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LOW DENSITY NON-WOVEN WEB

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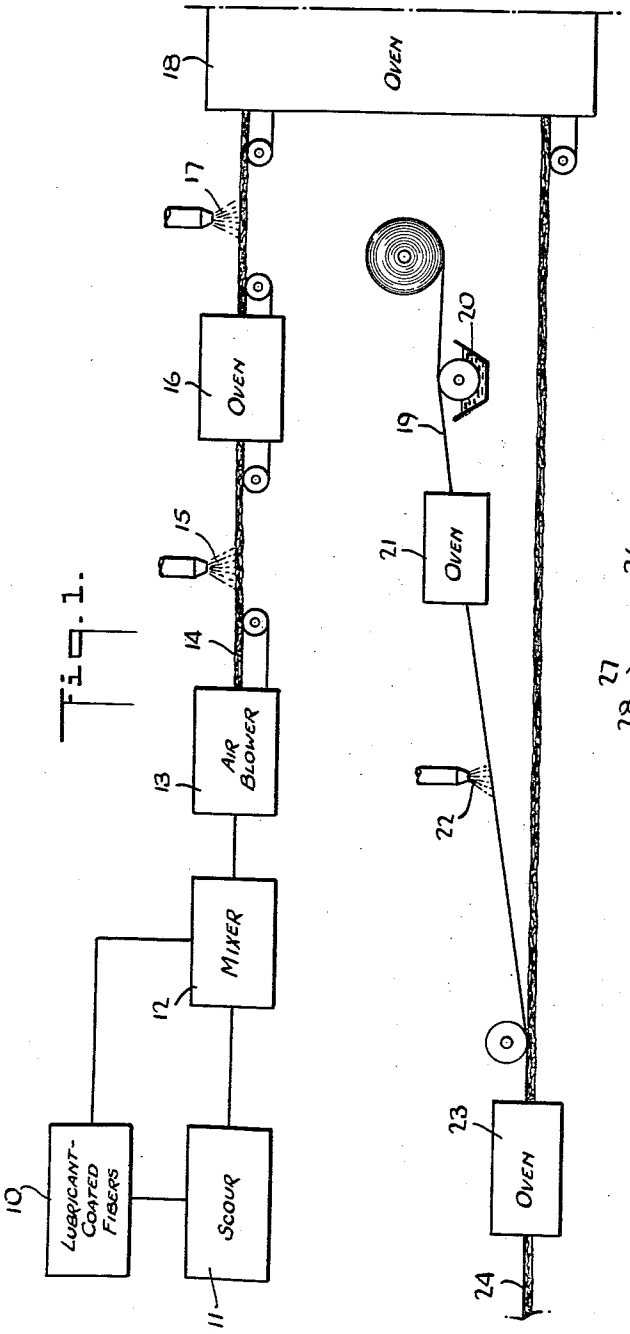


Fig. 1.

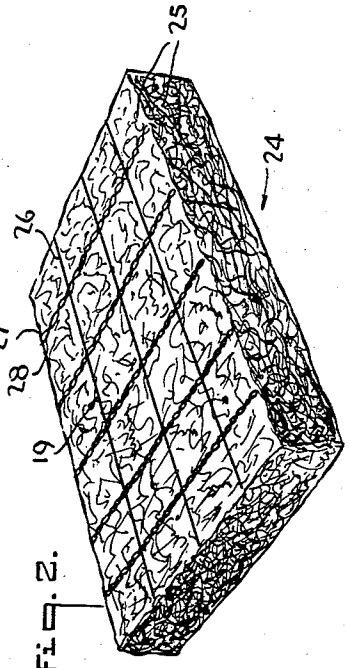


Fig. 2.

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LOW DENSITY NON-WOVEN WEB

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The present invention relates to the formation of fibrous non-woven webs or batts characterized by low density, high loft and resilience.

An important feature of the invention is the provision of air filters of sufficient rigidity to permit them to be used without frames, if desired, which filters achieve efficient filtration of dust with minimum resistance to the flow of air. The invention is particularly directed to the provision of rigid or semi-rigid disposable filter media for use in air conditioning units as well as for similar air filtering purposes. The invention includes the method of producing such webs or batts.

Filters suitable for use in air conditioners are generally formed by applying an adhesive or binder to a non-woven batt formed by carding or air-blowing staple fibers. Batts exhibiting desirable physical properties and yet low in cost can be produced using synthetic thermoplastic staple fibers. Such fibers are formed by extrusion of a solution or melt of filament-forming material through orifices to form continuous filaments to which an anti-static lubricant is applied, i.e. one which will prevent build up of static electricity, so as to permit the filaments to be held closely together as an aid in further processing. The filaments are gathered into a large bundle or tow, they are usually crimped and they are subsequently cut into short lengths, i.e. staple fibers, to be incorporated into non-woven batts as described.

