March 1, 1960 T. C. DUVALL 2,926,417

MIXED FIBER FELT

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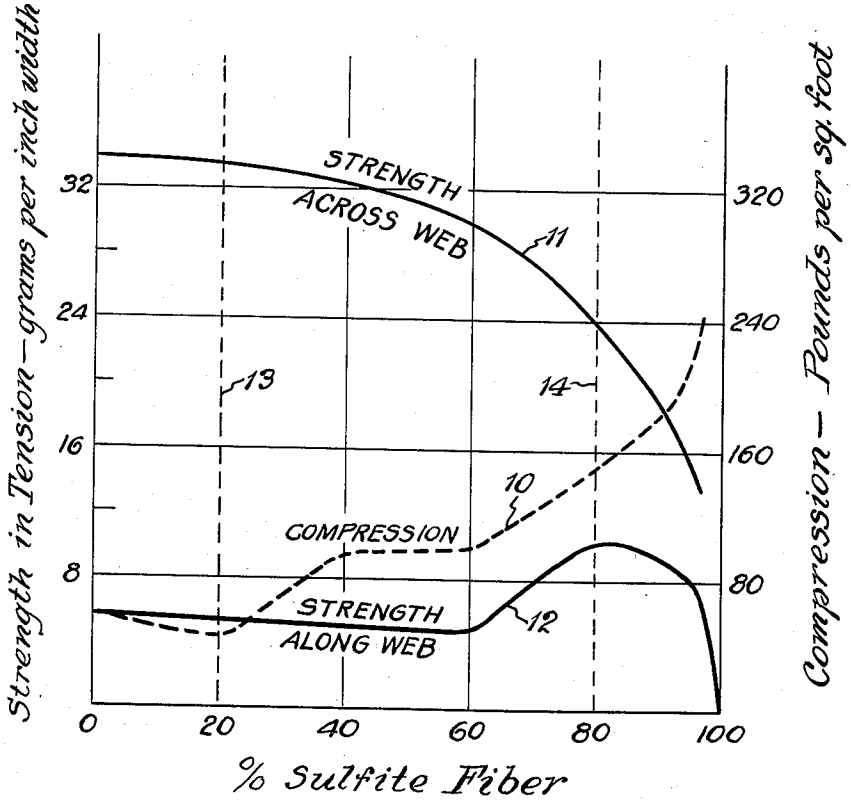


Fig. 1

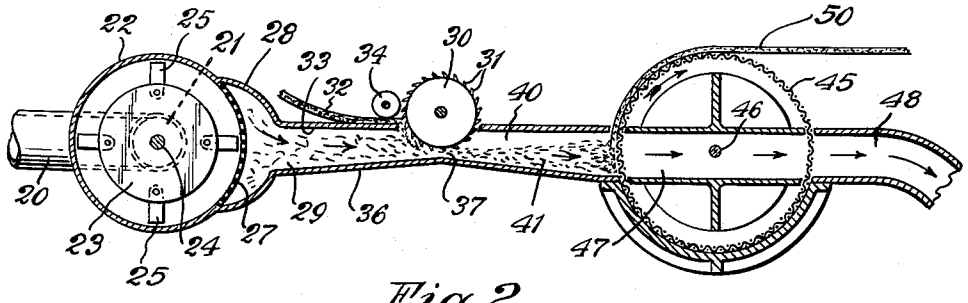


Fig. 2

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MIXED FIBER FELT

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6 Claims. (Cl. 28—78)

The present invention relates to fiber felts and felt bases, and in particular to dry-formed unbound felts having a mixture of relatively long fibers and relatively short fibers, all useful per se and as raw material for added binder or bonding treatment.

Long fibers of the kind generally referred to as textile fibers are variously individualized from masses thereof by mechanical combing or carding in such a way that individualized fibers may be taken up in air to form steady streams of substantially uniform content. Many kinds and combinations of machines are available. One disadvantage is the low capacity of such machinery for its bulk and its investment cost.

