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PAPERMAKERS FELTS AND METHOD OF MAKING THEM

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This invention relates to papermakers felts. More particularly it relates to the felts which are used at the wet end of papermaking and similar machines of the various types used in the production of felted fibrous products such as paper, paperboard, box-board, pulp laps and asbestos-cement boards, shingles and pipes. In general these so-called "wet felts" are used to pick up and to transport a freshly formed fibrous web through various dewatering devices in which the moisture content of the web is reduced to such a point that the web becomes self-supporting.

Papermakers wet felts should be as stable and durable as possible and also must have the characteristics of porosity and surface finish appropriate for the particular fibrous product being produced. The most widely used felts have been woven from woolen yarns and they have been fulled to form a stable and durable structure. Fulling is conducted in a fulling mill in which the fabric is worked in hot water, with or without additives, to promote felting of the fibers. Such operation requires a substantial period of time and results in some reduction in one or both dimensions of the fabric with attendant firming of the woven fabric, all as well known in the art. Stability and durability are enhanced by the use of larger diameter yarns and by weaving them closely together. On the other hand, porosity is enhanced by the use of small diameter yarns woven loosely. One or both of the surfaces of the woven structure may be treated as by brushing, teasing, and the like, to form a nap, particularly when critical grades of paper or other products are to be made wherein surface markings corresponding with the woven pattern of the felt would be objectionable. Napping of woven fabric by brushing or teasing is a subtractive process in that the fibers that are raised to form the nap are necessarily removed from the body of the yarns with resultant reduction in strength and in many cases a reduction in durability as regards abrasion resistance. To secure better finish characteristics with relatively open weave fabrics it is necessary to raise a substantial number of fibers to bridge the nap over the relatively large interstices between the yarn crossings.

Thus, it will be apparent that in the design and construction of woven wet felts, compromises must be made between what may be desired in the way of durability, porosity, and finish, because emphasis upon any one of these characteristics may be achieved only at the expense of one or both of the others. The effect is to limit the ranges of each of these characteristics which may be combined in a practical and satisfactory product.

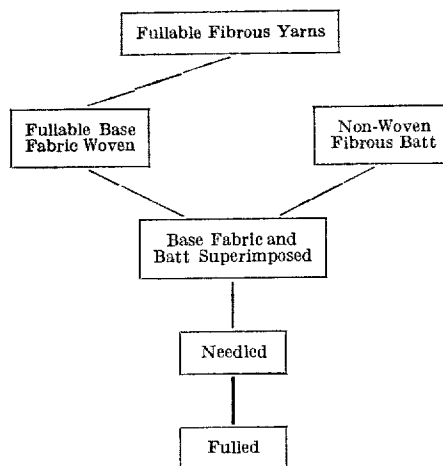
It is an object of the present invention to provide wet felts which embody those features which have made the traditional woven and fulled wet felts desirable and in addition, provide for compatible achievement of greater durability, more desirable porosity and unusually fine finishing characteristics in much broader ranges of combination than heretofore available.

Broadly speaking, the objectives of this invention are achieved by providing a woven base fabric capable of substantial fulling, to which is needled on one or both sides, unwoven fibrous material which will enhance the stability of the fabric and which may be applied in such quantity as to provide any nap that may be required for

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desired finishing characteristics, abrasion resistance and the like. After needling, the felt is fulled to final dimensions by traditional treatment in a fulling mill. The fulling provides a firm and durable structure and locks the needled fibers firmly in the fabric. The fulling also smooths the napped surface or surfaces by reducing or obliterating the pattern of needle holes.

A simplified flow diagram of a process in accordance with one preferred embodiment of the invention is as follows:



Since stability and durability of the felt are enhanced by the needled fibers the base fabric may be more open in weave and thus have greater porosity while still having desired stability and durability. Furthermore, the application of needled fibers to form nap is additive rather than subtractive insofar as strength is concerned whereby the imparting of finish characteristics is not made at the expense of strength.

A particularly important feature of the present invention is that the fullable base fabric is a good cushion and needs only a thin layer of unwoven fiber to cover the yarns. Such a thin layer could not be expected to cover and fill in the openings between the yarns to establish a smooth surface of uniform porosity. However, because the fabric is fulled after needling, the fibers in the applied layer which extend over and into the openings of the base fabric are condensed within each opening inasmuch as the openings are reduced in size by fulling. The yarns do not decrease in diameter during fulling but rather become firmer, and the filling yarns, especially, tend to increase in diameter. Thus the inner surface of the applied layer of fiber is conformed to the undulations of the base fabric while the other surface remains substantially planar.

