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Berger

[11] **3,811,451**

[45] **May 21, 1974**

[54] **TOBACCO SMOKE FILTER**

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[21] Appl. No.: **287,803**

[52] **U.S. Cl.**..... **131/10 R,** 131/10.5, 131/10.9, 131/261 R

[51] **Int. Cl.**..... **A24d 1/04**

[58] **Field of Search**..... 131/10 R, 10.5, 10.7, 10.9, 131/261 B, 261 R, 268

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Assistant Examiner—John F. Pitrelli
Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

A method and apparatus for making tobacco smoke filter means having totally enclosed inner cavities surrounded completely by the filtering material. Selected cavities may be filled with a sorbent smoke-modifying additive or the like in order to provide both gas phase filtration and solid phase filtration to the resultant product. Filter rods are manufactured by utilizing a reciprocating mandrel which is timed to the movement of a filtering material, such as a continuous cellulose acetate filamentary tow, through processing stations, particularly a steam-treating bonding station, with an annular wall of smoke-permeable bonded fibrous members of the filtering material being formed when the mandrel is in its forward-most position extending at least to the point where the bonding agent contacts the filtering material. At the rearward-most portion of the stroke of the mandrel the filtering material is permitted to extended transversely completely across the bonding zone before being contacted with the steam so as to form a smoke-permeable plug of filtering material before and after the annular wall portions, thereby defining the internal cavities. Selected cavities may be partially or completely filled with an additive passing through the mandrel which can be hollow, as the mandrel is withdrawn during its rearward stroke.

