

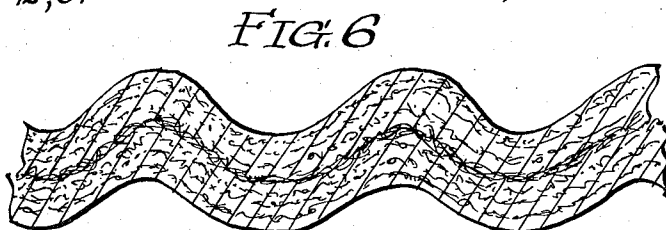
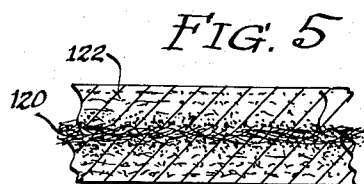
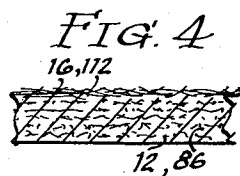
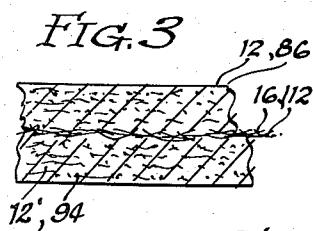
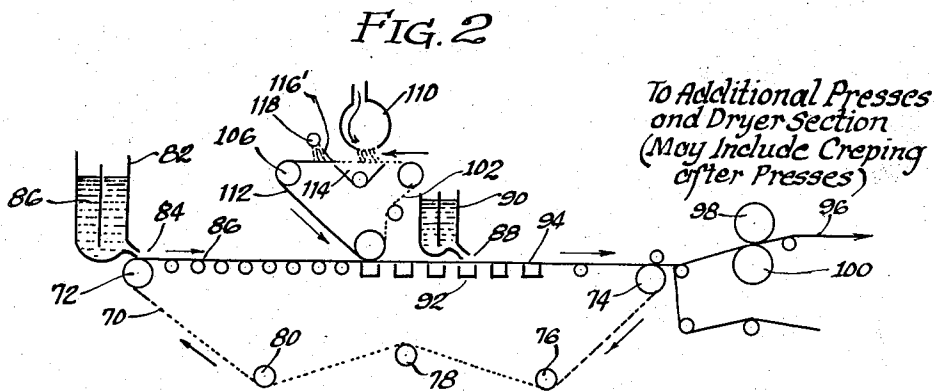
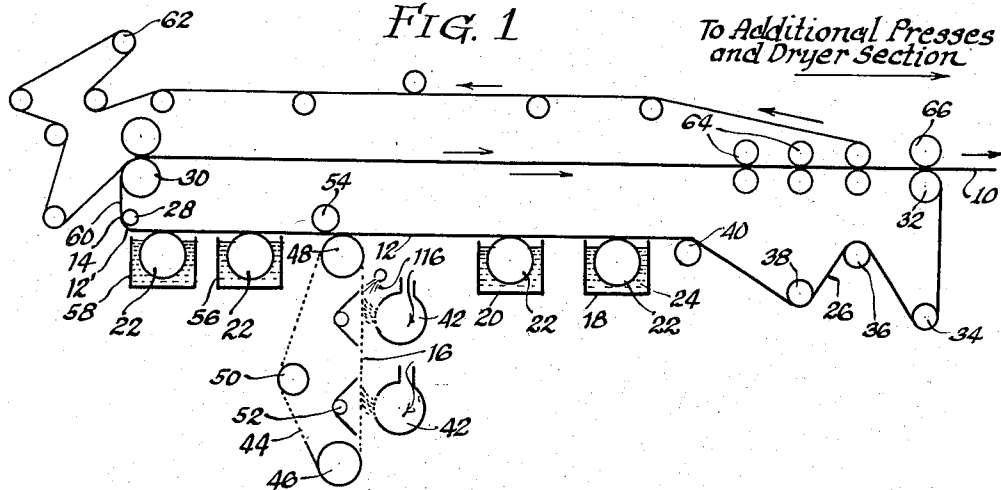
April 7, 1959

