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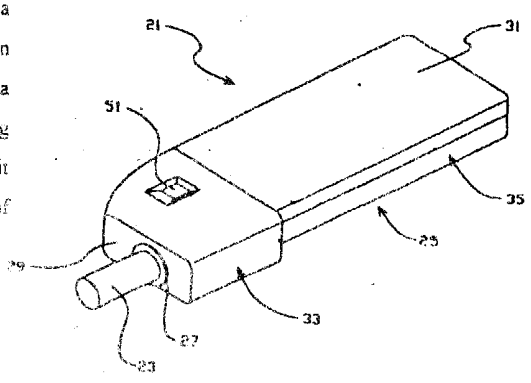
(54) Titre : Cigarette and heater for use in an electrical smoking system.

(57) Abrégé :

A cigarette (23) comprises a tobacco rod having filled and unfilled portions arranged so that electrical heater elements (37) may overlap both portions. The rod includes a tubular tobacco web. The web is constructed by converting tobacco feedstock into a continuous sheet of tobacco web and converting the continuous sheet of tobacco web into one or more bobbins of tobacco web suitable for automated manufacture of cigarettes. A heater (25) comprises a supporting hub and electrically resistive heater blades (37) defining a receptacle (27) for an inserted cigarette (23). Each blade comprises first and second heater blade legs each having a first end and a second end, and a connecting section connecting the second end of the first leg and the first end of the second leg. The blades (37) are heated by a resistive heating circuit and heat the inserted cigarette (23). The legs are separated by a gap to permit entrainment of flavour substances upon drawing.



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CIGARETTE AND HEATER FOR USE IN AN ELECTRICAL SMOKING SYSTEM

Field of Invention

The present invention relates generally to electrical smoking systems, and in particular to cigarettes adapted to cooperate with electrical lighters of electrical smoking systems, and to a heater for use in elctrical smoking systems.

Background of the Invention

Traditional cigarettes deliver flavor and aroma to the smoker as a result of combustion, during which a mass of combustible material, principally tobacco, is combusted at temperatures which often exceeds 800° C during a puff. Heat is drawn through an adjacent mass of tobacco by drawing on the mouth end. During heating, inefficient oxidation of the combustible material releases various gaseous combustion products and distillates from the tobacco. As these gaseous products are drawn through the cigarette, they cool and condense to form an aerosol which provides the tastes and aromas associated with smoking.

Traditional cigarettes have various perceived drawbacks associated with them. One of these is the production of sidestream smoke during smoldering between puffs which may be objectionable to non-smokers. Once lit, they must be fully consumed or be discarded. Re-lighting a traditional cigarette is possible but is usually an unattractive proposition to a discerning smoker for subjective reasons (flavor, taste, odor).

An alternative to the more traditional cigarettes includes those in which the combustible material itself does not itself release the tobacco aerosol. Such smoking articles may comprise a combustible, carbonaceous heating element (heat source) located at or about one end of the smoking article and a bed of tobacco-laden elements located adjacent the aforementioned heating element. The heating element is ignited with a match or cigarette lighter, and when a smoker draws upon the cigarette, heat generated by the heating element is communicated to the bed of tobacco-laden elements so as to cause the bed to release a tobacco aerosol. While this type of smoking device produces little or no sidestream smoke, it still generates products of combustion at the heat source, and once its heat source is ignited, it is not readily snuffed for future use in a practical sense.

In both the more conventional and carbon heated devices described above, combustion takes place during their use. This process naturally gives rise to many by-products

as the combusted material breaks down and interacts with the surrounding atmosphere.

Copending and commonly assigned, U.S. patent applications Serial No. 08/380,718, filed September 30, 1995 (PM 1697 Cont) and Serial No. 07/943,504, filed September 11, 1992 (PM 1550) together with US patents 5,093,894, 5,225,498, 5,060,671 and 5,095,921 disclose various heating elements and flavor generating articles which significantly reduce sidestream smoke while permitting the smoker to selectively suspend and reinitiate smoking. However the cigarette articles disclosed in these patents are not very durable and may collapse, tear or break from extended or heavy handling. In certain circumstances, these prior cigarettes may crush as they are even weaker and may tear or break as they are removed from the lighter.

The aforementioned, United States patent application Serial No. 08/380,718 (PM 1697 Cont) and US 5,388,594 describe an electrical smoking system including a novel electrically powered lighter and a novel cigarette that cooperates with the lighter. The preferred embodiment of the lighter includes a plurality of metallic serpentine heaters disposed in a configuration that slidingly receives a tobacco rod portion of the cigarette.

