

[54] **FILTER**

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[58] Field of Search. **131/268, 267, 266, 264, 261, 131/66, 66 A, 64, 64 A, 84, 84 A, 8, 10, 10.7, 10.9, 84 B**

[56] **References Cited**

UNITED STATES PATENTS

3,552,400	1/1971	Berger et al.	131/267 X
2,805,671	9/1957	Hackney et al.	131/266
3,050,430	8/1962	Gallagher.	131/268 UX
3,068,873	12/1962	Allman, Jr. et al.	131/10.7

3,225,390	12/1965	Kistler.	131/261 X
3,313,665	4/1967	Berger.	131/268 X
3,364,938	1/1968	Mumpower et al.	131/269 X
3,444,863	5/1969	Soehngen et al.	131/266 X

FOREIGN PATENTS OR APPLICATIONS

757,841	9/1956	Great Britain.	131/267
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[57]

ABSTRACT

Aerosol filters, particularly cigarette filters, are formed from short synthetic fibers containing a bonding agent by confining a random array of said fibers having an orientation predominantly transverse to the longitudinal axis of said filter in an area having the desired configuration and activating the bonding agent to form a coherent article.

3 Claims, 2 Drawing Figures

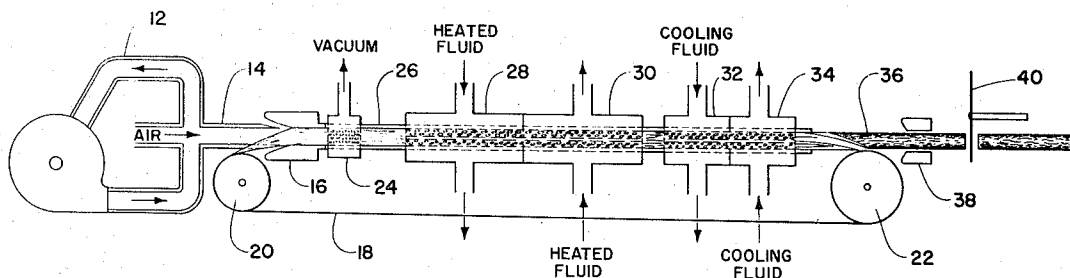
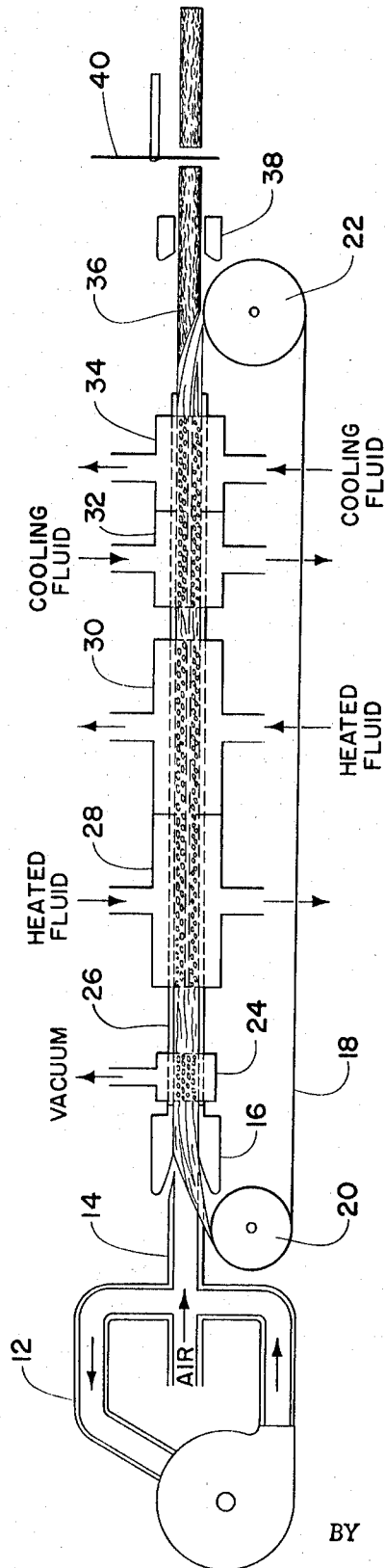
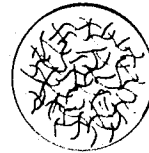


FIG. 1.



BY

FIG. 2.



