

April 26, 1960

T. HINDLE ET AL
PAPERMAKERS' DRYER FELTS

2,934,097

Filed Dec. 5, 1957

2 Sheets-Sheet 1

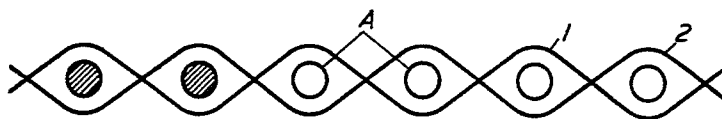


Fig. 1a.

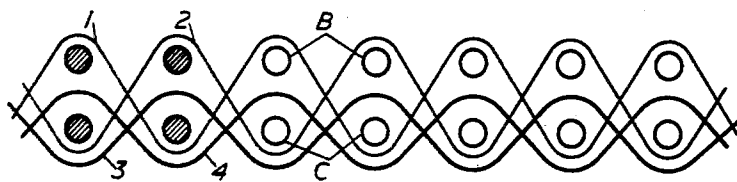


Fig. 1.

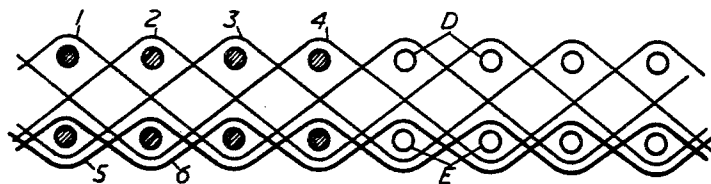


Fig. 2.

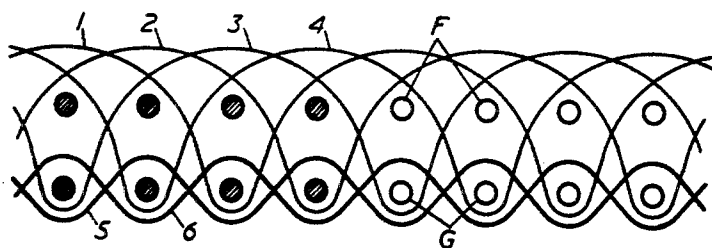


Fig. 3.

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2 Sheets-Sheet 2

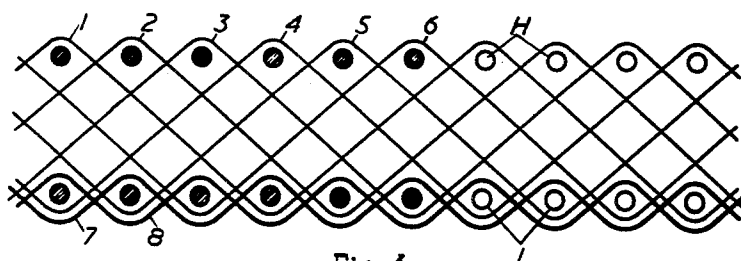


Fig. 4.

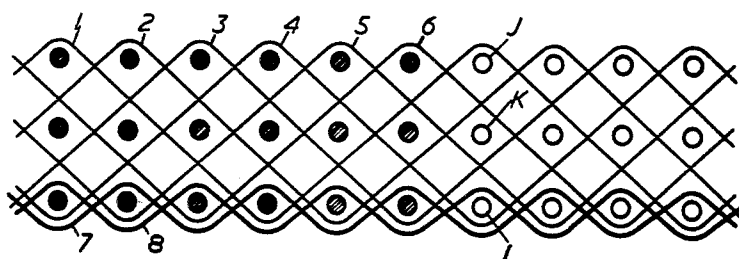


Fig. 5.

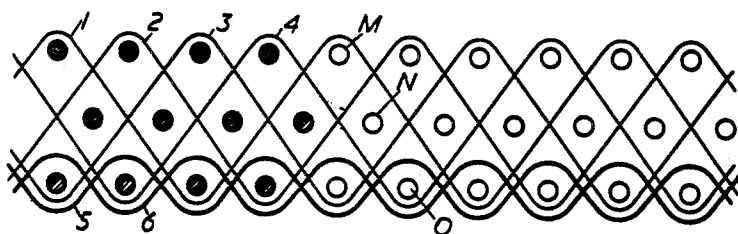


Fig. 6.

