

April 14, 1959

R. J. THOMAS ET AL
PAPER OR BOARD PRODUCT

2,881,669

Filed March 1, 1955

2 Sheets-Sheet 1

FIG. 1

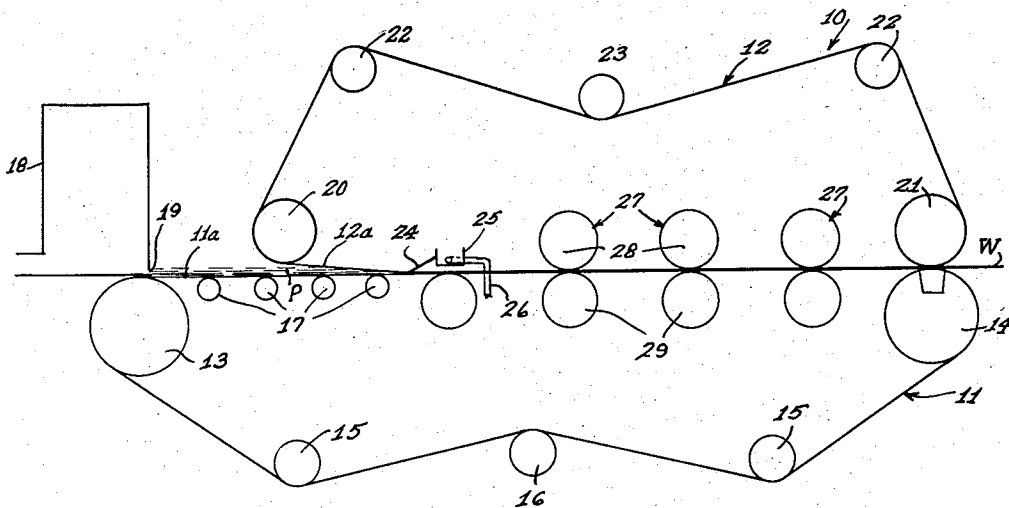


FIG. 2

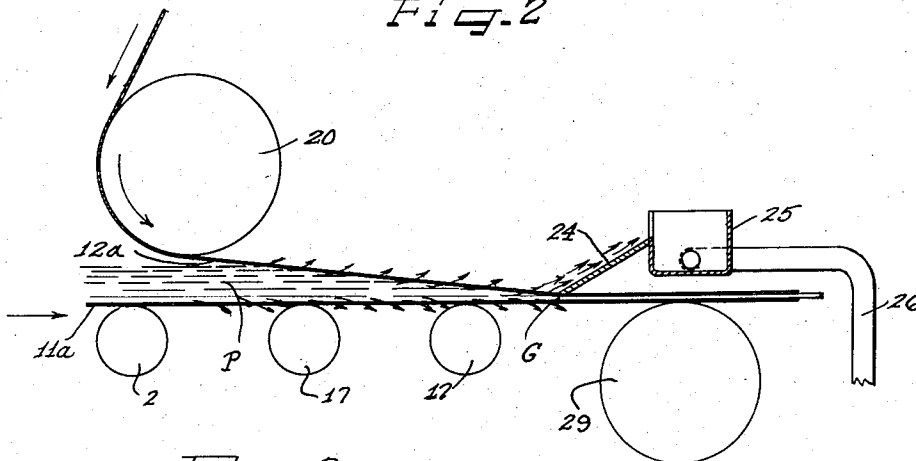
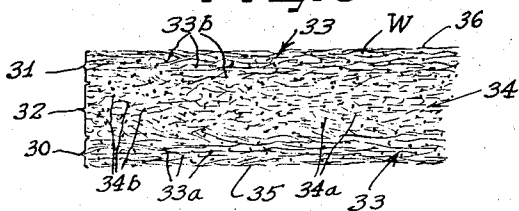


