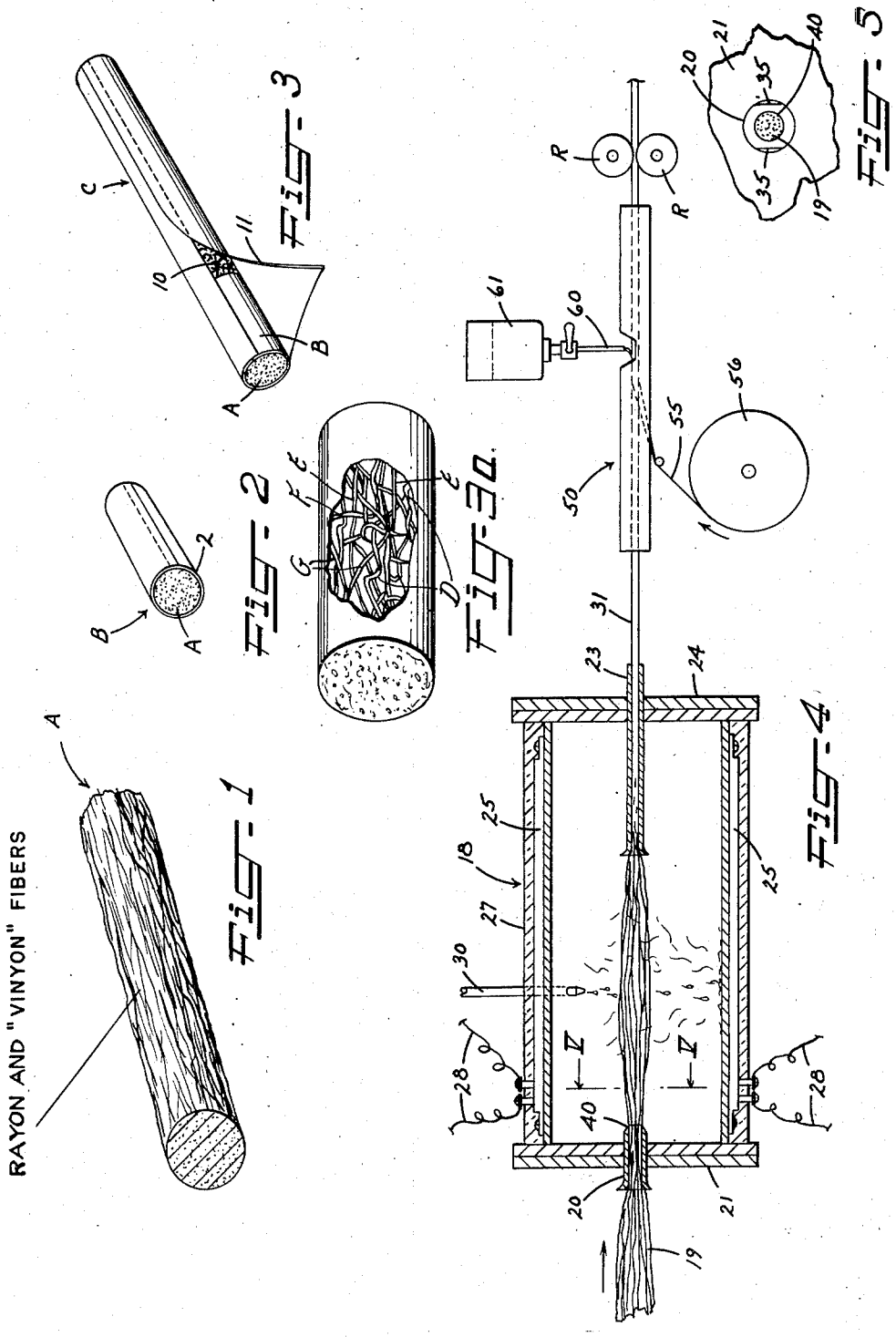
Nov. 12, 1957 R. MacHENRY 2,812,767

ABSORBENT ELEMENT FOR FILTERS AND THE LIKE

Filed May 17, 1955



United States Patent Office 2,812,767 Patented Nov. 12, 1957

2,812,767

ABSORBENT ELEMENT FOR FILTERS AND THE LIKE

Richard MacHenry, Prospect Park, Pa., assignor to American Viscose Corporation, Philadelphia, Pa., a corporation of Delaware

Application May 17, 1955, Serial No. 509,000

28 Claims. (Cl. 131—10)

The present invention relates to porous or sponge-like elements of synthetic fibers and more particularly to an improved filter suitable for cigarettes.

