United States Patent [19]

Harllee et al.

[11] **3,752,165**

[45] **Aug. 14, 1973**

[54] **SMOKE FILTER PLUG AND PROCESS AND CIGARETTE MADE THEREFROM**

[76] Inventors: **Gloria C. Harllee,** 605 Muirs Chapel Rd., Greensboro, N.C. 27410; **John D. Woods,** 3051 Magazine Dr., Winston-Salem, N.C. 27106

[22] Filed: **Dec. 20, 1971**

[21] Appl. No.: **209,797**

[52] **U.S. Cl.** ..... **131/10.5,** 131/261 B

[51] **Int. Cl.** .. **A24d 01/04,** A24f 07/04, A24f 13/06

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

[56] **References Cited**

UNITED STATES PATENTS

3,685,523	8/1972	Labbe	131/10.5 X
3,533,416	10/1970	Berger et al.	131/10.5 X
3,648,711	3/1972	Berger et al.	131/10.5 X
3,079,930	3/1963	Cobb et al.	131/268 X
3,093,142	6/1963	Swerdloff et al.	131/268 X
3,370,594	2/1968	Haslam	131/10.5 X
3,062,219	11/1962	Miller	131/10.5

FOREIGN PATENTS OR APPLICATIONS

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

Primary Examiner—Robert W. Michell

Assistant Examiner—John F. Pitrelli

Attorney—Albert H. Pendleton, Fred I. Williams et al.

[57] **ABSTRACT**

A porous filter plug for a smoking article comprising a tow of longitudinally extending fibers enclosed within a plug wrap and having a cavity molded in the outer surface at one end. The plug is formed by molding a conventional tow of thermoplastic filamentary material. In use, a portion of the smoke passes from end to end through the plug and the remainder passes through the channel formed by the cavity and then axially through the plug wrap and the plug.