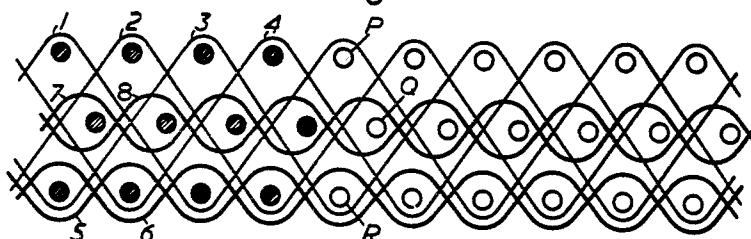


Fig. 7.

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2,934,097

PAPERMAKERS' DRYER FELTS

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Claims priority, application Great Britain
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13 Claims. (Cl. 139—383)

This invention concerns the endless woven bands which, in paper-making, are used to carry the sheet or web of paper in close contact with the drying cylinders of the paper machine. Such endless woven bands may be composed of cotton, or cotton and asbestos, or cotton and synthetic fibrous or filamentous material, or cotton, asbestos, and synthetic fibrous or filamentous material, or wholly or synthetic fibrous material. Although not subjected to any form of milling, and, therefore not "felts" in the recognised sense of the term, these endless woven bands have, by common usage, become to be known as "dryer felts." Such bands are generally woven flat and the ends thereafter joined to form an endless structure in manners well known in the art.

By established practice, that surface of the dryer felt which is in contact with the paper sheet as the latter passes over the drying cylinders is known as the "face" of the dryer felt, and that surface which does not contact the paper sheet is known as the "back" of the dryer felt. These terms are used hereinafter in describing the two surfaces of a dryer felt.

As the speeds of paper machines throughout the world continue to increase, more and more stress is being laid on the functions of dryer felts in the removal of water from the web of paper as it passes through the dryer part of the paper machine. It has been generally believed that the vapour, or gaseous, permeability of the dryer felt is of paramount importance in the removal of water from the paper sheet. However, as a result of our researches, both in the laboratory and on the paper machine, we have now discovered that, at the dryer part of the paper machine, water can be removed from the sheet in two forms: (a) as liquid water; (b) as vapour. We have discovered abundant evidence that on the first drying sections, i.e. when the sheet of paper is still relatively wet, a high proportion of water which leaves the paper does so as liquid water, and the only recipients of this water are the dryer felts. Water absorbed from the paper sheet in this manner must necessarily be dissipated from the felt as vapour at, at least, a corresponding rate, otherwise the felt rapidly becomes water-logged, in which event its efficiency as a means for drying the paper sheet falls off markedly, so that the speed of making paper may have to be reduced solely on this account.

While the face of the dryer felt is in contact with the paper which is pressed by the felt firmly against the heated surface of each successive drying cylinder, water can be dissipated as vapour only from the back of the felt. During this period, the viscosity of the water in the paper sheet is decreased due to its temperature being raised by the heat transmitted from the drying cylinder. The water expressed from the paper sheet is absorbed more rapidly by the face of the dryer felt because of its lowered viscosity and is dispersed throughout the felt, the rate and extent of dispersion being related to the strength of the inter-fibre and inter-yarn capillary forces which exist in the felt. Inter-fibre capillarity is, of course,

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due to the multiplicity of fibre capillaries formed between adjacent fibres in a yarn. Inter-yarn capillarity exists because most, if not all, dryer felts are manufactured from twisted multi-ply yarns; inter-yarn capillarity is, therefore, one form of inter-capillarity, the fibres from which the capillaries are derived belonging to different single threads of the same composite yarn. The liquid water which, by capillarity, is transmitted to the back of the felt can be dissipated as vapour into the atmosphere by virtue of the heat acquired from the drying cylinders and other heating devices. That proportion of the water which is dissipated as vapour from the back of the felt is continuously replaced by liquid water, flowing by capillarity, from the face of the felt, and that from the face is continuously replaced by more water from the sheet itself.