3 Claims, 14 Drawing Figures

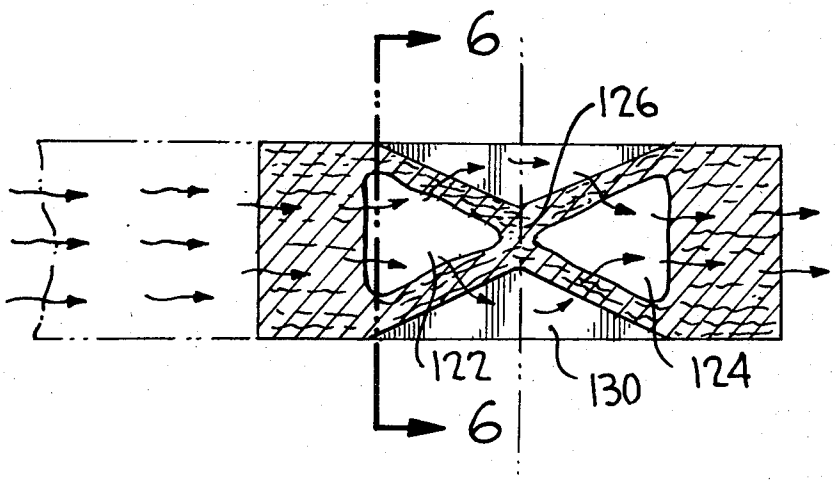


FIG. 1

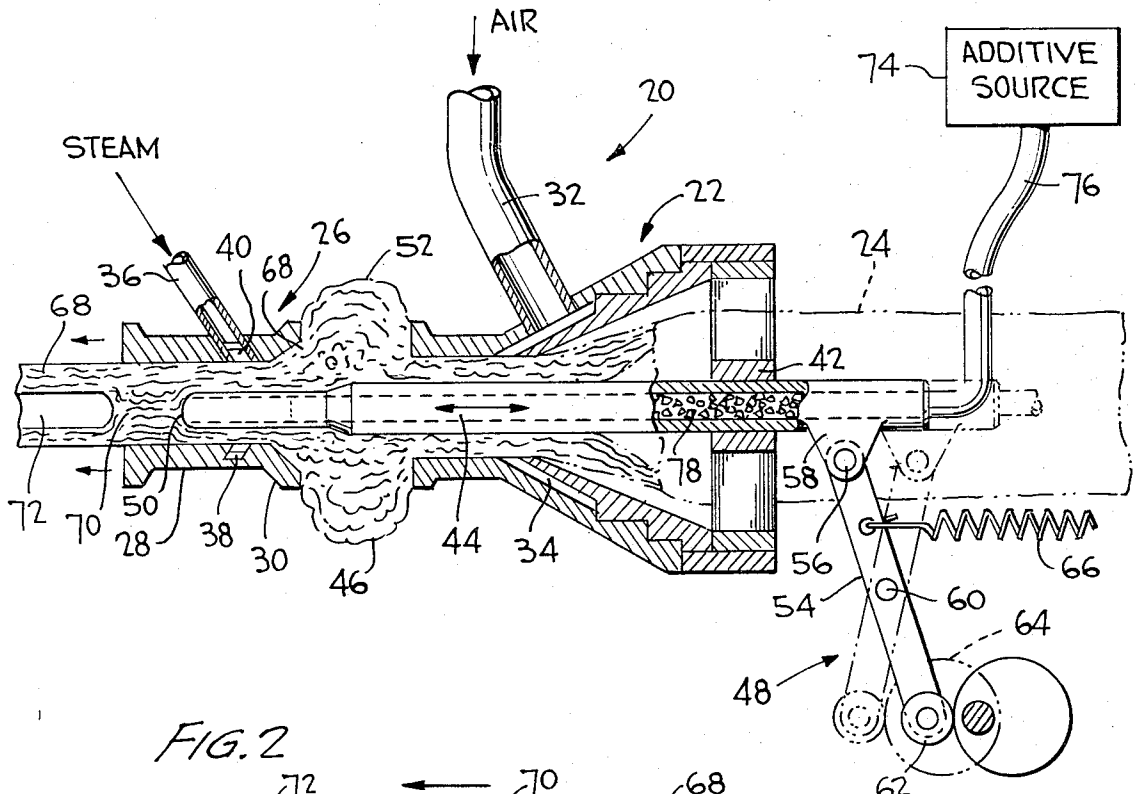


FIG. 2

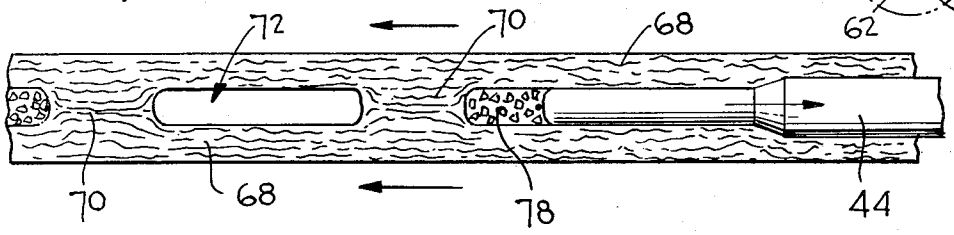


FIG. 3

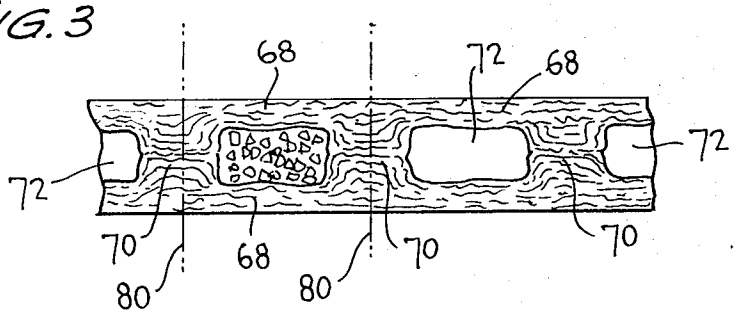


FIG. 4

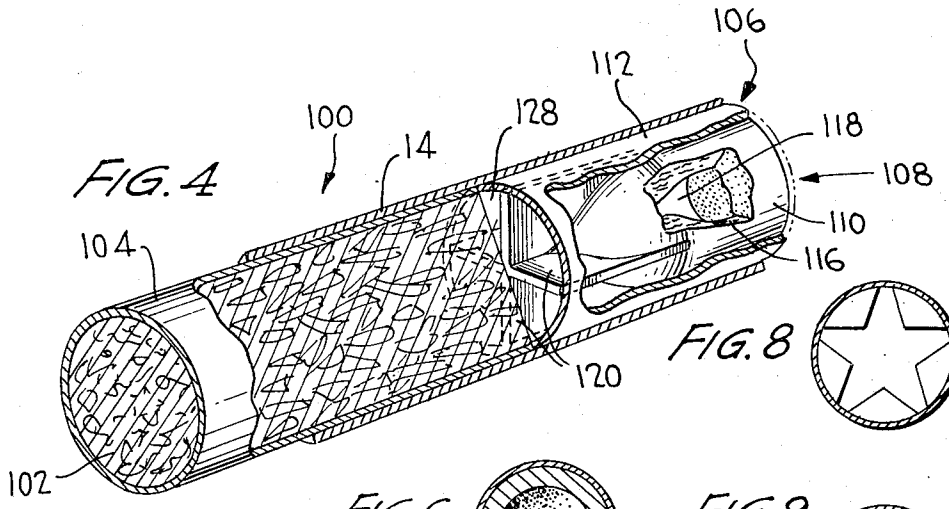


FIG. 8

FIG. 6

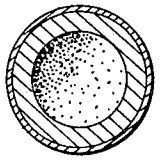


FIG. 9

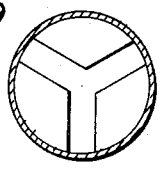


FIG. 5

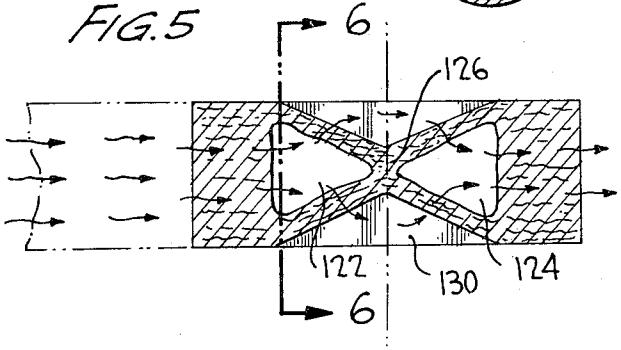


FIG. 10

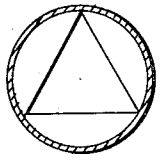


FIG. 11

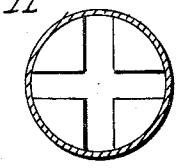


FIG. 14

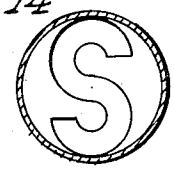


FIG. 12

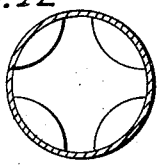
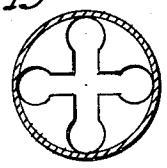


FIG. 7

FIG. 13



TOBACCO SMOKE FILTER

This invention relates to the production of filter means and relates more particularly to tobacco smoke filter elements. More specifically, the instant inventive concepts are primarily concerned with producing filter means for cigarettes, although the products of this 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 filtered cigarettes.

Various prior art techniques are known for making filters for use in connection with cigarettes, and the like, although the 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 ordinarly 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 cigarette filter means, it has been necessary, with prior art filter devices, to compromise the filtration efficiency in order to provide such filters with other properties, such as pressure drop, taste, hardness, appearance and cost, which are important from the stand-point of commercial 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 stand-point. While various suggestions have been made for the production of filter means which have improved filtering properties, such prior art developments, for the most part, have not been commercially acceptable either because the resulting 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.