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2,881,072

METHOD OF MAKING REINFORCED MULTIPLY PAPER

Filed Jan. 17, 1956



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2,881,072

METHOD OF MAKING REINFORCED MULTIPLY PAPER

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Application January 17, 1956, Serial No. 559,589

5 Claims. (Cl. 92—21)

This invention relates to the manufacture of papers and webs reinforced with fibers of substantial lengths and it relates more particularly to a thin laminate in the form of a paper fabricated of conventional cellulose pulp fibers having a lamina of fibers of reinforcing lengths integrated therewith to impart strength properties and other desirable characteristics to the structure and it relates further to a method for the manufacture of same.

In the present manufacture of paper wherein use is made of a furnish of pulp fibers thinly dispersed in an aqueous medium for application by way of a headbox upon a continuous moving wire of a Fourdrinier machine for the separation of the pulp fibers on the surface of the wire to form a web, it is difficult to incorporate and uniformly to distribute fibers of substantial lengths, such for example as fibers having lengths in excess of about 1/4 inch for deposition alone or in combination with the pulp fibers to produce a paper having increased tear strength, burst strength and tensile strength. Such strength properties are desirable in a paper intended to be used for bags, wrapping or sheets for the manufacture of case liner papers and the like in which high strength, wet strength and the like properties are important.

To the present, reinforcement with fibers has been limited either to the use of continuous filaments or threads which are fed in side by side parallel relation into the furnish as it is flowed on the wire for disposing the continuous threads or filaments in the described relationship within the web that is formed or else use has been made of a woven reticulated web which can be, in various ways, included as a part of the sheet of paper during its manufacture. When use is made of such endless filaments or threads, reinforcement is limited to the longitudinal direction without increasing the strength of the paper in the crosswise direction and the cost of the endless yarns, strands or threads or the cost of the woven, reticulated web is excessive by comparison with the rest of the materials making up the paper and application as a part of the paper becomes difficult with the result that the paper that is formed is expensive and limited in application to very special uses.

It is an object of this invention to produce and to provide a method for producing a paper in which use is made of fibers of substantial lengths for reinforcement, in which the reinforcing fibers are uniformly distributed in haphazard arrangement in the paper to impart strength in all direction, in which the reinforcing fibers of substantial lengths are formed of a material which differs from the pulp fibers comprising the main body of the paper, in which the fibers of reinforcing lengths can be treated in advance to impart new and improved properties to the fibrous structure into which it is incorporated, in which the fibers of reinforcing lengths are applied without marked increase in the cost of the process and without marked increase in the cost of the product over and above the differences in the cost of raw materials, and in which considerable flexibility is available in the arrangement

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of fibers as between the pulp fibers and the fibers of reinforcing lengths to produce structures for use in a number of different types of applications.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawing in which—

Figure 1 is a schematic diagram showing the arrangement of elements for use in the practice of this invention;

Figure 2 is a schematic diagram showing a different arrangement of elements for use in the practice of this invention;

Figure 3 is an enlarged sectional elevational view through a product which is prepared by the machine illustrated in Figures 1 and 2;

Figure 4 is an enlarged sectional elevational view of a modification in a product which embodies the features of this invention;

Figure 5 is a sectional elevational view of a further modification in a product produced in accordance with the practice of this invention, and

Figure 6 is a sectional elevational view of a still further product that can be manufactured in accordance with the practice of this invention.