The preferred embodiment of the cigarette in Serial No. 08/380,718 (PM 1697 Cont) and also disclosed in EP-A-0,613,611 comprises a tobacco-laden tubular carrier, a cigarette paper overwrapped about the tubular carrier, an

arrangement of flow-through filter plugs at a mouthpiece end of the carrier and a filter plug at the free (distal) end of the carrier. The cigarette and the lighter are configured such that when the cigarette is inserted into the lighter and as individual heaters are activated for each puff, localized charring occurs at spots about the cigarette in the locality where each heater was bearing against the cigarette (hereinafter referred to as a "heater footprint"). Once all the heaters have been activated, these charred spots are closely spaced from one another and encircle a central portion of the carrier portion of the cigarette.

Depending on the maximum temperatures and total energies delivered at the heaters, the charred spots manifest more than mere discolorations of the cigarette paper. In most applications, the charring will create at least minute breaks in the cigarette paper and the underlying carrier material, which breaks tends to mechanically weaken the cigarette. For the cigarette to be withdrawn from the lighter, the charred spots must be at least partially slid past the heaters. In aggravated circumstances, such as when the cigarette is wet or toyed with or twisted, the cigarette may be prone to break or leave pieces upon its withdrawal from the lighter. Pieces left in the lighter fixture can interfere with the proper operation of the lighter and/or deliver an off-taste to the smoke of the next cigarette. If the cigarette breaks in two while being withdrawn, the smoker may be faced not only with

the frustration of failed cigarette product, but also with the prospect of clearing debris from a clogged lighter before he or she can enjoy another cigarette.

The preferred embodiment of the cigarette of US Ser. No. 08/180,718, EP-A-0,615,411 and Patent No. 5,388,594 is essentially a hollow tube between the filter plugs at the mouthpiece end of the cigarette and the plug at the distal end. This construction is believed to elevate delivery to the smoker by providing sufficient space into which aerosol can evolve off the carrier with minimal impingement and condensation of the aerosol on any nearby surfaces.

Several proposals have been advanced which significantly reduce undesired sidestream smoke while permitting the smoker to suspend smoking of the article for a desired period and then to resume smoking. For example, commonly assigned U.S. Patent Nos. 5,093,894; 5,225,498; 5,061,671 and 5,095,921 disclose various heating elements and flavor generating systems. EP-A-0,615,411 and U.S. Patent No. 5,388,594 disclose an electrical smoking system having heaters which are actuated upon sensing of a draw by control and logic circuitry. The heaters are preferably a relatively thin serpentine structure to transfer adequate amounts of heat to the cigarette and is lightweight.

Although these devices and heaters overcome the observed problems and achieve the stated objectives, many embodiments are subject to mechanical weakening and possible failure due to stresses induced by inserting and removing

the cylindrical tobacco medium and also by adjusting or toying with the inserted cigarette.

Further, undesired electrical shorts can occur if the shape of a heater assembly is altered, e.g., by adjusting or toying with the inserted cigarette.

Also, the electrical smoking systems employ electrically resistive heaters which have necessitated relatively complex electrical connections which can be disturbed by insertion and removal of the cigarette.

When we included cut filler with the hollow structure of the cigarette in EP-A-0,615,411, it was discovered that such cigarettes when fully filled with cut filler tobacco tended to operate adequately in an electrical lighter for the first several puffs. Thereafter, its delivery would tend to taper off. The same phenomenon would tend to occur when more traditional cigarettes were smoked in an electrical lighter such as the electrical lighter disclosed in EP-A-0,615,411.

When left unfilled, the hollow cigarette structures of the preferred embodiments of EP-A-0,615,411 were also somewhat vulnerable to collapse from extreme or rough handling.

The invention, in its various aspects, is defined by the independent claims appended hereto.

A cigarette embodying aspects of the present invention has the advantage of containing cut filler yet being operable with consistency when smoked as part of an

electrical smoking system.

A cigarette embodying aspects of the invention has the advantage of containing cut filler, and being adapted to cooperate with an electrical lighter and render satisfying levels of taste and delivery.

A cigarette embodying aspects of the present invention has the advantage of including cut filler, yet providing improved consistency in delivery from puff to puff.

Cigarettes embodying aspects of the invention may be readily manufactured and packed into attractive packaging.

Cigarettes embodying aspects of the invention may be physically robust and minimize condensation and/or filtration of aerosol within the cigarette and/or the lighter. They may further be resistive to breakage during the withdrawal of the cigarette from the lighter thereof.

Cigarettes embodying aspects of the present invention and suited for consumption with a lighter of an electrical smoking system, and may be less vulnerable to collapse or breakage during rough handling by the consumer.

Cigarettes embodying aspects of the present invention and suited for consumption with a lighter of an electrical smoking system may not be prone to collapse or breakage during the manufacture or packing of the cigarette.

Cigarettes embodying aspects of the invention and operative with an electrical lighter may be conducive to cost-effective methods of manufacture, even at production speeds.

Heaters embodying aspects of the invention may generate smoke from a tobacco medium without sustained combustion, may reduce the creation of undesired sidestream smoke, may permit the smoker to suspend and resume use, and may improve aerosol generation within the smoking system.