High filtration efficiency is considered by the industry to be removal of 60 percent or more of total particulate matter. Cigarette filters having such properties are presently being produced in accordance with the teachings of U.S. Pat. Nos. 3,533,416, 3,599,646, and 3,648,711. Yet, the production of a cigarette filter having even a slightly increased filtration efficiency, without detrimentally affecting other desirable properties, e.g., pressure drop and the like, would be commercially important. Moreover, the production of a cigarette filter or the like having equivalent filtration efficiency, but utilizing substantially less material, thereby minimizing the cost of manufacturing, would also be quite commercially important. It is extremely significant to be able to provide improved filtration efficiency for a given level of pressure drop. Moreover, it is highly desirable to provide techniques for the production of cigarette filters and the like which are readily adaptable to

produce filter elements having a variety of characteristics enabling the manufacturer to select various features for his filter means almost at will.

Therefore, it is a primary object of the instant inventive concepts to provide a cigarette filter means or the like having improved filtration efficiency, without undesirably affecting other important commercial requirements.

Moreover, a very basic object of this invention is to enable the manufacture of filter means for cigarettes and the like wherein the filtration efficiency is increased for a given level of pressure drop.

A still further object of this invention is to provide methods for the manufacture of cigarette filter means which are simple and inexpensive to operate, while enabling high speed operation and which utilize relatively small amounts of filtering materials since a large proportion of the filtering material in each filter means is available to perform its primary function, that is, removal of undesirable constituents from smoke.

Another object of this invention is to provide a cigarette filter means which may have various characteristics, including both particulate matter filtration efficiency as well as gas phase filtration efficiency, if desired.

A further basic object of this invention is to provide for the production of cigarette filter means which may have various configurations to provide the final filtered cigarette with an aesthetically pleasing appearance.

Other and further objects of this invention reside in the chemical and physical characteristics of the filter product as well as the manipulative steps utilized in the production and the various features of construction found in the manufacturing apparatus. Still other objects will in part be obvious and in part be pointed out as the description of the invention proceeds, and as will be seen from the accompanying drawings wherein:

FIG. 1 is an enlarged longitudinal cross-sectional view showing a portion of a method and means for producing filter elements according to the instant inventive concepts, selected elements being shown in alternate positions in dotted lines;

FIG. 2 is a schematic cross-sectional view showing the deposition of an additive into alternate cavities of a filter rod as it is being produced;

FIG. 3 is a longitudinal cross-sectional view through one form of filter rod that can be produced according to the instant inventive concepts, showing how such a rod can be sub-divided to provide individual filter elements of selected characteristics;

FIG. 4 is an enlarged perspective view, partially in cross-section, showing a portion of a filtered cigarette incorporating a filter element according to one embodiment of the instant inventive concepts, parts being broken away for illustrative clarity;

FIG. 5 is a longitudinal cross-sectional view through a modified form of filter element according to the instant inventive concepts schematically illustrating the path that smoke would take in passing through such a filter element;

FIG. 6 is a transverse cross-sectional view taken substantially along lines 6—6 of FIG. 5;

FIG. 7 is an enlarged perspective view, partially in cross-section, through yet another modified form of filter element according to the instant inventive concepts; and

FIGS. 8–14 are elevational views of various filter elements which can be made in accordance with the instant invention, having different configurations for aesthetic and functional purposes.

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

Before proceeding in detail to a discussion of the specific methods, means and products of the instant invention, reference is made to the aforementioned United States Patents, the subject matter of which is incorporated herein in their entirety.

Referring particularly to FIG. 1 and to U.S. Pat. No. 3,637,447, commonly assigned with the instant application, it will be seen that FIG. 1 of this application shows a portion of a slightly modified form of the apparatus shown in FIGS. 1 and 19 of U.S. Pat. No. 3,637,447. The remaining portions of the apparatus according to the instant inventive concepts, as well as the techniques utilized, conform quite closely to those shown in the aforementioned patent and reference may be had to that disclosure for such details.

Although the products of this invention are preferably and primarily formed from a continuous tow of cellulose acetate filamentary material, the instant disclosure is not to be limited to this concept, since with slight modifications obvious to those skilled in the art, filamentary tow formed of other materials such as polyethylene, polypropylene and the like can be utilized, and, moreover, non-woven staple fibers of the type described in some detail in U.S. Pat. Nos. 3,297,041 and 3,552,400, also commonly assigned, the disclosures of which are incorporated herein by reference, may also be utilized. However, since cellulose acetate filamentary tow is the preferred material from a commercial stand-point, the remainder of this specification will be directed to the use of such material.