This invention embodies the combination of one or more layers of fibers formed, as by conventional processes, as represented by the wet process of a Fourdrinier machine, and one or more layers of dry fibers formed by an air deposition process of the type described in my copending applications Ser. No. 61,674, filed November 23, 1948, and Ser. No. 464,102 and now Patent No. 2,749,576, filed October 22, 1954, and Patents No. 2,702,005, issued October 11, 1955, and No. 2,698,271, issued December 28, 1954. As described in the aforementioned applications and patents, dry fibers are suspended in an air stream moving under positive pressure over the inner surface of a separating wall having forams therein dimensioned to enable passage of substantially separated fibers whereby a shower-head effect is developed to cause substantially equal volumes of air and fibers to pass through the openings in the separating wall to a collecting wall which is spaced a short distance below the separating wall. The collecting zone, usually in the form of an endless screen traveling continuously in one direction beneath the separating wall, separates out the fibers on the surface thereof as the stream of air continues through the screen to form a web on the surface in which the fibers are substantially uniformly distributed in a heterogeneous arrangement.

The system described can be used effectively with fibers of substantial lengths to produce a web ranging from a very thin layer of fibers to a layer of substantial thickness, depending upon the capacity of the fiber depositing head, the linear speed of the separating screen and the number of heads which are employed for the deposition of fibers. In addition to the ability to form a very uniform, randomly oriented and well dispersed thin web of interfelted fibers, the system can be practiced for the deposition of various types of fibers including glass fibers which are desirable because of their high strength, inertness, electrical resistance, low thermal conductivity and resistance to deterioration, or synthetic organic fibers, such as the polyesters (Dacron), polyamides (nylon), polytetrafluoroethylenes (Teflon), polyvinyl chloride (Vinyon), polyvinylidene copolymers (saran), cellulose ethers and esters and regenerated cellulose and protein fibers (rayon), and natural fibers such as flax, hemp, silk, cotton, wool and the like, or metallic fibers.

It is conceivable that the process described in the aforementioned copending applications and patents could be employed to form a non-woven structure of such fibers of

reinforcing lengths for use in substitution for the expensive woven, reticulated structures heretofore employed as an interlayer with the cellulose pulp fibers in the manufacture of high strength papers. However, the web of the type described for separate use must have adequate self-sufficiency to enable the web to be handled in forming, to enable the web to be rolled up into a compact package for transfer to different stations and to enable the web to be unrolled at the station of use for application as an interlayer or lamina in the fibrous structure that is formed. Even when the fibers of reinforcing lengths are formed to substantial thickness, the desired degree of self-sufficiency is incapable of being developed. As a result, it becomes necessary to make use of substantial amounts of binding agent with the result that the web is increased in cost and unless it is hydrophilic, the binder present may tend to interfere with the ability of the pulp fibers to become integrated with the bonded web of long fibers incorporated therewith. In addition, the use of a thin web of fibers of reinforcing lengths is complicated by the fact that speeds are maintained in operation for the manufacture of paper from pulp and that such operation at high speeds is continuous. This will be appreciated when it is realized that papers are generally fabricated on machines at speeds of upwards of 500 feet per minute in a continuous operation so that the incorporation to include a web presents a real problem when the length of the web is limited in the roll.

Thus, another object of this invention is to produce a reinforced high strength paper of the type described in an economical and efficient manner with a machine operating at high speed on a continuous process and it is a related object to provide a method whereby such webs of reinforcing fibers can be supplied as endless webs coordinated in operation with the paper making machine for coordination therewith in the manufacture of a fiber reinforced paper in which the paper is reinforced in all directions and in which the web is supplied at a speed equivalent to that used in the manufacture of paper and wherein the web is supplied continuously for incorporation with the paper as it is being formed.

Another object is to provide means for the incorporation of long fibers in uniform distribution and haphazard arrangement in a paper web without the expense and limitations imposed by the use of a woven or bonded structure preformed of the reinforcing fibers.

A further object is to produce an improved paper formed of the combination of the cellulose pulp fibers and a non-woven, open mesh fabric of fibers of reinforcing lengths wherein the fibers in the product are interfelted one with the others to resist delamination and to avoid the necessity for application of excessive amounts of bonding agents for securing the fibers one to the other in the structure.