In accordance with one aspect of the present invention it has been found that control of the composition of each fiber and of the mix permits production of non-woven batts and of filters characterized by greater loft, i.e. lower density, higher filtering efficiency and lower pressure drop than heretofore attained with generally similar filter constructions. The fiber mix to achieve these results is composed of some fibers which will not build up a static charge (or will dissipate the charge rapidly if built up), referred to hereinafter as "low static fibers," and some fibers which will readily build up and retain an electrostatic charge, referred to hereinafter as "high static fibers." The high static fibers build up and retain electrical charges so as to repel each other and produce a more lofty or bulky structure. Advantageously, at least 10% and preferably at least 15% by weight of the fibers are high static fibers to realize the desired advantages. Greater proportions of high static fibers increase the amount of repulsion but advantageously no more than 50% and preferably no more than 25% by weight are high static fibers. Greater amounts produce so much static repulsion that there is insufficient interlocking to form a coherent structure and in addition complicate processing since the fibers tends to stick to the processing machines due to their high static charges.

The high static fibers of the composition can be formed from synthetic thermoplastic filamentary material by a procedure identical with conventional practice except that application of an anti-static lubricant is omitted. Alternatively, an anti-static lubricant such as sulfonated and/or sulfated hydrocarbons, salts of a long chain fatty acids, alkyl phosphates, ethylene oxide derivatives of sorbitol, or the like, dissolved or emulsified in a liquid such as mineral oil or other hydrocarbon, can be applied so as to facilitate crimping and processing, for example, and the fibers can be scoured as in hot soap solution to remove the lubricant after which they are dried

and mixed with low static fibers, e.g. fibers which are inherently low static fibers such as cotton or rayon, or fibers carrying an antistatic finish or lubricant.

The denier of the component fibers may vary widely, e.g. from 0.5 to 35.0 or more, although lower denier fibers will provide more surface and finer spaces so as to improve filtration. The length of the fibers can also be varied within wide limits, e.g. to 3 inches or more. Generally the fiber length will range from about 1.5 to 2.5 inches to produce sufficient interlocking while also permitting easy processing on conventional equipment for forming non-woven batts.

The use of a mixture of different denier and different length fibers is advantageous because high denier per filament fibers provide structural strength as well as openness to the web whereas low denier per filament fibers provide greater surface area for high filtration.

As noted, the fibers are preferably crimped, containing from about 1 to 20 and preferably 6 to 12 crimps per inch of tensioned filament, i.e. in a length of filament which when tensioned just sufficiently to cause the crimps to disappear is one inch long. This crimp can be inserted either chemically (by immersion in a swelling agent followed by drying in relaxed condition) or mechanically or may inherently be present in the filaments as produced. The crimp increases the bulk and in addition aids in interlocking so as to form a stronger and more rigid structure. The use of fibers of non-circular cross-section further increases the bulk and rigidity.

The composition of the high static fibers may vary widely, representative fibers being thermoplastic and composed of polyamides such as nylon, polyesters such as polyethylene terephthalate, acrylonitrile polymers and copolymers, ethers of cellulose, organic acid esters of cellulose, and the like. Preferably they are composed of lower alkanoic esters of cellulose such as cellulose propionate, cellulose butyrate, cellulose acetate-butyrate, and the like, and especially cellulose acetate. The cellulose acetate may be conventional cellulose acetate having an acetyl value of about 55% by weight calculated as acetic acid or it may constitute cellulose triacetate having an acetyl value in excess of about 59%. The other organic acid esters of cellulose may have corresponding variations in their acyl and free hydroxyl contents. The low static fibers can comprise an inherently hydrophilic material such as cellulose, e.g. cotton, rayon (regenerated cellulose) or the like, or may comprise normally hydrophobic materials of the same composition as the high static fibers but treated with an anti-static finish.

