United States Patent

Berger et al.

[15] **3,648,711**

[45] **Mar. 14, 1972**

[54] TOBACCO SMOKE FILTER

[72] Inventors: **Richard M. Berger**, Richmond; **Elwin W. Brooks**, Mechanicsville, both of Va.

[73] Assignee: **American Filtrona Corporation**, Richmond, Va.

[22] Filed: **Aug. 11, 1970**

[21] Appl. No.: **62,871**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 45,109, June 10, 1970, and a continuation-in-part of Ser. No. 727,477, May 8, 1968, Pat. No. 3,533,416, and a continuation-in-part of Ser. No. 820,355, Apr. 30, 1969, Pat. No. 3,599,646, said Ser. No. 45,109, is a continuation-in-part of Ser. No. 820,355, , and a continuation-in-part of Ser. No. 727,477, , said Ser. No. 820,355, is a continuation-in-part of Ser. No. 727,477,.

[52] **U.S. Cl.** **131/265,** 131/10.5, 131/10.9, 131/210

[51] **Int. Cl.** **A24d 01/04,** A24d 01/16

[58] **Field of Search** 131/10–10.9, 9, 131/261–269

[56] **References Cited**

UNITED STATES PATENTS

3,094,450	6/1963	Davidson	131/10 R X
3,347,247	10/1967	Lloyd	131/10.7 X
3,533,416	10/1970	Berger et al.	131/266

FOREIGN PATENTS OR APPLICATIONS

1,118,860	3/1956	France	131/10.5

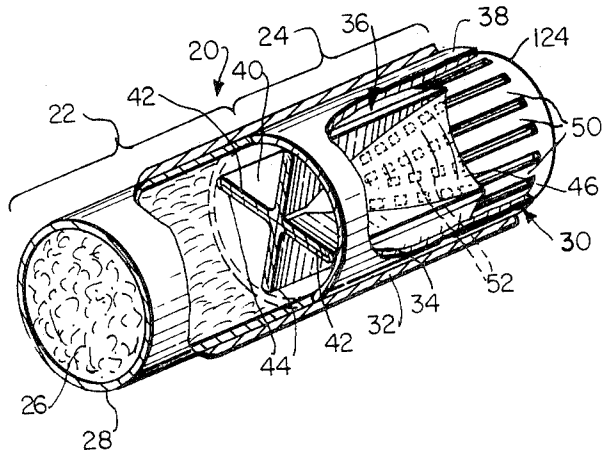
Primary Examiner—Melvin D. Rein

Attorney—Holman & Stern and Samuel L. Davidson

[57] **ABSTRACT**

Filter means of a type which is constructed to provide elongated, high surface area, cavities defined on opposite sides of a relatively thin wall formed of filtering material with only the ends of the filter means contacting an overwrapped outer tube thereby presenting maximum available surface area of the material from which the products are formed to the smoke for filtration. The filter comprises an outer elongated member in which an inner crimped filter is disposed. The latter has major portions of the outer surface spaced from the inner surface of the outer member to define a cavity means therebetween. A further cavity means is defined interiorly of the inner member, the smoke being compelled to pass through both cavity means, with at least one of the cavities being filled with a sorbent filtering material. Bonded activated carbon is disclosed as the preferred sorbent material.