With reference now to the drawing, illustration will be made of the practice of the concepts of the invention by the combination of a wet process and a dry process for the deposition of fibers in the manufacture of a paper product of the type heretofore produced by a conventional multi-cylinder board machine or the like but in which the product contains a uniform distribution of fibers of reinforcing lengths throughout a portion parallel with the flat faces of the formed paper or board.

In the modification illustrated in Figure 1 of the drawing, a high strength paper 10 is formed of a plurality of webs as represented by the numerals 12 and 14 brought together in the form of lamina with a web 16 of fibers of reinforcing lengths in between. For this purpose, use is made of a plurality of cylinder vats as represented by the numerals 18 and 20, of a conventional board machine having cylinders 22 mounted for rotational movement in the wet slurry 24 in the vats for the deposition of fibers on the periphery thereof to form individual webs. Passing in successive fashion over each of the cylinders 22 and substantially in contacting relation therewith is a pick-up felt 26 in the form of an endless woven blanket

which operates about rollers 28, 30, 32, 34, 36, 38 and 40, the last four of which are adjustable tensioning and aligning rollers. As the felt 26 passes over each cylinder 22, the web formed on the periphery is picked off to form additional lamina on the underside of the felt.

The web 16 of fibers of reinforcing lengths is incorporated as a lamina after the felt 26 has picked up one or more of the fibrous layers from the cylinders 22 to provide a corresponding number of wet layers as a web 12 on the underside of the felt. Unlike the web of fibers previously applied for incorporation to form the composite fibrous structure, the fibers of reinforcing lengths are provided in the form of a dry web 16 which is separately formed, as by the process previously described, at a rate corresponding to that for the formation of the wet web so that the web of dry fibers of reinforcing lengths may be couched for transfer onto the wet lamina or web 12 of the pulp fibers previously formed on the underside of the felt.

For this purpose, the fibers of reinforcing lengths are fed by suitable means into the fiber depositing head or heads 42, in the form of a cylindrical housing and either mechanical scrabbler means, as described in application Ser. No. 61,674, or air scrabbler means, as described in Patent No. 2,702,005, are employed to swirl the fibers in an air stream about the interior of the cylindrical housing to create a shower-head effect which causes uniform volumes of air and fibers to pass through the openings in the foraminous separating wall of the housing to the collecting wall, which in this instance is represented by an endless screen 44 operating about rollers 46, 48 and 50. The air is drawn through the wire or screen into a suitable suction chamber 52 located beyond the screen or wire in the fiber deposition zone and the fibers are separated from the air stream for deposition onto the surface of the wire to form a thin web 16 in which the fibers lie essentially in a haphazard arrangement. One such depositing head may be employed or more than one may be employed as illustrated to deposit one layer of fibers onto the other layer previously deposited with the fibers of the latter drawn into the layer of the fibers previously deposited to provide an interfelted web which is essentially incapable of delamination.

Instead of depositing the same fiber from each of the heads, one type of fiber can be deposited from one head for interfelted with fibers of a different composition or length from the other head or heads. By such means, a combination of glass fibers and cellulose fibers, or glass fibers, and a thermoplastic resinous heat softenable fiber may be deposited or else glass fibers of substantial lengths up to 2-3 inches may be deposited from one head for combination with fibers of ultra fine dimensions and of shorter lengths from the other heads and the like.

The web 16 of dry fibers of reinforcing lengths formed on the wire or screen 44 is couched onto the lamina 12 of wet fibers held onto the underside of the felt 26 as the wire 44 and the felt 26 pass together over the roller 48 with the webs formed on the respective surfaces in contacting relation one with the other.