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SUMMARY OF THE INVENTION

The present invention relates generally to the formation of aerosol filters, and more particularly to cigarette filters. Briefly, the cigarette filters of the present invention comprise a substantially cylindrical rod comprised of short synthetic fibers bonded at their points of contact with one another by a suitable bonding agent. The arrangement of the fibers within said rod may be described as random with the exception that the fibers are predominantly lengthwise oriented in a primarily vertical plane.

The filters of the present invention are preferably formed by dispersing a plurality of short fibers associated with a latent bonding agent into a rapidly flowing, preferably turbulent, air stream, sweeping said fibers in said air stream into a cylindrical zone to form a rod conforming to the interior dimensions of said zone, confining said fibers in the cylindrical configuration by wrapping a porous belt about the rod as it exits from said zone in order to transport said rod through succeeding processing zones, removing air from the confined fibers, heating the rod to activate the bonding agent therein and form a coherent structure, cooling the coherent structure, removing the belt from about the coherent structure, treating the surface of the coherent structure to remove irregularities therefrom, and cutting the coherent structure to the desired length.

DRAWING

FIG. 1 is a side view of the apparatus described in the specification.

FIG. 2 is a cross-sectional view of a cigarette filter showing the transversely oriented fibers.

DETAILED DESCRIPTION OF THE DRAWING

Aerosol filters, particularly cigarette filters, have conventionally been produced from corrugated sheets of paper or from synthetic continuous filament tows in which the filaments are generally aligned with the longitudinal axis of the filter. While other techniques, such as baffles, etc. have been attempted, only the paper filters and filters of continuous synthetic filaments, particularly cellulose acetate, have met with any wide commercial acceptance.

Paper filters are generally characterized by a higher filtration as measured by smoke removal efficiency at a given pressure drop, but suffer the disadvantage of adversely affecting taste and odor of the delivered smoke stream. Moreover, the phenol selectivity of paper filters is generally significantly lower than that available with conventional tow filters. Also, paper filters are susceptible to collapse during smoking, whereby the filter medium may become separated from the containing wrapper, permitting the smoke to "channel" about the medium and arrive at the smoker's mouth essentially unfiltered.

On the other hand, tow filters, particularly bonded cellulose acetate tow filters, are more successful in selectively removing phenols, and generally exhibit acceptable compressibility, i.e., resistance to lateral deformation, but would desirably exhibit enhanced smoke removal efficiencies without loss in organoleptic quality of the delivered smoke stream.

Accordingly, the principal object of this invention is to provide an aerosol filter especially adapted for the filtration of tobacco smoke, characterized by high filtration efficiency, suitable compressibility, and an aesthetically acceptable delivered smoke stream.

In accordance with the primary teachings of this invention, there is provided a gas filter consisting essentially of discrete fiber elements bonded at random points of contact therebetween into a structure wherein the predominant orientation of the fibers is transverse to the gas stream path.

Generally, the present filters may be characterized as being of lower weight and improved compressibility at equivalent pressure drop and smoke removal efficiency in comparison with conventional continuous filament tow filters.

While the theory of smoke filtration has not been thoroughly elucidated, many studies point to an impact phenomenon as extremely significant. It is postulated, without limitation arising therefrom, that the improvement in filtration afforded by the filters of this invention resides at least in part in the transverse orientation of the fiber elements, increasing the probability of impact with the particulate matter in the aerosol stream.

The desirability of fiber orientation normal to the axis of the cigarette filter plug has not gone unnoticed in the art, but each of the prior suggestions have proven unworkable in practice. Thus, U.S. Pat. No. 2,855,937 describes a structure used by disposing fibers vertically on a paper wrapper and then forming a cylindrical rod therefrom wherein the fibers "intermesh" with each other and are directed toward a common center. While this construction provides transverse orientation of the fiber elements, it will be seen by inspection that the concept requires a cross section having a variable density. Accordingly, the concentrated mass of intermeshed fibers at the common center tends to force the smoke to the periphery of the plug where a relatively low density of the medium is available to act on the smoke stream. Acceptable compressibility, as well as the construction methods, necessitate a stiff wrapper, and production techniques are extremely critical.

Allman et al., in U.S. Pat. No. 3,068,873 also describes a filter structure containing transversely oriented fiber segments, the individual segments thereof containing no internal free fiber ends which may interact to form a coherent continuous filter rod, adapted to handling in a commercial cigarette-making operation.