The finished felts produced in accordance with this invention thus may present a smooth and uniform napped surface on one or both sides when such a surface or surfaces may be desired for imparting fine finish to paper or other fibrous webs. The smoothness and uniformity of the surface can be made to exceed that of conventional woven and napped felts wherein the concentration of fibers raised by teasing is greatest at the yarns and is smallest in the openings between yarns. Consequently, it has been necessary to raise a teased nap that may be too heavy at the yarns and still may be insufficient in the openings. In contrast with this, the present invention affords concentration of needled fibers in the openings whereby the added fibers produce a smooth surface with an unexpectedly uniform porosity in all areas of the finished felt. Because of this uniformity the quantity of

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added fiber may be kept at a minimum to favor good porosity while still achieving a fine finish.

The felts of the present invention are an even greater improvement over the needled felts heretofore available comprising coarse base fabrics of non-fullable fiber, such as cotton, to which unwoven fleeces of natural or synthetic fibers or blends of natural and synthetic fibers are needled to one or both sides. While, in the past, structures of this type have found some utility in connection with the manufacture of fibrous webs wherein finish is not important, they have not found much success in the production of fine papers or other products requiring good finish. With these structures, wherein the base fabric is a hard, open, sleazy construction more similar to fishnet than to a papermakers felt, it has been necessary to apply, by needling, very substantial quantities of non-woven fibrous material merely to cover the coarse yarn structure and to stabilize the open sleazy weave. Even greater quantities are needed if it is attempted to bridge the openings in the weave. When such large quantities of added fiber are used the porosity of the resultant structure is non-uniform and usually is unsatisfactorily low at the beginning and rapidly decreases as a result of plugging in use.

In an attempt to improve the characteristics of the needled felts available in the past, it has been proposed to utilize fleeces of synthetic fibers or blends of natural and synthetic fibers which will not tend to full during use of the felt. The synthetic fibers thus proposed have surfaces which are smoother than the surfaces of wool fibers and are less likely to retain solid materials. However, the base fabric, which is usually cotton, does not have a sufficient tendency to retain the needled fibrous material and particularly to retain needled synthetic fibers, in firmly anchored condition. As a result, considerable difficulty has been experienced in shedding of fibers during use, which fibers may adhere to the paper to such an extent as to downgrade the paper.

Also, it has been proposed in the past to use as a base fabric one which has been woven from natural fibers such as wool and which has been fullled prior to needling. Here again it has been considered essential that all tendency of the base fabric to full be utilized before the needling so that the final product will exhibit no tendency toward fulling when it is put into use. While the resultant structure somewhat more closely resembles a papermakers felt because it has a woolen base fabric, the needled nap cannot afford uniform porosity and smooth surface unless it is applied in layers of such thickness that the original porosity is too low for most practical applications. It will be apparent that the thick layers are required whenever it is attempted to provide a smooth outer surface because the applied nap must have sufficient strength and stability in itself to bridge the openings between the yarns of the base fabric. Thus the provision of good finish characteristics is approximately as incompatible with high porosity and freedom from plugging when a fullled base fabric is used as it is when a non-fullable base fabric is used. The tendency toward shedding of fibers is also present when a fullled base fabric is used and increasing the number of needle penetrations per unit area in an effort to more firmly entangle the fibers tends to reduce the strength of the yarns in the base fabric.

The design and construction of papermakers felts in accordance with the present invention represents an approach to the problem which differs fundamentally from the approach represented by needled felts heretofore used or proposed. In one sense the present invention represents the utilization of base fabrics which themselves are conventional woven papermakers felts consisting of fullable fibrous yarn structures and the formation on said structures of a nap or naps by needling of additional fiber rather than by teasing fibers from the yarn structure. Because the structure is fullled after needling the needle holes through the yarns are closed. The added fibers are

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firmly gripped by the yarns of the base fabric and they are distorted out of the generally linear or perpendicular path followed by the fibers during insertion thereof into the yarns by the needles and the needling loom. Each yarn of the final structure thus is interlocked with the added fiber by random entanglement. The porosity of the final felt is not dependent upon the existence of the needle holes with vertically directed fibers therein as are the needled felts heretofore proposed.