By adjusting the vertical position of the roller 54 which follows roller 48 and engages the upper wall of the felt 26, it has been found possible to achieve a clean and substantially complete transfer of the dry web 16 of fibers of reinforcing lengths from the wire 44 to the wet layer 12 of pulp fibers without the necessity for wetting the wire 44. Thereafter, the felt 26 with the webs adhered to the underside thereof is passed successively over one or more additional cylinders 22 in the vats 56 and 58. Provided that the web has not been made undesirably thick, the cylinders 22 in the subsequent vats 56 and 58 and the like will contribute additional wet lamina to the underside of the felt to provide a composite structure consisting of the web 16 of fibers of reinforcing lengths sandwiched between the paper stock lamina 12 acquired from the vat sections 18 and 20 and the lamina 12' from the

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vat sections 56 and 58, as represented by the enlarged sectional view in Figure 3 of the drawing. The composite structure indicated by the numeral 60 then passes in a conventional manner between the press rolls 62 and 30, the baby presses 64, subsequent press rolls formed as of the rollers 66 and 32, and thereafter into additional press sections and driers. The presses operate to squeeze out free water from the web 60 to compact it and to embody or encase the filaments of reinforcing lengths in the dry web 16 into the adjacent lamina 12 and 12' of the shorter paper fibers generally of the paper pulp type. The compacted composite structure indicated by the numeral 10 is then dried and finished by operations which are substantially conventional in the various steps described upon leaving the final vats 56 and 58.

In the modification of Figure 2, use is made of a conventional Fourdrinier machine having an endless wire operating about rollers 72, 74, 76, 78 and 80 with a head box 82 on the lead-in end of the wire which supplies a continuous stream 84 of slurry 86 containing paper pulp fibers onto the wire for the separation of the fibers thereon to form a web 86 as the water drains through. Along the wire another stream 88 of paper pulp in a slurry is flowed onto the web 86 from a secondary headbox 90 located over a series of suction boxes 92 to deposit a face lamina 94 of paper stock onto the web, after which the composite web 96 passes from the wire to between the first press rolls 98 and 100 and then through subsequent press sections and driers, as employed in a conventional paper making machine of the Fourdrinier type.

After the first web 86 has been formed on the wire 70 from the slurry of the first headbox 82 and prior to the formation of the face lamina 94 by the slurry from the second headbox 90, a dry web of fibers of reinforcing lengths is applied to the web 86 for sandwiching between the wet webs 86 and 94.

As illustrated in the drawing, the dry web of fibers of reinforcing lengths is formed on a wire 102 such as an endless wire which operates about rollers 104, 106 and 108 for passage as the collecting surface beneath a fiber depositing head 110 of the type previously described. Fibers of the desired lengths and composition are introduced into the cylinder of the head 110 for entrainment in an air stream with which it circulates about the housing for passage, in the described manner, through the openings in the bottom wall of the housing to the separating wall whereby the fibers are deposited on the surface of the screen in interfelted relation to form a web 112 as the air is drawn through the screen by the suction box 114. When the amount of air withdrawn by the suction box is greater by a slight amount than the air which passes with the fibers through the separating wall of the fiber depositing head 110, the area between the head and the screen may be left open to the atmosphere, as illustrated, since the deficiency will be made up by a slight inflow of air from the surrounding atmosphere to prevent the fibers from being blown out into the room. The roller 108 employed to bring the web 112 into contacting relationship with the wet web 86 for couching the dry web of fibers of reinforcing lengths onto the deposited wet web 86 of fibers may be situated immediately in advance of the suction boxes 92 or within the suction box section, as on or beyond the first or second box, and the pressure of the roller 108 is so adjusted as to cause a clean transfer of the dry web 112 of fibers of reinforcing lengths which is deposited by the head 110 on the wire 102. With the arrangement illustrated, a surface lamina 94 of paper stock is applied over the transferred dry web 112 by the secondary head box 90 and the sandwich so formed is pressed and dried in the press and drier sections conventionally employed, as previously described. If desired, the composite web 96 may be creped before drying by well known means which need not here be described to provide a structure such as is illustrated in Figure 6 of the drawing.

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A product such as may be formed in accordance with this invention is illustrated in Figure 3 of the drawing where the web 16 or 112 of the dry filaments of substantial length is laminated between the outer wet deposited web of fibers 12 or 86 and 12' or 94. It will be understood that in the use of a multi-cylinder machine, as shown in Figure 1, more than one layer of filaments may be incorporated in the finished web 60 by adding other dry depositing systems of the type described by the more than one pair of vats 22.