A heater structure embodying the invention may provide a desired number of puffs and be straightforwardly modified to change the number and/or duration of puffs provided without sacrificing subjective qualities of the tobacco.

A heating element embodying the invention may be mechanically suitable for insertion and removal of a cigarette.

An electrically resisting heater embodying spects of the invention may have simplified connections to an associated power source.

A heating element embodying aspects of the invention may be mechanically stable during heating cycles.

Embodiments of the invention may minimize variation of an interface between the heating element and the cigarette to avoid changes in heat transfer.

A heater embodying the invention may be more economical to manufacture.

One preferred embodiment provides a smoking system for delivering a flavored tobacco response to a smoker. The system includes a cigarette and an electrically operated lighter, which lighter includes a plurality of electrical heaters, with each of the heaters being adapted to, either

singularly or in concert, to thermally release a predetermined quantity of tobacco aerosol from the cigarette upon its/their activation. The cigarette comprises a tubular tobacco web, wherein a first portion of the tubular tobacco web is filled with a column of tobacco, preferably in the form of cut filler, and a second portion of the tubular tobacco web is left unfilled or hollow so as to define a void in the tobacco column.

More particularly, the aforementioned cigarette preferably comprises a tobacco rod formed from a tubular tobacco web and a plug of tobacco located within the tubular tobacco web. The tobacco rod is adapted to be slidingly received by an electrical heater fixture such that the heater elements locate alongside the tobacco rod at a location between the free end and an opposite end of the tobacco rod. Preferably the plug (or column) of tobacco extends from the free end of the tobacco rod to a location that is spaced from the opposite end of the tobacco rod so as to define a void (or hollow portion) adjacent the opposite end.

The relative dimensions of the cigarette and the heater fixture of the lighter are determined such that upon insertion of the cigarette into the lighter, each heater will locate alongside the tobacco rod at a predetermined location along the tobacco rod and, preferably, such that the longitudinal extent of contact between the heater and the cigarette (hereinafter "heater footprint") superposes at

least a portion of the aforementioned void and at least a portion of the plug of tobacco. In so doing, consistent and satisfactory delivery is obtained when the cigarette is electrically smoked, and condensation of tobacco aerosol at or about the heater elements is reduced.

In the alternative, the relative dimensions of the cigarette and the heater fixture of the lighter are determined such that upon insertion of the cigarette into the lighter, each heater will locate alongside the tobacco rod such that at least some, if not all of the heater footprints superpose only the filled portion of the tobacco rod (over the tobacco plug). In such configurations, the void may still be employed to facilitate aerosol formation and to help cool the smoke.

Preferably, a cigarette paper is wrapped about the tubular tobacco web so as to provide the appearance and feel of the more traditional cigarette during handling by the smoker.

The tobacco web preferably comprises a nonwoven tobacco base web and a layer of tobacco material located along at least one side of the tobacco base web.

The cigarette preferably also includes filter tipping at the aforementioned opposite end of the tobacco rod, which comprises a flow- through filter plug (also known in the art as "whistle-through" plugs), a mouthpiece filter plug and tipping paper attaching the plugs to the tobacco rod.

When a cigarette embodying the present invention is

inserted into a lighter of an electrical smoking system, the cigarette registers against a stop located within the heater fixture of the lighter (or at some equivalent registration) so that the electrical heating elements of the lighter locate consistently alongside the cigarette at generally the same location for each cigarette. As a puff is initiated, at least one of the heaters of the lighter is responsively activated to heat the cigarette at the aforementioned location along the tobacco rod. As a puff progresses, the tobacco rod is heated and aerosol is driven off the tobacco web and the filler. Where the heater footprint superposes the void in the tobacco rod, tobacco aerosol is almost immediately released into the space defined within the unfilled portion of the tobacco rod and drawn out of the cigarette. The tobacco web contributes most of this fraction of the total aerosol delivered by the cigarette and its immediacy is believed to favorably affect the nature and extent of the smoker's draw on the cigarette. Because of the greater mass of tobacco at the filled portion of the tobacco rod, there is a slight delay in the release of aerosol from where the heater footprint superposes the filled portion of the rod. The aerosol which is driven off the filled portion of the tobacco rod contributes an additional, dominating flavor and character to the smoke.

A further aspect of the present invention is the capacity to adjust delivery of a cigarette of an electrical smoking system, wherein the proportional amount of overlap

between the filled and unfilled portions of the tobacco rod by the heater footprint effects desired adjustments in delivery from one brand of cigarette to another or within line extensions of the same brand.

Yet another aspect of the present invention is a method of improving levels and consistency of delivery of aerosol from a cigarette operated with an electronic heater device, wherein the cigarette has a free end and an opposite end. The method comprises the steps of superposing a heater footprint over both a tobacco-filled portion of the cigarette adjacent the free end and an unfilled portion of the cigarette adjacent the opposite end, while simultaneously resistively heating along the heater footprint and drawing on the cigarette through the opposite end thereof.