Following formation of the batt using an air-blowing apparatus or a cotton card and camel-back cross-laying apparatus, a bonding agent is applied to bond the fibers. Suitable bonding agents include solutions or dispersions in organic solvents or water, i.e. latexes of binders such as natural or synthetic rubber, polyvinyl acetate, copolymers of vinyl acetate and vinyl chloride, commercial modified urea or melamine formaldehydes, phenolics, acrylic or epoxy resins, insolubilized starches and the like. Where there are desired filters of sufficient rigidity to be self-sustaining without a frame, flexible but comparatively stiff bonders such as polyvinyl acetate and the commercial modified urea formaldehydes give particularly good results. Conventional anti-oxidants, pigments, filters, and the like may be present as well as vulcanizing agents and/or accelerants when required. The bonding agent can be applied by immersing the non-woven in the bonding agent, by spraying the bonding agent on the non-woven possibly with the aid of suction to draw the bonding agent through the non-woven, by depositing the bonding agent in the form of a foam on the non-woven, or the like. The impregnated non-woven is then dried to remove

liquid and other volatiles and is cured or vulcanized if necessary. The ratio of binder solids to fibers generally ranges from about 10 to 40%, and preferably 15 to 30%, by weight.

To increase the dimensional stability of the filter it may be backed with an open mesh scrim, e.g. cotton woven with an open Leno weave with successive warps and fillings spaced about 0.25 inch from each other. The scrim may be applied after the filter is completely formed or it may be positioned on one or both surfaces of the non-woven batt while the bonding agent is applied so as to be joined thereto simultaneously with bonding. If desired, the scrim may be sandwiched between two batts.

Subsequently, the filters are desirably fireproofed as by spraying or impregnating the bonded fiber web or batt with a fireproofing agent. A particularly preferred fireproofing agent is a 1:1 mixture of borax and boric acid which may be applied in the form of a 20% by weight solution in water. This 1:1 mixture of borax and boric acid is outstanding because it provides effective fire retardency combined with ability to cling to the bonded filter. If the scrim is not already present during this treatment it may be similarly treated separately.

The invention is illustrated in the accompanying drawing in which

FIG. 1 is a flow sheet illustrating a continuous manner of carrying out the process of the invention; and

FIG. 2 is a perspective view of a filter produced thereby.

Referring to FIG. 1, fiber coated with an anti-static lubricant is supplied from a source 10 and part of the lubricant-coated fibers is scoured as indicated at 11 with the two types of fibers then being supplied to a mixer 12 and to an air blowing device 13 to produce a batt 14 of mixed randomly arranged fibers. The batt 14 is sprayed with a bonding agent at 15 and the bonding agent is cured in the oven 16. The bonded batt is then sprayed with a fire retardant as indicated at 17 and the fireproofed batt is dried in the oven 18. In the preferred form of the invention which is illustrated, a scrim 19 is saturated with a fireproofing agent in the saturator 20 and then dried in the oven 21, after which the scrim is sprayed with adhesive as indicated at 22 and then contacted with the batt and bonded thereto in the oven 23. The finished product emerging from the oven 23 is indicated by the numeral 24.

If desired, the process can be effected discontinuously with batts of predetermined size.

As seen in FIG. 2, the filter 24 comprises a coherent mass of fibers 25 bonded to each other with scrim 19 bonded to the upper surface. The scrim 19 comprises warp threads 26 each held in position by an entwined pair of filling threads 27, 28.

Filters produced in accordance with the present invention are sufficiently rigid and possess sufficient integrity to withstand substantial air velocity without the use of a frame. They are capable of effective dust removal, such effective dust removal being indicated by an efficiency rating of about 50% or better as determined by the Department of Commerce Recommended Standard Testing Procedure, TS–5315, dated May 21, 1956. They possess a minimum resistance to the passage of air therethrough. Thus, with a filter thickness of ½–⅝ inch, the maximum initial restriction is less than 0.09 inch of water at a face air velocity of 350 feet per minute. Moreover, the structure of the filter is such that after 100 grams of standard test dust is supplied to a 6 x 6 inch sample batt, the restriction to air passing through the batt at a face velocity of 350 feet per minute still does not exceed 0.18 inch of water. The standard test dust is composed of 72% by weight of standardized air cleaner test dust fine, 25% by weight of K–1 carbon black and 3% by weight of No. 7 cotton linters ground in Wiley Mill with 4 millimeter screen.

While the non-woven batts have been described with respect to their use as air filters, either with or without bonding agents they have other fields of utility. Thus, they can be used as stuffing in mattresses, cushions, etc. as well as in any applications requiring a lofty, resilient non-woven structure. They can be laminated to desired thickness or directly made of any thickness.

The following examples are given to illustrate the invention further.