In practicing the invention it has been found desirable to limit the thickness of the web of included dry fibers of reinforcing lengths to one that is thin enough to provide a sufficiency of openness between the deposited filaments so as to enable the pulp fibers of the sandwiching lamina 12 or 86 and 12' or 94 to come into mutual contact one with the other when the composite web is subsequently processed as in the presses and driers thereby at least partially to envelope the individual dry filaments of reinforcing lengths which are incorporated therebetween. The filaments or other fibers of reinforcing lengths which are contemplated for use in the practice of this invention are, in general, incapable of being bonded together by mere moistening and pressing but the filaments can be incorporated into the web in a bonded relationship by encasement with the moist paper pulp fibers in the adjacent lamina thereby to enable the entire laminated structure to be formed into a composite unit during pressing and drying to form a strong self-sufficient web which resists delamination to a satisfactory degree without the necessity to add extraneous binding materials.

For certain purposes, such as to impart a higher resistance to delamination while dry or a higher degree of strength when subsequently wetted or to impart other properties to the composite sheet or web, it is often desirable to embody a small amount of an adhesive such as animal glue, carboxymethyl cellulose, starch, or the like, or a thermo-reactive resinous binder such as a urea-formaldehyde resin, a phenol-aldehyde resin or a melamine-formaldehyde resin for wet strength or in the alternative, or in addition, to embody a sizing agent as an emulsion of wax or rosin. The bonding materials and the sizing materials, when incorporated, may be applied in the form of a solution, or an emulsion or a suspension, as by spraying the additive onto the dry web 16 or 112 formed of the fibers of reinforcing lengths during or after its formation as by means of sprays 116 or 116' directed from spray guns 118 onto the formed web immediately after formation and prior to couching onto the wet lamina of paper fibers formed as by other systems as described in my issued Patent No. 2,698,271. By this procedure it has been found possible to incorporate the desired additive in the final sheet in a manner which insures almost complete retention as distinguished from the application of such additive by means of the stock or slurry employed for manufacture of the paper lamina, as in the usual practice. When such additives are applied in the paper stock, a substantial portion of the additive is lost by drainage on the forming wire or else is squeezed out by the presses. Since the fibers of reinforcing lengths are incorporated in the form of a dry lamina and because the dry lamina is centered by sandwiching between the wet layers in the final structure, the additive is, for all practical purposes, believed wholly to be retained on the fibers and in the web, especially if it is added in the form of a suspension or an emulsion wherein the liquid or dissolved additive has a high viscosity.

If the material added to the fibers in the manner described is capable of functioning as a binder for the filaments, such for example as when use is made of a thermo-reactive resin, it is found possible to form the dry layer of fibers of reinforcing lengths to any thickness which may be desired since the dependency for strength and bonding by the use of the outer layers of paper fibers from the paper stock is then minimized. However, when

making a composite sheet with a thin lamina of fibers of reinforcing lengths, the addition of a small quantity such as even a fraction of 1 percent by weight of a suitable resin based upon the weight of the dry deposited web of fibers is often desirable since most specifications for reinforced papers are met more effectively by the addition of coating materials to provide a substantial degree of wet strength. Moreover, as has been pointed out, the beneficial effects derived from the use of small quantities of resin added in the manner described are usually substantially greater in the system described than that which is made available from the use of the same amount of resinous materials added to papers made by processes which have heretofore been employed.