FIG. 3



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2 Sheets-Sheet 2

Fig. 4

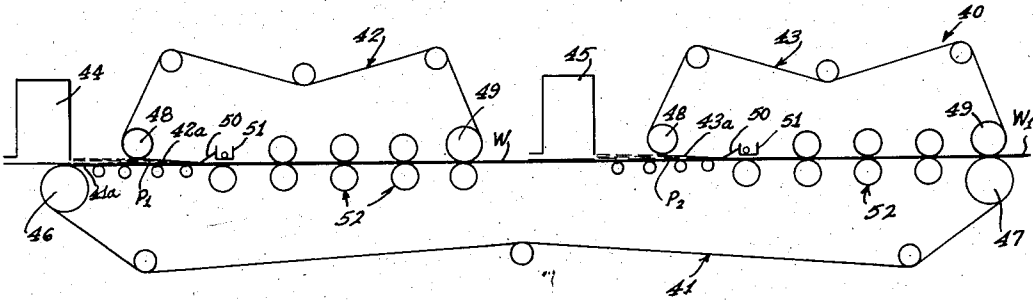


Fig. 5

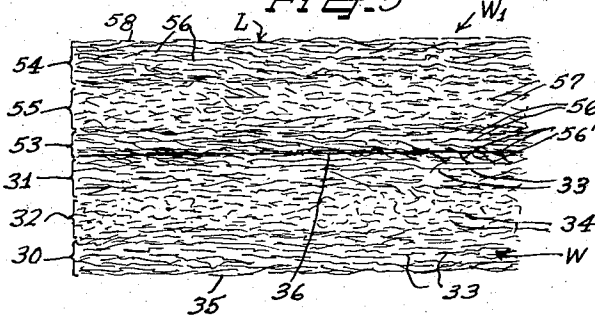


Fig. 6

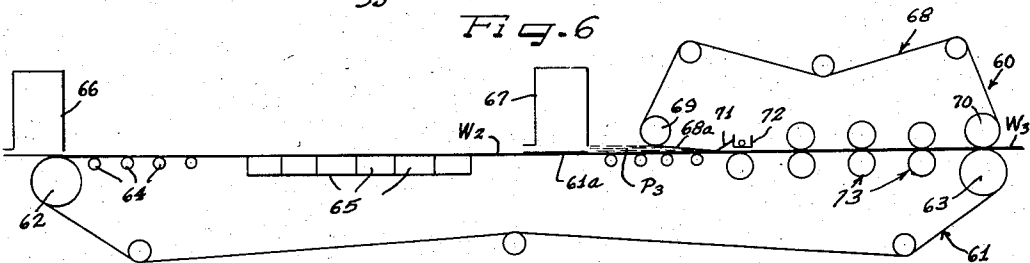
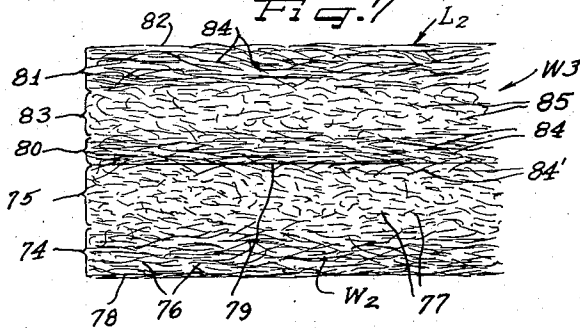


Fig. 7



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2,881,669

PAPER OR BOARD PRODUCT

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Application March 1, 1955, Serial No. 491,492

5 Claims. (Cl. 92—39)

This invention relates to fibrous webs of enhanced strength and surface characteristics. Specifically, this invention deals with paper or board having the constituent fibers thereof so oriented that the longer fibers lie on opposite sides of a zone of shorter fibers and all of the fibers are so interlaced and matted that no separation can occur between the short fiber and long fiber zones.

This application is a continuation-in-part of our parent application, Serial No. 373,382, filed August 10, 1953, entitled: "Dewatering Pulp or Stock on a Paper or Board Making Machine," issued January 28, 1958 as Patent 2,821,120.

According to the present invention, there is provided single ply paper or multi-ply board wherein the long fibers thereof are predominantly distributed on both sides of a short fiber zone and yet are so graduated and interlaced with the short fibers that separation of the short and long fiber zones cannot occur. The fibrous webs of this invention have enhanced strength since the center contains the short fibers and fillers while the surfaces of this invention contain the longer and stronger fibers producing an I-beam effect. In addition, the fibrous webs of this invention have improved surface characteristics because the long fibers at the surface avoid roughness, voids, and unevenness characteristic of short fiber surfaces.