18 Claims, 14 Drawing Figures



Patented March 14, 1972 3,648,711

3 Sheets-Sheet 1

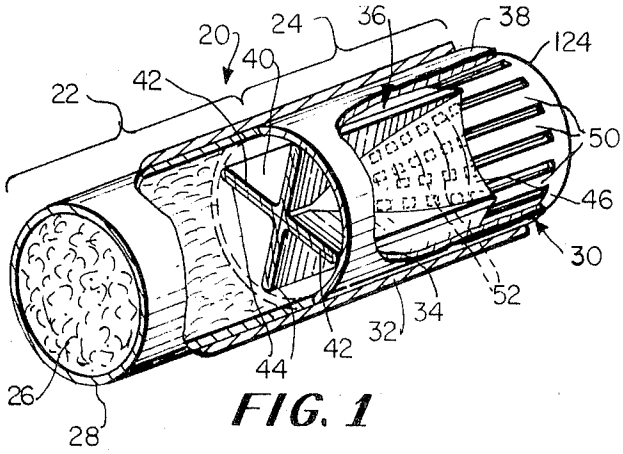


FIG. 1

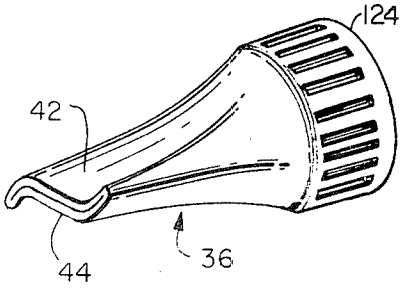


FIG. 6

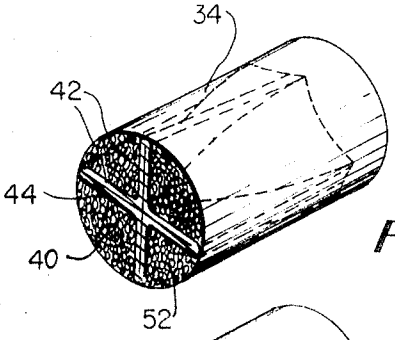


FIG. 2

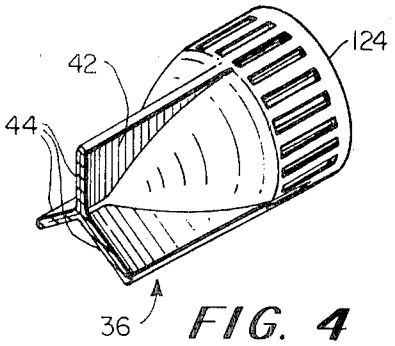


FIG. 4

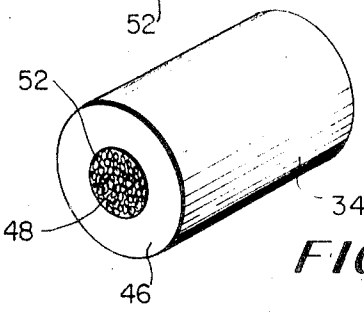


FIG. 3

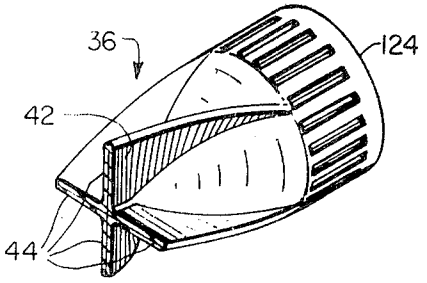


FIG. 5

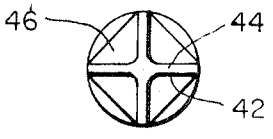


FIG. 8

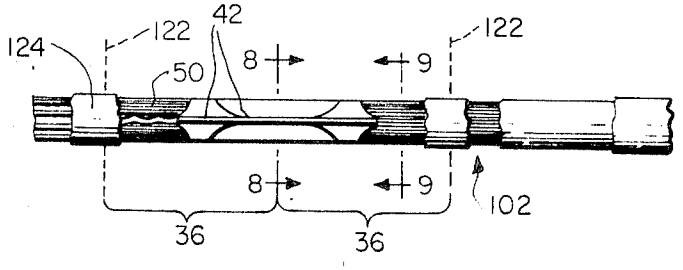


FIG. 7

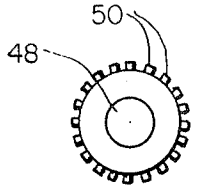


FIG. 9

INVENTOR
RICHARD M. BERGER
ELWIN W. BROOKS

BY Jacobi, Davidson, Lilling & Siegel
ATTORNEY

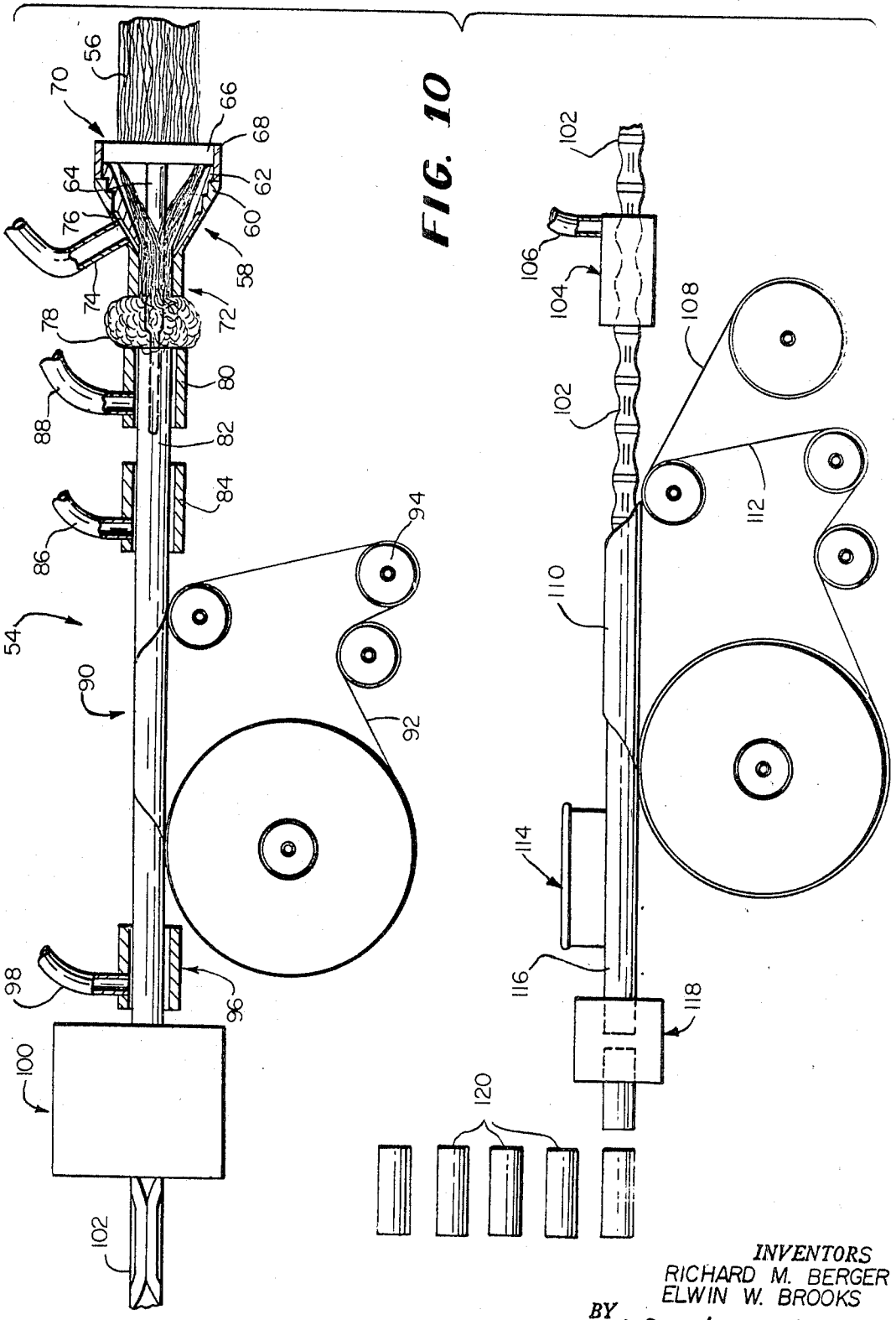


FIG. 10

INVENTORS
RICHARD M. BERGER
ELWIN W. BROOKS

BY
Jacobi, Davidson, Lilling & Siegel
ATTORNEY

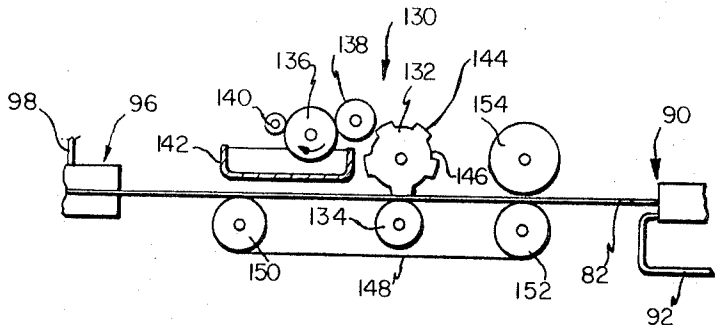


FIG. 12

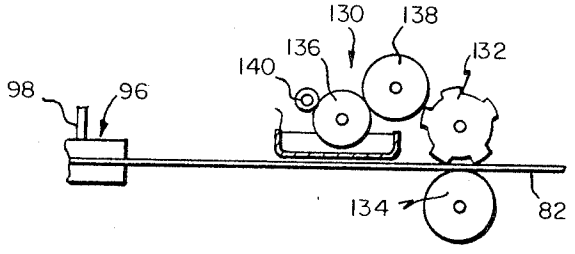


FIG. 13

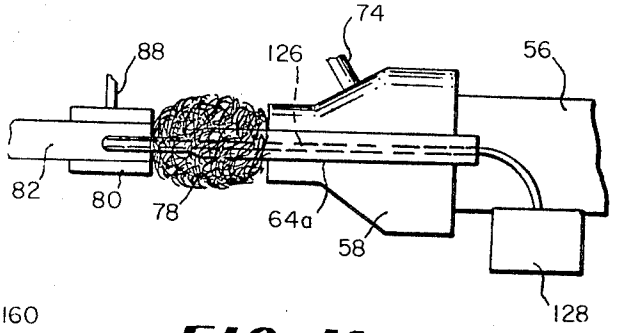


FIG. 11

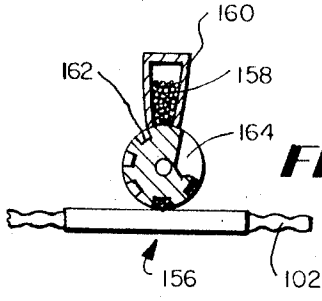


FIG. 14

INVENTORS
RICHARD M. BERGER
ELWIN W. BROOKS

BY Jacobi, Davidson, Lilling & Siegel
ATTORNEY

TOBACCO SMOKE FILTER

This application is a continuation-in-part of a copending application Ser. No. 45,109 filed June 10, 1970, now Pat. No. 3,637,447 and of copending application Ser. No. 727,477, filed May 8, 1968, now U.S. Pat. No. 3,533,416 and of copending application Ser. No. 820,355, filed Apr. 30, 1969 now U.S. Pat. No. 3,599,646. Application Ser. No. 45,109 is, in turn, a continuation-in-part of application Ser. No. 820,355, and application Ser. No. 727,477. Application Ser. No. 820,355 is, in turn, a continuation-in-part of application Ser. No. 727,477.

This invention relates to the production of filter means and more particularly to tobacco smoke filter elements. More specifically, the instant inventive concepts are primarily concerned with providing filter means for cigarettes, although the products of the instant invention are generally useful as filters, particularly for tobacco smoking means whether they be cigarettes, cigars, pipes or the like. Since filters for cigarettes are particularly commercially important the basic embodiments of the instant invention will be discussed as they relate to the production of filter cigarettes.

Various prior art techniques are known for making filters for use in connection with cigarettes, and the like, although he resulting products, in general, have one or more disadvantages. Perhaps the most important property of a filter means is its efficiency, that is, its ability to remove undesirable constituents from tobacco smoke. Filtration efficiency is ordinarily measured in terms of the percentage of total particulate matter (TPM) removed from the smoke, although there is also some concern for the percentage of gas phase constituents which a filter means is capable of removing. While filtration efficiency is perhaps the most important property of a cigarette filter means, it has been necessary, with prior art filter devices, to comprise the filtration efficiency in order to provide this filter with other properties, such as pressure drop, taste, hardness, appearance and cost, which are important from the standpoint of acceptability. For example, the most commonly utilized cellulose acetate filter means has a relatively low filtration efficiency since increased efficiency can only be obtained either by increasing the density of the filter material or the length of the filter element, both of which produce a pressure drop across the filter which is excessive and unacceptable from a commercial standpoint. While various suggestions have been made for the production of filter means which have improved filtering properties, such prior art developments have not become commercial either because the resultant filter means have been found to have objectionable "taste" characteristics whereby cigarettes provided with such filtering means fail to satisfy a large segment of the smoking public or because the techniques and/or the materials utilized in the production of such filter means have increased the cost excessively.