My present invention, as disclosed herein, is a continuation-in-part of my United States patent application Serial No. 501,894, filed April 18, 1955.

The invention described and claimed herein is directed primarily to the improved cigarette filter and the core or body from which it is made. In various other sizes and shapes, the filter body per se has other uses such as the absorbent element in dental and surgical pads, dressings, tampons and the like.

Tobacco smoke is made up of a mixture of gaseous compounds and finely divided solids, for example, tar, phenol, acetic acid, acrolein, carbon dioxide, water vapor, and dust particles. These compounds and elements are formed and derived from the disintegration of the tobacco and, in the case of cigarettes, the paper wrapper. While cigarette filters have been known in the past and used to a certain extent, the necessity for providing an adequate filter and the shortcomings of previous filters have only recently been appreciated. The requirements for a satisfactory tobacco smoke filter are, first, that it effectively remove toxic or harmful ingredients from the smoke drawn into the user's mouth. Secondly, the filter must be sufficiently porous so that it does not interfere with free passage of the smoke or what is commonly termed the "draw." In addition, a cigarette filter must be sufficiently firm to support the cigarette without bending or becoming undesirably soft and flabby. It will be appreciated from the above requirements that good "draw" is ordinarily inversely proportional to filtering ability, namely, the denser the filter, the more effective is the filtering, but suction required to draw the smoke through the filter is also higher. Due to the peculiarly beneficial structure resulting from a uniform mixture of a major proportion of crimped staple fibers and a minor proportion of potentially adhesive fibers which serve to bond the mixture together, I have been able to produce a filter which approaches the desired results of maximum filtering combined with easy draw.

A primary object therefore of the invention is to provide a fibrous element of high porosity and absorbency.

A further object of the invention is to provide an internally bound, firm bodied, absorbent element of uniform rigidity for medical and surgical uses.

A still further object of the invention is to provide a tobacco smoke filter having maximum filter effectiveness and maximum draw.

A still further object of the invention is to provide a tobacco smoke filter made up of a fiber bonded mixture of non-adhesive textile fibers and potentially adhesive fibers to form a porous filtering element.

A still further object of the invention is to provide a tobacco smoke filter made up of a mixture of crimped non-adhesive textile fibers and potentially adhesive textile fibers bonded together to form a porous filtering element.

Another object of my invention is to provide a filter of the above objects which filter has numerous minute traps for the entrapping of the components of the smoke passing through the filter.

Another object of my invention is to provide a tobacco smoke filter wherein the filtering efficiency increases during use.

Still a further object of my invention is to provide a tobacco smoke filter which may have incorporated therein additional substances such as perfume, menthol or other additional desired or essential oils.

Still another object of my invention is to provide tobacco smoke filters of varied color.

It is still another object of my invention to provide a filter type cigarette incorporating therein the filter of the above objects.

Further objects will be apparent from the specification and drawing in which:

Figure 1 is a perspective of my improved porous element;

Figure 2 is a perspective showing a cigarette filter plug formed from the element of Figure 1;

Figure 3 is a perspective showing the filter plug of Figure 2 incorporated in a cigarette;

Figure 3A is a magnified view of the fibrous filter element showing in detail the interrelationship of the fibers in greater detail;

Figure 4 is a schematic sectional view of the apparatus for fabricating my improved porous elements; and

Figure 5 is a fragmentary detail on an enlarged scale as seen at V—V of Figure 4.