In the manufacture of single ply paper and board on conventional Fourdrinier machines, the long fibers concentrate on the "wire" side of the web because in the initial dewatering of the layer of pulp on the traveling forming wire the "fines" flow through the wire with the white water of the pulp until the longer fibers interlace and mat on the wire to form a filter for the fines. Similar formation occurs on the conventional cylinder mold machine where the long fibers are initially retained on the cylinder molds to form the starting mat or bed for the web.

It is, therefore, characteristic of single ply paper or board, as made on conventional Fourdrinier and cylinder mold machines, that the long fibers are distributed at and toward the "wire" side only and the remaining fibers graduate in fiber length to provide dominant short fiber formation on the opposite or non-wire side of the paper or board.

In the production of multi-ply board and paper, the fibrous distribution is such that the long fibers are concentrated adjacent the wire side only during formation of each ply resulting in a multi-ply paper having alternate layers of long and short fibers with one side of the resulting multi-layer product consisting predominantly of long fibers and the other side consisting predominantly of short fibers.

In the multi-ply paper or board produced on so-called twin wire Fourdrinier machines, the short fibers are distributed on both sides of the paper and the long fibers are concentrated in the middle or central zone of the paper.

Heretofore, any attempt to produce a paper web with

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the long fibers concentrated at the surface areas and on opposite sides of a zone of short fibers, has always resulted in the production of a multi-ply or non-unitary type of sheet. Thus, prior to this invention, it has not been possible to produce a single ply or unitary multi-ply board with the long fibers predominating in the surface areas and integrally intermatted and interlaced with short fibers predominating in the middle or central zone.

In the single ply sheets of this invention the short fibers are sandwiched between the long fibers on the two sides of the sheet.

In the multi-ply sheets or boards of this invention, the sequence is long fibers, short fibers, long fibers, short fibers, and so on, according to the number of plies, but always starting and finishing with long fibers predominating. Thus, both outer faces of the multi-ply sheet will predominate in long fibers. Further, the plies or layers of the multi-ply web are more intimately interlaced and intermatted than conventional multi-ply paper or board because, according to this invention, even when a second ply forming stock is deposited on a previously formed mat or web, some of the fibers from the stock will be pulled into integral intermeshed relation with the underlying mat.

The novel structure of the sheets of this invention improve physical properties as well as texture. For example, whereas burst tests made on opposite sides of a single-ply paper produced on a conventional Fourdrinier machine give a ratio of about 1.3 to 1 showing greater resistance on the "wire" side, similar tests on a single-ply paper having long fibers predominating on both sides, provide a ratio of about 1 to 1 showing uniformity of strength on both sides.

The sheets of this invention also have marked improvement in fiber formation and are free from clots or lumps which normally give a streaky appearance to paper or board.

While it is desirable, in many kinds of board or paper, to have the fibers oriented equally in the longitudinal and lateral directions, equally good orientation cannot be secured in the conventional cylinder machine and excessive shaking is necessary to obtain cross-grain orientation on conventional Fourdrinier machines. Cylinder machines conventionally exhibit fiber orientation in the proportion of about 3½ to 1 (length width) whereas the sheets of this invention have fiber orientation of about 1½ to 1.

The improved fiber distribution, formation and orientation of the sheets of this invention, is of particular value in the case of board or paper made from well beaten or hydrated stock that is difficult to dewater. In accordance with the present invention, initial dewatering is effected outwardly from both sides of the sheet and the well beaten stock can form in the same way as the freer stocks, viz., long fiber formation on both sides of the short fiber zone. The invention greatly facilitates the making of multi-ply sheets in which one or more of the layers of pulp is impermeable or composed of slow draining stock or of a non-cellulosic stock.

It is then an object of this invention to provide fibrous web materials having the long fibers thereof predominating on opposite sides of a short fiber zone but integrally interlaced and matted therewith.

A further object of the invention is to provide a paper sheet having the long fibers thereof predominating in both surface areas on opposite sides of a short fiber central zone.

Another object of the invention is to provide a paper web composed of a unitary intermatted arrangement of fibers with the length of the fibers gradually diminishing inwardly from both surfaces of the sheet.

A further object of this invention is to provide a

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multi-ply fibrous web with short fibers predominating in both outer faces of the web and with the constituent plies having the fibers interlaced into integral relation.

A still further object of this invention is to provide a unitary sheet of paper of improved surface texture and strength wherein the fiber length diminishes progressively inward from the surfaces of the sheet and the short fibers and fines are concentrated in the middle of the sheet.