14 Claims, 4 Drawing Figures

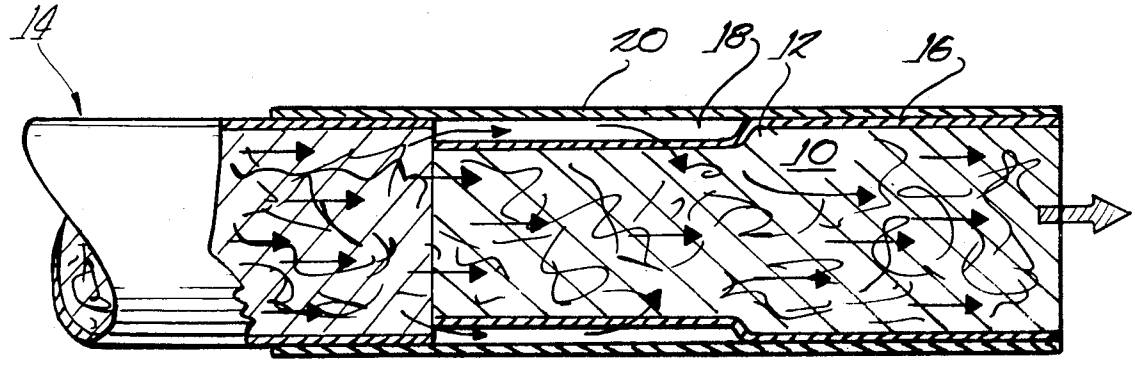


Fig. 1

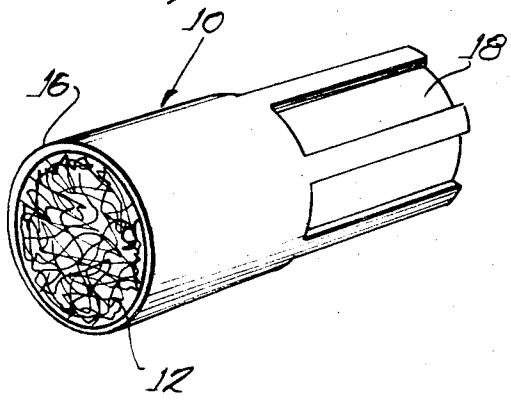


Fig. 2

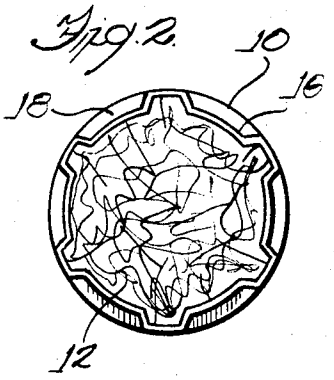


Fig. 3

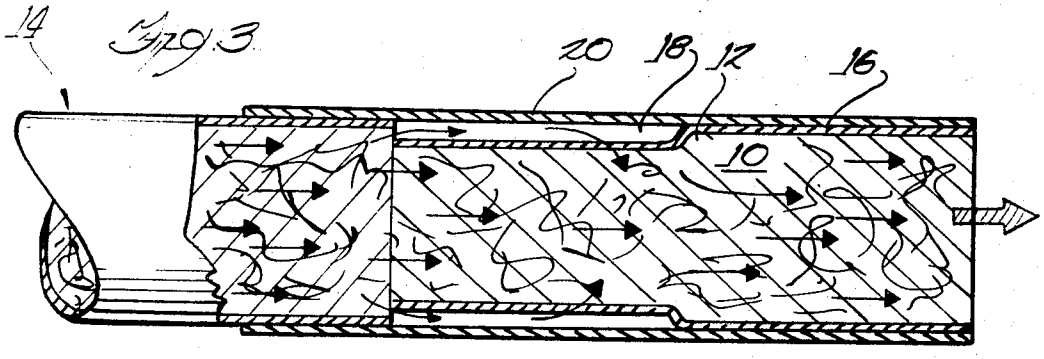
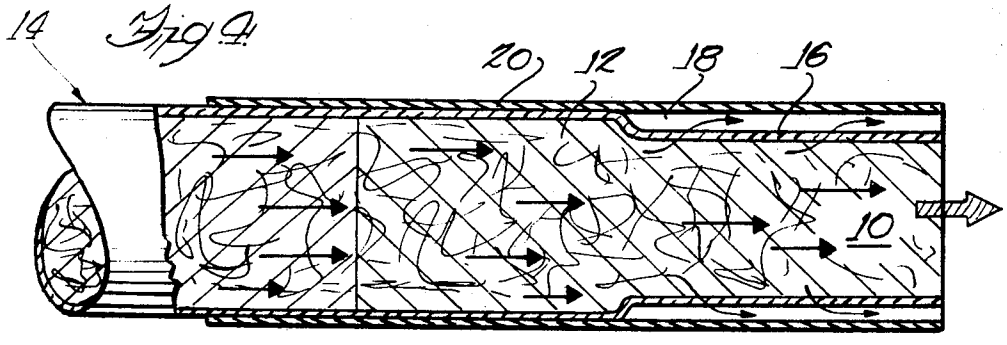


Fig. 4



SMOKE FILTER PLUG AND PROCESS AND CIGARETTE MADE THEREFROM

BACKGROUND OF THE INVENTION

This invention relates to a porous filter plug for a smoking article, to a process of making the plug, and to a cigarette which incorporates the plug as an essential element.

Most commercially available cigarette filters are limited in their performance characteristics. For example, conventional cellulose acetate fiber filters remove only 40 to 45 percent of the particulate material in the smoke when the pressure drop across the filter is around 2.0 to 2.5 inches of water. An increase in particulate material removal efficiency may be obtained by increasing the pressure drop across the filter but a high pressure drop is objectionable and not acceptable to the majority of smokers.

The filter described in U.S. Pat. No. 3,533,416 is in some respects an exception to the general rule concerning cellulose acetate fiber filters since the performance of that filter is high at an acceptable pressure drop and the smoke from the cigarette has a good taste. However, the filter disclosed in that patent is difficult to produce and requires the use of an excessive amount of filter material. As a result, it is comparatively expensive to manufacture.