Various modifications may be embodied in the practice of this invention to produce structures having different fiber arrangements as by adjustment in the location of the position for couching or otherwise transferring the dry web of reinforcing fibers onto the wet web of paper stock with respect to the elements by which the webs of paper stock fibers are formed. For example, in Figure 4 of the drawing, illustration is made of a product having a paper stock layer, such as would be formed of the webs 12 or 86 with the webs 16 or 112 of fibers of reinforcing lengths on the surface thereof without an overlying layer of wet paper stock fibers. A structure of this character could be fabricated by the use of the vats 18 and 20 in combination with the system for the formation and transfer of the dry web 16 of fibers of reinforcing lengths without the subsequent use of the vats 56 and 58 or else the structure might be formed by omission of the second headbox 90 in the system illustrated in Figure 2 of the drawing.

While it is preferred to make application of a small amount of resinous binder to the dry web of fibers of reinforcing lengths to improve the bonding relation with the paper stock fibers and to impart greater web strength to the product, structures formed without such binder additions are capable of many uses such as for conversion into a reinforced multi-ply sheet represented by Figure 5 of the drawing. In the fabrication of a multi-ply sheet of the type described, a suitable potential laminant 120 formed of a material such as a water suspension of asphalt or microcrystalline wax or a solution or an emulsion of a resin is laminated between webs of the type illustrated in Figure 4 with the face plies 16 or 112 of the fibers of reinforcing lengths in surface contact with the laminant 120. Instead of making use of two plies of reinforced webs of fibers illustrated in Figure 4, use may be made of one of the reinforced plies on one side of the laminate with another ply 122 formed of an unreinforced web of fibers on the other side. If sufficient asphalt or resin or other laminant is employed, it will function as a binder which substantially fills the interstices between the fibers in lamina 16 or 112 whereby a very thick layer of such fibers of reinforcing lengths may be incorporated, if desired, in the structure without increasing the possibility for delamination.

While the preferred method of applying the randomly deposited filament lamina as represented by the webs 16 or 112 has been disclosed to form the composite sheet, it will be understood that the point or points of application of such lamina or dry webs is not limited to the positions described. Instead, application, as previously indicated, can be deferred until after the couching and at least part of the pressing operations. For example, when a combined Fourdrinier machine and a multiple cylinder machine is employed, or when use is made of a pair of duplexing Fourdrinier machines, it can be made more convenient to apply the dry web 16 or 112 or reinforcing fibers after the couching operation has been completed and the wet web removed from the primary carrier or wire. However, for practical application, it is preferred to maintain the outer plies of paper stock wet enough to cohere together when pressed and provision should be made to

press the composite web firmly together before drying so that the sandwiching outer paper stock plies will cohere to cause their fine fibers to envelope the individual filaments of the dry web of fibers. If sufficient binder is added to the filaments, the laminating operation may be deferred until the sandwiching webs are considerably drier but it is preferred to maintain at least one of the webs sufficiently moist for molding of the type which would cause displacement of the paper stock fibers to the space between the filaments of the dry web of fibers substantially to envelope the filaments in subsequent pressing operations.

Suitable filaments for use in the preparation of the reinforcing web are preferably selected to have a length greater than $\frac{1}{4}$ inch and preferably greater than $\frac{3}{8}$ inch with the maximum length of fibers being determined by that conveniently handled in a fiber depositing head of the type described. Efficient operation can be achieved with fibers having lengths as great as $2\frac{1}{2}$ to 3 inches. In practice, it is preferred to make use of reinforcing fibers or filaments having a length between $\frac{1}{2}$ to $1\frac{1}{2}$ inches unless a fiber depositing head of the type described in application Ser. No. 464,102 is employed where use can be made of reinforcing filaments and fibers of greater lengths. The thickness of the filaments should not be so great as to impair the smoothness of the resulting composite sheet that is formed. However, especially if adequate pressure is applied to the composite laminae before drying, the filaments of fibers of reinforcing lengths may be almost as thick as the final dried and calendered sheet without being unduly prominent.