Other and further objects of this invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of preferred examples, illustrate several types of sheets and board of this invention together with machines for making the same.

On the drawings:

Figure 1 is a fragmentary diagrammatic illustration of a paper machine for forming a single ply sheet according to this invention.

Figure 2 is an enlarged fragmentary diagrammatic view of the forming area of the machine of Figure 1.

Figure 3 is a magnified illustrative cross-sectional view of the fiber formation of the single ply sheet made on the machine of Figures 1 and 2.

Figure 4 is a diagrammatic view, similar to Figure 1, but illustrating a machine for making a multiple ply sheet according to this invention.

Figure 5 is a view similar to Figure 3 but illustrating the multiple ply unitary sheet made on the machine of Figure 4.

Figure 6 is a diagrammatic view similar to Figure 1 but illustrating a machine for making a multiple ply sheet according to this invention including a conventionally formed base ply.

Figure 7 is a view similar to Figure 1 but illustrating the multiple ply unitary sheet made on the machine of Figure 6.

As shown on the drawings:

The machine 10 of Figure 1 includes a main Fourdrinier forming wire 11 and a top forming wire 12. The wire 11 is trained around a breast roll 13 and suction couch roll 14 to have a substantially horizontal upper run 11a therebetween. Guide rolls 15 hold the wire in an open loop and a tension roll 16 maintains the loop under the proper tension. Table rolls such as 17 support the upper run of the wire.

A stock inlet or head box 18 is positioned immediately behind and above the breast roll end of the wire to discharge paper stock under a slice 19 onto the upper run 11a of the wire.

The top wire 12 is trained between an oncoming roll 20 and an offgoing roll 21. Guide rolls 22 above these rolls 20 and 21, hold this wire in an open loop and a tension roll 23 maintains the loop in the desired taut condition.

A doctor or slice plate or chute 24 is mounted in the loop of the wire 12 downstream from the oncoming roll 20 and depresses the wire to provide an inclined run 12a above the upper run 11a of the wire 11. The doctor or slice plate 24 slopes upwardly and rearwardly with its upper rear end discharging into a transverse trough 25 mounted in the loop of the wire and having a drain outlet 26 at the end thereof beyond the side of the wire.

Suction or plain presses 27 are provided downstream from the trough 25 and each are composed of a top roll 28 in the loop of the wire 12 and a bottom roll 29 in the loop of the wire 11. The presses 27 act on the bottom run of the top wire and the top run of the bottom wire to squeeze a web W between the wires.

As best illustrated in Figure 2, aqueous paper stock from the head box or inlet 18 forms a pool P in the converging gap between the wire runs 11a and 12a and as the wires advance in the direction of the arrows, the gap narrows down to a throat or gap G at the slice

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or doctor 24. Water from the pond P is discharged through both wires and the advancing momentum or inertia imparted to this water by the wires, will cause the water ejected through the wire run 12a to cascade over the doctor or slice 24 into the trough 25 from which it is discharged. The converging forming area for the pool P creates a wedge-like squeeze on the stock in the pool up to the throat gap G to assist the initial dewatering of the stock.

After the wires pass under the slice or doctor 24, the presses 27 further squeeze the wires together to further dewater the web between the wires. This dewatering by the presses can be assisted with suction rolls, suction slices, or the like.

The wires 11 and 12 are separated from the web W at the couch roll 14 and return roll 21. Further dewatering can take place at this point of separation by utilization of a suction couch and a suction return roll if desired.

It will be noted that drainage is effected both upwardly and downwardly as shown in Figure 2, and as a result, fiber formation occurs simultaneously on both the wires 11 and 12. The fine fibers will pass through the wires with the water until the long fibers build up a filtering mat. The web W, therefore, as shown in Figure 3, has three zones of fibers including a bottom zone 30, a top zone 31 and a middle zone 32 with the long fibers 33 predominating in the top and bottom zones and with the short fibers 34 predominating in the middle zone 32. However, it will be noted that the fiber length diminishes gradually inwardly from the bottom face 35 and the top face 36 of the web and that the zones 30 and 31 are integrally interlaced and intermeshed with the zone 32.

The long fibers 33 adjacent the surfaces 35 and 36 improve the texture and burst strength of the web. Since drainage occurs outwardly from the center of the forming pool P as shown in Figure 2, the middle zone 32 can be quite thick if desired, and can contain fines and fillers that ordinarily would not intermesh with long fibers during a conventional Fourdrinier forming operation.