The prior art is replete with various proposed structures for filtering cigarette smoke under conditions which wil provide high efficiency at a low pressure drop. However, most all of these, and particularly those which have been disclosed in the patent literature, have not been commercially adopted because they are too expensive to produce and are not adaptable for production on high speed cigarette-making machines.

Accordingly, an object of this invention is to provide a filter for a smoking article which has a high efficiency for the removal of tars from cigarette smoke at an acceptable pressure drop.

A further object of this invention is the provision of a tobacco smoke filter which may be prepared from a lesser quantity of filtering material than has heretofore been necessary for the manufacture of a high efficiency filter.

A still further object of this invention is the provision of a filter and a process for making it which is readily adaptable for manufacture by high speed cigarette-manufacturing machines.

A still further object of this invention is the provision of a high efficiency filter which may be prepared from materials that are already commercially used for the purpose with a minimum modification of existing equipment.

A still further object of this invention is the provision of a process for making a filter plug from a thermoplastic filamentary or fibrous material which involves a simple molding step which may be rapidly carried out without concomitantly heating the material to such a degree that it sticks to the mold during the forming operation.

Further and additional objects will appear from the following description, accompanying drawing and the appended claims.

GENERAL DESCRIPTION OF THE INVENTION

In accordance with this invention, a fiber filter has been provided for attachment to the downstream end

of a smoking article such as a cigarette in which the smoke passes both longitudinally and axially through the filter. A portion of the smoke passes longitudinally through the filter in a conventional manner from one end to the other and a second portion of the smoke is diverted through a channel formed by a cavity molded in one end of the filter plug. More specifically, a filter plug is provided which comprises a tow of longitudinally extending fibers exposed at opposed ends for the passage of smoke therethrough from end to end. The plug is provided with a porous overwrap closely embracing the side wall of the tow between the ends and the plug has a cavity molded in the plug wrap and in the side wall providing at least one smoke channel in the exterior side wall of the plug extending longitudinally from one of the end walls to a location spaced from the other (i.e., short of) of the end walls. Preferably, there are a plurality of longitudinally extending cavities molded into the end of the plug and they are arranged in circumferentially spaced, parallel relationship. The porous plug wrap is formed of a non-thermoplastic material such as paper having a porosity of less than about two seconds and preferably between 0.1 and two seconds. This porosity may be the "natural" porosity of the paper or it may be an "artificial" porosity resulting from mechanically or electrically providing small holes or perforations in a paper of lesser porosity in order to increase its porosity to the indicated level.

The filter plug of this invention is assembled onto a cigarette or other smoking article in a manner analogous to that currently being used commerically for attaching fibrous filters to tobacco rods. This procedure essentially involves the attachment of the filter plug to the tobacco rod by tipping paper which comprises an essentially smoke impervious sleeve overlying portions of the plug and the tobacco rod for holding them in assembled relationship. In the structure of this invention, the tipping paper overlies the cavity or cavities in the exterior surface of the filter plug and provides the smoke channel or channels which accommodate that portion of the smoke which is not drawn from end to end throughout the entire length of the tow of the filter.

The fibrous material that is employed for making the tow comprising the main body portion of the filter plug of this invention is cellulose acetate or any other thermoplastic material that is known to be suitable for making fibrous filters. In commercial operation, the denier of the individual filaments is preferably between about 1.3 and 16 while the total denier of the tow is preferably between about 38,000 and 100,000.

