the fabric. Further, the MS crimp differential of the fabric is -0.0081 as compared to -0.0051 indicating the weft yarns stand prouder from the MS surface of the fabric than those of the comparison fabric. This will prove beneficial with respect to the wear resistance properties of the fabric.

It will be noticed however that the air permeability of the experimental fabric is 20% lower than that of the comparison; this is due to the additional weft yarns in the MS surface. Further, although the caliper value of the comparison fabric is not provided, it is expected to be thinner than that of the experimental fabric. It is anticipated that both of these properties could be easily modified in the experimental fabric by replacing the MS weft yarns with smaller diameter yarns. This is not expected to adversely impact the wear resistance of the fabric due to the much higher wear volume present on the MS.

Figure 5 is a representation of an alternate embodiment of a fabric according to the present invention. In this case, the fabric is a triple layer warp integrated sheet support binder type such as is described in US 7,426,944 (Danby et al.). In this representation, which is a cross section taken through the weft yarns, the warp yarns 1 and 2 run from left to right across the drawing and the weft yarns are shown in cross-section. The PS weft yarns are numbered 10-33 and the MS weft yarns are numbered 50-73 to provide 24 weft on each of the PS and MS layers of the fabric. In this instance, the MS weft yarns are arranged as complementary weft pairs and the paths of the warp yarns are shown as they would occur in the fabric. Starting at the left side of Figure 5, warp yarn 2 passes between MS weft pairs 50 and 51, under pairs 52 and 53, and then between weft pairs 54/55, 56/57 and 58/59. Warp 1 passes over both weft yarns 60 and 61 and then interweaves with PS weft yarns 22-33, at which point it repeats the pattern. Warp yarn 22 follows a similar path, interweaving with PS weft yarns10-20, then passing beneath weft 21 and down onto the MS where it passes between weft pairs 62/63, and 64/65. Warp 1 then interweaves with weft pair 66/67 and then passes between weft pairs 68/69, 70/71 and 72/73 and then up into the PS of the fabric to repeat the pattern.

CLAIMS

1. A multilayer woven industrial fabric, having a paper side layer and a machine side layer, comprising at least one set of warp yarns interwoven with at least one set of paper side layer weft yarns and a set of machine side layer weft yarns in a repeating weave pattern wherein all the machine side layer weft yarns comprise complementary pairs, each pair comprising a first member and a second member, which alternate with each other at exchange points to interweave with selected warp yarns in the machine side layer such that for each complementary pair
(i) the first and second members of the pair appear only in the machine side layer of the fabric; and
(ii) when the first member of the pair appears in the machine side layer of the fabric, the second member of the pair is carried within the fabric.

2. A fabric according to Claim 1, wherein the paper side layer and the machine side layer are bound together by pairs of intrinsic weft binder yarns.

3. A fabric according to Claim 1, wherein the paper side layer and the machine side layer are bound together by pairs of intrinsic warp binder yarns.