Still another aspect of the present invention is to provide a filler containing cigarette that is operative with an electrical lighter, which cigarette includes a tobacco rod having a free-flow filter and a filler-free rod portion adjacent the free flow filter so as to promote consistent aerosol production.

Another aspect of the present invention is a reinforced tubular tobacco web having flax or wood cellulosic fiber added to its base web so as to provide additional strength. In the alternative, cellulosic fiber from tobacco stem feedstock may be included in the composition of the base web as a reinforcing agent.

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Robustness of the cigarette is improved by the inclusion of cut filler within the confines of its tubular tobacco web so as to provide a cigarette which can better withstand handling, including handling by cigarette manufacturing machines and by consumers.

A heater embodying the invention preferably comprises a supporting hub and a plurality of electrically resistive heater blades defining a receptacle to receive an inserted cigarette. Each blade comprises a first heater blade leg having a first end and a second end and extending at the first end from the supporting hub, a second heater blade leg having a first end and a second end, and a connecting section connecting the second end of the first leg and the first end of the second leg. The second end of the second leg extends toward the supporting hub and is electrically insulated therefrom. A resistive heating circuit is formed to heat the electrically resistive heater blade which in turn heats the inserted cigarette. The first and second legs are separated by a gap to permit entrainment of air to aid in evolving flavor substances from the heated cigarette upon drawing by a smoker.

Embodiments of the invention will now be described, by way of example, and with reference to the accompanying drawings, wherein:

Figs. 1 and 2 are perspective views of an electronic smoking system in accordance with a preferred embodiment of the present invention;

Fig. 3 is a breakaway perspective view of a cigarette engaged within the heater fixture of the smoking system shown in Fig. 1;

Fig. 4A is a sectional side view of a cigarette constructed in accordance with a preferred embodiment of the present invention;

Fig. 4B is a detailed perspective view of the cigarette shown in Fig. 4A, with certain components of the cigarette being partially unravelled;

Figs. 5A and 5B are flow diagrams of steps in a preferred process of making bobbins of the tobacco web of the cigarette shown in Figs. 4A and 4B, wherein Fig. 5A shows the steps of converting tobacco feedstock into a sheet of tobacco web, and Fig. 5B shows the steps of converting the tobacco web sheet into bobbins of tobacco web;

Fig. 6A is a cross-sectional side view of a cigarette constructed in accordance with a substantially hollow embodiment of the present invention;

Fig. 6B is a graphical representation of aerosol production versus time during each puff as generated by a cigarette constructed in accordance with the substantially hollow embodiment of the present invention of Fig. 6A;

Fig. 6C is a layout of a smoke measuring device that was used to establish data that is represented in Figs. 6B, 7B and 8;

Fig. 7A is a cross-sectional side view of a cigarette constructed in accordance with a fully-filled embodiment of

the present invention;

Fig. 7B is a graphical representation of aerosol production versus time during each puff as generated by a cigarette constructed in accordance with the fully-filled embodiment of Fig. 7A;

Fig. 8 is a graphical comparison of aerosol volume at each sequential puff as delivered by each cigarette of those described in reference to Figs. 4A, 6A and 7A;

Fig. 9 is a graphical presentation of the relationship between the delivery of total particulate matter (TPM) and the amount of heater overlap over the filled portion of the partially filled cigarette constructed in accordance with the preferred embodiment (Fig 4A) of the present invention;

Fig. 10 is a cross-sectional side view of a cigarette constructed in accordance with a second preferred embodiment of the present invention;

Fig. 11 is a cross-sectional side view of a cigarette constructed in accordance with a third preferred embodiment of the present invention;

FIG. 12 is a side, cross-sectional view of a heater fixture embodying a further aspect of the present invention;

FIG. 13 is a side view of a heater assembly embodying a further aspect of the present invention;

FIG. 14 is a side, cross-sectional view of a heater fixture embodying a further aspect of the present invention employing an electrical insulator coating;

FIG. 15 is a side, cross-sectional view of a heater

fixture embodying an aspect of the present invention employing an electrical insulator coating forming a hub;

FIG. 16 is a side, cross-sectional view of a heater fixture embodying an aspect of the present invention having serpentine shaped heater blade legs;

FIG. 17A is front, cross-sectional view of a heater blade having a planar underside facing an inserted cigarette;

FIG. 17B is a front, cross-sectional view of a heater blade having an angled underside facing an inserted cigarette;

FIG. 17C is a front, cross-sectional view of a heater blade having a curved underside facing an inserted cigarette;

FIG. 18 is a top view of a symmetrical arrangement of heater blades in a flat state prior to rolling;

FIG. 19 is a top view of a non-symmetrical arrangement of heater blades in a flat state prior to rolling;

FIG. 20 is a radial cross-sectional view of the electrical smoking system embodying the present invention, showing an alternative heater embodiment;

FIG. 21 is a longitudinal cross-sectional view of the flavor cartridge receiving cavity of the electrical smoking system of FIG. 20, taken from line A--A of FIG. 20;

FIG. 22 is a radial cross-sectional view showing another alternative heater embodiment; and

FIG. 23 is a longitudinal cross-sectional view of the

flaver cartridge receiving cavity of the electrical smoking system of FIG. 22, taken from line B--B of FIG. 22.