Example I

A non-woven batt ⅝ inch thick was produced by air-blowing cellulose acetate fibers, acetyl value 54%, comprising the following weight composition:

75% of 2 inch fibers, 35 denier per fiber, lubricated
10% of 2 inch fibers, 17 denier per fiber, lubricant-free
15% of 1.6 inch fibers, 5.5 denier per fiber, lubricant-free

All the fibers were crimped to the extent of about 8 crimps per tensioned inch. The anti-static lubricant was present on the 35 denier fibers to the extent of 3% by weight and comprised mineral oil plus sulfonated hydrocarbon. The lubricant-free fibers were Y-shaped in cross-section to impart increased bulk. The batt was sprayed with a 20% dispersion of polyvinyl acetate in water in an amount sufficient to deposit on the fibers of their weight of polyvinyl acetate. The sprayed batt was heated for 2 minutes in an oven at 350° F. and weighed 6 ounces per square yard. Its thickness was only slightly less than ⅝ inch. Its filtration characteristics as an air conditioning filter were excellent, giving high filtration efficiency at low pressure drop.

Example II

By the same process outlined in Example I a filter was formed of a fiber mix made up as follows:

75% of 3 inch fibers, 35 denier per fiber, lubricated
15% of 1.6 inch fibers, 5.5 denier per fiber, lubricant-free
10% of 1.6 inch fibers, 3 denier per fiber, lubricant-free.

Example III

The following fiber mix by the process of Example I gave a filter weighing 4.3 ounces per square yard and almost ⅝ inch thick, with almost the same filtration characteristic:

75% of 3 inch fibers, 35 denier per fiber, lubricated
25% of 1.6 inch fibers, 5.5 denier per fiber, lubricant-free.

Example IV

The fibers of Example III when mixed in equal proportions and processed as in Example I produced a filter almost ⅝ inch thick, weighing 5.1 ounces per square yard and of approximately the same filtration characteristic as in Example III.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of our invention.

Having described our invention what we desire to secure by Letters Patent is:

1. A non-woven batt comprising high static thermoplastic resinous fibers and low static thermoplastic resinous fibers carrying an antistatic lubricant, about 10 to 50% of the total fiber weight comprising high static fibers.

2. A batt as recited in claim 1 in which said batt includes a resilient binder securing the fibers thereof to one another.

3. A batt as recited in claim 2 including an open mesh scrim adhesively secured thereto.

4. A batt as recited in claim 1 in which said high static fibers comprise an organic acid ester of cellulose free of antistatic lubricants.

5. A batt as recited in claim 1 in which said high static fibers comprise cellulose acetate.

6. A batt as recited in claim 1 in which said high static fibers comprise about 15 to 25% of the total weight of said fibers.

7. A non-woven batt comprising antistatic lubricant-carrying low static thermoplastic resinous fibers and high static crimped thermoplastic resinous fibers, the fiber mixture including fibers of different deniers and fibers of different lengths, about 10 to 50% of the total weight of said fibers comprising high static fibers, the fibers of said batt being secured together by a resilient binder.

8. A non-woven batt as recited in claim 7 in which said binder is present in about 15 to 30% by weight of the fibers.

9. A non-woven batt as recited in claim 7 impregnated with a fireproofing agent.

10. A non-woven batt as recited in claim 7 including an open mesh scrim adhesively secured thereto.

11. A non-woven batt comprising antistatic lubricant-carrying low static thermoplastic resinous fibers and crimped cellulose acetate fibers free of antistatic lubricant, the length and denier of the lubricant-free cellulose acetate fibers being different from those of at least some of the lubricant-carrying fibers, the denier of said fibers ranging from about 0.5 to 35.

12. A non-woven batt comprising antistatic lubricant-carrying low static crimped cellulose acetate fibers and crimped cellulose acetate fibers, free of antistatic lubricants, ranging in denier from about 0.5 to 35, and about 15 to 25% of the total fiber weight comprising lubricant-free fibers, and a resilient binder adhesively securing said fibers to each other.

13. A non-woven batt as recited in claim 12 wherein said binder comprises polyvinyl acetate present in about 15 to 30% by weight of the fibers.

14. A fiber mixture adapted for the formation of non-woven batts comprising high static thermoplastic resinous fibers and low static thermoplastic resinous fibers carrying an antistatic lubricant, about 10 to 50% of the total fiber weight comprising high static fibers.

15. In the production of a highly porous non-woven filter wherein fibers are formed into a non-woven batt and a binder is applied to said batt to secure said fibers to each other, the improvement which comprises employing as said fibers a mixture of low static thermoplastic resinous fibers carrying an antistatic lubricant and high static thermoplastic resinous fibers, about 10 to 50% of the total fiber weight comprising high static fibers.

16. The process recited in claim 15 in which said high static fibers comprise cellulose acetate, free of antistatic lubricants.

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