Briefly the improved absorbent element, which is useful either as a tobacco smoke filter or as an absorbent pad for medical and surgical purposes, comprises a uniform mixture of crimped, non-adhesive textile fibers of relatively low denier and potentially adhesive textile fibers which have been secured to the non-adhesive fibers by rendering the initially potentially adhesive fibers tacky. A major portion of the mixture is composed of the non-adhesive fibers which are previously crimped and of staple length. The mixing of the fibers is effected when the potentially adhesive fibers are in a non-adhesive condition. Thence, the potentially adhesive fibers are activated or made adhesive by the application of heat or suitable solvents or both. The fibrous mixture with the potentially adhesive fibers in tacky condition is compressed to the desired form and the adhesive fibers allowed to dry or harden to a non-tacky condition. The resulting compressed fibrous form is internally supported by the bonding of the potentially adhesive fibers to themselves and other fibers. It will be understood that throughout the following specification and claims, the terms "non-adhesive" and "potentially adhesive" refer to types of fibers, one of which becomes tacky or adhesive under conditions under which the other fiber is relatively unaffected. Where the tacky or adhesive condition results from elevated temperature, the potentially adhesive fibers will, of course, be of a thermoplastic nature. Ordinarily, the non-adhesive fiber will not be thermoplastic but a thermoplastic fiber could be used provided the temperature at which it became tacky is sufficiently higher than the temperature at which the other potentially adhesive fiber becomes tacky. By way of example, the potentially adhesive fibers are formed from vinyl resins resulting from the polymerization of compounds containing the vinyl group such as polyvinylchloride or copolymers of vinyl chloride and vinyl acetate. Other potentially adhesive fibers, however, may be used successfully in the present invention, for example, certain copolymers of vinyl chloride and acrylonitrile.

Referring now to the drawings wherein preferred em-

bodiments of my invention are shown, Figure 1 shows the fibrous element in bundle or sliver form. As seen therein, the sliver A is a carefully blended mixture of non-adhesive regenerated cellulose fibers such as rayon staple and potentially adhesive or thermoplastic fibers. The fibers mentioned above are of the "textile fiber" class having diameters of at least 9 microns.

The mixture of the present invention can be satisfactorily formed by uniformly distributing 10–25% of the potentially adhesive fibers into the major proportion, 75–90% by weight, of crimped rayon staple fiber. It has been found that the potentially adhesive fibers should comprise at least 10% by weight of the mixture and preferably should be in the range of 10–15% by weight.

The length of the individual fibers, both potentially adhesive and non-adhesive, may vary from ⅝ to 2½ inches and should be between 1 to 2½ denier, preferably 1 to 1½ denier. Due to the crimp in the non-adhesive fibers and, if desired, in the potentially adhesive fibers, minute traps or voids are formed within the body of the element which enhance the absorptiveness of the element and also provide for the porosity which in turn permits easy draw.

The fibers specified above range in weight from 100–125 grains and the fine relatively short length fibers provide a compact, dense structure in which many of the shorter length fibers will lie across the general longitudinal axis of the element.

An important feature of my invention is that the non-adhesive or rayon fibers within the fibrous mass are crimped. In the case of rayon, the fibers may be crimped chemically as distinguished from a mechanical crimp. Such chemical crimping is disclosed and claimed in United States Patent 2,517,694. This crimping remains in the fiber even when it is wet. The filaments, however, may be mechanically crimped according to well known processes and apparatus. Since relatively small denier fibers are used to form the element and since the fibers are crimped, numerous minute traps or voids are formed within the element which render the fibrous element capable of entrapping and retaining liquids, moisture and minute solid particles. The potentially adhesive fibers may or may not be crimped. When converting the fibrous sliver A to specific articles of use, the potentially adhesive fibers are activated, as will be explained hereinafter, to autogenously bond together the non-adhesive fibers in the sliver A. The fibers are compressed, as will also be explained, after the potentially adhesive fibers have been activated to provide a compact article of good strength.

A tobacco smoke filter or plug B formed from the fibrous mass or sliver A of Figure 1 is shown in Figure 2 of the drawing. The tobacco smoke filter B, in this instance, is of cylindrical shape. The potentially adhesive fibers have been activated and compressed to autogenously bond together the non-adhesive rayon fibers and the potentially adhesive fibers to provide a compact cylindrical shaped article of good strength. When the completed element is to be used as a cigarette filter, the bonded element is wrapped or stuffed in a paper wrapper 2 and cut into suitable lengths to form the filter plug B.