Detailed Description of the Preferred Embodiments

Referring to Figs. 1 and 2, a preferred embodiment of the present invention provides a smoking system 21 which includes a partially-filled, filler cigarette 23 and a reusable lighter 25. The cigarette 23 is adapted to be inserted into and removed from a receptacle 27 at a front end portion 29 of the lighter 25. Once the cigarette 23 is inserted, the smoking system 21 is used in much the same fashion as a more traditional cigarette, but without lighting or smoldering the cigarette 23 . The cigarette 23 is discarded after one or more puff cycles. Preferably, each cigarette 23 provides a total of eight puffs (puff cycles) or more per smoke; however it is a matter design expedient to adjust to a lesser or greater total number of available puffs.

The lighter 25 includes a housing 31 having front and rear housing portions 33 and 35. One or more batteries 35a are removably located within the rear housing portion 35 and supply energy to a plurality of electrically resistive, heating elements 37 which are arranged within the front housing portion 33 adjacent the receptacle 27. A control circuit 41 in the front housing portion 33 establishes

electrical communication between the batteries 35a and the heater elements 37. Preferably, the rear portion 35 is adapted to be readily opened and closed, such as with screws or snap-fit components, to facilitate replacement of the batteries. If desired, an electrical socket or contacts may be provided for recharging the batteries with house current or the like.

Preferably, the front housing portion 33 is removably joined to the rear housing portion 35, such as with a dovetail joint or a socket fit. The housing 31 is preferably made from a hard, heat-resistant material. Preferred materials include metallic or, more preferably, polymeric materials. Preferably, the housing 31 has overall dimensions of about 10.7 cm by 3.8 cm by 1.5 cm. so that it may fit comfortably in the hand of a smoker.

The batteries 35a are sized to provide sufficient power for the heaters 37 to function as intended and preferably comprise a replaceable and rechargeable type. Alternative sources of power are suitable, such as capacitors. In the preferred embodiment, the power source comprises four nickel-cadmium battery cells connected in series with a total, non-loaded voltage of approximately 4.8 to 5.6 volts. The characteristics required of the power source are, however, selected in view of the characteristics of other components in the smoking system 21, particularly the characteristics of the heating elements 37. U.S. Patent No. 5,144,962 (PM 1345), hereby incorporated by reference,

describes several types of power sources useful in connection with the smoking system of the present invention, such as rechargeable battery sources and power arrangements which comprise a capacitor which is recharged by a battery.

Referring now to Fig 3, the front housing portion 33 of the lighter 25 supports a substantially cylindrical heater fixture 39 which slidingly receives the cigarette 23. The heater fixture 39 houses the heater elements 37 and is adapted to support an inserted cigarette 23 in a fixed relation to the heater elements 37 such that the heater elements 37 are positioned alongside the cigarette at approximately the same location along each cigarette. Where each heater element 37 bears against (or is in thermal contact with) a fully inserted cigarette 23 is referred to herein as the heater footprint.

To assure consistent placement of the heating elements 37 relative to each cigarette 23 from cigarette to cigarette, the heater fixture 39 is provided with a stop 182 against which the cigarette is urged during its placement into the lighter 25. Other expedients for registering the cigarette 23 relative to the lighter 25 could be used instead.

The front housing portion 33 of the lighter 25 also includes an electrical control circuitry 41 which delivers a predetermined amount of energy from the power source 35a to the heating elements 37. In the preferred embodiment, the heater fixture 39 includes eight circumferentially

spaced-apart heating elements 37 which are concentrically aligned with the receptacle 27 and of serpentine form. Details of the heaters 37 are illustrated and described in commonly assigned U.S. Serial No. 07/943,504 (PM 1550), copending herewith and in commonly assigned, U.S. Patent No. 5,388,594 (PM 1697), both of which documents are incorporated herein by reference in their entireties. Additional heater fixtures 37 that are operable as part of the lighter 25 include those disclosed in commonly assigned, copending U. S. patent application Serial No. _____ filed January 6, 1995 (Attorney Docket No. PM 1729B CIP II); in commonly assigned, copending U.S. Serial No. 08/291,690, filed August 16, 1994 (Attorney Docket No. PM 1719), all which documents are incorporated herein by reference in their entireties; and in the later portion of this description given with respect to Figures 13 to 23. Preferably, the heaters 37 are individually energized by the power source 35a under the control of the circuitry 41 to heat the cigarette 23 preferably eight times at spaced locations about the periphery of the cigarette 23. The heating renders eight puffs from the cigarette 23, as is commonly achieved with the smoking of a more traditional cigarette. It may be preferred to fire more than one heater simultaneously for one or more of the puffs.