As previously indicated, the plug wrap is preferably formed of a non-thermoplastic material such as paper, and in order to obtain a cigarette having a tar removal efficiency of greater than 50 percent at a pressure drop of between 2 and 2.5 inches of water, the porosity of the paper is preferably less than about 2 seconds, most preferably between 0.1 and 2 seconds. As suggested above, this porosity may be the "natural" porosity of the paper or an artificial porosity achieved by mechanically or spark perforating a paper which is more impermeable than that above specified. As is well known, the porosity of papers of this type is measured in terms of seconds, and as used herein, the term means the average number of seconds required for the displacement of 100 cubic centimeters of air through the dry paper in an area of 1.0 square inch obtained by testing five specimens with the "felt" side up and five additional

specimens with the "wire" side up. The method employed for this purpose has been standardized by the American Society for Testing Materials and has received the ASTM designation D726–55T which is a revision of ASTM designation D726–48. This standard method has also been recognized by the Technical Association of Pulp and Paper Industry under TAPPI Tentative Standard T460m–49. Inasmuch as the porosity is a measurement of the rate of flow of air in seconds through a sample of dry paper, it will be apparent that papers having the greater porosity are valued in the lower number of seconds and the higher number of seconds reflect the more impervious papers.

It will be appreciated that the performance characteristics of the filter of this invention will be dependent in part not only upon the type and the denier of the filamentary material and the tow but also upon the porosity of the plug wrap through which a portion of the smoke flows during smoking. In this connection, most flexibility is achieved if the total exposed area of the cavity or cavities through which a portion of the smoke passes is such that it is between about 1 and 15 times (preferably between about 5 and 10 times) the area presented by the filter plug at the exposed end surface from which the cavities extend. In other words, it is preferred that the ratio of the total exposed surface of the cavity or cavities to the exposed area of the end of the tow adjacent the cavities be between about 1 to 1 and 15 to 1, most preferably between about 5 to 1 and 10 to 1. Also, it is preferred that the percentage of the total surface area presented by the cavity or cavities with respect to the total side wall surface area of the filter plug be within the range of from 20 to 90 percent, and preferably in the range from 70 to 85 percent.

The filter plug of this invention is readily prepared by providing a tow of filamentary or fibrous thermoplastic material having the appropriate denier and overwrapped with the plug paper having the indicated porosity. The ends of the fibers or filaments are exposed at the opposite ends of the tow. The resulting assembly is subjected to a hot molding operation to impress the cavity or cavities so that one end of the plug will have the desired cavity configuration molded into the overwrap and the tow. This may be effected by plunging one end of the plug into a hot ring mold having a scalloped interior configuration but having a cross-section somewhat less than the overwrapped tow. A machine that may be adapted for such a plunging operation is described in the copending application of Beard et al. Ser. No. 171,448, filed Aug. 13, 1971, and assigned to the same assignee as this application. Alternatively, the molding may be effected by clamping the overwrapped tow between hot mold plates having the desired configuration.

DESCRIPTION OF THE DRAWING

For a more complete understanding of this invention, reference will now be made to the accompanying drawing in which:

FIG. 1 is a perspective view of a filter plug constructed in accordance with one embodiment of this invention;

FIG. 2 is an end elevational view of the plug shown in FIG. 1;

FIG. 3 is a sectional view of one end of a cigarette constructed in accordance with one embodiment of this invention using the plug shown in FIGS. 1 and 2 with the cavity end of the plug in an upstream orientation; and

FIG. 4 is the same as FIG. 3 except that the plug is arranged with the cavity end in a downstream orientation.

With more particular reference to the drawings, the filter plug 10 consists essentially of a tow 12 of cellulose acetate filaments or fibers arranged in a longitudinal direction. The ends of the filaments in the tow are exposed at the opposite ends of the plug so that as smoke is drawn through the device at least a portion of it will flow through the filter from end to end in the conventional manner. The filter plug 10 is generally cylindrical in shape and has essentially the same diameter as the tobacco section or rod 14 including cigarette paper to which it is attached. The side walls of the plug 10 between the opposite ends are closely embraced by a plug overwrap 16 which is formed from thin porous paper, preferably having a porosity within the range previously indicated. In the drawing the relative thickness of the plug wrap is magnified in the interest of clarity. A plurality of cavities 18 are molded in the plug wrap and in the tow at one end of the filter plug. In the modification shown in the drawings, there are six of these cavities, extending longitudinally in parallel, circumferentially spaced relationship. The cavities extend from one end of the plug to a position short of the opposite end and when overwrapped with smoke impervious tipping paper 20, as shown in FIGS. 3 and 4, provide smoke channels for the flow of that portion of the smoke which does not pass throughout the entire length of the filter plug. It will be noted that in the end of the plug opposite the end containing the cavities, a portion of the porous wrap 16 is in 360° angle contacting non-spaced relationship with the tipping paper or sleeve 20.