While the three zones 30, 31 and 32 have been designated in Figure 3, it will be noted that there is no parting line or ply line of demarcation between these zones. The web W is, therefore, unitary.

It will also be noted that the longitudinal long fibers 33a are about evenly intertwined with the transverse or cross long fibers 33b and that the longitudinal short fibers 34a are about evenly balanced with the transverse or cross fibers 34b. Since the drainage capacity of the machine is greatly enhanced by the top wire 12, fiber formation upon initial dewatering is quite rapid and the fibers can be deposited in substantially the same hodgepodge relation existing in the inlet 18.

In the machine 40 of Figure 4, a main Fourdrinier forming wire 41 cooperates with two top wires 42 and 43 and two head boxes or inlets 44 and 45. The main or bottom wire 41 is trained between a breast roll 46 and a couch roll 47 to provide a substantially horizontal top run 41a. The top wires 42 and 43 are trained between oncoming rolls 48 and offgoing rolls 49 to provide bottom runs 42a and 43a, respectively, overlying the top run 41a. Each top wire 42 and 43 has a slice or doctor 50 in the loop thereof downstream from the oncoming roll 48 and discharging into a transverse trough 51 as described above in connection with the machine 10. Presses 52 act on the wires downstream from the slices or doctors 50 to squeeze the web W¹ between the wires.

Stock from the inlet 44 forms a first pool P¹ between the top run 41a of the bottom wire 41 and the inclined bottom run 42a of the top wire 42 between the oncoming roll 48 and the doctor 50. Stock formation occurs in the same manner as shown in Figure 2. A base web W having the same fiber characteristics as the web W of Figure 3 is formed but this web remains on the top

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run of the bottom wire 41a to receive thereover a pond P² of stock from the inlet 45. A top ply or stock layer L is thus formed on top of the web W to produce a multiple ply web W¹ as shown in Figure 5. The formation at the second top wire run 43a is similar to that shown in Figure 2 except that the downward drainage is somewhat impeded by the web W and the long fiber deposition on top of the web W may not be as predominant as the long fiber deposition at the wire run 42a.

In the diagrammatic illustration of the web W¹ of Figure 5, the base web constituent W includes the same long fiber zones 30 and 31 and central short fiber zone 32 but the top face 36 of the web is integrated with a top ply or layer L composed of a relatively thin long fiber bottom zone 53, a relatively thicker top long fiber zone 54, and a central or middle short fiber zone 55. Some of the long fibers in the zone 53 such as the fibers 56' pass through the surface 36 of the web W into interlocked and intermeshed relation with the long fibers 33 to interlock the layer L with the web W and to partially obliterate the surface 36. This fiber formation occurs because a small portion of the drainage from the pool P² will occur downwardly.

The layer L is, therefore, composed of a thin zone 53 of long fibers 56, some of which as shown at 56', are pulled through the surface 36 of the web W, a thicker top layer of long fibers 56 and a middle zone of short fibers 57. No lines of demarcation or separation occur between the layers 53, 54 and 55 since the long fibers 56 gradually diminish toward the zone 55 and are integrally intertwined and intermatted with the short fibers 57. The layer L is integral. In addition, the layer L is integrally interlocked with the underlying web W so that ply separation cannot occur.

If desired, any number of succeeding layers could be deposited on top of the layer L by adding one or more top wires downstream from the wire 43 on the machine 40. The succeeding layers, however, would each have a top surface composed of the long fibers and gradually diminishing in fiber length toward a central zone.

The multi-ply webs or sheets formed on the machine such as the machine 40, will, therefore, be composed of a base web portion having long fibers on opposite sides of a short fiber zone and one or more overlying layers having long fibers on opposite sides of a short fiber zone wherein the long fiber zone immediately adjacent the underlying layer or web will be somewhat thinner than the top zone of the underlying web. In each instance, the long fibers will predominate at the surfaces of the sheet as shown at 35 and 58 in Figure 5.