Figure 3 shows the wrapped filter plug B of Figure 2 incorporated in a cigarette C. The tobacco **10** and the filter plug B are formed into a unitary cigarette having the usual cigarette paper **11**.

The interrelationship of the fibers making up the fibrous structure is shown in detail in Figure 3A of the drawing. As seen therein, the crimped non-adhesive fibers, generally designated as D, D, are bonded to the non-crimped adhesive fibers E, E at points of fiber intersection G, G. Some of the shorter fibers identified as F lie crosswise of the longitudinal axis of the filter element. The short fibers F may be of either the crimped non-adhesive fibers D, D or the potentially adhesive fibers E, E.

The apparatus for forming and converting the mixed sliver to a tow or rod from which filter elements can be cut has been designed to insure a combination of all the desired properties for a cigarette filter. Such a filter element must have firmness or body, maximum filtering ability and porosity to permit free and easy draw. As is well known in the filter art, density of the filter is directly proportional to the pressure required to force the fluid through the filter. Stated conversely, good draw which is, of course, low pressure is inversely proportional to filtering ability or filter density. In the present filter and apparatus, it has been possible to obtain maximum filtering and absorbing properties without increasing the density to the point where there is an objectionable lack of draw. The crimped fibers which are autogenously bonded into a uniform element with the minor proportion of either crimped or uncrimped potentially adhesive fibers cooperate to provide this unexpected and desired result.

The apparatus in which the relatively loose sliver is activated and transformed into a comparatively strong, dense but porous rod comprises a chamber or tube **18** into which the sliver **19** is drawn through a funnel shaped die **20** mounted in the forward end wall **21** of the chamber. The tacky sliver is drawn out of the chamber **18** through a relatively longer die **23** mounted in the rear wall **24** of the chamber in alignment with die **20**. Die **23** has a substantially smaller bore than entrance die **20**. The preferred diameters for the entrance and exit dies are ¾ and ⅜ of an inch respectively when it is desired to fabricate a cigarette filter. For other articles the dimension of the bores may be changed but substantially the same ratio be maintained. The inside of the chamber **18** is maintained at an elevated temperature of approximately 110° C. by means of one or more heating elements **25, 25** which surround the walls of the chamber. If desired, the heating elements are covered by suitable insulating material **27** through which electrical connections to the heaters may be made at **28, 28**. At a point approximately midway between the downstream terminus of die **20** and the upstream terminus of die **23**, a liquid softening or activating agent such as acetone is introduced into the chamber through a nozzle **30**. The acetone may fall directly on the sliver in the chamber or it may be vaporized when it falls onto the heated chamber wall. In either event the potentially adhesive or thermoplastic fibers in the sliver are sufficiently softened throughout the sliver so that when the sliver is drawn through die **23** there is a compression or rearrangement of the structure to provide a firm, compact, internally bound but porous tow or rod **31**. The adhesive fibers set up after leaving die **23** when they are cooled and the acetone evaporates or is otherwise removed. Partial setting up may take place in the bore of die **23** and the length and relative axial position of this forming die in the end wall **24** is controlled to provide the results which may be desired. In order to eliminate sticking or deposition of material in the bore of either of the dies, they are preferably made of polytetrafluoroethylene, sold commercially under the trade name of Teflon.

Depending upon the degree of activation found desirable and the speed with which the sliver is drawn through chamber **18** by means of draw rolls R, R, it may be found necessary or desirable to provide limited venting for the chamber. This can be accomplished by the provision of one or more flats **35, 35** (Figure 5) along the side of the entrance die **20**. These flats extend through the end wall **21** so that limited venting of the interior of chamber **18** is achieved. By providing an annular bevel **40** on the downstream end of die **20**, it is possible to prevent build-up or adherence of fibers to any part of die **20**.