U.S. Pat. No. 3,225,390 emphasizes the desirability of increasing the transverse orientation of loose fibrous material in filter plugs to enhance the lateral strength thereof, and discloses formation of plugs from a web having about 25 percent to 50 percent of the fibers therein oriented in a direction $\pm 30^\circ$ of the perpendicular to the axis of the plug being formed. The desired effect on filtration efficiency resulting from this limited reorientation of fiber elements is necessarily minimal, which is also the failing of some other suggested approaches, such as those of U.S. Pat. Nos. 2,805,671 and 3,033,212.

It will be seen from the foregoing discussion that while the desirability of transversely oriented fiber elements in a cigarette plug may have been appreciated, no acceptable product having a high order of transverse orientation has heretofore been developed, and no process is available whereby such products may be uniformly and continuously manufactured on a commercial scale.

Accordingly, a further and more specific object of the present invention is a provision of a cigarette filter rod having a uniform cross-sectional density, a high order of resistance to lateral compression even without any wrapping material, and sufficient longitudinal coherency or structural integrity to permit handling in subsequent processing of relatively long lengths thereof without splitting or cracking. Another major object of the invention is the provision of an uncomplicated and economical process for manufacturing the aforesaid filters in a continuous, high-speed, commercial scale. A still further object is to provide a manufacturing line utilizing equipment especially adapted to affect the process for making such filters.

Still other objects of the present invention, if not specifically set forth herein, will become apparent to one skilled in the art upon a reading of the following detailed description of the invention taken in conjunction with the drawing.

Essentially, the filters of the present invention are prepared from short fibers of approximately 0.5 mm. to 8 mm., and preferably 1 mm. to about 3 mm. in length. For the sake of convenience, these fibers will be referred to herein as flock.

The flock utilized in the preferred embodiment of the present invention is prepared from filamentary materials which preferably comprise organic derivatives of cellulose such as esters or ethers thereof, e.g., cellulose organic acid esters such as cellulose acetate, cellulose propionate, cellulose butyrate, cellulose benzoate, cellulose acetate formate, cellu-

lose acetate propionate, cellulose acetate butyrate, and the like, and ethers such as ethyl cellulose etc. The esters may be ripened and acetone-soluble, such as conventional cellulose acetate, or may be substantially fully esterified, i.e., contain fewer than 0.29 free hydroxyl groups per anhydroglucose unit, such as cellulose triacetate.

In preparing this flock, continuous filaments are spun from a suitable spinnerette of conventional design, taken up into a raw tow of a type well known in the cigarette filtration art, and packaged, preferably in a bale. The continuous filament tow may then, optionally, but not necessarily, be removed from the bale and passed through a conventional banding jet and a subsequent opening means which serves to deregister the crimps in the filaments. This portion of the process is more fully described and a suitable device for performing this operation is shown, for example, in U.S. Pat. No. 3,156,016. After deregistration of the crimped tow, the tow may be passed through a means for applying a suitable plasticizer and/or adhesive bonding agent thereto. A suitable applicator for this purpose is shown, for example, in U.S. Pat. No. 3,387,992. Other applicators such as wick applicators or jet spray means may be utilized for this purpose. The plasticized tow is then passed through a cutting device which severs the tow into the desired lengths. As an alternative, the tow may be cut into short lengths prior to application of the plasticizer, and the plasticizer may then be sprayed onto or otherwise applied to the chopped fibers. For example, the plasticizer may be mixed with the fibers as they are in the turbulent stream jet prior to rod formation.

Plasticized short fibers thus prepared are then passed into a holding bin or other suitable container, or may be passed directly into the apparatus of the present invention.

In the preferred embodiment of the present invention, flock prepared in the manner described above is passed to a feed loop 12. The feed loop 12 conducts a rapidly moving stream of flock past the opening of tube 14. The flock is then blown into tube 14 which terminates within housing 16. Flock blown into nonporous tube 14 is compacted into rod form with the individual fibers being predominantly aligned in a transverse direction. This transverse alignment is attributable to formation within the nonporous tube and the presence of preceding fibers which serve as an impact barrier.

As the flock, now in the shape of a cylindrical rod exits from tube 14, a continuous porous belt 18, preferably a woven nylon or Teflon coated fiberglass belt, is wrapped around the exiting mass of flock to confine the flock into the cylindrical rod configuration produced by tube 14. Belt 18 is threaded around pulleys 20 and 22, at least one of which provides a rotary motion to belt 18. As the belt and encased flock exits from housing 16, it passes through a vacuum chamber 24 which is employed to create an area of vacuum used to draw the flock into tube 14. Chamber 24 is to be considered optional since the air stream alone may be sufficient to convey the flock into tube 14.