4. A fabric according to any one of Claims 1 to 3, wherein the fabric is a papermakers' forming fabric.

Figure 1

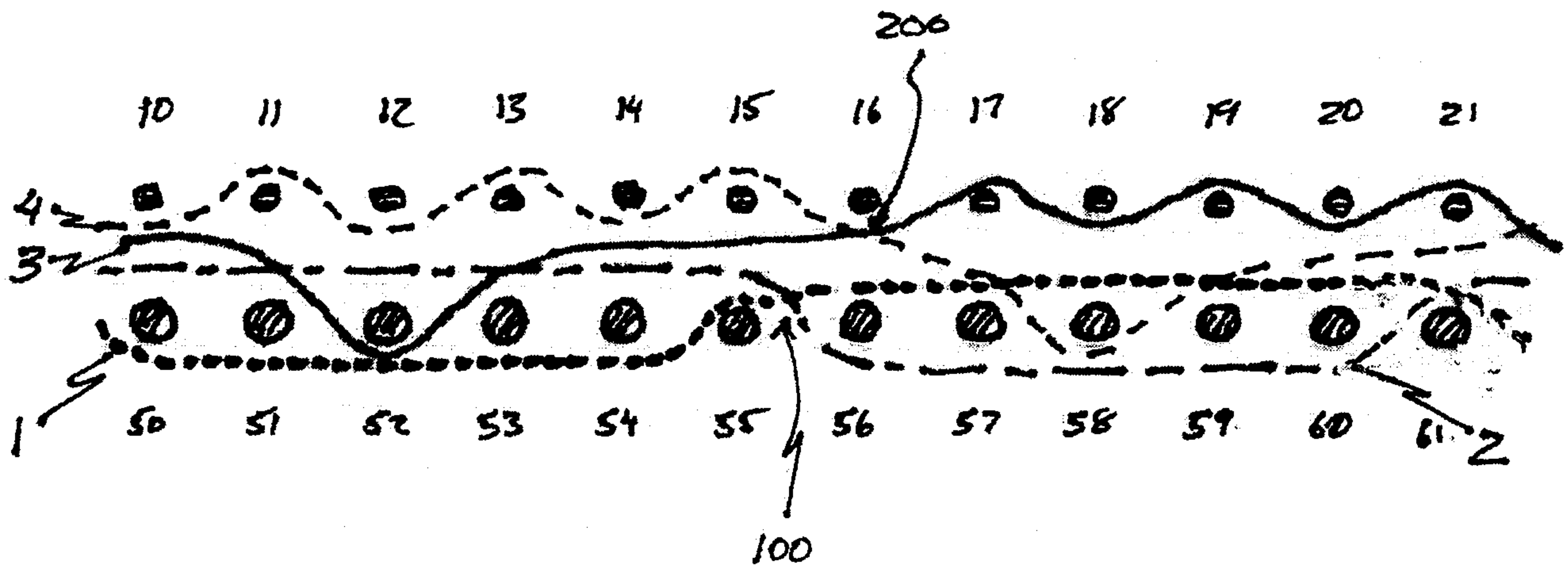

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Figure 2