Another preferred heater arrangement is set forth in co-pending, commonly assigned, U.S. patent application Serial No. 08/224,848, filed April 8, 1994 (PM-1729B),

hereby incorporated by reference in its entirety.

Referring back to Fig. 2, preferably, the circuitry 41 is activated by a puff-actuated sensor 45 that is sensitive to either changes in pressure or changes in rate of air flow which occur upon initiation of a draw on the cigarette 23 by a smoker. The puff-actuated sensor 45 is preferably located within the front housing portion 33 of the lighter 25 and is communicated with a space inside the heater fixture 39 adjacent the cigarette 23 through a passageway extending through a spacer at the base of the heater fixture 39 and, if desired, a puff sensor tube (not shown). A puff-actuated sensor 45 suitable for use in the smoking system 21 is described in commonly assigned U.S. Patent No. 5,060,671 (PM 1337), the disclosure of which is incorporated herein by reference. The puff sensor 45 preferably comprises a Model 163PC01D35 silicon sensor, manufactured by the MicroSwitch division of Honeywell, Inc., Freeport, Illinois. Flow sensing devices, such as those using hot-wire anemometry principles, have also been successfully demonstrated to be useful for activating an appropriate one of the heater elements 37 upon detection of a change in air flow. Once activated by the sensor 45, the control circuitry 41 directs electric current to an appropriate one of the heater elements 37.

An indicator 51 is provided at a location along the exterior of the lighter 25, preferably on the front housing portion 33, to indicate the number of puffs remaining in a

smoke of a cigarette 23. The indicator 51 preferably includes a seven-segment liquid crystal display. In the preferred embodiment, the indicator 51 displays the digit "8" when a cigarette detector 53 detects the presence of a cigarette in the heater fixture 39. The detector 53 preferably comprises a light sensor at the base of the heater fixture 39 that detects when a beam of light is reflected off an inserted cigarette 23. Thereupon the cigarette detector 53 provides a signal to the circuitry 41 which, in turn, responsively provides a signal to the indicator 51. The display of the digit "8" on the indicator 51 reflects that the eight puffs provided on each cigarette 23 are available, i.e., none of the heater elements 37 have been activated to heat the cigarette 23. After the cigarette 23 is fully smoked, the indicator displays the digit "0". When the cigarette 23 is removed from the lighter 25, the cigarette detector 53 no longer detects a presence of a cigarette 23 and the indicator 51 is turned off. The cigarette detector 53 is modulated so that it does not constantly emit a beam of light, which would otherwise create an unnecessary drain on the power source 35a. A preferred cigarette detector 53 suitable for use with the smoking system 21 is a Type OPR5005 Light Sensor, manufactured by OPTEX Technology, Inc., 1215 West Crosby Road, Carrollton, Texas 75006, USA.

In the alternative to displaying the remainder of the puff count, the detector display may instead be arranged to

indicate whether the system is active or inactive ("on" or "off").

As one of several possible alternatives to using the above-noted cigarette detector 53, a mechanical switch (not shown) may be provided to detect the presence or absence of a cigarette 23 and a reset button (not shown) may be provided for resetting the circuitry 41 when a new cigarette is inserted into the lighter 25, e.g., to cause the indicator 51 to display the digit "8", etc. Power sources, circuitry, puff-actuated sensors, and indicators useful with the smoking system 21 of the present invention are described in commonly assigned, U.S. Patent No. 5,060,671 (PM 1337) and the commonly assigned U.S. patent application Serial No. 07/943,504, (PM 1550) both of which are incorporated by reference.

Referring now to Figs. 4A and 4b, the cigarette 23 as constructed in accordance with the preferred embodiment of the present invention comprises a tobacco rod 60 and a filter tipping 62, which are joined together with tipping paper 64.

The partially-filled, filler cigarette 23 preferably has an essentially constant diameter along its length and, which like more traditional cigarettes, is preferably between approximately 7.5 mm and 8.5 mm in diameter so that the smoking system 21 provides a smoker a familiar "mouth feel". In the preferred embodiment, the cigarette 23 is 62 mm in overall length, thereby facilitating the use of

conventional packaging machines in the packaging of the cigarettes 23. The combined length of the mouthpiece filter 104 and the free-flow filter 102 is preferably 30 mm. The tipping paper preferably extends approximately 6 mm over the tobacco rod 60. The total length of the tobacco rod 62 is preferably 32 mm. Other proportions, lengths and diameters may be selected instead of those recited above for the preferred embodiment.