Short fibers, such as those ultimate fibers derived from wood, have no value as textile fibers when used alone, and may not be used as felts unless bound fiber to fiber. When so bound, the felt has undesirably low strength at low density, as in flexible insulation and cushioning felts, and greater strength as the density increases, as in rigid insulation board, cardboard and paper.

The said low-density bonded fiber felts are lacking in high tensile strength because of the shortness of fibers and the greater spacing of bonds. However, integral fiber bodies composed of short fibers such as from wood, are in use extensively because of the relatively greater capacity of equipment to handle such fibers, when compared to the textile fiber field.

Although it is a simple idea that such a short-fiber product may be strengthened by incorporating longer or textile fibers throughout it, this has not been commercially accomplished with retention of the low cost of production applicable to the short-fiber field.

In this description and in the claims the terms "long fibers" and "textile fibers" signify those natural or synthetic fibers other than those of wood having length which enables them to be spun to form threads having useful strength without use of binder or adhesive in the thread. The terms "short fibers" and "non-textile fibers" include all fibers of wood and other fibers having such lengths as preclude spinning them to threads having useful strength without use of adhesive or binder. In general, the authorities give a length of 5.08 mm. (.2 inch) as the lower limit of length for making economically useful spun threads (see Matthews Textile Fibers, 1947 ed., page 27). There are a few wood fibers having lengths in the range from 5 to 7 mm. as follows:

Grand fir	5.0
Douglas fir	5.0
Western larch	5.0
Southern yellow pines	4 to 6
Sitka spruce	5.5
Bald cypress	6.0
Redwood	7.0

These as well as all the shorter fibers of wood are not economically spinnable. Hence, all wood fibers are included herein as "short fibers." In the present invention, wherein "short fibers" are mixed with "long fibers," it is to be understood that the latter are so chosen as to be longer than the former, even though the definitions as given would otherwise permit the reverse relation.

In my copending prior application Serial No. 276,150, filed March 12, 1952, subsequently abandoned, of which the present application is a continuation-in-part, there are described numerous ways by which air-laid dry felts

of mixed long and short fibers may be made. Therein, it has been the objective to make felts of mixed long and short fibers by use of fiber-dispersing and felting processes commercially suitable for one but not the other of such long and short fibers.

The object of the present invention is to produce an air-laid dry fiber felt having fibers consisting of mixed long and short fibers but in a limited range of admixture in order to secure maximum benefits from the mixture.

It is a general object of the invention to provide an air-laid dry felt of fibers consisting of 20 to 80 parts of long fiber to 80 to 20 parts of short fiber.

It is a particular object of the invention to provide an air-laid dry fiber felt having 20 to 80 parts of long fiber cotton to 80 to 20 parts of wood cellulose fiber.

It is an object of the invention to produce open and porous low density dry-formed mixed fiber felts of the kind described, and to introduce fluid binder material into the felt for treatment to form bound felts.

It is an additional object of the invention to provide bonded felts which are the air-laid felts of the foregoing objectives to which dry binder has been added before or after felting, and only activated to adhesiveness within the felt, with or without compression of the air-laid felt.

Various other and ancillary objects and advantages of the present invention will become apparent from the following description and explanation of the invention, given in reference to the accompanying drawing in which:

Fig. 1 is a plot of property values over the entire range of admixture of long and short fibers.

Fig. 2 is a general vertical sectional view of apparatus by which the product may be made.

Largely because textile fibers are more costly as raw material and more costly and slower to handle mechanically in forming air-laid felts, all relative to wood fiber, it has become an important objective to combine the two fibers in air-laid felts with substantial retention of the desirable properties deriving from textile fibers and substantial retention of the lower cost and greater capacity in operations with wood fiber. The product of the present invention meets those objectives.