The strength, durability and drainage characteristics of felts made in accordance with this invention may be established by the selection, over very wide ranges, of yarns, yarn counts and weaves for the base fabric with the knowledge that desired finish characteristics and uniform, stable porosity may be derived from the fibers which are added by needling. Because unexpectedly good finishing characteristics may be obtained by the needling to such a base fabric of thin, continuous batts of unwoven fiber, the woven base fabric may be made of substantially coarser, stronger yarns woven more openly than could have been used in the manufacture of a conventional felt with a raised nap.

In some instances the fullable base fabric chosen for a particular felt in accordance with this invention may be originally woven in such an open pattern as to be sleazy and subject to deformation and damage if handled. In such cases the base fabric should be partially fullled before needling to make it sufficiently firm to withstand handling but still capable of substantial additional fulling. In other instances the base fabric may be sufficiently firm as originally woven so that all fulling may be performed after needling.

The base fabric, as woven, or partially fullled as desired, is then placed in the needling loom and the desired quantity of non-woven fiber is needled to one or both sides in the usual fashion. The unwoven fiber preferably is in the form of smoothly carded batts or fleeces which are of sufficient width and length to form a uniform layer throughout the area of the side of the base fabric to which they are to be applied.

The needling loom preferably is arranged to produce a random pattern of closely spaced needle penetrations through the layer of unwoven fiber whereby the barbs on the needles will carry individual fibers or small groups thereof downwardly into the yarns and openings of the base fabric. The fibers engaged by the needle barbs thus become intimately entangled with the yarn structure of the base fabric as well as with other fibers in the unwoven fleece. A substantial portion of the length of most of the unwoven fibers, however, will remain in generally horizontal position so that when needling is completed the entire area of the base fabric will be covered by a quite firm, smooth and horizontally disposed nap.

After the nap has been applied to one side of the base fabric it may be fullled and otherwise treated and finished for use. However, it may be desired to turn the fabric in the needle loom to needle the opposite side. In some instances a similar or different type of unwoven fiber may be needled to the opposite side and in other instances the opposite side may be needled without additional fiber to turn certain of the fibers of the first layer back upon themselves, thus to become more firmly entangled with and secured to the base fabric. When layers are to be added to both sides it is sometimes preferred to perform an additional needling with bare needles on the side opposite that to which the last layer was applied.

The woven base fabrics for use in the present invention may be made from yarns at least a substantial percentage of which are fullable and they may be woven endless or they may be woven in continuous lengths the ends of which are joined by splicing to form endless structures. When woven endless the weft yarns extend lengthwise of the endless belt of fabric and when woven as continuous lengths the warp yarns extend lengthwise of the spliced belt of fabric. In either event at least a substantial percentage of the yarns should be fullable for

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use in the present invention. The fullable yarns may consist entirely of natural fibers such as wool or they may consist of blends of natural fibers with suitable synthetic fibers such as polyamide, polyester, polyacrylonitrile, poly-
paraffin, polyvinyl and polyvinylidene fibers and similar
fibers including fibers made of copolymers of any such
materials. The blended yarns must contain sufficient
quantities of natural fiber to be capable of substantial
fulling.

The non-woven fiber may be fullable or not as desired. When fullable fibers or fullable blends of fibers are used the needled nap will full along with the base fabric, the most noticeable effect being a reduction in thickness with increase in firmness of the nap. In addition, the fullable nap will tend to full to the base fabric thus enhancing the firmness of attachment of the nap to the base fabric. When non-fullable fibers or blends are needed to the fullable base fabric the average thickness of the nap is little affected by fulling of the final felt. However, in both instances the applied non-woven fibers will condense to a substantially greater degree within the interstices of the weave than they will over the yarns. This condensation of fibers within the interstices of the weave can be so controlled by selection of quantity of applied fiber and selection of the yarns, yarn count and weave of the base fabric as to provide in the fulled final product a porosity within the interstices which is substantially the same as the porosity of the inherently porous, cushiony yarns of the base fabric.