When the activated sliver is to be used for tobacco smoke filters, the rod **31**, after leaving the chamber **18**, passes through a wrapping apparatus **50** wherein a continuous sheet of wrapping paper **55** supplied from a

reel **56** is folded around the rod **31**. The wrapper **55** is sealed by applying an adhesive from a liquid adhesive applicator **60** connected with an adhesive supply container **61**. The diameter of the bore of the wrapping apparatus **50** through which the activated sliver passes is somewhat smaller than the diameter of the exit die **23** of the chamber **18** whereby the diameter of the tow is further reduced to correspond with the diameter of a cigarette or tobacco cylinder with which the filter plug B is to be incorporated.

Vaporized acetone as an activating agent for the potentially adhesive fibers is preferred in that it has been found that the fibers within the sliver **19** which have been subjected to vaporized acetone are more firmly bonded together and the finished filter plug exhibits greater stiffness with excellent draw properties. It has also been found that a very clean cut may be made with the acetone activated filter plug. In the apparatus described above, the softening of the potentially adhesive fibers is achieved primarily by means of the solvent, namely, acetone, which is applied to the fibers. However, it will be understood that the temperature in chamber **18** may be sufficiently elevated to assist or, if desired, completely provide for the softening of the minor proportion fibers.

Another important feature of my invention is that the filtering efficiency of a tobacco smoke filter improves during use. An inherent property of viscose rayon is that it swells considerably when in contact with water or moisture. When my filter is incorporated with a cigarette, the filtering action improves as the tobacco burns since the rayon fibers swell when contacted by the moisture carried by the smoke. The smoke components or ingredients which have been filtered out by the base portion of the tobacco cylinder will therefore be more effectively filtered out by the swollen fibers as the base portion of the tobacco cylinder burns.

Various colored fibers may be used in the filter to provide a variety of color schemes for the filter. The dye pigment matter may be incorporated with the filament forming spinning solution. Undyed extruded filaments, from which the staple is cut, may be dyed by passing the filaments through suitable dye baths.

If desired, aromatics such as perfume or menthol may be incorporated with the filter material to provide a filter having a pleasing aroma. In addition, other desired or essential oils may be incorporated with the filter.

My tobacco smoke filter plug is porous and has excellent draw properties which permit the smoker to easily pull the smoke through the filter. The filter is economical to produce and has sufficient strength and firmness to permit normal processing of the filter when manufacturing cigarettes or other tobacco smoking articles. As explained above, the filter plug contains many minute voids or traps because fine denier fibers are used and because the fibers are crimped. The traps easily catch and retain the vapor and solid components of the smoke passing therethrough.

My fibrous element has numerous uses since it has good liquid and moisture retention properties. Among the uses is that of dental saliva pads which are placed within the patient's mouth to absorb excess saliva. Tampons may also be produced from my fibrous absorptive element. The fibrous element may also be used in other fields of medicine and surgery wherein liquid retentive pads are required.

It is to be understood that changes and variations may be made without departing from the spirit and scope of the present invention as defined in the appended claims.

Having thus described my invention, I claim:

1. An absorbent porous filter element consisting of a uniform mixture of bonded together fibers comprising crimped non-adhesive fibers, and adhesive fibers, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

2. An absorbent porous filter element according to claim 1 wherein the adhesive fibers comprise at least 10% of the element by weight.

3. An absorbent, porous filter element having uniform rigidity throughout and consisting of a uniform mixture of bonded together fibers comprising crimped non-adhesive staple fibers and adhesive fibers, said adhesive fibers comprising at least 10% of the element by weight, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

4. An absorbent, porous filter element having uniform rigidity throughout and consisting of a uniform mixture of bonded together fibers comprising crimped, non-adhesive staple fibers and potentially adhesive fibers which have been activated, said potentially adhesive fibers comprising at least 10% of the element by weight and the fibers being ⅝ to 2½ inches in length, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

5. An absorbent, porous filter element having uniform rigidity throughout and consisting of a uniform mixture of bonded together fibers comprising crimped 1 to 2½ denier non-adhesive staple fibers ⅝ to 2½ inches in length and potentially adhesive 1 to 2½ denier textile fibers which have been activated, said potentially adhesive fibers comprising at least 10% of the element by weight and being ⅝ to 2½ inches in length, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

6. An absorbent, porous filter element having uniform rigidity throughout and consisting of a uniform mixture of bonded together fibers comprising crimped viscose rayon fibers and at least 10% by weight of fibers formed from copolymers of vinyl chloride and vinyl acetate which have been activated, said crimped viscose rayon fibers being capable of permanently retaining their crimp in either a dry or wet condition.