Thereafter, the belt and rod pass through a section of tubing 26 which acts as a pressure drop area to prevent fluid injected in subsequent operations from being withdrawn by vacuum chamber 24.

After tube 26, the flock and belt pass through heating chambers 28 and 30 wherein the flock is subjected to a heated fluid which activates the bonding agent within the flock to produce bonding between the individual fibers and create a coherent cylindrical structure.

In the drawing and the preferred embodiment of the present invention, the heating chamber is shown as a two-part device. In the portion designated as 28, the heated fluid is passed downwardly through the flock and in portion 30 the heated fluid is passed upwardly through the flock. In this manner, both sides of the flock are uniformly heated to obtain uniform bonding. Of course, it will be understood, that it is only preferred that the two segments inject fluid into the cylindrical material from substantially opposite directions, and need not be positioned such that the heating fluid flows downwardly in

one segment and upwardly through the other. The preferred fluid in the present invention is heated air. However, other gases or steam may be employed with equally desirable results.

After heat activation of the bonding agent, the flock is passed into a cooling chamber to complete bonding. This chamber, like the heating chamber, is a two-part device designated in the drawings as 32 and 34. In this portion of the apparatus, cool air is passed in one direction through the flock in the first segment of the cooling chamber and in the opposite direction in the second segment of the cooling chamber. Thereafter, the flock and porous belt exit from the cooling chambers 32 and 34 and the porous belt is then opened from about the coherent cylinder of flock and rotates around pulley 22 to return to the initial phase of the operation. The coherent bonded rod 36 extruded from the operation then passes through a skinner device 38. The skinner device 38 is preferably a Teflon coated gland having a heating source around the opening therein. Passing of the rod through skinner 38 serves to remove the longitudinal seam created by belt 18 from the surface of the rod, as well as any other surface irregularities. After removal of surface irregularities by passing of the rod 36 through skinner 38, rod 36 is then passed to a cutter 40 which is timed to sever rod 36 into the desired lengths.

It is to be understood that the preceding description is of the preferred embodiment of the present invention and that many modifications are possible. For example, a dielectric heater may be used instead of a heated fluid. Also, the cooling chamber may be eliminated and the rods stored for a period of time to insure satisfactory bonding.

While the preferred embodiment has been described in conjunction with cellulose acetate flock having thereon as a bonding agent, e.g., triacetin, it will be understood by one skilled in the art that flock may be prepared from other fiber-forming polymers. Examples of suitable polymers are the polyamides such as nylon, polyesters such as polyethylene terephthalate, polyglycolic acid and copolymers thereof, acrylonitrile polymers and copolymers, polymers and copolymers of olefin and vinyl esters such as ethylene, propylene, vinyl chloride, vinylidene chloride, vinyl acetate, and the like.

The preferred plasticizer used in conjunction with the preferred cellulose ester fibers of the present invention is triacetin. However, other suitable plasticizers such as dibutyl phthalate, ethyl glycolate, triethyl citrate, polyalkylene glycols and esters thereof, or the like may be employed. It will also be understood by the skilled artisan that a suitable plasticizer or adhesive bonding agent may be employed when using other of the above described fiber sources.

It is also within the scope of the present invention to add other filtration materials to the flock prior to filter formation, e.g., by addition of such materials to the rapidly moving air stream along with the flock. Particularly suitable materials include activated carbon, alumina, silica gel, diatomaceous earth, and other high surface area solids. In addition, additives such as wood pulp and non-bonded fibers may be employed. Generally, these additives will be used in amount of from about 2 to about 50 percent of the total weight of the filter and more preferably from about 5 to about 20 percent of the total weight. It is to be understood, of course, that the amount employed will depend to a degree upon the particular additive being used.

Preferably, the fibers described herein will have a dpf i.e., denier per filament of from about 0.5 to about 25, and even more preferably from about 1.0 to about 5. With a dpf much above 5, there is a sacrifice in filtration performance. Because of the structure of the present filter, it is possible to utilize lower dpf fibers without a sacrifice in the compressibility, i.e., resistance to lateral deformation, than has heretofore been experienced in utilizing these lower dpf fibers.

While the present filters have sufficient structural rigidity to function without a supporting wrapping, it is within the scope of the present invention to use additional wrappings about the filters, if desired.