Thus, when the paper sheet and the dryer felt leave the heated cylinder to go their separate ways, the dryer felt carries water dispersed throughout its thickness from face to back. While the dryer felt is travelling from one cylinder to the next, such water can be dissipated as vapour from both the face and back of the felt, except for the period during which the felt is passing round a felt roll which prevents dissipation of water as vapour from the back of the felt, because it is the latter which is in contact with the surface of the felt roll.

Thus, water is dissipated as vapour from the back of the felt continuously except for the short period when the back is in contact with the felt rolls, but from the face of the felt water is dissipated as vapour only intermittently, i.e., while the felt is passing from one cylinder to the next.

For these reasons, we estimate that, even with dryer felts of existing structures, at least one-half of the water absorbed as liquid water by the face of the dryer felt must be transmitted to the back of the felt by virtue of inter-fibre and inter-yarn capillary forces which exist in the felt. It follows, therefore, that, contrary to general belief, air permeability of dryer felts which clothe the first sections of the dryer parts of paper-making machines plays virtually no part in drying the sheet of paper. On the other hand, the greater the capillarity, or wick-feed action of the felts clothing the earlier sections, the more efficient will the dryer felts be in water removal from the paper sheet and dissipation from the felt of water as vapour.

We have discovered that in a dryer felt, whether it be of a single-layer or a multi-layer construction, the greatest capillarity is achieved when all the warp ends inter-weave so as to appear on both face and back of the woven felt. Under such conditions, each warp end acts, by capillarity, to conduct liquid water all of the way through the felt from one face to the other. For example, in a plain-woven single-layer felt, all the warp ends appear on both surfaces, and the fact that such a felt exhibits a high degree of capillarity is, we have established, due to such bi-facial appearance of the warp ends. However, the relatively severe degradation which occurs to the face of a felt due to the action of moist heat and, in most instances, also of acid, together with the unavoidable disintegration of the yarns and fibres of the felt caused by the continual flexing which the felt undergoes in passing at high speed round the felt rolls, tend to result in disintegration of the face of the dryer felt. Furthermore, this flexural degradation, accentuated by the often severe abrasion which occurs to the back of the felt when it passes round the felt rolls, tends to result in disintegration of the back of the felt. In most cases, disintegration of the face of the felt is more rapid than that of the back, although in isolated instances, because of rough felt rolls or faulty bearings,

disintegration of the back of the felt may proceed more rapidly than that of the face. Now, in the case of a plain-woven, single-layer fabric, whether the face or the back degrades more rapidly, when either surface disintegrates the entire felt also disintegrates. Consequently, although the capillarity of such a felt is of a high order, its service life on the paper machine is economically too short.

The primary object of this invention is to provide a dryer felt having a plurality, for example either two or three, layers of weft in which the liquid water conducted by capillarity from face to back is greater than in multi-layer felts previously manufactured and at the same time, to provide dryer felts in which disintegration of the face does not result in disintegration of the structure as a whole, and disintegration of the back is very substantially delayed.

As hereinafter stated in greater detail, the yarns employed in the practice of this invention may be of any of the materials customarily used, or which may hereafter be found useful, in the manufacture of papermakers' dryer felts, and the invention is concerned solely with the manner in which the constituent yarns are interwoven. For convenience of description, those warps, regardless of the material of which they are made, which pass from face to face of the felt and thus, by capillarity, act to lead the water in liquid form directly from one face to the other of the felt are referred to as "water conducting warps," thereby to distinguish these particular warps which extend all of the way through the fabric from those warps which do not afford an easy path for water flow from one face to the other of the fabric.

According to the invention a papermakers' dryer felt woven with warp and weft yarns and having the weft arranged in a plurality of layers is characterised in that at least half of the warp yarns are interwoven with both outer weft layers so as to appear on both the face and the back of the felt and in that the remaining warp yarns are interwoven with weft other than the face weft layer.

The papermakers' dryer felt aforesaid may be further characterised in that each of the said remaining warp yarns is interwoven with only one weft layer.