As previously indicated, the total exposed surface area presented by the cavities is that of the bottom, side and end walls of each which provide the total surface through which the smoke passes to or from the channels. This surface is preferably 1 to 15, most preferably 5 to 10, times the end wall surface of the plug adjacent the cavities (i.e., the end wall seen in FIG. 2). Also, this total exposed cavity surface is preferably between about 20 to 90 percent, most preferably 70 to 85 percent, of the total side wall surface of the plug.

In the modification shown in FIG. 3, the open ends of the channels 18 are located adjacent the tobacco rod 14 so that during draw a first portion of the smoke enters the end of the plug and passes from end to end therethrough while a second portion of the smoke passes directly from the tobacco rod into the channels formed by the cavities 18 and then through the porous paper plug overwrap 16 and into the tow 12 for discharge through the downstream end. In FIG. 4 the plug has been reversed so that the smoke stream divides after it is within the main body of the tow, a portion continuing its progress out through the downstream end and the other portion being diverted or escaping through the porous plug wrap 16 and then into the channels formed by the cavities 18. In order to permit the desired flow of smoke through the channels to an effective degree, the depth of the cavity or cavities (i.e., the distance from the bottom of the cavity 18 to the inner surface of the tipping paper 20) should preferably be greater than about 0.004 inch and suitably about 0.008 inch.

Thus, it will be apparent that a filter plug for a cigarette has been provided which presents a large surface area for the introduction or withdrawal of the smoke from the filter. One portion of this area constitutes the end wall of the tow forming the plug and another portion of this area is made up of the side walls of the cavities formed in the plug. By this structure the efficiency and pressure drop characteristics of the filter may be readily adjusted over a wide range to satisfy a desired requirement. As indicated, this may be done by modifying the filament and tow denier, the porosity of the paper plug wrap and the dimension and size of the cavity or cavities in the plug.

METHOD OF MANUFACTURE

An important feature of this invention resides in the ease with which the filter plug may be manufactured at high speeds with a minimum modification of presently existing cigarette manufacturing machinery. As indicated, the tow per se is formed of filamentary thermoplastic material such as cellulose acetate containing a suitable plasticizer and the plug overwrap is a conventional high porosity paper which is normally used in the manufacture of filter plug for fiber type filters. It has been discovered that this conventional filter plug is readily adaptable for use in preparing the modified plug of this invention by a simple molding operation. The method involves providing the tow of fibrous material overwrapped with the porous paper and then subjecting the composite to hot molding to the desired configuration at a temperature and for a time sufficient to deform and set the thermoplastic material and paper overwrap to the desired cavity-containing configuration. The plasticizer plays an important role in the heat setting properties of the thermoplastic material. A plasticizer such as triacetin is used in amounts ranging from 3 to 15 percent by weight of tow and preferably from 8 to 12 percent. The porous paper overwrap permits the use of a relatively high mold temperature since it is not melted by the heat and it prevents direct contact of the mold with the thermoplastic fibrous material. Thus, the heat of the mold rapidly sets the fibrous material in the desired and predetermined configuration without melting. By use of the high temperature, suitably between 175° and 300° C., the dwell time in the mold may be reduced to less than one second. As previously indicated, it will be appreciated that the molding operation may be effected by plunging one end of the filter plug through a ring-shaped heated mold having a reduced diameter and adapted to produce the desired configuration of the cavities in the end of the filter plug. If desired, the mold may be one which closes around one end of the plug, or it may close around a central portion of a "2 up" plug assembly followed by cutting through a center line to form two plugs, as will be apparent to one skilled in the art.