In any event, it is well-known in the industry that there is no filter means presently on the market which provides relatively high filtration efficiency, on the order of 60–95 percent (TPM), without suffering from undesirably high manufacturing costs, poor taste, high pressure drop or other such commercially unacceptable characteristics. The need and desirability of providing such a filter means is believed to be readily apparent, and the invention described and claimed in the aforementioned copending application Ser. No. 727,477, is directed to this need. That invention provides a filter means for use with a cigarette, or the like, having exceptionally high filtration efficiency, in many embodiments removing as much as 95 percent of the total particulate matter, while having an acceptable pressure drop, as well as satisfactory "taste," hardness and appearance. Further, there is described in the aforesaid copending application Ser. No. 727,477 various techniques for the production of a filter means of the type described utilizing inexpensive materials in relatively small quantities, as well as simple and efficient procedures whereby such filter means can be manufactured on a mass production basis at a cost which is acceptable to the industry. Copending application Ser. No. 45,109 describes processing equipment and techniques which permit high speed, continuous production of integral products of this nature without the use for handling special baffles or other extraneous elements which tend to slow down production rates and increase rejects due to the difficulty in manipulating such small articles in a commercial operation. Copending application Ser. No. 45,109 also describes cigarette means having a particular configuration.

Another feature of the invention of copending application Ser. No. 727,477 is the provision of a filter means which, in addition to having exceptionally high total particulate matter filtration efficiency, can be readily modified to provide exceptionally high gas phase filtration efficiency without adversely affecting the pressure drop, "taste," hardness, appearance, or cost. In this regard, a filter means can be produced according to the inventive concepts of copending application Ser. No. 727,477 includes a sorbent filtering material in particulate form having excellent gas or vapor phase filtration characteristics, such as, for example, activated carbon or the like while requiring a substantially smaller quantity of such particulate sorbent filtering material than prior art filter means which have included the same, with similar or better gas phase filtration efficiency. Further, this invention provides for use of a filtration medium which can be "tailor-made" to fit the desired use with filtration efficiency, "taste" properties and other such characteristics being readily modified by varying the materials utilized in the production of the filtration medium according to simple and inexpensive procedures.

Yet another feature of the inventive concepts of copending application Ser. No. 727,477 is the provision of a filter means which, due to its unique construction and manufacturing methods, permits the same to be self-sustaining and self-centering, with an integral construction, and with a maximum available surface area being presented for filtration of smoke passing therethrough. It is this unique construction of the filter means comprising the invention of copending application Ser. No. 727,477 which provides the basis for the improved filter construction according to the concepts of the instant invention.