7. An absorbent porous filter element having uniform rigidity throughout and consisting of a uniform mixture of crimped non-adhesive staple fibers and adhesive fibers, at least some of said staple fibers being bonded to some adhesive fibers, said adhesive fibers comprising at least 10% of said porous element by weight, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

8. An absorbent porous filter element having uniform rigidity throughout and consisting of a uniform mixture of crimped non-adhesive fibers and activated potentially adhesive fibers all of which are ⅝ to 2½" in length, at least some of said non-adhesive fibers being bonded to some adhesive fibers, said potentially adhesive fibers comprising at least 10% of the element by weight, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

9. An absorbent porous filter element having uniform rigidity throughout and consisting of a uniform mixture of crimped non-adhesive staple fibers and activated potentially adhesive fibers all of which fibers are ⅝ to 2½" in length and of 1 to 2½ denier, at least some of said staple fibers being bonded to some adhesive fibers, said potentially adhesive fibers comprising at least 10% of the element by weight, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

10. An absorbent porous filter element having uniform rigidity throughout and consisting of a uniform mixture of crimped viscose rayon fibers and activated potentially adhesive fibers formed from copolymers of vinyl chloride and vinyl acetate, at least some of said rayon fibers being bonded to some adhesive fibers, said potentially adhesive fibers comprising at least 10% of the element by weight, said crimped viscose rayon fibers being capable of permanently retaining their crimp in either a dry or wet condition.

11. As an article of manufacture, a tobacco smoke filter having uniform rigidity throughout and comprising

a compressed mass of a uniform mixture of crimped non-adhesive fibers and activated potentially adhesive fibers of staple length, at least some of said non-adhesive fibers being bonded to some adhesive fibers, said potentially adhesive fibers comprising at least 10% by weight of the filter, said crimped non-adhesive fibers being capable of permanently retaining their crimp in either a dry or wet condition.

12. As an article of manufacture, a tobacco smoke filter having uniform rigidity throughout and comprising a compressed mass of a uniform mixture of crimped non-adhesive fibers bonded to staple length, potentially adhesive fibers which have been activated, said non-adhesive crimped fibers being capable of permanently retaining their crimp in both a dry and wet condition.

13. A tobacco smoke filter according to claim 11 having a paper wrapper around the filter.

14. A tobacco smoke filter according to claim 11 comprising non-adhesive and potentially adhesive fibers of 5/8 to 2½ inches in length.

15. A tobacco smoke filter according to claim 11 comprising non-adhesive and potentially adhesive fibers of 1 to 1½ denier.

16. A tobacco smoke filter according to claim 11 wherein the non-adhesive fibers comprise viscose rayon fibers and the potentially adhesive fibers comprise fibers formed from copolymers of vinyl acetate and vinyl chloride.

17. As an article of manufacture, a tobacco smoke filter cylinder of uniform rigidity throughout comprising a compressed mass of a uniform mixture of 75 to 90% by weight of the filter of crimped non-adhesive fibers and 10 to 25% by weight of activated potentially adhesive fibers, at least some of said non-adhesive fibers being bonded to some adhesive fibers, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

18. As an article of manufacture, a filter type cigarette comprising a tobacco cylinder, a filter cylinder at one end of the tobacco cylinder, and a cigarette paper wrapper around the filter cylinder and the tobacco cylinder, said filter cylinder comprising a compact porous mass of uniform rigidity throughout and formed of a uniform mixture of crimped non-adhesive fibers bonded to staple length, potentially adhesive fibers which have been activated, said non-adhesive crimped fibers being capable of permanently retaining their crimp in both a dry and wet condition.