The tobacco rod 60 of the cigarette 23 preferably includes a tobacco web 66 which has been folded into a tubular (cylindrical) form.

An overwrap 71 intimately enwraps the tobacco web 66 and is held together along a longitudinal seam as is common in construction of more traditional cigarettes. The overwrap 71 retains the tobacco web 66 in a wrapped condition about a free-flow filter 74 and a tobacco plug 80.

Preferably, the cigarette overwrap paper 71 is wrapped intimately about the tobacco web 66 so as to render external appearance and feel of a more traditional cigarette. It has been found that a better tasting smoke is achieved when the overwrap paper 71 is a standard type of cigarette paper, preferably a flax paper of approximately 20 to 50 CORESTA (defined as the amount of air, measured in cubic centimeters, that passes through one square centimeter of material, e.g., a paper sheet, in one minute at a pressure drop of 1.0 kilopascal) and more preferably of about 30 to 45 CORESTA, a basis weight of approximately 23 to 35 grams

per meter squared (g/m^2) and more preferably about 23 to 30 g/m^2, and a filler loading (preferably calcium carbonate) of approximately 23 to 35% by weight and more preferably 28 to 33% by weight.

The overwrap paper 71 preferably contains little or no citrate or other burn modifiers, with preferred levels of citrate ranging from 0 to approximately 2.6% by weight of the overwrap paper 71 and more preferably less than 1%.

The tobacco web 66 itself preferably comprises a base web 68 and a layer of tobacco flavor material 70 located along the inside surface of the base web 68. At the tipped end 72 of the tobacco rod 60, the tobacco web 66 together with the overwrap 71 are wrapped about the tubular free-flow filter plug 74. The free-flow filter 74 provides structural definition and support at the tipped end 72 of the tobacco rod 60 and permits aerosol to be withdrawn from the interior of the tobacco rod 60 with a minimum pressure drop. The free-flow filter 74 also acts as a flow constriction at the tipped end 72 of the tobacco rod 60, which is believed to help promote the formation of aerosol during a draw on the cigarette 23. The free-flow filter is preferably at least 7 millimeters long to facilitate machine handling and is preferably annular, although other shapes and types of low efficiency filters are suitable, including cylindrical filter plugs.

At the free end 78 of the tobacco rod 60, the tobacco web 66 together with the overwrap 71 are wrapped about a

cylindrical tobacco plug 80. Preferably, the tobacco plug 80 is constructed separately from the tobacco web 66 and comprises a relatively short column of cut filler tobacco that has been wrapped within and retained by a plug wrap 84.

Preferably the tobacco plug 80 is constructed on a conventional cigarette rod making machine wherein cut filler (preferably blended) is air formed into a continuous rod of tobacco on a traveling belt and enwrapped with a continuous ribbon of plug wrap 84 which is then glued along its longitudinal seam and heat sealed. However, in accordance with the preferred embodiment of the present invention, the plug wrap 84 is preferably constructed from a cellulosic web of little or no filler, sizing or burn additives (each at levels below 0.5% weight percent) and preferably little or no sizing. Preferably, the tobacco plug wrap 84 has a low basis weight of below 15 grams per meter squared and more preferably about 13 grams per meter squared. The tobacco plug wrap 84 preferably has a high permeability in the range of about 20,000 to 35,000 CORESTA and more preferably in the range of about 25,000 to 35,000 CORESTA, and is constructed preferably from soft wood fiber pulp, abaca-type cellulose or other long fibered pulp. Such papers are available from Papierfabrik Schoeller and Hoescht GMBH, Postfach 1155, D-76584, Gernsback, GERMANY; another paper suitable for use as the plug wrap 84 is the paper TW 2000 from DeMauduit of Quimperle FRANCE, with the addition of carboxy-methyl cellulose at a 2.5 weight percent level.

The tobacco rod making machine is operated so as to provide a tobacco rod density of approximately .17 to .30 grams per cubic centimeter (g/cc), but more preferably in a range of at least .20 to .30 g/cc and most preferably between about .24 to .28 g/cc. The elevated densities are preferred for the avoidance of loose ends at the free end 78 of the tobacco rod 60. However, it is to be understood that the lower rod densities will allow the tobacco column 82 to contribute a greater proportion of aerosol and flavor to the smoke. Accordingly, a balance must be struck between aerosol delivery (which favors a low rod density in the tobacco column 82) and the avoidance of loose-ends (which favors the elevated ranges of rod densities).

The tobacco column 84 preferably comprises cut filler of a blend of tobaccos typical of the industry, including blends comprising bright, burley and oriental tobaccos together with, optionally, reconstituted tobaccos and other blend components, including traditional cigarette flavors. However, in the preferred embodiment, the cut filler of the tobacco column 84 comprises a blend of bright, burly and oriental tobaccos at the ratio of approximately 45:30:25 for the U.S. market, without inclusion of reconstituted tobaccos or any after cut flavorings. Optionally, an expanded tobacco component might be included in the blend to adjust rod density, and flavors may be added.