SPECIFIC EXAMPLE

A 1.6/45,000 denier cellulose acetate filter plug 25 millimeters long and 8 millimeters in diameter was wrapped with paper having a porosity of 0.34 second and subjected to a molding operation to give a plug having the general appearance shown in the drawings. To effect the molding a metal ring with a scalloped design inside the ring and sized so as to permit the 8-millimeter diameter filter plug to be snugly inserted therein served as the mold. The metal mold was heated to about 275° C. and the 25-millimeter long filter plug was quickly pushed into the mold and withdrawn, the total dwell time being about one-half second. The shape of the plug was permanently altered by the action of the hot mold to give six equally spaced, longitudinal channels 20 millimeters long on the surface of the plug. The modified filter plug was attached to a tobacco rod of the same diameter by means of tipping paper with the modified end of the plug abutting the tobacco rod. The pressure drop (P) across the filter was determined to be 2.35 inches of water (measured at a flow rate of 14.5 cubic centimeters per second) and the exposed surface area associated with the longitudinal channels was approximately 340 square millimeters (equivalent to a ratio of about 7 to 1 for the exposed surface area on the side of the plug versus the end). Machine-smoking under standard conditions resulted in a total particulate removal (TPM) efficiency (E) of 66.3 percent or an E/P ratio of 28.2 The E/P ratio for a conventional 1.6/45,000 denier cellulose acetate filter plug smoked in the same manner was found to be 17.6 (74 percent efficiency and a 4.20-inch pressure drop).

While the drawings and the specific example show cavities having an essentially U-shaped cross-section, it will be apparent that other cross-sectional shapes are possible and the shape of the mold may take on a number of shapes, e.g., hexagonal, square, etc. The cavity in such instances comprises a discontinuity in the otherwise cylindrical surface of the plug which, when enclosed by the sleeve of tipping paper, defines the necessary longitudinal passageway for the smoke in accordance with this invention.

While several specific embodiments have been indicated in the foregoing, it will be apparent that many modifications may be made without departing from the spirit and scope of this invention as defined in the appended claims.

We claim:

1. A filter plug for a smoking article comprising a smoke impervious sleeve embracing a porous tow of longitudinally extending thermoplastic fibers exposed at opposite ends for the passage of smoke therethrough from end to end and a thin non-thermoplastic porous wrap for said tow, embracing in contacting non-spaced relationship the side wall of said tow between said ends, said wrap being in 360° angle contacting non-spaced relationship with said sleeve for a substantial first portion of its length, said tow having a cavity molded in the wrap and said side wall and providing a smoke channel defined by the exterior surface of said wrap and a substantial second portion of the length of said sleeve, said channel extending from one of said ends to a location spaced from the other of said ends.

2. The filter recited in claim **1** wherein the porosity index of said porous wrap is less than about 2 seconds.

3. The filter recited in claim **1** in which there are a plurality of said cavities providing a plurality of said smoke channels.

4. The filter recited in claim **3** in which said channels are arranged in spaced, parallel, longitudinally extending relationship.

5. The filter recited in claim **3** wherein ratio of the surface area defined by said cavities to the surface area of said one end is between about 1 to 1 and 15 to 1.

6. A filter plug for a smoking article being in the form of a cylinder of essentially uniform cross-section throughout its length and comprising a smoke impervi-

ous sleeve embracing a porous tow of longitudinally extending thermoplastic fibers exposed at opposite ends for the passage of smoke therethrough from end to end and a porous paper wrap for said tow, closely embracing in contacting non-spaced relationship the cylindrical side walls of said tow between said ends, said wrap being in 360° angle contacting non-spaced relationship with said sleeve for a substantial first portion of its length, said paper wrap having a porosity index less than about 2 seconds, said tow having a plurality of longitudinal, parallel, spaced cavities, molded in the paper wrap and the side wall of said tow, providing smoke channels in the cylindrical side wall of said tow defined by the exterior surface of said wrap and a substantial second portion of the length of said sleeve, said channels extending from one of said ends to a location spaced from the other of said ends, and the ratio of the exterior surface areas presented by said cavities to the exterior surface area of said one end is between about 1 to 1 and 15 to 1.