The improved cigarette filter according to the instant invention not only has a high filtration efficiency, removing as much as 95 percent of the total particulate matter, while having an acceptable pressure drop, as well as satisfactory "taste," hardness, and appearance, but also is extremely efficient in removing a high percentage of acrolein from cigarette smoke. This latter advantage is achieved by the use of bonded activated carbon in the basic inventive filter structure.

Accordingly, it is a primary object of the present invention to provide a filter having exceptionally high filtration efficiency for both particulate matter and acrolein.

It is another object of the present invention to provide a filter having a high filtration efficiency for particulate matter and for acrolein, while having an acceptable pressure drop.

It is a further object of the present invention to provide a filter having high filtration efficiency for both particulate matter and acrolein as well as satisfactory "taste," hardness, and appearance.

It is yet another object of the present invention to provide a filter having high filtration efficiency of particulate matter as well as excellent gas or vapor phase filtration characteristics and which can be made in a variety of lengths without significantly effecting pressure drop characteristics by using various filtering media.

Consistent with the foregoing objects, it is still another object of the present invention to provide a filter which is self-sustaining and self-centering, with an integral construction, and with a maximum available surface area being presented for filtration of smoke passing therethrough.

Other objects of the present invention will either be set forth specifically hereinafter or will be obvious from the following detailed description. Such description makes reference to the annexed drawings wherein:

FIG. 1 is an enlarged fragmentary perspective view of a portion of a filter cigarette incorporating a filter element manu-

factured according to the instant inventive concepts, parts being broken away and in section for illustrative clarity;

FIG. 2 is an enlarged fragmentary perspective view of a filter according to the present invention;

FIG. 3 is an enlarged fragmentary perspective view of the filter according to the present invention;

FIGS. 4, 5, and 6 are enlarged fragmentary perspective views of other embodiments of the filter of FIG. 1;

FIG. 7 is a side view, partially broken away, of a filter rod from which the filter of the present invention is cut;

FIG. 8 is a transverse cross-sectional view, taken along line 8—8 of FIG. 7;

FIG. 9 is a transverse cross-sectional view taken along line 9—9 of FIG. 7;

FIG. 10 is a schematic view illustrating a method and means for making filter elements according to the present invention;

FIG. 11 is a fragmentary schematic view of a portion of the apparatus shown in FIG. 10;

FIGS. 12 and 13 are fragmentary schematic views of alternative portions of the apparatus for making one embodiment of the filter of the present invention; and

FIG. 14 is a fragmentary schematic view, partially in cross section of a portion of apparatus for making still another embodiment of the filter of the present invention.

Like reference characters refer to like parts throughout the several views of the drawings.

Referring now to the drawings in general, and more particularly to FIG. 1, a portion of a filtered cigarette is designated generally by the reference numeral 20 and comprises basically a tobacco portion 22 and a filter portion 24. The tobacco portion 22 comprises a rod of tobacco 26 overwrapped with paper or the like 28, as usual. The filter portion 24, in the embodiment shown in FIG. 1, comprises one form of filter element according to the instant inventive concepts designated generally by the reference numeral 30 and secured in end-to-end relationship with one end of the tobacco portion 22 as by a tipping overwrap 32.

The filter element 30 includes basically an axially elongated, hollow, outer member 34 and an axially elongated, hollow, inner member, 36, disposed within the outer member 34.

In the embodiment of FIG. 1, the outer member 34 is shown as a cylinder of ordinary "plug" wrap as is conventionally used in the manufacture of filter elements for cigarettes, although this member may be formed of plastic or other materials, if desired.

The inner member 36 comprises what may be called a "tube" formed primarily of any one or a combination of various filtering media as will be explained in more detail hereinafter. One end portion 38 is cylindrical providing peripheral portions of the outer surface of the inner member 36, limited in axial extent, which are juxtaposed to portions of the inner surface of the outer member 34 to at least substantially preclude axial passage of smoke across the area therebetween. Any desired adhesive means (not shown) may be included in this area to provide a smoke-tight seal, although the outer member 34 may merely be overwrapped about the inner member 36 to provide a substantially smoke-tight seal in this area. The important characteristics of this area is that smoke will pass through portions of the filtering material of the inner member 36 as explained hereinafter before bypassing the inner member across this area.

It will be noted that the major portions of the outer surface of the inner member 36 are spaced from the inner surface of the outer member 34 to define first elongated, high surface area, cavity means 40 therebetween, this cavity means including the area surrounding the end of the inner member 36 spaced from the sealed area at 38 particularly if this end of the inner member is spaced inwardly (not shown) from the corresponding end of the outer member 34.

First integral portions 42 of the inner member 36 define a first area which extends across the interior of the inner member 36 and which offers at least as much resistance to passage of smoke as the filtering material from which the inner member 36 is primarily formed. These first portions 42, in the embodiment of FIG. 1, are defined by the end of the inner member 36 remote from the sealed area at 38 being crimped and preferably sealed, in a manner to be described in more detail hereinafter. In this manner, the use of a separate baffle or closing element is avoided. Basically, these first portions 42 preclude preferred entry of the smoke from the tobacco portion 22 into the interior of the inner member 36 through this end of the inner member 36 and insure that the smoke will pass more uniformly through the filtering material of the inner member 36 from the first cavity means 40. As will be seen in FIG. 1, the first portions 42 are crimped to form a generally cruciform-shaped cross section, the laterally terminal edges 44 of which contact the inner surface of the outer member 34 to assist in centering the inner member 36 within the outer member 34 and in defining the first cavity means 40. In the preferred embodiment of this invention, only these laterally terminal edges 44 and the aforementioned peripheral portions 38 of the inner member 36 contact the outer member 34, the remainder of the outer surface of the inner member 36 being spaced from the inner surface of the outer member 34 as will be seen particularly in FIG. 2, thereby utilizing the maximum available surface area for filtration.

Alternative forms of crimping are shown in FIGS. 4, 5, and 6. The support given to the outer member 34 by the Y-shaped ribs shown in FIG. 4 is almost equal to that given by the cruciform-shaped crimp shown in FIG. 1 and better than the "S" or "Z" crimp shown in FIG. 6. In FIG. 5, a further alternative form of inner member 36 is shown. In this embodiment, the walls of member 36 are crimped so as to leave ribs which are arranged helically around the longitudinal access of the member 42. By this means, good support is given to the outer member 34 and the cross section of the latter may, when it is made of thin materials, be kept substantially circular.