In view of the fact that papermakers wet felts in their intended use do not behave like sieves but rather must have porosity in at least two directions the uniformity of porosity which may be achieved throughout the body of felts made in accordance with this invention is of particular value. It is vastly preferable to the non-uniform, sieve-like constructions heretofore produced by needling fibers to bases which are deliberately incapable of fulling in order that the needle perforations and vertically positioned fibers may promote drainage only in one direction.

It has been indicated above that finish characteristics suitable for the manufacture of fine paper can be achieved in accordance with this invention by the use of thinner layers or batts of unwoven fibers that have been used in the past. Direct comparison is not practicable since the thinnest layers heretofore needled to cotton or other non-fullable base fabrics have only been effective to cover the yarns and to stabilize the sleazy base fabric and the weave pattern of the base fabric is inevitably marked on the paper or other product. For example, with non-fullable base fabrics with relatively coarse yarns and open weave it has not been possible to use less than about 2-oz. per square foot (finished dimensions) of non-woven fibers simply to obtain the stabilization and yarn cover mentioned above. In contrast with this the present invention makes it possible to produce a true papermakers wet felt with excellent finish characteristics when about 1½ oz. or less per square foot (finished dimensions) of unwoven fiber is needed to a fullable base fabric of similarly coarse open construction which is thereafter fulled to its finished dimensions. With other constructions of fullable base fabrics much less added fiber may be needed to give excellent finishing characteristics. Finishing characteristics to meet various demands may be obtained by the use of progressively lighter applied naps, all the way down to the lower limit established by the ability to form continuous non-woven webs of fiber, which, in the present state of the art is believed to be about ¼ oz. per square foot (of the web).

The reason that the present invention permits of so little non-woven fiber to meet varying finish requirements is that the stability and bonding of the woven base fabric comes primarily from fulling and is not solely dependent upon the needled fiber as in the case of non-fullable base fabrics. The full range of quantity of added non-woven fiber is thus available for the design of felts in accordance

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with this invention to produce felts ranging from extremely light weight felts with coarse finish or fine finish to extremely heavy, dense felts with many heavy layers of added fiber. This invention is also applicable to fullable base fabrics woven with two or more plies of fabric of the same or of different construction, yarn count or other characteristics. For example, a relatively fine count and small yarn diameter may be used for an upper ply while a coarser, stronger construction may be used for the back ply. In such event, the finish characteristics of the upper ply may be still further improved by the needling thereto of a very moderate amount of unwoven fiber, followed by fulling of the whole structure.

No unusual fulling techniques are necessary in connection with felts made in accordance with the present invention. Well known procedures with respect to time, temperature, amount of manipulation and the like may be followed in the same manner as heretofore applied to the manufacture of fullable, woven felts. In those cases under the present invention wherein the base fabric is partially fulled before needling it is preferred that such partial fulling not exceed about 85% of the total fullability of the fabric and in many cases a substantially larger amount of fullability may be left for fulling after the needling operation.

In some situations, such as in cases where extremely fine finish characteristics are of particular importance, it is advantageous to trim the added non-woven fibers forming the nap to a substantially uniform level in any well known manner. As an illustration, the nap may be trimmed by shearing or singeing, for example, to thereby further insure a smooth and even surface finish.

As indicated heretofore, upon the completion of the final fulling of the fabric, the added non-woven fibers are firmly anchored to the base material. As a result, the tendency toward shedding of fibers during use is substantially reduced, and the possibility of the paper being downgraded as a result of such shedding is diminished. Particularly for extremely fine grades of paper, it is sometimes desirable to apply a vacuum to the fabric to remove any extraneous unanchored fibers and thereby further reduce the possibility of shedding. Such vacuuming preferably is accomplished after the final fulling, although the fabric may be in either its wet or dry state or both. Thus, in one particularly advantageous arrangement, the fulled fabric is first vacuumed in its wet condition and is then dried and trimmed. The vacuuming of the fabric in its wet state not only serves to loosen any extraneous fibers but also orients the nap forming fibers in an upright position, thereby greatly facilitating trimming. Upon the completion of the drying and trimming operations, the fabric is again vacuumed to remove any remaining unanchored fibers, including those separated from the nap during trimming.