Upon examining a composite sheet prepared in accordance with the practice of this invention, the filaments in the reinforcing lamina will be found to be uniformly distributed and randomly oriented with respect to the faces of the sheet. Unless the reinforcing lamina is bound with an additive or else comprises thermoplastic filaments, adequate space remains between the fibers of the filaments to permit the lamina adjacent to the filaments to envelope the fibers and cohere with sufficient strength to permit normal use of the composite sheet as a paper in the manufacture of bags and the like without noticeable delamination of the plies. When use is made of a web of reinforcing fibers as a thin layer in combination with webs of paper stock having a thickness substantially greater than that of the reinforcing filaments, sufficient of the filaments will be present to cause an increase in tear strength to at least 120 percent of that and possibly several times that available from the same weight of paper without the added filaments. A product prepared in accordance with the practice of this invention can be readily distinguished over paper stock in which similar filaments of fibers of reinforcing lengths are incorporated with the pulp fibers since such filaments will be located in admixture with the pulp fibers in the paper plies with the filaments more or less oriented with the direction of movement of the wire whereas a product prepared in accordance with the practice of this invention will be characterized by the fact that the filaments lie in a particular lamina and are not oriented in the direction in which the sheet was made.

If a thick lamina of reinforcing filaments is incorporated in a composite sheet in accordance with the practice of this invention, preferably with the addition of a binder or by the use of thermoplastic fibers as a bonding agent, the filaments in at least one face of the lamina will become imbedded in the adjacent lamina of paper stock which would be characteristic of the filaments having been applied to the adjacent lamina of the paper stock prior to pressing and drying, in addition to the fact that the filaments will be uniformly distributed and randomly oriented in the reinforcing lamina.

For certain applications, such as in the fabrication of paper sacks or case liners, it is desirable to crepe or crinkle the paper sheet either before or after drying so as to provide the sheet with sufficient stretch to minimize

breaking. A sheet of the type described is illustrated in Figure 6 of the drawing. Creping the sheet before drying is preferred from the standpoint of economy and convenience over and above the process for creping or crinkling subsequent to drying which would require a separate operation or special machines. For this purpose, it is preferred to make use of an additional layer of reinforcing fibers to compensate for the loss in strengths occasioned by the more economical wet creping process described. The economy achieved by wet creping more than offsets the additional cost which might be involved in the application in use of additional lamina of reinforcing fibers.

It will be understood that various changes may be made in the details of construction, arrangement and in products that are formed in accordance with the practice of this invention without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. The method of making a reinforced multiply paper comprising the steps of moving an endless member continuously in one direction, depositing a wet layer of paper pulp fibers as a continuous layer on the surface of the moving member, moving another foraminous member continuously in one direction at a linear speed corresponding to that of the first member and with a portion thereof passing in closely spaced relation and in the same direction with a portion of the first moving member having the wet web of pulp fibers on the surface thereof, passing a stream of air containing dry fibers of reinforcing lengths uniformly distributed therein through the foraminous member to separate out dry fibers of reinforcing lengths in uniform distribution on the surface thereof to form an endless web of dry fibers on the foraminous member, contacting the web of wet pulp fibers with the web of dry reinforcing fibers as the moving member and foraminous member travel in the same di-

rection together in closely spaced relation with each other whereby the web of dry reinforcing fibers is pressed onto the web of wet pulp fibers and is couched from the foraminous member onto the layer of web fibers to form the top ply on the layer of wet pulp fibers, compressing the formed layers for consolidation, and then drying the consolidated layers to form a paper.

2. The method as claimed in claim 1 which includes the additional step of creping the consolidated web before drying.

3. The method as claimed in claim 1 which includes the additional step of forming a wet layer of paper pulp fibers as a continuous web on the surface of the web of dry reinforcing fibers couched onto the underlying layer of wet pulp fibers, compressing the layers to form a consolidated structure, and then drying the consolidated structure to form a paper.

4. The method as claimed in claim 1 in which the dry web of reinforcing fibers is formed of glass fibers having a length in the range of $\frac{1}{2}$ to $2\frac{1}{2}$ inches.

5. The method as claimed in claim 1 which includes the additional step of applying a binder onto the web of dry fibers prior to their being couched onto the formed layer of wet pulp fibers on the first moving surface.

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