The invention is best described by reference to the diagram shown in Figs. 1a to 7. Fig. 1a is an idealised cross-section through a straight weft of a plain-woven, single-layer felt, and Figs. 1 to 7 are diagrams representing idealised cross-sections through straight wefts of felts manufactured in accordance with the present invention. As can be seen from Fig. 1a, all the warp ends 1 and 2 are arranged in plain order about the wefts A and appear on both face and back of the woven felt thus giving a high degree of capillarity through the felt, but destruction of either the face or the back results in disintegration of the felt as a whole.

Example I

In accordance with the present invention, the simplest modification of the plain weave structure is shown in Fig. 1 which illustrates a felt, having two layers of weft, B and C, in which the warp ends 1 and 2 appear on both face and back, thereby constituting capillary water conductors extending from face to face of the felt, and the warp ends 3 and 4 interweave with the back layer C of weft only, thereby maintaining the integrity of the fabric even if the "binder" warp yarns 1 and 2 are ruptured, as well as reinforcing the back of the felt against mechanical disintegration. In such a structure 50% of the warp ends inter-weave so as to appear on both the face and the back of the felt.

In felts manufactured in accordance with the structure shown in Fig. 1, the warp ends are in plain formation, and consequently the face of the felt will have a ribbed appearance. Because of this, the proportion of the total area of the face of the felt which actually contacts the paper sheet as it passes over the drying cyl-

inders will be relatively small, with the result that transmission of heat from the cylinders to the paper and felt will also be relatively small. This defect is overcome when the felt is manufactured, still in accordance with the present invention, in the structures shown in Figs. 2, 3 and 4.

Example II

In the two layer structure shown in Fig. 2, having wefts D and E the warp ends 1, 2, 3 and 4 inter-weave so as to appear on both face and back of the felt, the surface warp yarns being arranged in $\frac{1}{2}$ broken twill order. Consequently, the face or upper side of the felt is smoother than those of felts woven with the structures of Figs. 1a and 1, and the percentage area of contact of the face with the paper sheet is correspondingly greater, giving in turn a greater efficiency of heat-transmission from the drying cylinders to the paper sheet. In a felt woven according to the structure shown in Fig. 2 the warp ends 5 and 6 inter-weave with the back layer E only of weft, thereby ensuring that rupture of the binder yarns 1, 2, 3 and 4 does not result in disintegration of the fabric, and at the same time reinforcing the back or under side of the felt. In such a structure, 66 $\frac{2}{3}$ % of the warp ends appear on both the face and the back, thereby producing a felt with a high capillarity effect.

Example III

In a two-layer felt woven in accordance with the structure shown in Fig. 3, having weft layers F and G the warp ends 1, 2, 3 and 4 appear on both face and back of the felt, those of the face being arranged in 3/1 broken twill order. The warp ends 5 and 6 are interwoven with the back layer G only of weft, giving the desired reinforcement against disintegration of the fabric as a whole. The relatively long float of the face warp yarns produces a smooth front surface structure giving a high degree of contact between felt and paper surfaces. Again, 66 $\frac{2}{3}$ % of the warp ends appear on both the face and the back of the felt.

Example IV

In a two layer felt woven in accordance with the structure shown in Fig. 4, having weft layers H and I the warp ends 1, 2, 3, 4, 5 and 6 appear on both the face and the back of the fabric and are arranged in 6-end satin order. The warp ends 7 and 8 are inter-woven plain with the back layer I only of weft giving the desired reinforcement. In accordance with the invention, in this structure 75% of the warp ends appear on both the face and the back of the felt giving an extremely high capillarity effect.

In all existing structures of dryer felts employing three layers of weft, no warp ends pass directly from face to back. Consequently, transfer of water from the face to the back of the felt is limited, due to the fact that such transference is dependent upon water being exchanged from the binder yarns which pass from the face to the centre layer, to the binder yarns which pass from the centre layer to the back of the felt. In accordance with the present invention, structures of felts containing three layers of weft have been devised in which a high percentage of the warp ends inter-weave so as to appear on both face and back of the woven felt. Examples of such structures are illustrated in Figs. 5, 6 and 7.