Returning to FIG. 1, second portions 46 of the inner member 36 define a second area extending across the interior of the inner member 36 which offers less resistance to passage of smoke than the sealed area at 38. These second portions 46 may merely be the inner surface of the end portion of the inner member 36 remote from the first portions 42 which define an opening as shown in FIG. 1. The interior of the inner member 36 between the first portions 42 and the second portions 46 defines second elongated, high surface area, cavity means 48 as particularly shown in FIG. 3. Thus, it will be seen that smoke passing through the filter element between opposite ends thereof must travel through both the first cavity means 40 and the second cavity means 48 and must pass through the filtering material from which the inner member 36 is primarily formed. This construction provides an extremely high surface area for contact between the filtering material and the smoke, on the order of seven times or more the surface area presented by the end portion of a conventional cellulose acetate filter. Peripheral portion 38 of inner member 36 contains a series of crimps or ribs 50 which provide a proper seal between the outer surface of the inner member and the inner surface of the outer member. This insures the proper passage of smoke through the filter.

An additional smoke-modifying material 52 is provided in either the first cavity means 40 or second cavity means 48. Alternatively, the additional smoke-modifying means 52 could be included in both first cavity means 40 and second cavity means 48. The additional smoke-modifying material 52 is a bonded activated carbon or bonded silica gel. The bonded activated carbon is the preferred material, and the invention will, therefore, be described with reference to the same. The activated carbon particles are bonded by a thermoplastic material such as polyethylene. This bonded carbon has been found to possess excellent gas phase filtration characteristics and retains a high percentage of acrolein.

Turning now to FIG. 10, the method of making the basic filter element of the instant invention will become readily apparent. The apparatus for making the inventive filter element is designated generally by the numeral 54. Filtering material in

band form is designated 56. This filtering material in band form is coming from a bale and band forming apparatus conventional in the trade which are not shown. The filtering material 56 can comprise any suitable substance, such as, for example, cellulose acetate fibers in the form of a continuous filamentary tow. For certain uses and to achieve certain filtering and/or adsorbing and/or liquid-holding properties, the cellulose acetate fibers may be mixed with other materials, such as, cellulose, viscose, cotton, cellulose acetate-butyrate, cellulose propionate, activated carbon, asbestos, glass fibers, metal fibers, wood fibers, and the like. The material is preferably opened, crimped, continuous filamentary cellulose acetate tow having about 9 percent glycerin triacetate as a plasticizer in fine droplets distributed upon its surface. Any suitable plasticizer may be used, such materials being well-known in the art.

The term "continuous filamentary tow," as used in this specification and the appended claims, is intended to define a material such as that which results when filaments extruded from a plurality of spinnerets are brought together and combined to form a continuous body of fibers randomly oriented primarily in a longitudinal direction. In such a tow, the filaments are generally longitudinally aligned in substantially parallel orientation, but include crimped portions which may form short sections running more or less at random in non-parallel diverging and converging directions.

Continuous filamentary tows of plasticized cellulose acetate fibers as well as various other plastic materials, such as polyethylene, polypropylene, nylon, and the like, have been used heretofore in the manufacture of smoke filters for cigarettes, cigars, and the like. Although the process of this invention is applicable to the various filamentary materials of this type, since plasticized cellulose acetate is the most common plastic used in the manufacture of cigarette filters, the specification hereof will be generally set forth in terms of this material. However, it is to be understood that the instant inventive concepts are not to be limited to this preferred embodiment.

Generally, the fibers of a cellulose acetate tow merging from the spinneret are bunched together to form a "raw tow" which is collected into a bale for subsequent processing. Such processing usually involves, in addition to unwinding of the "raw tow," spreading apart of the fibers to provide a relatively thin layer of the same, tensioning of the fibers to render the crimp of uniform character, and impregnating the fibrous layer with plasticizer to bind adjacent fibers together.

The two of the filtering material 56 in band form is fed into a stuffer jet, or air nozzle 58. The air nozzle 58 comprises an outer member 60, an inner member 62, a mandrel 64, a mandrel support 66, and a retaining ring 68. The air nozzle 58 is generally shaped as a truncated cone, thereby having a greater cross section at the entrance end 70 than at the exit end 72. The inner member 62 is suitably connected to the outer member 60 as, for example, by threaded portions (not shown). The alignment of inner member 62 in outer member 60 can be adjusted for a purpose which will become apparent. Mandrel support 66 is secured in place by retaining ring 68.

Outer member 60 has a connection 74 for compressed air. The inner wall of outer member 60 and the outer wall of inner member 62 are of such a relationship that, when assembled, an annular space 76 is created. The purpose of annular chamber 76 will become apparent from the following description.

In this stage of the manufacture of the inventive filter element, the elongated band of filtering material 56 enters the rearward end 70 of air nozzle 58 passing through the mandrel support 66 and generally being forced, in a random manner, around an inner portion of the mandrel support 66. The tow at this point is generally a hollow tubular element which continues around mandrel 64 to the forward end 72 of air nozzle 58. As the tow emerges from the forward end 72 of air nozzle 58, it is mixed with air supplied through fitting 74 and passing though chamber 76 to exit, or forward, end 72 of air nozzle 58. Adjustment of inner member 62 in outer member 60 by means of threaded portions or the like creates a venturilike opening at the exit end 72 of air nozzle 58, between the forward end of inner member 62 and the forward end portion of outer member 60. This opening could range in size from fully closed to about three-fourths inch, but the practical limits of use, in order to obtain the desired venturi effect at customary air pressures, are from about 0.005 to bout 0.050 inch. The tow emerging from the exit end 72 of air nozzle 58, mixed with air, "explodes" or blooms into a uniformly random fluffy mass 78 before passing into the first curing station 80. Mandrel 64 passes through air nozzle 58 and into the first curing station 80.

The first curing station 80 is a heating and shaping apparatus, such as that disclosed in U.S. Pat. No. 3,095,343, granted on June 25, 1963, to Richard M. Berger. Since this apparatus is now known in the art, it need only be described herein in general terms, reference being had to the aforementioned U.S. Pat. No. 3,095,343 for details of its construction.