In using given equipment to make a range of felts varying in composition from 100% long fibers to 100% short fibers, the product derived varies in density and thickness. For comparison of properties, one variable must be fixed. In presenting property variations for explaining the present invention, the weight of material per unit area is held substantially constant as will appear in Table I below. This value is not dependent upon the properties of the mixture, but upon the fixed rates of feed of material and of operation of the apparatus.

In Fig. 1 there is shown a plot of property values of a series of felts made from 1-inch staple cotton fiber and sulfite wood cellulose. The mixed dry fibers individualized in a moving stream of air have been felted on a cylinder by a continuous procedure hereinafter described, and the felts evaluated. Fig. 1 is a plot of evaluations from the following Table I.

In Table I, the columns are numbered. In full, the columns are:

Col. 1. Percent by weight of cotton (remainder wood fiber).
Col. 2. Thickness in inches.
Col. 3. Density in pounds per cu. ft.
Col. 4. Weight of mat in pounds per 1,000 sq. ft.
Col. 5. Tensile strength in direction of web, measured in grams pull to maximum load on 1 inch width.
Col. 6. Tensile strength across web (units as in col. 5).
Col. 7. Stretchability in percent, to maximum load, in direction of web.

Col. 8. Stretchability in percent, to maximum load across web.

Col. 9. Compressibility to one-third original thickness, in pounds per sq. ft.

Col. 10. Percent of original thickness recovered on immediate release from test for col. 9.

Table I

1	2	3	4	5	6	7	8	9	10
5	.471	1.87	75	8.0	15.7	18.1	24.5	245	87.5
10	.517	1.82	78	9.0	20.0	22.0	26.4	180	90.6
20	.550	1.60	73	10.3	23.3	22 2	29 8	156	88 7
40	.660	1.26	70	4.7	30.3	26 6	32.4	99	94.0
60	.763	1.14	72	5 3	32.3	28.9	38.2	92	90 9
80	.897	0 98	73	5.0	30.7	32.0	32.8	48	88 3
100	.914	0.97	75	5.7	36.0	30.0	38 7	61	95.2

Fig. 1 shows that the properties of the 100%-cotton felt are little changed by inclusion of wood fibers up to about 20% content. At this point the compression value on line **10** (col. 9 of Table I) begins to improve, and the strength across the web, on line **11** (col. 6 of Table I), begins to drop. The compression improves only gradually and after 60% wood fiber it rises with accelerated loss of strength in curve **11**, but with a beginning of increase in strength with the web, as on line **12** (col. 5 of Table I).

As the percentage of wood fiber increases above 60%, both the compression values on line **10** and the tensile strength values on line **12** increase up to 80% of wood fiber, at which point the tensile strength curve **12** begins a sharp drop. But these values alone are not disadvantageous above 80% of wood fiber, being higher than their values from 0 to about 65% of wood fiber. The said drop of values in curve **12** is accompanied by an acceleration in the drop of curve **11**, the slope of which passes through the 45° angle at about 80% of wood fiber content.

The plot shows an optimum combination of values in the range between dotted lines **13** and **14**, which are taken as the limits for the present invention.

A mixed fiber felt may be formed by a suitable deposition of fibers from an air suspension of a mixture of individualized long fibers and short fibers. Mixing and individualizing the fibers may be effected in various ways. To maintain individualization the air suspending the fibers must be kept in motion. Felting may be accomplished in numerous ways. The fibers may be allowed to drop out of the air as in gravity deposition, but the formed felt is of such low density that it must be compressed before it has strength enabling it to be handled or moved from its support.

The practical process is to felt by filtering on a foraminous member such as a wire screen, and to have the screen move continuously through a deposition area. This permits the continuous formation of a web of which every cross-severed portion is alike. By virtue of such continuous formation, there is an inherent unidirectional character to the structure and its properties. These are reflected in the properties graphed in Fig. 1, wherein the tensile strength across the web direction is greater than in the web direction. This signifies that long fibers tend to lie crosswise of the web. Hence, as the proportion of long fibers decreases, the strength across the web should decrease, as shown by line **11**.