Example V

In the three-layer felt woven in accordance with the structure shown in Fig. 5 having weft layers J, K and L, the warp ends 1, 2, 3, 4, 5 and 6 inter-weave the 6-end satin order, so as to appear on both face and back of the felt, and the warp ends 7 and 8 inter-weave in plain order with the back layer L only of weft. In a felt woven according to this structure, 75% of the warp ends appear on both face and back and water is able to pass

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freely and rapidly along the inter-fibre and inter-yarn capillaries which are continuous from the face to the back of the felt.

Example VI

In the three-layer felt woven in accordance with the structure shown in Fig. 6 having weft layers M, N and O, the warp ends 1, 2, 3 and 4 inter-weave in 1/3 broken twill order, so as to appear on both face and back of the felt, and the warp ends 5 and 6 inter-weave in plain order with the back layer of weft. In a felt woven according to this structure, 66⅔% of the warp ends appear on both face and back of the felt.

Example VII

In a three-layer felt woven in accordance with the structure shown in Fig. 7 having weft layers P, Q and R, the warp ends 1, 2, 3, 4, 5 and 6 inter-weave in a manner identical with those of Example VI. In addition two extra warp ends 7 and 8, inter-weave in plain order with the centre-layer of weft Q, which is thereby reinforced. In such a structure 50% of the warp ends appear on both face and back of the felt.

In the fabric herein disclosed those of the warps which extend from the face to the back of the fabric, i.e. the water-conducting warps, are actually interwoven with wefts of both of the outer layers, that is to say, these water-conducting warps pass, at regularly recurrent intervals, over and under wefts of both layers.

Moreover, it will be noted that the fabric disclosed is of symmetrical construction such that the crossing points of adjacent warps are always equidistant from successive wefts of the face layer, while successive wefts of the face layer are always directly above successive wefts of the back layer.

It is to be understood that the invention is not to be limited to the above examples.

The woven dryer felts employed at the dryer part of a paper machine vary considerably in weight, counts of yarn and other factors. Also, many different fibres are used in the production of the yarns from which the dryer felts are made. It is to be understood that yarns of the type, quality, counts, twist and the like, could be used to produce a dryer felt according to the invention as have been normally used hitherto. Similarly, it is to be understood that papermakers' dryer felts of the quality, threads per inch and the like, as have been hitherto manufactured for the drying sections of paper machines, are in accordance with the invention when in such dryer felts half at least of the warp ends inter-weave so as to appear on both face and back of the woven felt, the other warp ends being inter-woven in plain order with a layer or layers of weft other than the face layer.

Dryer felts constructed in accordance with this invention have a high capillarity resulting in a high rate of water transmission through the felt from face to back, which in turn results in a high rate of water transference from paper sheet to felt, with the beneficial result that the speed of making paper can be increased.

We claim:

1. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, comprising warp and weft yarns, the weft yarns being disposed in a plurality of layers, one of said layers being a face layer and the other a back layer, at least one-half of the warp yarns being water-conducting warps which are interwoven with wefts of both face and back layers, passing at recurrent intervals over and under wefts of each respective layer and appearing at both of the exposed surfaces of the felt, the remaining warps being body warps which do

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not appear at the face of the felt, but which are interwoven solely with wefts other than those of the face layer.

2. A papermakers' dryer felt according to claim 1 further characterised in that each of the said remaining warp yarns is interwoven with only the back weft layer.

3. A papermakers' dryer felt according to claim 1 characterized in having at least one additional layer of weft yarns, disposed between the face layer and back layer.

4. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, comprising warp and weft yarns, the weft yarns being disposed in two layers, one of said layers being a face layer and the other a back layer, more than one-half of the warp yarns being water-conducting warps which are interwoven with wefts of both of the face and back layers, passing at recurrent intervals over and under wefts of each respective layer and appearing at the exposed surfaces of the felt, the water-conducting warps embracing wefts of both layers simultaneously in pairs in plain order, and the remainder of the warps embracing only the back wefts in plain order.

5. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, which comprises warp and weft yarns and has the weft disposed in two layers characterized in that two-thirds of the warp yarns embrace the weft of both layers in 1/3 broken twill order with one weft pass only covered at face and back, and the remaining warp yarns embrace only the back weft layer in plain order.

6. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, which comprises warp and weft yarns and has the weft disposed in two layers characterized in that two-thirds of the warp yarns embrace the weft of both layers in 3/1 broken twill order with the weft passes on the face covered in groups of three and with the weft passes at the back covered singly and the remaining warp yarns embrace only the back weft layer in plain order.

7. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, which comprises warp and weft yarns and has the weft disposed in two layers characterized in that three-quarters of the warp yarns are arranged in 6-end satin weave order, the remaining warp yarns embrace only the back weft layer in plain order.

8. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, which comprises warp and weft yarns and has the weft disposed in three layers characterized in that three-quarters of the warp yarns

are arranged in 6-end satin weave order with a single weft pass of each outer layer covered thereby and merely passing between the weft passes of the middle layer and with the remaining warp yarns arranged in plain order with the weft passes of the back layer only.

9. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, which comprises warp and weft yarns and has the weft disposed in three layers characterised in that two-thirds of the warp yarns are arranged in 1/3 broken twill order with a single weft pass of each outer layer covered thereby and merely passing between weft passes of the middle layer, the remaining warp yarns being in plain order with the weft passes of the back layer only.

10. A papermakers' dryer felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, which comprises warp and weft yarns and has the weft disposed in three layers characterised in that one half of the warp yarns are arranged in 1/3 broken twill order with a single weft pass of each outer layer covered thereby and merely passing between weft passes of the middle layer, one-quarter of the warp yarns being arranged in plain order with the weft passes of the back layer only and the final quarter of the warp yarns arranged in plain order with the weft passes of the centre layer only.

11. A papermakers' dryer-felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, comprising warp and weft yarns, the weft yarns being disposed in two layers, one of which is a face layer and the other a back layer, more than one-half of said warp yarns being water-conducting warps which are interwoven with wefts of both the face and back layers, passing at recurrent intervals over and under wefts of each respective layer and appearing at both of the exposed surfaces of the felt, the remainder of the warps being body warps which are interwoven only with wefts of the back layer, the crossing points of adjacent warps in the face layer being equidistant from successive wefts,

12. A papermakers' dryer-felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, comprising warps and wefts, the wefts being disposed in a plurality of layers, one of said layers being a face layer and the other a back layer, at least one-half of said warps being water-conducting warps which are interwoven with wefts of both the face and back layers, passing at regularly recurrent intervals over and under wefts of each respective layer and appearing on the exposed surfaces of both of said layers, the remainder of the warps being body warps which do not appear at the face of the felt, but which are interwoven only with wefts of the back layer, successive wefts of the face layer being disposed directly above successive wefts of the back layer.

13. A papermakers' dryer-felt which is of abnormally high capillarity thereby to expedite the conduction of liquid water from the paper-contacting face to the back of the felt, and which is of a weave such that disintegration of the face of the felt does not necessarily result in structural disintegration of the felt as a whole, said felt being a multiple-weave fabric, said felt being of symmetrical weave and comprising at least two spaced parallel layers of weft yarns, one of said layers being a face layer and the other a back or body layer respectively, the wefts of said back or body layer being interwoven with a set of body warps, each of said body warps being interwoven with the wefts of the back or body layer only, passing at recurrent intervals over and under wefts of said body or rear layer, the number of warps so interwoven with the wefts of the back or rear layer not exceeding one-half the total number of warps comprised in the felt, and warps of good capillarity which pass through the felt from the face to the back thereby to facilitate the conduction of liquid water through the entire thickness of the felt, each of said water-conducting warps passing at recurrent intervals over and under wefts of the face layer and also passing at recurrent intervals over and under wefts of the back or body layer, adjacent water-conducting wefts crossing at points within the thickness of the felt which are equidistant from adjacent wefts of the face layer.

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