7. The filter recited in claim **6** wherein the percentage of the exposed surface areas within said cavities is between about 25 and 90 percent of the total side wall surface area of said tow.

8. The filter recited in claim **6** wherein the fibers are cellulose acetate filaments, the denier of the filaments is between about 1.3 and 16 and the total denier of the tow is between about 38,000 and 100,000.

9. A cigarette comprising a tobacco section overwrapped with cigarette paper, a porous filter plug positioned at one end of said tobacco section, and a smoke impervious sleeve overlying portions of said plug and said tobacco section for holding them in fixed relationship, said plug comprising a tow of longitudinally extending thermoplastic fibers for the passage of smoke therethrough from end to end and a thin non-thermoplastic porous plug wrap, embracing and in contacting non-spaced relationship with the side wall of said tow between the ends thereof, said plug having a cavity, molded in the plug wrap and said side wall, said wrap being in 360° angle contacting non-spaced relationship with said sleeve for a substantial portion of its length providing a smoke channel defined by the interior surface of said sleeve and the exterior surface of said wrap extending from one end of said plug to a location spaced short of the opposite end thereof whereby a portion of the smoke from the tobacco section passes through said tow from end to end of said plug and another portion of said smoke passes through said channel, said porous plug wrap and a portion of the two in said plug.

10. The cigarette recited in claim **9** wherein said one end of said plug faces upstream.

11. The cigarette recited in claim **9** wherein said one end of said plug faces downstream.

12. A cigarette comprising a tobacco section overwrapped with cigarette paper, a porous filter plug positioned at one end of said tobacco section, and a smoke impervious sleeve overlying portions of said plug and said tobacco section for holding them in fixed relationship, said plug having a uniform cross-section substantially the same as that of the tobacco section throughout its length and consisting essentially of a tow of longitudinally extending thermoplastic fibers for passage of smoke therethrough from end to end and a porous paper plug wrap, closely embracing and in non-spaced contacting relationship with the side walls of said tow between the ends thereof, said plug having a plurality of longitudinal, parallel, circumferentially spaced cavities, molded in the paper plug wrap and the side wAll of said tow, said wrap being in 360° angle contacting non-spaced relationship with said sleeve for a substantial portion of its length provIding a plurality of smoke channels defined by the interior surface of said sleeve and the exterior surface of said wrap extending from one end of said plug to a location short of the opposite end thereof whereby a portion of the smoke from the tobacco section passes through said tow from end to end of said plug and another portion of said smoke passes through said channels, said porous plug wrap and a portion of the tow in said plug.

13. The cigarette recited in claim **12** wherein the porosity index of said paper plug wrap is between about 0.1 and 2 seconds.

14. The cigarette recited in claim **13** wherein the ratio of the exterior surface areas presented by said cavities in the plug to the exterior surface area of said one end wall is between about 1 to 1 and 15 to 1.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,752,165 Dated August 14, 1973

Inventor(s) Gloria C. Harllee and John D. Woods

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

TITLE PAGE:

Insert -- Assignee: R. J. Reynolds Tobacco Company
Winston-Salem, North Carolina 27102 --;

"Attorney ... Fred I. Williams" should be
-- Attorney ... Fred T. Williams --.

Column 6, line 19, insert a period (.) after "28.2".

Column 8, line 5, "two" should be -- tow --;

line 25, "wAll" should be -- wall --;

line 28, "provIding" should be -- providing --.

Signed and sealed this 12th day of February 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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