Fig. 2 represents for the purpose of illustration one way in which the described felt may be formed. Numeral **20** represents an infeed duct for air and undispersed short-fiber material. The duct **20** enters into a side opening **21** of a cylindrical housing **22** in which is a high speed rotor, consisting of numerous spaced plates **23** on axle **24**. To and between adjacent plates **23** are mounted swinging hammers or blades **25** which just clear the interior of housing **22** in rotation of the rotor. An arcuate portion of the cylindrical housing **22** is perforated as shown at **27**, over which is a crescent shaped (in cross-section) collecting hood **28**, leading to a discharge nozzle-like conduit **29**. High speed rotation of the rotor causes a fan-like action, drawing in air at **20** and discharging air at super-atmospheric pressure in conduit **29**. The fibrous material is individualized, and individual fibers pass through the perforated section **27**.

The disperser above described is a type unsuitable for long or textile fibers, and extremely suitable for handling wood fibers at high capacity. The resulting stream of air carrying wood fibers in conduit **29** is used to doff textile fibers carded onto any conventional or special lickerin roll or carder of the textile industry.

All illustrative form of carding device is shown in functioning relation to the nozzle **29**. It consists of a carding cylinder **30** with teeth **31** for carding textile material **32** suitably fed to it at a space between the top of top wall **33** of conduit **29** and a feed roll **34**. The carding is effected at a level near and preferably below the center of lickerin roll **30**, so that the carded textile fibers are brought downwardly to the lowermost portion of the roll **30**, to be doffed by the stream of air and fiber from conduit **29**. For this purpose the lower wall **36** of conduit **29** slopes upwardly to a narrow doffing zone **37**. The narrowing of conduit **29** to the doffing zone increases the velocity of the doffing stream to enhance its doffing action. By this procedure, uniformly fed textile material **32** is dispersed and uniformly mixed into the short fiber material, also fed at a uniform rate. By control of rates of feed and operation, the proportion of long and short fibers may be controlled for uniformity over a long period of continuous operation.

The mixed stream of fibers is housed in a duct **40** leading to a deposition area on a continuously moving foraminous conveyer. Although the duct **40** is shown as flaring, this is not essential, where the deposition area is larger than the cross-sectional area of the doffing zone. As shown, the mixed dispersion **41** expands from the doffing zone **37** to the deposition area indicated. This expansion causes fibers to move apart relatively, lessening the opportunity for them to flocculate, whereby individual fibers rather than flocks are deposited. It is to be understood that the stream **41** of mixed fibers may be produced in other ways, for example, by feeding both the textile sheet **32** and a wood fiber lap to the carding device.

The foraminous conveyer may be of any continuous type, and as shown is a cylindrical screen **45** of the character shown in U.S. Patent No. 2,451,915 to Buresh. Cylinder **45** turns at a controlled rate on axle **46** with its surface against the end of conduit **40**. Within the cylinder is a duct **47** which is in effect a continuation of duct **40**, and which extends diametrically of cylinder **45** to an outside duct **48**, effective as a continuation of duct **46**. Duct **48** leads to exhaust or to a suction device, which latter may be operated to augment and control the effective differential pressure under which the fibers form the felt **50**, shown as lifted from cylinder **45**.

The unbonded felts produced as described are very flexible, of low density and suitably strong, being useful per se, as for cushioning and insulation purposes. The felts may be greatly strengthened and changed advantageously in many properties, with and without compression. There may be present in the felt dry binder material which is activatable to adhesiveness as by subjection to heat, or high humidity, or vapors of absorbable solvent-like materials. Such binder may be present at the time of felting or added after felting. It may be a coating on either the short fibers or the long fibers, or some of such fibers may consist of such binder material, for example, cellulose acetate. It may be a powder mixed into the stream of mixed fibers, so that it is lodged in the felt as formed. Such practice, however, involves passage of some of the binder through the filter, wherefrom it may

be recovered. However, to effect a controlled composition of fiber and of binder so added, more complicated equipment is required.