The machine 60 of Figure 6, has a conventional Fourdrinier forming wire 61 trained between a breast roll 62 and a couch roll 63 to provide a horizontal upper run 61a therebetween. Table rolls, such as 64, are provided adjacent the breast roll 62 to support the upper run 61a and suction boxes, such as 65, receive the upper run 61a thereover. A first inlet or head box 66 deposits paper stock on the upper run 61a and this stock is initially dewatered to form a conventional Fourdrinier web W² thereon. This web, while still supported on the upper run 61a, receives a pool P³ of stock from a second head box or inlet 67. A top wire 68 having a bottom run 68a between an oncoming roll 69 and an offgoing roll 70, confines the pool P³ and a slice or doctor 71 acts on the bottom run 68a to depress the same and form a throat or gap where the runs 68a, 61a converge. A trough 72 coacts with the slice or doctor 71 to receive white water cascading thereover in the manner shown in Figure 2. Presses 73 downstream from the trough 72 squeeze the bottom run 68a of the wire 68 and the top run 61a of the wire 61 together to further dewater the web therebetween. Thus, a layer of stock L² is deposited on the web W² to form a web W³ shown in Figure 7.

As shown in Figure 7, the web W³, composed of the base web W² and the layer L², includes a long fiber zone

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74 at the bottom of the web W² covered by a short fiber zone 75. The long fibers 76 in the bottom zone 74 diminish gradually in length to the short fibers 77 in the zone 75 so that the bottom surface 78 predominates in long fibers while the top surface 79 predominates in short fibers. The web W², therefore, is a conventional Fourdrinier formed sheet with the wire side having the long fibers and the non-wire side predominating in the short fibers.

The layer L² on the web W has a thin long fiber zone 80 on top of the web surface 79, a relatively thick long fiber zone 81 at the top surface 82 of the layer, and a short fiber middle zone 83. Some of the long fibers 84' of the fibers 84 in the zone 80, are pulled through the surface 79 of the web W² to integrate the layer L² with the web. The short fibers 85, of course, are integrated with and gradually merge into the long fibers 84. The web W³ thus has long fibers predominating in the surfaces 78 and 82 thereof as is the case in all of the sheets formed according to this invention but the short fibers 77 in the web portion W² are only covered with a relatively thin zone of long fibers 84 from the layer L². Of course, if desired, an additional layer or layers could be deposited on top of the layer L² by adding another top wire or a plurality of such wires to the machine 60 downstream from the top wire 68.

Since, according to this invention, initial dewatering occurs in an upward direction as well as in a downward direction, it is possible to form a base sheet which is substantially impermeable to water drainage. The only disadvantage in increasing the impermeability of the base web is the decrease in the locking fibers between the base web and the overlying layer. It should be appreciated from the showings in Figures 4 to 7, that the long fiber distribution at both sides or surfaces of the multi-ply paper or board facilitates the making of multi-ply sheets in which one or more layers of the pulp is impermeable, or is to be constituted so that water removed from a subsequent layer does not wash out fillers or the like, or is composed of paper stock which forms quickly, or is composed of a non-paper stock such as for example, a wax emulsion.

The concentration of the long fibers in the surface zones of the sheets of this invention, produce an I-beam effect in providing strong surface zones on opposite sides of a bridging short fiber zone. The burst resistance of the sheet is substantially equal on both sides of the paper. The surface texture of the sheets is greatly improved because the long fibers minimize voids, unevenness and streaks or waves. It is now possible to produce paper sheets from board forming stock wherein the surface areas are so smooth in texture that they can directly receive printing thereon. The heretofore required finish paper covers for board are now eliminated.

Beta radiography examination of paper board formation produced according to this invention shows a more uniform texture than has been heretofore available. This examination included a Beta ray emitter plate covered by a sample of the paper board to be tested and a sheet of X-ray film over the sample. The emitter plate gave off a flux of electrons which are stopped or slowed down in greater or lesser degree according to the basic weight of the area of the board immediately above. The transmitted electrons, on striking the X-ray film, produce a latent image. The film when developed and printed, is a picture of the basic weight variation from place to place in the sheet thus showing the formation and texture of the board. In actual test runs, the following comparisons were made:

Example I

Paper board, such as the board W¹ of Figure 5, made on the machine 40 of Figure 4, including a ground wood pulp base layer covered with a sulphite pulp top liner layer and having a weight of 195 pounds per ream (500 sheets, 30" x 40"), and formed at a speed of 500 feet

per minute, was compared with board formed on a five-cylinder machine composed of sulphite top and back liners with three middle plies of ground wood pulp and having a weight of 185 pounds per ream and being formed at a speed of 290 feet per minute, the Beta ray comparison showed a much more uniform and smoother texture in the sheet W¹ than in the slower formed more expensive cylinder sheet. The printing characteristics of the sheet W¹ were far superior, having a better clarity, sharpness and levelness than the cylinder made sheet.