An additional advantage of the present filter is its relatively light weight. For example, filters prepared in accordance with the procedure described herein need weigh only about 60-80 percent (exclusive of wrapping) as much as conventional acetate tow filters having satisfactory pressure drop (resistance to draw) and S.R.E. (smoke removal efficiency). At the same time, this light weight does not detract from desirable filtration. To illustrate, present filters of 20 mm in length and 8 mm. in diameter, having a pressure drop of about 20-90 mm. of water weigh about 0.08 to about 0.14 gram and have a smoke removal efficiency of about 25 to about 55 percent. In comparison, conventional cellulose acetate tow filters within this pressure drop and S.R.E. range have a weight of fiber and plasticizer of about 0.11 to about 0.16 gram.

Compressibility, i.e., resistance to lateral deformation, of the herein described filter is also superior to that of a conventional cellulose acetate tow filter. Conventional tow filters having the above pressure drop, S.R.E. and dimensions have a compressibility of about 30 to about 55 percent. On the other hand, comparable present filters have a compressibility of only about 5 to about 30 percent. In other words, the compressibility of the present filter is about 15 to about 55 percent of the compressibility of the conventional cellulose acetate tow filters of comparable size and pressure drop and S.R.E.

The above values have compressibility which was obtained using a TMI precision dead-weight micrometer manual Model 551 manufactured by Testing Machines, Inc., Mineola, N.Y. Compressibility was determined by measuring the initial diameter of the rod with a micrometer, dropping a 300 gram weight on the rod from a height of 0.425 inches and reading the compressed diameter of the rod after the weight had come to rest. Percent compressibility was then calculated from these figures.

It is to be understood that the above values were preferred filters having properties within the commercially acceptable ranges. Of course, one may also prepare filters of even lighter weight or further improved compressibility by following the teachings of the present invention.

The above superior properties of the present filters are felt to be attributable primarily to the fiber orientation in the filter structure. Testing has shown that approximately 40 to 60 percent of the fibers are aligned within $\pm 10^\circ$ to the perpendicular of the filter axis. Also, the fibers are substantially uniformly disposed across the filter cross section.

The above data on fiber orientation was determined by taking 20 micron slices across a filter and cutting strips of 100 microns in width from the filter slice. All the fibers in the section were first counted. Then all fibers having a length greater than 100 microns, i.e., all substantially perpendicular fibers, were counted. From these figures the percent of substantially perpendicular fibers were calculated. Substantial uniformity across the filter section was determined by taking samples at

various angles and comparing the variations in results obtained in the test procedure, the variation observed to be only minor.

The following example is presented for the sake of illustration only, and should not be construed as being in limitation of the present invention.

EXAMPLE

Filters of 8mm in diameter and 20 mm. in length were prepared from fibers of 2 mm. in length and the dpf noted below using the previously described apparatus and process. The noted properties were determined and are compared with conventionally prepared cellulose acetate filters.

TABLE

	dpf	Weight grams	S.R.E. (%)	Pressure Drop mm H ₂ O	Compress- ibility (%)
Present filter	1.6	0.090	48.7	50	28.6
Present Filter	3.3	0.113	45.8	50	20.4
Conven- tional CA Tow Filter	1.6	—	—	50	Collapsed
Conven- tional CA Tow Filter	3.3	0.141	44.0	50	48

While the preceding description has emphasized the utility of the present invention in conjunction with aerosol filters, other uses such as tampons, wicks, "felt-tipped" pens, packing material, etc., will be obvious to the skilled artisan.

It will be apparent to one skilled in the art that many modifications and variations of the hereinbefore described invention are possible.

What we claim is:

1. A cigarette filter comprising a mass of fibers, the majority of said fibers consisting essentially of very short thermoplastic fibers having a length from about 1 mm. to substantially less than 3 mm. and bonded at their points of contact, 40 to 60 percent of said fibers being aligned within at least $\pm 10^\circ$ percent of the perpendicular of the axis of said filter and substantially uniformly disposed across the cross section of the filter, said filter when being approximately 8 mm. in diameter and 20 mm. in length exhibiting a pressure drop of 20 to 90 mm. of water, a smoke removal efficiency of from about 25 to about 55 percent, a weight of from about 0.08 to about 0.14 grams, and a compressibility of from about 5 to about 30 percent.

2. The cigarette filter of claim 1 wherein said fibers are cellulose acetate fibers.

3. The cigarette filter of claim 1 wherein said fibers have a denier per filament of from about 1 to about 5.

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