It is, therefore, preferred to add binder after the felting. Solid binder may be dusted or worked into the felt, or carried into it by an air stream. Such non-liquid binders are activated according to their character, for example, thermoplastic or thermosetting powders, coatings, or fibers, are activated by heat, with or without compression of the felt.

Liquid binders may be impregnated into or sprayed into or onto the dry-formed felt. For example, a single thickness of the formed felt may be moved in contact with a roll bearing the liquid, to coat and impregnate the felt. The felt may pass through the nip of two rolls and through a pool of the liquid adhesive located in the nip, on one or both sides of the felt. A single thickness of felt passing over a suction area may be sprayed with liquid adhesive to load the interior with binder, followed, if desired, by further distribution by rolling and compressing. Still another way is to bring two webs together to form one, and to spray adhesive into the interfacial regian, or to precoat the combining faces, followed by rolling compression to spread and distribute the applied liquid. According to the liquid, the setting of the adhesive may vary. For example, latex emulsions need only to be dried, or dried and cured.

When binder is added, the property values may be varied greatly by the proportion of binder to fiber, the kind of binder, and the density at which binding is effected. These effects greatly outweigh the significance of proportions as charted in Fig. 1, so that in bound felts the component parts may be outside the range between lines 13 and 14. But practically, the felts formed as described without binder, must be mechanically handled and moved to effect their impregnation, and it is in these stages of manufacturing bound felts that the strength values are important. Dry unbound felts having from 0 to 80% of short fiber are readily carried to and through the impregnating steps, but above 80% of short fiber, the small amount of long fiber is insufficient to permit continuing a process through steps to add liquid or dry binder as described.

The following Table II evaluates bound mats of sulfite fiber and cotton waste, made as described, and then impregnated with an aqueous suspension of synthetic elastomer solids, effected by various dilutions of commercial latices having about 50% of solids.

The impregnating latex dilution may contain antioxidant agents for the binder to add to the permanence of the bound felt. It also may contain water-soluble wetting agent to accelerate the rate of impregnation of the felt by the liquid suspension. Where the impregnation is carried on continuously in a line including the felting apparatus, such as exemplified by Fig. 2, the amount of wetting agent in the liquid may be varied for each particular impregnating apparatus, so that the impregnation may be timed for the speed of formation of the felt.

The impregnated felt may be compressed to various densities before heating, drying and curing the binder, thus to form mats of various densities as illustrated in Table II.

Table II

Sample S-677	Percent Fiber		Lbs. Latex solids per 100 lbs. Fiber	Bound Mat, Density in lbs. per cu. ft.	Bound Mat, Weight in lbs. per M sq. ft.	Tensile Strength in pounds per inch of width	
	Sulfite	Cotton Waste				Width	Across
270	25	75	28.2	16.1	99	12.5	15.2
274	50	50	26.3	18.1	104	17.3	20.5
278	75	25	27.5	20.8	94	17.7	18.7
293	0	100	15.4	11.0	79	2.5	4.7
271	25	75	20.9	14.2	92	8.7	10.4
275	50	50	19.6	16.2	90	10.1	11.7
279	75	25	18.4	18.4	89	11.1	13.9
272	25	75	11.5	12.5	86	4.6	5.7
276	50	50	12.3	14.3	81	4.5	5.6
280	75	25	11.0	16.8	76	5.6	5.7
273	25	75	6.1	11.8	84	1.7	2.1
277	50	50	6.9	13.4	72	2.5	2.6
281	75	25	5.6	15.4	74	2.7	3.3

The invention is not limited to cotton as the long fiber. Wool, jute, reclaimed tire cord and others may be used. Where latex, such as that described above, is used in the products of Tables II and III, its bond increases on aging, as indicated by values in Table III. Table III also shows use of other combinations of short and long fibers.