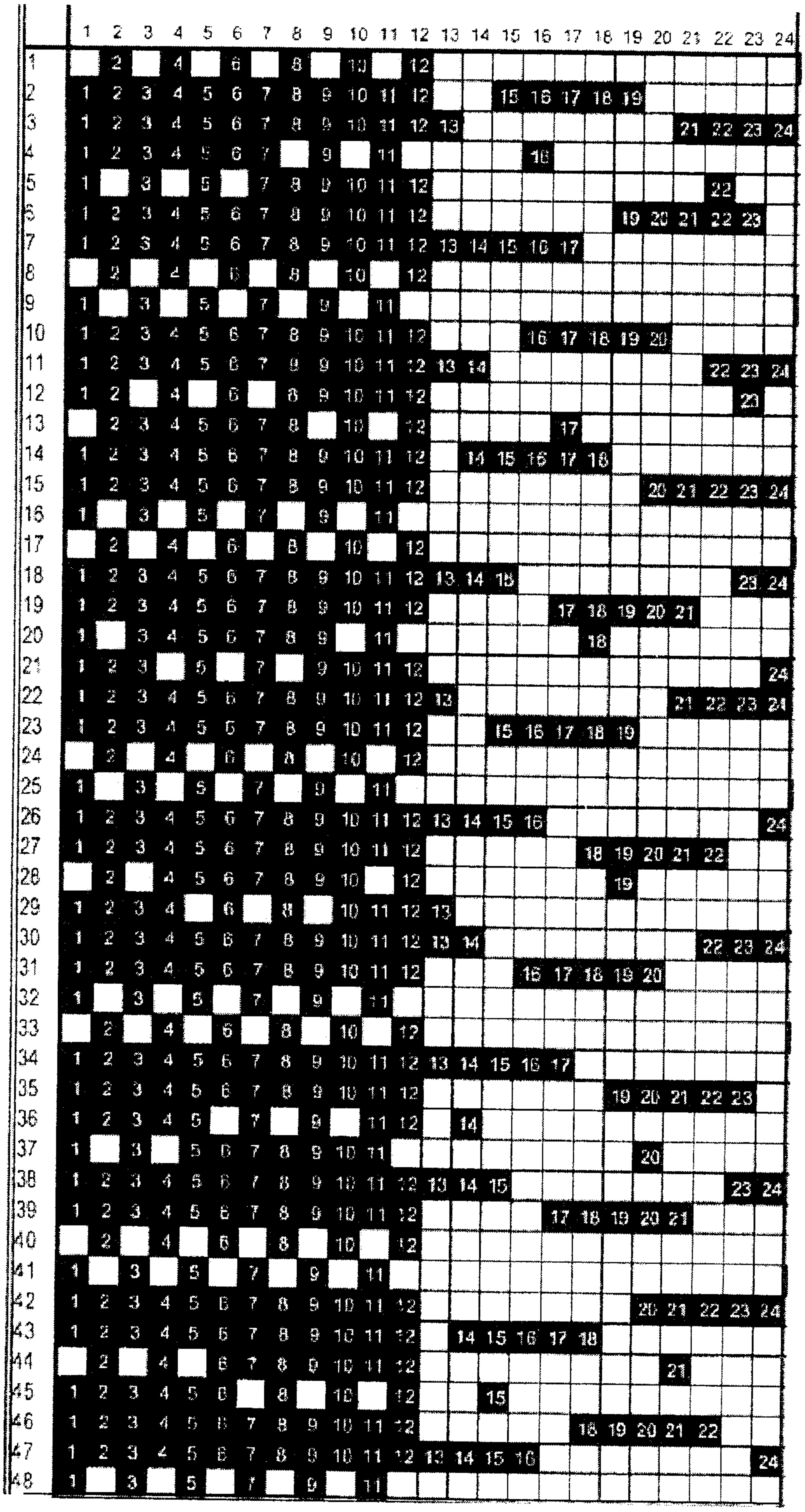


Figure 3

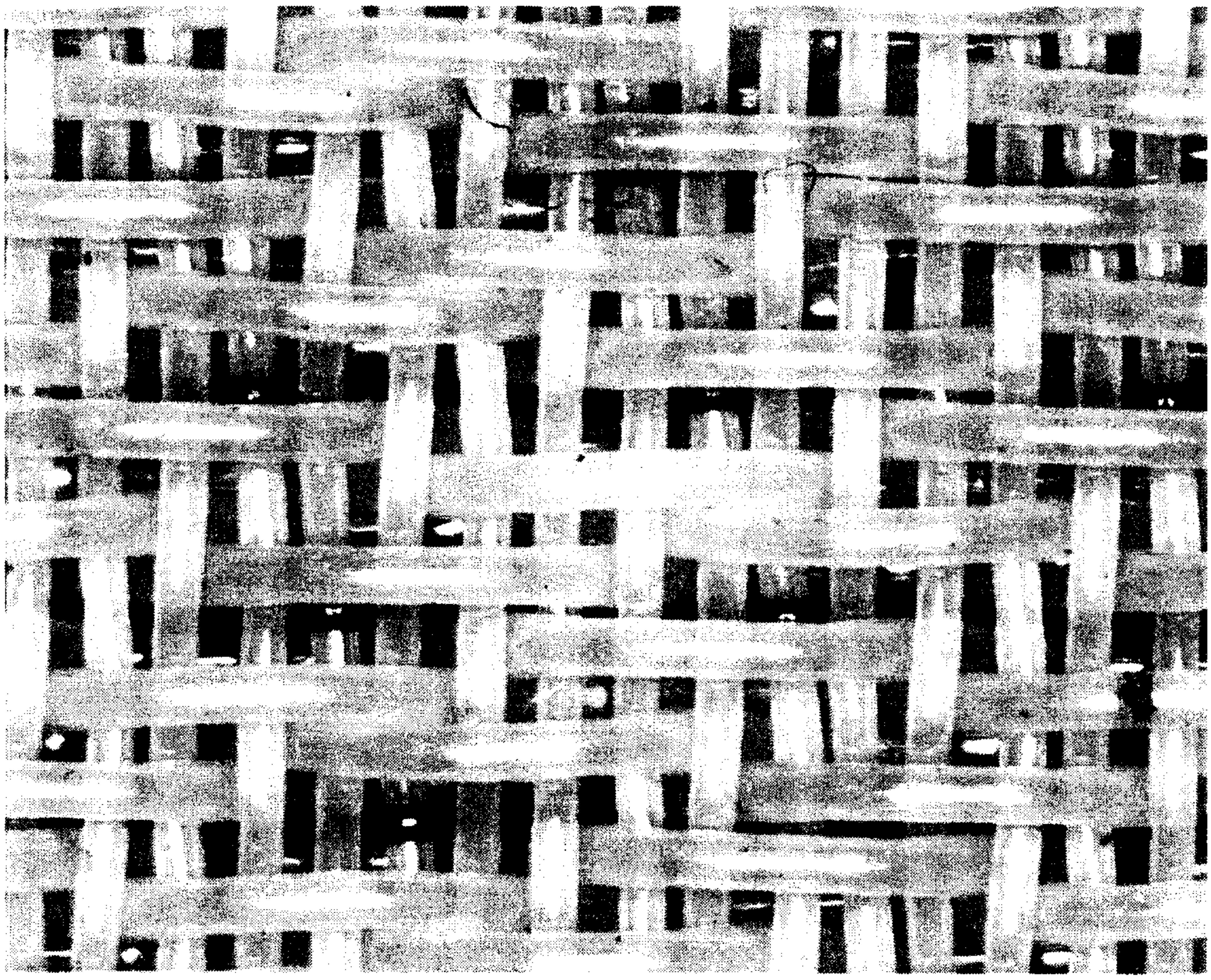


Figure 4

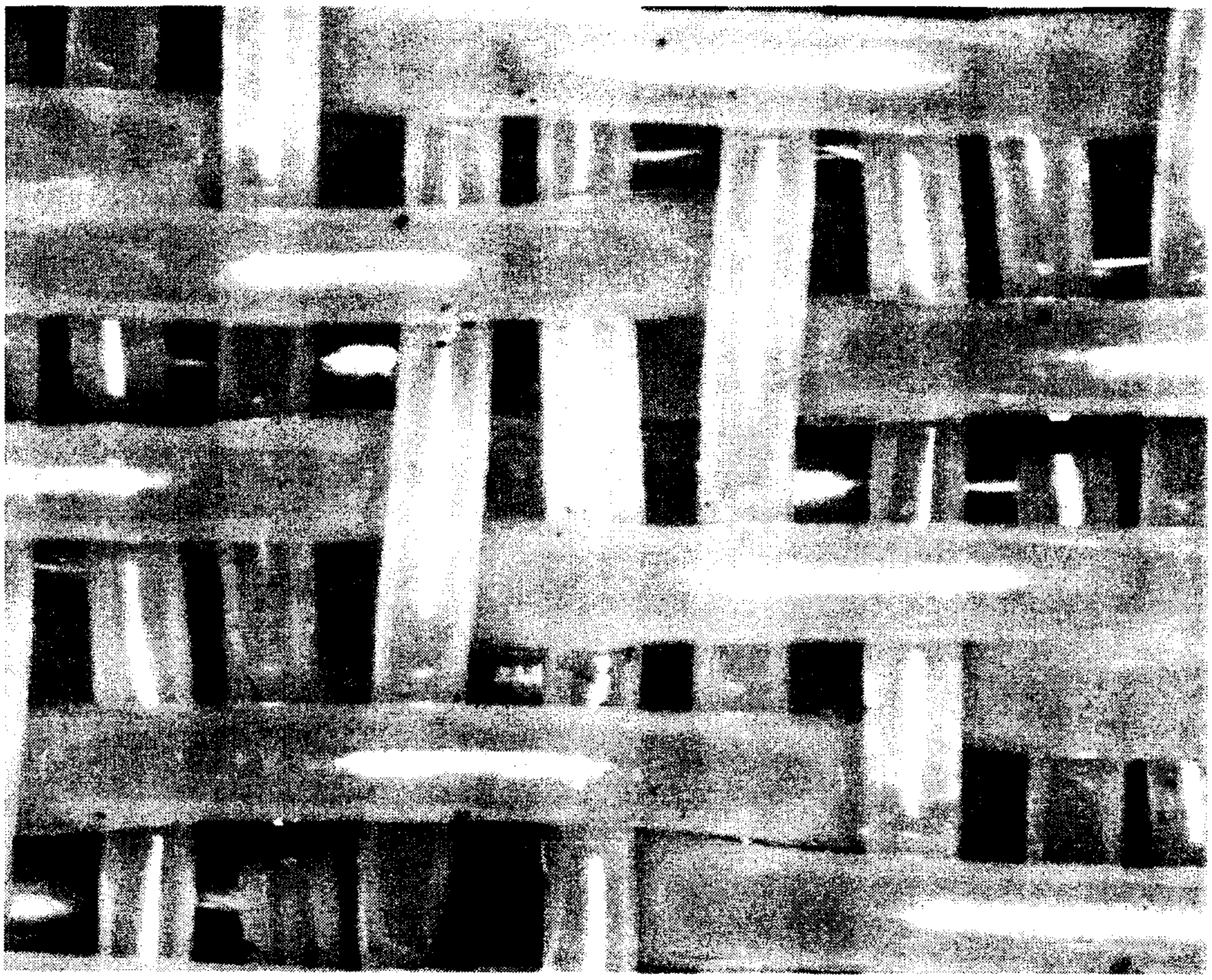