The heating and shaping apparatus making up the first curing station 80 is constructed in such a way that the moving tow which is being formed into a generally rodlike formation is contacted with steam as it passes through a die. The application of the stem to the filamentary tow as it is gathered together appears to result in softening of the tow fibers and the plasticizer carried thereon, and definitely has the effect of uniformly bonding the fibers of the two together as they are gathered. By passing the steam onto the tow under pressure in a confined area at an angle to the longitudinal axis, and in a direction opposite the direction of movement of the tow, the steam is caused to pass through the tow, between the fibers and past the fibers as they are being gathered together. All of the filaments and all of the plasticizer are thus at least substantially uniformly heated, and bonding is at least substantially uniform throughout. Thus, the steam-treating apparatus of the aforementioned U.S. Pat. No. 3,095,343 produces a tubular, rodlike tow which proceeds to further treatment. Using the apparatus of the present invention, however, with the forward end of the mandrel 64 extending into and through the first curing station 80, the tow is converted to an axially elongated, hollow element 82.

The cured tow emerging from the first curing station is generally self-sustaining in shape and in cured condition. The term "cursed," as used in the art, means a tow obtained from a process by which the fibers of the tow are bonded to adjacent fibers after the fibers have been gathered into a rodlike structure. The cured tow 82 then passes to a second curing station 84 wherein dry air is passed on to the tow and through the tow to set the fiber components and plasticizer components of the tow so that it has complete dimensional stability without excess stiffness or fiber fusion. Preferably, the air which is passed on to the tow at the second curing station 84 is perfectly dry, has a temperature of 90° F. or below, and is maintained under a pressure of between 15 and 100 p.s.i.g. Moreover, for optimum results, the air should be passed on to the tow countercurrent thereto and at an angle of substantially 45° to the longitudinal axis of the tow, in much the same way as the stem contacts the tow in the first curing station 80. A suitable apparatus for air-treating the tow at the second curing station 84 is described in detail in the aforementioned U.S. Pat. No. 3,095,343. The air inlet to the second curing station 84 is indicated at 86, while the steam inlet to the first curing station 80 is indicated at 88.

After leaving the second curing station 84, the tow 82 passes to a pulling device generally designated by the numeral 90. The pulling device 90 can be any conventional device for applying motive power to the continuous filter rod 82 to move the same through the apparatus. As depicted in FIG. 1, the pulling device could be a conventional overwrap garniture with an endless belt 92 imparting a pulling movement to tow 82. The belt 92 is driven by drive means schematically shown as 94.

When the tow, or tube **82** which will be used to make the inner portion **36** of the filter, leaves the pulling device **90**, it passes into a third curing station **96**. Basically the construction of the steam jet in third curing station **96** is the same as that used in first curing station **80** with several minor modifications which will be apparent to one skilled in the art. Steam enters third curing station **96** through inlet **98** and passes through and around the tow **82** as it moves through the steam jet. Unlike the first curing station **80**, however, the steam in third curing station **96** need not necessarily run counter-flow to the tow, but may actually pass co-currently with the same. In fact, in a preferred embodiment, the steam runs with the tow rather than counter to the same in third curing station **96**. According to the concepts of the instant invention, this second steam treatment is an important preconditioning of the rod in order to prepare the same for the crimping operation to be performed in crimping station **100**. The crimping could be performed without this preconditioning, but the amount of heat and pressure which would be necessary renders such a step less desirable. It has been found that when the tow is preconditioned in third curing station **96**, the crimping can be done extremely easily. The crimping station **100**, of course, will impart the desired configuration to the rod, as shown in FIGS. **1** through **6**. For a further understanding of crimping means **100**, attention is directed to the aforementioned copending application Ser. No. 45,109, filed June 10, 1970, now U.S. Pat. No. 3,637,447, wherein the crimping means is shown and described in more detail.

The crimped rod **102** emerging from crimping means **100** passes to fourth curing station **104**. Fourth curing station **104** is an air jet similar to second curing station **84** having air supplied thereto through connection **106**. This final curing stage sets the crimped rod **102** into its final shape. The rod **102** of crimped inner elements **36** is then overwrapped, for example, with a sheet of ordinary "plug" wrap, such as shown at **108**, bypassing the crimped rod **102** and the plug wrap **108** through a means **110** which is a conventional overwrap garniture, with the assistance of an endless belt **112**. The plug wrap **108** forms an axially elongated hollow outer element **34**, the lateral edges of which may be secured together to form a longitudinal butt seam, or a longitudinal lapped seam, as is well-known, sealing means **114** being shown for this purpose.

The continuous rod **116** of overwrapped combined inner and outer elements **34** and **36** may then be cut in any conventional manner, as by means schematically shown at **118**, to provide a plurality of segments **120**. For convenience in handling, each segment **120** may initially include four filter elements, the segments being first further subdivided, as shown by the dotted lines **122** in FIG. **7**, to provide segments including two filter elements. The segments may then be associated with a pair of tobacco portions and overwrapped with a tipping paper before further subdividing the same to form two filter cigarettes, each including a single filter element of the type shown, for example in FIG. **1**. The rod **102** of crimped inner elements **36** has unembossed areas **124** adjacent crimped areas **50**. Since the rod **82** is a hollow tube, the crimped rod **102** retains the hollow configuration in those areas which have not been compressed by crimping means **100**. This hollow configuration is shown in FIG. **9** wherein the cavity means **48** appears. Thus, the final filter, includes cavity means **48** at one end thereof and cavity means **40** at the other.

The foregoing detailed description is drawn to the basic construction of the filter element of the present invention and to the method of manufacture thereof. The filter element itself includes an additional material providing a required filtering or other effect upon tobacco smoke and unitary with the basic filter element section. The additional material, as mentioned above, is a bonded active material and preferably bonded activated carbon. This additional material can be, prior to its application to the basic filter means, in particulate, liquid, or suspended state although activated carbon has been mentioned as the preferred particulate material, other well-known sorbent materials such as activated alumina, silica gel, molecular sieves, and the like may be readily substituted therefor. Reference is had to U.S. Pat. No. 3,217,715, granted to Richard M. Berger and Reavis C. Sproull on Nov. 16, 1965, for a description of the preferred material. The material therein disclosed consists essentially of activated carbon particles bonded together by a bonding agent. According to one embodiment of the present invention, cavity means **40** and/or cavity means **48** are filled with finely divided activated carbon particles integrally mixed with a bonding agent, the bonding agent then bonding the carbon particles by the application of heat. According to another embodiment of the present invention, the activated carbon particles and the bonding agent are heated to form the bonded carbon, particles of which are then placed in cavity means **40** and/or cavity means **48**, after which heat is applied to fuse the bonding agent thereby providing structural integrity.