19. As an article of manufacture, a filter type cigarette comprising a tobacco cylinder, a filter cylinder adjacent one end of the tobacco cylinder, and a cigarette paper wrapper around the filter cylinder and the tobacco cylinder, said filter cylinder comprising a compact, porous mass of uniform rigidity throughout and formed of a uniform mixture of crimped non-adhesive fibers and staple length activated potentially adhesive fibers, at least some of said non-adhesive fibers being bonded to some potentially adhesive fibers, said potentially adhesive fibers comprising at least 10% by weight of the filter cylinder, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

20. A filter type cigarette according to claim 19 wherein the filter cylinder comprises non-adhesive and potentially adhesive fibers of 5/8 to 2½ inches in length.

21. A filter type cigarette according to claim 19 wherein the filter cylinder comprises non-adhesive and potentially adhesive fibers of 1 to 2½ denier.

22. A filter type cigarette according to claim 19 wherein the non-adhesive fibers of the filter cylinder comprise viscose rayon fibers and the potentially adhesive fibers comprise fibers formed from copolymers of vinyl chloride and vinyl acetate.

23. As an article of manufacture, a filter type cigarette comprising a tobacco cylinder, a filter cylinder adjacent one end of the tobacco cylinder, and a cigarette paper wrapper around the filter and tobacco cylinders, said filter cylinder comprising a compact porous mass of uniform rigidity throughout formed of a uniform mixture of 75 to 90% by weight of crimped non-adhesive fibers and 10 to 25% by weight of activated potentially adhesive fibers, at least some of said non-adhesive fibers being bonded to some adhesive fibers, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

24. A filter type cigarette according to claim 23 wherein the non-adhesive fibers comprise viscose rayon fibers and the potentially adhesive fibers are formed from copolymers of vinyl chloride and vinyl acetate.

25. An absorbent, porous filter element having uniform rigidity throughout and consisting of a uniform mixture of bonded together fibers comprising crimped non-adhesive staple fibers and uncrimped adhesive fibers which have been activated, said adhesive fibers comprising at least 10% of the element by weight, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

26. As an article of manufacture, a tobacco smoke filter having uniform rigidity throughout and comprising a compressed mass of a uniform mixture of crimped non-adhesive fibers and staple length uncrimped activated potentially adhesive fibers, at least some of the non-adhesive fibers being bonded to some potentially adhesive fibers, the potentially adhesive fibers comprising at least 10% by weight of the filter, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

27. As an article of manufacture, a filter type cigarette comprising a tobacco cylinder, a filter cylinder adjacent one end of the tobacco cylinder, and a cigarette paper wrapper around the filter cylinder and the tobacco cylinder, said filter cylinder comprising a compact porous mass of uniform rigidity throughout and formed of a mixture of crimped non-adhesive fibers and staple length non-crimped activated potentially adhesive fibers, at least some of the non-adhesive fibers being bonded to some potentially adhesive fibers, the potentially adhesive fibers comprising at least 10% by weight of the filter cylinder, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

28. An absorbent, porous elongated element having uniform rigidity throughout and consisting of a uniform mixture of bonded together fibers comprising crimped 1 to 2½ denier non-adhesive staple fibers 5/8 to 2½ inches in length and at least 10% by weight of potentially adhesive fibers of 1 to 2½ denier and 5/8 to 2½ inches in length which have been activated, a portion of said shorter fibers lying widthwise of the longitudinal axis of the element, said non-adhesive crimped fibers being capable of permanently retaining their crimp in either a dry or wet condition.

References Cited in the file of this patent

UNITED STATES PATENTS

2,126,422	Tarrant	Aug. 9, 1938
2,164,702	Davidson	July 4, 1939
2,252,999	Wallach	Aug. 19, 1941
2,357,392	Francis	Sept. 5, 1944
2,459,804	Francis	Jan. 25, 1949
2,476,582	Browne et al.	Jan. 19, 1949
2,483,406	Francis	Oct. 4, 1949
2,688,380	MacHenry	Sept. 7, 1954
2,707,308	Taylor et al.	May 3, 1955
2,707,690	Janecke	May 10, 1955
2,708,982	McGuff et al.	May 24, 1955

OTHER REFERENCES

"The Modern Textile Dictionary" by G. E. Linton. Pages 642–643. Published 1954 by Duell, Sloan and Pearce Little, Brown and Co., Boston, Mass.