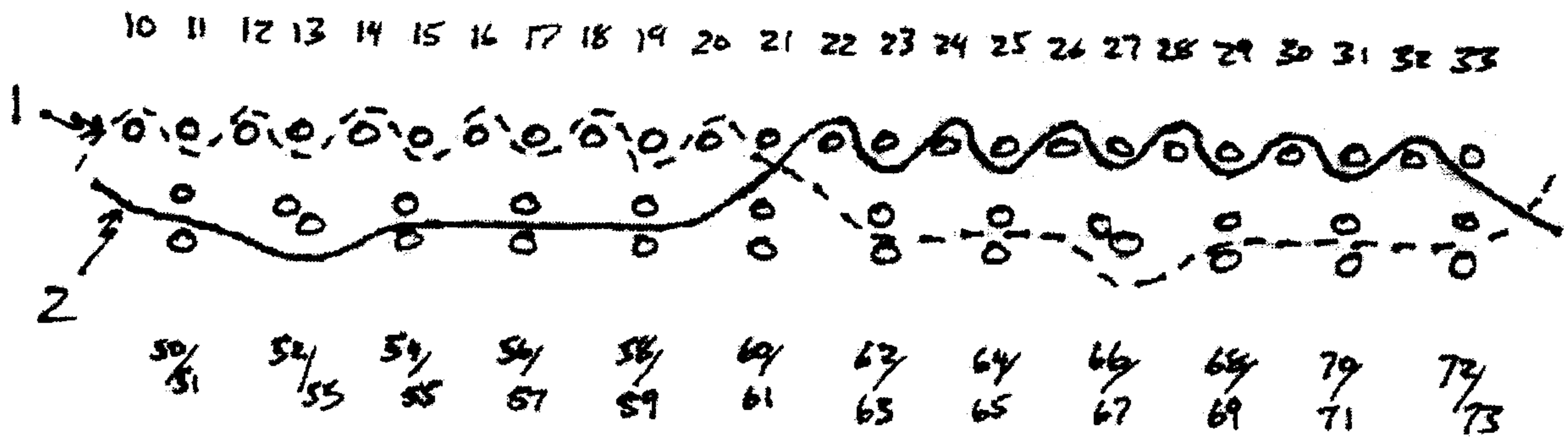


Figure 5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