With reference now to FIG. 1, a portion of a method for forming filter elements according to the instant inventive concepts is designated generally by the reference numeral 20 and the portion shown will be seen to include air nozzle or stuffer-jet 22 spaced along the path of travel of a filtering material 24 toward a first curing station 26.

The details of constructions of the stuffer-jet 22 correspond basically to the similar element designated 14 in U.S. Pat. No. 3,636,447, whereby further details need not be incorporated at this point.

The first curing station 26 is similar in construction to the element 60 in U.S. Pat. No. 3,636,447, although somewhat further details are shown in the instant application. Specifically, this first curing station which may be referred to as a bonding zone includes a generally cylindrical portion 28 and a flared or conical entry portion 30.

Just as air is introduced into the stuffer jet 22 through the conduit 32 which communicates with a manifold 34 to be fed into the tow 24 in an annular direction, steam or other means capable of activating a bonding agent within the filtering material is introduced through a conduit 36 into a manifold 38 from which it passes through a multiplicity of spaced apertures 40 into the tow intermediate the path of travel of the tow through the cylindrical portion 28 of the bonding zone 26.

Thus, it will be seen that an elongated band of filtering material 24 enters the rearward end of the stuffer-jet 22 passing around a mandrel support 42 to form, at this point, a generally hollow tubular element which continues to be moved forwardly around a mandrel 44 actually disposed within the stuffer-jet 22 and passing at least partially into the bonding zone 26. As the tow emerges from the forward end of the stuffer jet 22 it is mixed with air supplied from the conduit 32. Adjustments of the various elements of the stuffer-jet 22 in the manner described in U.S. Pat. No. 3,636,447 creates a venturilike opening at the exit of the stuffer-jet 22 to cause the emerging tow to "explode" or "bloom" as shown at 46 into a uniformly random fluffy mass before passing into the bonding zone or curing station 26.

It should be pointed out that since the bonding agent inherent in the filamentary tow is not activated during passage through the stuffer-jet 22, the ultimate shape imparted to the tow which is formed of a plurality of plasticized random fibrous members, is not affected at this point.

It is not until the tow is contacted with a bonding agent, in this instance, steam, that the fibrous members of the filtering material are bonded to each other at spaced contact points to form an elongated, smoke-permeable, rod which defines a tortuous path for passage of smoke therethrough.

As will be seen, the heating and shaping apparatus for bonding zone 26 is so constructed that the moving tow which is being formed into a generally rod-like shape is contacted with steam during its passage through the cylindrical portion thereof. The application of the steam to the filamentary tow as it is gathered together results in a softening of the tow fibers and the plasticizer carried thereon and has the effect of uniformly bonding the fiber members of the tow together at spaced points. By passing the steam into the tow under pressure in a confined area and preferably at an angle to the longitudinal axis in a direction opposite to the direction of movement of the tow, the steam enters the tow, between the fibers and contacts the fibers as they are being gathered together. All of the fibrous members and all of the plasticizer are thus generally substantially uniformly heated whereby a substantially uniform bonding at spaced contact points of the fibrous members if effected.

In the absence of the mandrel 44 a smoke-permeable generally cylindrical continuous rod would be formed as the tow passed through the first curing station 26. However, the presence of the mandrel 44 defines within the bonding zone 26 an annular space through which the filtering material must pass thereby forming, instead of what may be called a solid rod, an internal cavity, that is, a hollow rod.

According to the teachings of U.S. Pat. No. 3,637,447, the product that exits from the first curing station is, in fact, a continuous hollow or annular element. It is at this point that instant inventive concepts depart from the teachings of the aforementioned U.S. Patent.

As will be seen particularly in FIG. 1, the mandrel 44 is provided with means 48 which function to reciprocate the mandrel within its supporting element 42, and more specifically, which function to reciprocate the forward end portion 50 of the mandrel 44 between a first position which is at least as far forward in the path of travel of the filtering material 24 as the point at which the filtering material is contacted by the bonding agent, and a second position, designated by dotted lines 52 spaced rearwardly of such point.