The bonding agent can comprise any thermoplastic material, such as polyhydrocarbons having from two to 10 carbon atoms, preferably polyolefins, e.g., polyethylene and polypropylene, other thermoplastics such as vinyl acetate, other vinyl homopolymers and copolymers, plasticized cellulose acetate, Artrite (a thermoplastic polyester resin), Escorex (a fine powdered petroleum hydrocarbon resin), and combination of any of the above, all of these materials being of the type which are effective to provide bonding at temperatures in excess of that of the normal smoke temperature passing through the filter. The best results, however, are obtained when the bonding agent is a polyolefin or, more specifically, polyethylene, polypropylene, or combinations thereof.

Activated carbon particles are initially mixed with the bonding agent particles, and the particles providing the bonding agent are so selected that they have a size no greater than equal to, and preferably substantially less than, the particle size of the activated carbon particles. Preferably, the activated carbon particles have a particle size of between 10 and 200 mesh and the binder has a particle size of less than 100, preferably less than 50, microns. The mixing is carried out in any suitable manner, but with the activated carbon particles present in relative amount of between 50 and 95 percent by weight, preferably 70 or even 85 to 93½percent by weight, and the particles of the bonding agent present in a relative amount of between 5 and 50 percent by weight, preferably 6½to 30 percent by weight. After the carbon and bonding particles are integrally mixed, the mixture is filled into cavity means **40** and/or cavity means **48** with heat being applied to soften the bonding agent whereby it adheres to the adjacent carbon particles and serves as a binder therebetween while, at the same time, adhering to the walls of the cavity means. This procedure inherently results in a multiplicity of bonding bridges between binder particles predominantly individually smaller than the carbon particles.

Alternative means for applying the bonded activated charcoal **52** to the basic filter structure are shown in FIGS. **11** through **14**, to which attention is now directed. In FIG. **11** is shown a modification of air nozzle **58** which is used to inject a mixture, or slurry, of additional material, such as activated carbon combined with a binder, into hollow inner portion **48** of the tow **82** at first curing station **80**. In this apparatus there is provided a mandrel **64***a* which is hollow, as indicated by the broken lines **126**. Hollow mandrel **64***a* is fed, at its rear or inlet end, with the slurry from a reservoir **128**. The slurry is ejected for the hollow mandrel **64***a* at its forward end, in the neighborhood of first curing station **80**, to deposit the slurry in the hollow tube **82**. The slurry is injected in this manner by means of a pulsating feed to the mandrel. The mandrel **64***a*, in effect, serves as a pulsating nozzle. The pulsating feed from reservoir **128** to hollow mandrel **64***a* is accomplished by known means which need not be herein described. As disclosed in copending application Ser. No. 45,109, this pulsating feed is properly synchronized with other elements of the apparatus so that the desired effect will be achieved.

In another embodiment of the present invention, the slurry can be applied to the rod **82** as it leaves pulling device **90**, and

prior to entering third curing station 96, by passing through applicator device 130. Applicator device 130 comprises an applicator roll 132, a pressure roll 134, a fountain roll 136, a further fountain roll 138, a doctor roll 140, and a trough 142. The trough 142 contains slurry to be applied to the filter. The fountain roll 136 dips into the slurry in the trough 142 at its lowest part and is in surface contact with the further fountain roll 138, which in turn is in surface contact with the applicator roller 132. The doctor roll 140 is so disposed as to doctor, or meter, the amount of slurry carried round by the roll 136 to be, ultimately, transferred to the applicator roller 132. The applicator roller 132 comprises a plurality of surfaces 144 separated from one another by axially directed valleys 146. The surfaces 144 conform to an imaginary cylinder coaxial with the roller 132. Each surface 144 may have an arcuate length equal to whatever length of slurry of the additional material it is designed to "print" onto the filter means. Additionally, the surfaces 144 may be separated from one another by any desired arcuate length. The pressure roll 134 serves to press the rod 82 into contact with the surfaces 144. The rod 82 passes into and through applicator device 130 on endless belt 148 which is entrained about two rollers 150 and 152. The rod 82 passes between the nip of roller 152 and roller 154 as it enters onto endless belt 148.

In FIG. 13, applicator device 130 also comprises applicator roll 132, a pressure roll 134, fountain roll 136, further fountain roll 138, doctor roll 140, and trough 142. The endless belt and its accompanying drive rollers are not used in this modification, the rod 82 merely passing between applicator roller 132 and pressure roll 134. In both FIGS. 12 and 13, it can be seen that as rod 82 leaves the applicator device 130, it passes into third curing station 96 where it is again cured with steam and where the bonding agent in the slurry is fused and bonded before the rod 82 enters crimping means 100.

The additional material of bonded activated charcoal 52 could be provided in cavity means 40 in any convenient manner. For example, "fingers" or needles could inject the same after outer member 34 is applied to inner member 36. Alternatively, the pre-bonded activated carbon could be placed around the crimped section, or the voids, as the rod 102 enters overwrap garniture 110. As the overwrap 108 encircles the rod 102, the bonded activated carbon will be entrapped and sealed into place. One means of performing this operation is illustrated in FIG. 14 wherein it can be seen that as rod 102 enters filling station 156 the slurry 158 is deposited in the crimped areas. The slurry 158 is contained in a hopper 160 from which it is deposited into pockets in wheel 64. The pockets 162 are spaced in relation to distance between the annular areas in rod 102 wherein the slurry will be deposited, and the rate of rotation of wheel 164 is correlated in any conventional manner with the rate of feed of rod 102 through filling station 156, whereby predetermined quantities of additive material 158 automatically fill the annular areas in the rod 102.

The foregoing embodiments are merely presented to emphasize the great versatility in materials and manufacturing techniques which are useful in the production of filter means without departing from the instant inventive concepts. The various details in the different embodiments may be combined to provide even further embodiments. Moreover, an individual filter element according to any of the embodiments shown, when associated with a rod of tobacco in a filter cigarette, may be disposed with either end portion in facing relationship to the tobacco, although it has been found to be desirable to dispose the end having first portions 42 closer to the tobacco than the end having second portions 46. Further, a plurality of filter elements according to the instant inventive concept may be utilized with a single tobacco portion, or a filter element according to this invention may be utilized in combination with other forms of filter elements, if desired. The high filtration efficiency of filter means in accordance with this invention and the great versatility of such filter means in being capable of including one or more layers of various filter media, however, ordinarily avoids the necessity for the use of multiple filters in a single filter cigarette.