In other cases, such as where the deleterious effects of shedding are of minor importance, the vacuuming and/or trimming operations safely may be eliminated without departing from the spirit or scope of the invention.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions, of excluding any equivalents of the described features, or portions thereof, it being recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. The method of making a papermakers felt comprising a woven base fabric with a nap of non-woven fibrous material firmly secured to at least one side thereof, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fiber material to render the woven fabric capable of substantial fulling, needling a continuous batt of non-woven fibrous material to at least one side of said fullable woven base fabric, and fulling said fullable base fabric with said fibrous material

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needed thereto to form a fulled napped papermakers felt.

2. A papermakers felt made in accordance with the process set forth in claim 1.

3. The method of making a papermakers wet felt comprising a woven base fabric with a nap of non-woven fibrous material firmly secured to at least one side thereof, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fibrous material to render said woven base fabric capable of substantial fulling, needling a continuous batt of fullable non-woven fibrous material to at least one side of said fullable woven base fabric, and thereafter simultaneously fulling said fullable woven base fabric and the non-woven fibrous material needled thereto, to thereby form a fulled napped papermakers felt with non-woven fibers firmly interlocked with and fulled to the yarns of said base fabric.

4. The method of making a papermakers wet felt comprising a woven base fabric with a nap of non-woven fibrous material firmly secured to at least one side thereof, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fibrous material to render said woven base fabric capable of substantial fulling, needling a thin, continuous batt of non-woven fibrous material to at least one side of said fullable woven base fabric, and fulling said fullable woven base fabric with the non-woven fibrous material needled thereto, to thereby form a fulled napped papermakers felt with non-woven fibers firmly interlocked with the yarns of said base fabric and condensed to a greater degree within the interstices of said fabric than over said yarns, the amount of non-woven fibrous material needled to said base fabric being not greater than about one and one-half ounces per square foot of the fulled base fabric.

5. The method of making a papermakers wet felt comprising a woven base fabric with a nap of non-woven fibrous material firmly secured to at least one side thereof, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fibrous material to render said woven base fabric capable of substantial fulling, preliminarily partially fulling said base fabric to a point wherein it is still capable of substantial further fulling, needling a continuous batt of non-woven fibrous material to at least one side of said partially-fulled woven base fabric, and thereafter completing the fulling of said woven base fabric with said fibrous material needled thereto to form a fulled napped papermakers felt.

6. A papermakers felt made in accordance with the process set forth in claim 5.

7. The method of making a papermakers wet felt comprising a woven base fabric with a nap of non-woven fibrous material firmly secured to at least one side thereof, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fibrous ma-

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terial to render said woven base fabric capable of substantial fulling, preliminarily partially fulling said base fabric to a point not in excess of about eight-five percent of the total fullability of said fabric, needling a continuous batt of non-woven fibrous material containing fullable fibers to at least one side of said partially-fulled woven base fabric, and thereafter simultaneously completing the fulling of said woven base fabric and fulling the non-woven fibrous material needled thereto, to thereby form a fulled napped papermakers felt with non-woven fibers firmly interlocked with and fulled to the yarns of said base fabric.

8. The method of making a papermakers wet felt comprising a woven base fabric with a nap of non-woven fibrous material firmly secured to at least one side thereof, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fibrous material to render said woven base fabric capable of substantial fulling, preliminarily partially fulling said base fabric to a point wherein it is still capable of substantial further fulling, needling a thin, continuous batt of non-woven fibrous material to at least one side of said partially-fulled woven base fabric, and thereafter completing the fulling of said woven base fabric with the non-woven fibrous material firmly secured to at least one side thereof, papermakers felt, the amount of non-woven fibrous material needled to said base fabric being not greater than about one and one-half ounces per square foot of the fulled base fabric.

9. The method of making a papermakers wet felt comprising a woven base fabric with a nap of non-woven fibrous material needled thereto to form a fulled napped of, which consists of weaving a base fabric from yarns at least some of which contain sufficient fullable fibrous material to render said woven base fabric capable of substantial fulling, needling a continuous batt of non-woven fibrous material to at least one side of said fullable woven base fabric, fulling said fullable woven base fabric with the non-woven fibrous material needled thereto, to thereby form a fulled napped papermakers felt with non-woven fibers firmly interlocked with the yarns of said base fabric and condensed to a greater degree within the interstices of said fabric than over said yarns, and vacuuming said fulled napped papermakers felt in its wet condition.

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