The reciprocating means **48** can comprise any mechanical construction capable of moving the mandrel **44** forwardly and rearwardly along the axis of the processing machinery. In the embodiment shown, which is intended only to be illustrative, a link **54** is pivoted at one end **56** to a bracket **58** carried by the rearward portion of the mandrel **44** and is pivoted intermediate its ends as designated at **60** to some fixed support (not shown). The opposite end of the link **54** carries a cam follower or roller **62** normally urged into contact with an eccentric **64** by a spring means **66.**

When the mandrel **44** is at its forward-most position it will be seen that the filtering material **24** is confined within an annular space between the exterior of the mandrel **44** and the interior of the cylindrical portion **28** of the bonding zone **26.** Since the filtering material is contacted with steam or some equivalent bonding agent at this point, the fibrous members of the filtering material are formed into a smoke-permeable annular wall portion **68.**

However, as the mandrel **44** is withdrawn on its return stroke to the position where the forward end portion is located at the point designated by the dotted lines **52** a portion of the filtering material is permitted to extend transversely completely across the bonding zone before being contacted by the bonding agent. This is especially true when the point **52** is chosen to fall within the conical section **30** of the first curing station **26.** In this manner, a smoke-permeable plug of bonded fibrous members **70,** which is integral with the annular wall **68,** is formed as this portion of the filtering material is contacted by the bonding agent during its forward movement.

Of course, the various elements causing forward movement of the filtering material and reciprocation of the mandrel must be synchronized and timed to provide for a proper relationship, depending upon the desired functional characteristics of the product, but means to accomplish this end are well within the ordinary skill of the art and need not be dealt with in any great detail.

It will now be seen that the method and means described enable the production of intermittent internal cavities totally enclosed and surrounded by the annular wall **68** and front and rear plugs **70.**

According to a further feature of the instant inventive concepts, the internal cavities can be filled or partially filled, or selected cavities can be filled with an additive material, such as, for example, a sorbent smoke-modifying material. To this end, the mandrel **44** maybe made hollow as shown in FIG. **1** and an additive source **74** can communicate with the rear end of the mandrel **44** through a flexible conduit **76.** By any ordinary actuating means (not shown), a pre-selected quantity or charge of additive material may be fed through the mandrel into one or more selected cavities as the mandrel is being moved rearwardly during its return stroke. Obviously, the operation of the additive feeding means can be so coordinated with the manufacture of the filter rod that additive material in any desired quantity can be fed into each and every cavity being formed, or only into selected, such as alternate, cavities. Moreover, the additive material may be particulate in nature such as activated carbon or, perhaps, silica gel or other such sorbent materials, an additive of this type being designated generally by the reference numeral **78,** or alternatively it may be a mixture of such materials and/or liquid materials so long as they do not deleteriously affect the properties of the filter rod being manufactured.

The size of the cavities formed, the thickness of the annular wall, the extent of the plugs between the cavities, the use, level of charge, and type of additive may all be readily varied well within the skill of the art. Additionally, once a filter rod is completely formed, as will be explained in more detail hereinafter, it may be selectively sub-divided at any point along its length such as shown, for example, by the dotted lines **80** in FIG. **3** to form individual filter elements. Of course, ordinarily, severing of the filtering rod will not take place until it has been overwrapped with paper or the like in a manner such as described in U.S. Pat. No. 3,637,447, but it is of importance to note that filter elements may be provided having a single internal cavity, or alternatively, a plurality of internal cavities, one or more of which maybe filled with an additive material so as to provide filter elements having any desirable combination of characteristics, depending upon the intended use therefor.