It has been found that the filter of the instant invention, at the same pressure drop, provides substantially higher particulate filtration efficiency than other conventional filters, in each instance in excess of 60 percent, and in some instances above 90 percent. Yet, such extremely high filtration efficiencies are provided with extremely low pressure drops, in each below 2 inches of water. Moreover, such desirable characteristics are provided in a filter means which can be formed as a self-sustaining, self-centering, integral element in a highly efficient and continuous manner.

The filter with bonded activated carbon in first cavity means 40, has been shown to have at least about 35 percent gas phase filtration efficiency. By "gas phase filtration efficiency" is meant the percent removal of acrolein from the smoke. In tests a filter according to the present invention having 75 mg. of carbon showed 80 percent gas phase filtration efficiency. In comparison, the filter without the bonded activated carbon removed no acrolein from the smoke although particle removal was equally high. In order to achieve 80 percent gas phase filtration efficiency with only a bonded activated carbon filter, an amount of carbon in the order of 200 mg. must be used. Thus, the obvious advantage of a filter according to the present invention is clear when compared with the prior filters.

Having now described the product of the present invention and having set forth various advantages thereof, it should be apparent that the objects set forth at the outset of this specification have been successfully achieved. While this invention has been described with reference to presently preferred exemplary embodiments thereof, it should be clearly understood that the invention is not limited thereto but may be variously practiced within the scope of the following claims.

What is claimed:

1. A filter means including a filter element comprising:
   a. an axially elongated, hollow, outer member;
   b. an axially elongated, hollow, inner member disposed within said outer member;
   c. said outer member including an inner surface and an outer surface and having spaced end portions;
   d. said inner member comprising a filtering material and including an inner surface and an outer surface and having spaced end portions;
   e. integral peripheral portions of said outer surface of said inner member being juxtaposed to portions of said inner surface of said outer member to at least substantially preclude axial passage of smoke across the area therebetween;
   f. the major portions of said outer surface of said inner member being spaced from said inner surface of said outer member to define first elongated cavity means therebetween;
   g. integral first portions of said inner member defining a first area extending across the interior of said inner member which offers at least as must resistance to passage of smoke as said filtering material, said first portions being axially spaced from said peripheral portions;
   h. second portions of said inner member defining a second area extending across the interior of said inner member which offers less resistance to passage of smoke than the area between said peripheral portions of said inner member and said inner surface of said outer member, said second portions being axially spaced from said first portions toward said peripheral portions;
   i. the interior of said inner member between said first and second portions defining second elongated cavity means, whereby smoke passing through said filter element between opposite ends thereof must travel through both said cavity means and through said filtering material;
   j. a quantity of a sorbent smoke-modifying material carried in at least one of said first and said second cavity means.

2. A filter means of claim 1 wherein said sorbent smoke-modifying material is in said first cavity means.

3. The filter means of claim 1 wherein said sorbent smoke-modifying material is in said second cavity means.

4. The filter means of claim 1 wherein said sorbent smoke-modifying material is bonded activated carbon.

5. The filter means of claim 4 wherein said bonded activated carbon consists essentially of the following:

a. From in excess of 50 to approximately 95 percent by weight of activated carbon particles, said activated carbon particles having a maximum dimension which is a small fraction of the minimum dimension of said cavity means; and

b. from at least 5 to approximately 50 percent by weight of a thermoplastic resin, said thermoplastic resin being operative essentially alone to effect bonding bridges between juxtaposed constituents through heating and subsequent cooling, with the temperature of the resin at which the bonding is effective exceeding that the normal temperatures of smoke passing through said filter,

said bonded activated carbon further being characterized by:

1. said thermoplastic resin essentially alone serving as a binder between said activated carbon particles and said thermoplastic resin and defining a multiplicity of discrete bonding means predominantly individually smaller than said activated carbon particles;

2. said activated carbon particles cooperating through said bonding means to give structural continuity to said further smoke-modifying material;

said filter means thereby being self-sustaining and self-centering.

6. The filter means of claim 5 wherein said thermoplastic resin is polyethylene.

7. The filter means of claim 5 wherein said activated carbon particles are present in said further smoke-modifying material in a relative amount of about 93½ and 70 percent by weight and said thermoplastic resin is present in said plug in a relative amount of between about 6½ and 30 percent by weight.

8. The filter means of claim 1 wherein said filter element has a pressure drop no greater than about 2.5 inches of water, a total particulate matter filtration efficiency of at least about 60 percent, and a gas phase filtration efficiency of at least about 35 percent.

9. The filter means of claim 8 wherein said filter element has a total particulate matter filtration efficiency of at least about 90 percent.

10. The filter means of claim 8 wherein said filter element has a total gas phase filtration efficiency of at least about 80 percent.

11. The filter means of claim 1 wherein said filtering material comprises at least about 25 percent by weight of cellulose acetate.

12. The filter means of claim 11 wherein said cellulose acetate is secondary cellulose acetate.

13. The filter means of claim 1 wherein said first area is defined by integral portions of said inner member crimped together at one of said end portions of said inner member.

14. The filter means of claim 13 wherein spaced parts of the periphery of said crimped portions contact said inner surface of said outer member to assist in centering said inner member within said outer member and in defining said first cavity means.

15. The filter means of claim 14 wherein said spaced parts of the periphery of said crimped portions contact said inner surface of said outer member only at said one end portions of said inner member, the entire outer surface of said inner member being spaced from said inner surface of said outer member except at said spaced end portions.

16. The filter means of claim 1 wherein said inner member is tubular, the outer surface of one end portion of said inner member defining said peripheral portions, the other end portions of said inner member being crimped and sealed together to define said first area, spaced parts of the periphery of said crimped portions contacting said inner surface of said outer member to assist in centering said inner member within said outer member and in defining said first cavity means, the inner surface of said one end portion of said inner member being open to define said second area.

17. The filter means of claim 16 wherein said spaced parts of the periphery of said crimped portions contact said inner surface of said outer member only at said other end portions of said inner member, the entire outer surface of said inner member being spaced from said inner surface of said outer member except at said spaced end portions.

18. The filter means of claim 17 wherein said other end portion of said inner member is crimped to form a generally cruciform-shaped cross section, only the laterally terminal edges of the cruciform-shaped portions and said peripheral portions of said outer surface of said inner member contacting said inner surface of said outer member.

* * * * *