Example II

Sheets W¹ formed on the machine 40 of Figure 4, at 500 feet per minute, were compared with sheets of substantially the same weight and composed of the same stock but formed on the machine at 1,000 feet per minute. The higher speed formation produced a better uniform texture. The Beta ray examination showed a denser more uniform sheet at high speed formation. The formation was more dense and uniform than a cylinder made sheet of heavier weight but formed at very low speeds of 145 feet per minute and composed of the same type of stock.

Example III

The directional properties of the sheets of this invention are far superior to sheets of comparative weights and identical constituent stock as is evidenced by the following comparative table:

	Cylinder Board, 270'/min. 220 lbs./rm.	Cylinder Board, 280'/min.	Web W ¹ 500'/min. 195 lbs./rm.	Web W ¹ 1,000'/ 185 lbs./rm.
Ratio: tensile strength machine direction to cross direction-----	3.54	3.90	1.55	1.50

The above ratios show that the webs W¹ of this invention are more uniform in strength in the cross and machine directions.

Example IV

In burst tests, it was found that a single ply web W of this invention, had a ratio of burst in the up and down direction of 0.86.

A single ply sheet made on the conventional Fourdrinier machine of comparative weight and identical stock furnish, had a burst ratio of 1.28 in the up and down direction.

Thus, the sheets of this invention have a more even up and down burst ratio than conventional Fourdrinier sheets.

Example V

A sheet W³ of this invention composed of a base layer W² of 100% ground wood pulp and a top layer L² of grease-proof hydrated pulp, had excellent adhesion at the ply line 79 thereof and resulted in a unique product obtained direct from a board machine.

From the above descriptions it will, therefore, be understood that this invention now provides a novel paper and board having long fibers predominating in the surface areas thereof and gradually diminishing in length toward a central zone while, at the same time, having the constituent zones thereof so intermatted and interlaced that ply separation cannot occur.

It will be understood that variations and modifications

may be effected without departing from the scope of the novel concepts of this invention.

We claim as our invention:

1. A paper sheet which comprises an integral unitary web having long fiber zones adjacent the surface areas thereof and a short fiber zone between the long fiber zones, the fibers in the long fiber zones gradually diminishing in length as they approach the short fiber zones and being dispersed in all directions, and all zones of said web being integrally interlaced and intermatted to obliterate lines of division therebetween.

2. A paper sheet which comprises a single ply web having the surface areas on both faces thereof predominating in long fibers and the fiber length progressively diminishing inwardly toward the central zone of the web, the long fibers being dispersed in all directions to provide substantially uniform strength characteristics.

3. A multi-ply paper sheet which comprises a base sheet having a bottom surface area predominating in long fibers, a short fiber central zone integrated with the long fibers and a long fiber zone covering the short fiber zone, a covering layer having a long fiber zone covering the long fiber zone of the base sheet and integrated therewith by long fibers extending through the dividing line therebetween, a short fiber zone integrated with and overlying the long fiber zone of the covering layer, and a top surface zone predominating in long fibers integrated with the short fiber zone of the covering layer, all of said long fibers being dispersed in all directions thereby providing substantially uniform strength characteristics in said sheet.

4. A multi-ply board which comprises a base sheet having a bottom face predominating in long fiber formation and a top face predominating in short fiber formation, a covering layer on said top face having long fibers extending into the top face to integrate the layers, a short fiber zone on top of the long fiber zone of the covering layer and a long fiber zone on the top face of the covering layer, said long fiber zones being integrated with the intermediate short fiber zones to provide a unitary ply and being dispersed in all directions to provide uniform strength of said board.

5. A paper board which comprises a base web of hydrated grease-proof stock with long fibers predominating on the exposed face thereof and diminishing in length inwardly from said face, a covering web integrated with the base web by fibers interlocking the two webs, said covering web having a printing face composed predominantly of long fibers and an underlying short fiber zone integrally interlaced with the long fibers, all of said fibers being dispersed in all directions.

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