Subsequent processing of the filter rod may follow quite closely the procedures outlined in U.S. Pat. No. 3,637,447. Thus, any desired means may be provided such as the common arrangement shown at 70 in the aforementioned patent to continuously pull the filter rod through the processing apparatus shown in FIG. **1** of the instant application. Moreover, a subsequent curing station such as illustrated at 114 in U.S. Pat. No. 3,637,447 may be provided, particularly if the filter rod is to be crimped as designated at 118 in that patent prior to being cured and overwrapped in the conventional manner shown at 146 and 152 in U.S. Pat. No. 3,637,447.

During the overwrapping procedure it is quite important for a portion of the external surface of one of the plugs **70** of the filter rod to be in continuous peripheral contact with the internal surface of the overwrapping material. This forms a sealed area through which smoke cannot pass. For a better understanding of such an arrangement reference is made to FIG. **4** where a fragmentary portion of a filtered cigarette is designated generally by the reference numeral **100** and is seen to comprise a conventional tobacco rod **102** overwrapped with cigarette paper **104** and secured in end-to-end relationship with a filter element according to the instant inventive concepts designated generally by the reference numeral **106.** In the embodiment of filter element **106** shown in FIG. **4,** the inner member which is a sub-divided portion of the filter rod manufactured according to the techniques shown in FIG. **1** is referred to generally as **108** and will be seen to comprise a plug **110** at the mouth-piece end, the external surface of which is juxtaposed to the internal surface of the overwrapping material **112** to form the aforementioned sealed area. Finally, a tipping overwrap **114** is illustrated to secure the filter portion to the tobacco portion in a conventional manner. The annular wall of the filter element **106** will be seen at **116** as will the internal cavity at **118.** In the embodiment shown in FIG. **4,** one end of the filter element **106** has been crimped, in the manner described in U.S. Pat. No. 3,637,447 to form a plurality of cruciform-shaped fins **120,** the external or peripheral edges of which are in contact with the internal surface of the overwrapping material **112** in order

to assist in centering the inner member within the outer member.

By reference to FIGS. 8–14 alternate configurations for the crimped end of the filter element will be seen. In each instance, only the shape of the crimping means need be modified in order to provide the desired configuration, again, a matter of design well within the skill of the art which needs no further explanation.

It should be recognized that the filter means according to this invention can be used either singly or doubly, or in fact in any multiple units. For example reference is made to the embodiments of FIG. 5 and 6 wherein it will be seen that the filter rod has been crimped intermediate a cavity to form a plurality of independent cavity means **122,124**, with a crimped separating wall portion **126** therebetween. With the previous embodiments it was necessary for smoke passing from one end of the filter element to the other to pass through the plug and into the internal cavity, which has a lower resistance to passage of smoke than the filtering material itself, and then again out of the filter element through the filtering material so that, in each instance, the smoke must pass at least twice through the filtering material. Moreover, in an embodiment such as shown in FIG. 4 where a portion of the filter element has been crimped to form an external cavity, in this instance, a multiplicity of external cavities **128**, the smoke must also pass through these cavities from the tobacco to the smoker.

In contrast, with the embodiment of FIG. **5**, the smoke must actually pass four times through the filtering material, considering the fact that it passes through one of the end plugs, into the internal cavity **122**, through the filtering material again into the external cavity **130**, back through the filtering material into the internal cavity **124** and finally through the filtering material of the plug at the mouth-piece end of the filter element.

The variations of the aforementioned arrangements are only limited by the ingenuity of the processor, and in no way need depart from the instant inventive concepts in order to result in filter elements of an almost infinite variety of functional and aesthetic properties.

The embodiment of FIG. 7 is quite similar to the previous embodiments, with the exception that it is provided with a plurality of external, longitudinally extending, cavities **132** formed between ribs **134** almost in the manner of a gear. Of course, such cavities cannot extend the full length of the exterior of the filter element since it is necessary to provide an uninterrupted circumferential surface at one end of the filter element in order to produce the necessary sealed area which forces the smoke through the filtering material and precludes by-passing. The cavities **132** increase the external surface area of the filter element permitting a greater capability for the smoke to pass the length of the filter element into the internal cavity, which in the embodiment of FIG. 7 is shown as filled with a sorbent smoke-modifying additive material.