Table III

Sample S-677	Unbound Mat—Fiber Composition	Bound Mat				Tensile Strength in lbs. per inch width			
		Lbs. Latex per 100 lbs. Fiber	Thickness, Inches	Pounds per cu. ft.	Pounds per M sq. ft.	Before Aging			After Aging—Aver.
						Width	Across	Aver.	
330	70% Sulfite Fiber 30% Cotton Thread Waste	0	0.103	8.98	77	0.30	0.60	0.45	0.73
331	70% Sulfite Fiber 30% Cotton Thread Waste	2	0.090	11.5	86	1.2	0.9	1.1	1.11
338	20% Sulfite Fiber 30% Jute Waste 50% Reclaimed Tire Cord	13.5	0.103	11.7	100	1.3	2.3	1.8	3.26
343	20% Sulfite Fiber 40% Jute Waste 40% Wool Napper Flock	14.9	0.141	7.32	86	2.7	2.9	2.8	2.78
351	70% Sulfite Fiber 30% Cotton Thread Waste	26.6	0.079	16.7	110	16.2	21.8	19.0	2.58
352	30% Sulfite Fiber 40% Cotton Thread Waste 30% Cotton Napper Waste	7.1	0.117	7.28	71	1.1	1.6	1.4	1.34
369	70% Sulfite Fiber 30% Cotton Thread Waste	5.0	0.036	8.66	26	0.75	0.78	0.77	0.63
373	30% Sulfite Fiber 70% Cotton Thread Waste	8.7	0.052	6.93	30	0.73	1.00	0.87	1.74

Webs of the present invention are sufficiently strong to permit couching in a horizontal direction as an unsupported span from one carrier to another, as for example, from one endless belt discharging the web from its forming equipment to another endless belt, such as one open-mesh wire screen to carry it through liquid impregnating equipment.

The invention is not limited to the exemplary embodiments herein given, and it is contemplated that numerous changes may be made within the scope of the invention expressed in the appended claims.

I claim:

1. An air-laid felt in the form of a piece of continuously formed web characterized by uniform differences in structure and properties in right angular directions respectively with and across the direction of formation of the web, said web comprising a felt of fibers extending generally in different directions which fibers consist of individualized long fibers and individualized short fibers, said long fibers being staple cotton fibers having a length of at least 5.08 millimeters, and said short fibers being wood fibers from which substantially all the lignin has been removed by chemical digestion, which wood fibers are shorter than said long fibers and have lengths not greater than 7 millimeters, the long fibers being present by weight in amount from 20 to 80 parts to 80 to 20 parts of short fibers, said felt having a greater tensile strength in one of said directions than in the other.

2. An air-laid felt in the form of a piece of continuously formed web characterized by uniform differencess in structure and properties in right angular directions respectively with and across the direction of formation of the web, said web comprising a felt of fibers extending generally in different directions which fibers consist of individualized long fibers and individualized short fibers, said long fibers being staple cotton fibers having a length of at least 5.08 millimeters, and said short fibers being sulfite cellulose wood fibers and shorter than said long fibers and having lengths not greater than 7 millimeters, the long fibers being present by weight in amount from 20 to 80 parts to 80 to 20 parts of short fibers, said felt having a greater tensile strength in one of said directions than in the other.

3. A felt according to claim 1 in which the fibers are individually free except for their interfelted relation.

4. A felt according to claim 2 in which the fibers are individually free except for their interfelted relation.

5. A felt according to claim 1 in which the fibers are bonded one to another.

6. A felt according to claim 2 in which the fibers are bonded one to another.

References Cited in the file of this patent

UNITED STATES PATENTS

1,695,805	Gatti	Dec. 18, 1928
2,266,907	Riehl	Dec. 23, 1941
2,398,159	Riehl	Apr. 9, 1946
2,622,308	Harris et al.	Dec. 23, 1952
2,635,301	Schubert et al.	Apr. 21, 1953

FOREIGN PATENTS

16,308	Great Britain	of 1891