It is to be noted that there are two quite important features of each and every embodiment of filter element formed according to the instant inventive concepts. First of all it must be recognized that the primary purpose of the filtering material is to function to eliminate or reduce undesirable constituents from smoke passing therethrough, and with respect to the fibers or filamentary portion of the filter element, it is especially the particulate matter or solid phase constitutents of the smoke that are being affected.

A significant reduction in filtration efficiency results whenever the smoke-permeable rod of filtering material is compressed or crimped and it is for this reason that each filter element according to the instant inventive concepts includes at least one end portion which is in the form of a smoke-permeable uncrimped plug, the outer surface of this portion at least in part forming the sealed area with the overwrapping material. By maximizing the uncrimped portion of the filter element, filtration efficiency is increased significantly, thereby permitting the filtering material to perform its primary function in an optimum manner.

Another basic important feature of each filter element produced according to the instant inventive concepts is the presence of at least one internal totally enclosed cavity means surrounded by the filtering material. Heretofore it has not been possible to produce such an internal cavity means wherein the filtering material that formed or defined the cavity was integral both with respect to the end portions and the annular or peripheral wall extending therebetween. By enabling the production of a filtering element wherein the internal cavity is completely surrounded by integral filtering material which is not necessarily crimped, nor otherwise secured together by extraneous material such as adhesives and the like, the highest level of filtration efficiency per unit of filtering material can be realized.

Thus the instant inventive concepts enable the production of a filter element having increased filtration efficiency for a given pressure drop, while retaining all of the other desirable characteristics of cigarette filters, including such properties as "taste," appearance and minimized cost through simplicity in manufacturing techniques and apparatus as well as reduction in the quantity of filtering material for a given level of efficiency.

Again, it should be emphasized that filter elements of the type shown, for example, in FIG. **2** may be utilized by themselves, with no subsequent crimping necessary, providing a plug of smoke-permeable material extending transversely completely across each end of the filter element with, if desired, a sorbent smoke-modifying additive provided therewithin during the manufacturing process in an extremely simplified manner and by a technique which precludes channeling of the smoke past the additive particles increasing the gas phase efficiency of the final product as well. Alternatively, and for particular applications, crimping can be utilized to modify the appearance or functional properties of the filter means, again emphasising the versatility of the instant inventive concepts, both from the standpoint of manufacturing and the final product characteristics.

Having now considered the foregoing detailed description it will be seen that there is herein provided an improved method and means for producing tobacco smoke filters having all of the advantages set forth hereinabove, and others, including many features of great commercial significance.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A smoke filter means including a filter element comprising:

a. an axially elongated, hollow, outer member;

b. an axially elongated inner member disposed within said outer member;
c. said outer member including an inner surface and having spaced end portions;
d. said inner member comprising a filtering material and including 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. integral, longitudinally spaced first and second portions of said inner member extending transversely across the full diameter of said inner member in the form of plugs of filtering material including means defining a tortuous path for smoke therethrough, the outer surfaces of said integral first and second portions of said inner member at least partially defining said peripheral portions;
g. a totally enclosed unfilled inner cavity means surrounded by the filtering material of said inner member including said integral first and second portions and integral, annular, connecting portions extending longitudinally between said first and second portions;
h. integral portions of said inner member extending transversely across said inner member intermediate said first and second portions to divide said inner cavity means into at least two discrete unfilled inner cavity members;
i. portions of the outer surface of said connecting portions of said inner member being spaced from said inner surface of said outer member to define an outer cavity means therebetween;
j. said inner and outer cavity means each having less resistance to flow of smoke than said filtering material, whereby smoke passing through said filter element from one end portion of said inner member to the other end portion thereof must pass through said outer cavity means and each of said inner cavity members and must pass at least four times through said filtering material.

2. A cigarette comprising, in combination, a tobacco rod and a filter means secured in end-to-end relationship to one end of said tobacco rod, said filter means including a filter element as defined in claim **1.**

3. A filter means according to claim **1** wherein said filtering material comprises cellulose acetate tow.

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