The continuous tobacco rod formed as described above is sliced in accordance with a predetermined plug length for

the tobacco plug 80. This length is preferably at least 7 mm in order to facilitate machine handling. However, the length may vary from about 7 mm to 25 mm or more depending on preferences in cigarette design which will become apparent in the description which follows, with particular reference to Figs. 4A and 4b.

As a general matter, the length 86 of the tobacco plug 80 is preferably set relative to the total length 88 of the tobacco rod 60 such that a void 90 is defined along the tobacco rod 60 between the free-flow filter 74 and the tobacco plug 80. The void 90 corresponds to an unfilled portion of the tobacco rod 60 and is in immediate fluid communication with the tipping 62 through the free flow filter 74 of the tobacco rod 60.

Referring particularly to Fig.4A, the length 86 of the tobacco plug 80 and its relative position along the tobacco rod 60 is also selected in relation to features of the heater elements 37. When a cigarette is properly positioned against the stop 182 of the heater fixture 39, a portion 92 of each heater element 37 will contact the tobacco rod 60 along a region of the tobacco rod 60. This region of contact is referred to as a heater footprint 94. The heater footprint 94 (as shown with a double arrow in Fig. 4A) is not part of the cigarette structure itself, but instead is a representation of that region of the tobacco rod 60 where the heater element 37 would be expected to reach operative heating temperatures during smoking of the cigarette 23.

Because the heating elements 37 are a fixed distance 96 from the stop 182 of the heater fixture 39, the heater foot print 94 consistently locates along the tobacco rod 60 at the same predetermined distance 96 from the free end 78 of the tobacco rod 60 for every cigarette 23 that is fully inserted into the lighter 25.

Preferably, the length of the tobacco plug 80, the length of the heater footprint 94 and the distance between the heater footprint 94 and the stop 182 are selected such that the heater footprint 94 extends beyond the tobacco plug 80 and superposes a portion of the void 90 by a distance 98. The distance 98 by which the heater footprint 94 superposes the void 90 (the unfilled portion of the tobacco rod 60) is also referred to as the "heater-void overlap" 98. The distance by which the remainder of the heater footprint 94 superposes the tobacco plug 80 is referred to as the "heater-filler overlap" 99.

The tipping 62 preferably comprises a free-flow filter 102 located adjacent the tobacco rod 60 and a mouthpiece filter plug 104 at the opposite end of the tipping from the tobacco rod 60. Preferably the free-flow filter 102 is tubular and transmits air with very little pressure drop. Other low efficiency filters of standard configuration could be used instead, however. The inside diameter of the free flow filter 96 is preferably at or between 2 to 6 millimeters and is preferably greater than that of the free flow filter 74 of the tobacco rod 60.

The mouthpiece filter plug 104 closes off the free end of the tipping 62 for purposes of appearance and, if desired, to effect some filtration, although it is preferred that the mouthpiece filter plug 104 comprise a low efficiency filter of preferably about 15 to 25 percent efficiency.

The free-flow filter 102 and the mouthpiece filter plug 104 are preferably joined together as a combined plug 110 with a plug wrap 112. The plug wrap 112 is preferably a porous, low weight plug wrap as is conventionally available to those in the art of cigarette making. The combined plug 110 is attached to the tobacco rod 60 by the tipping paper 64 of specifications that are standard and conventionally used throughout the cigarette industry. The tipping paper 64 may be either cork, white or any other color as decorative preferences might suggest.

Preferably, a cigarette 23 constructed in accordance with the preferred embodiment has an overall length of approximately 62 mm, of which 30 mm comprises the combined plug 110 of the tipping 62. Accordingly, the tobacco rod 60 is 32 mm long. Preferably, the free-flow filter 74 of the tobacco rod 60 is at least 7 mm long and the void 91 between the free-flow filter 74 and the tobacco plug 80 is preferably at least 7 mm long. In the preferred embodiment, the heater foot print 94 is approximately 12 mm long and located such that it provides a 3 mm heater-void overlap 98, leaving 9 mm of the heater foot

print 94 superposing the tobacco plug 80.

It is to be understood that the length of the void 91 and the length of the tobacco plug 80 may be adjusted to facilitate manufacturing and more importantly, to adjust the smoking characteristics of the cigarette 23, including adjustments in its taste, draw and delivery. The length of the void 91 and the amount of heater-filler overlap (and heater-void overlap) may also be manipulated to adjust the immediacy of response, to promote consistency in delivery (on a puff-to-puff basis as well as between cigarettes) and to control condensation of aerosol at or about the heaters.

In the preferred embodiment, the void 91 (the filler-free portion of the tobacco rod 60) extends approximately 7 mm to assure adequate clearance between the heater foot print 94 and the free-flow filter 74. In this way, margin is provided such that the heater foot print 94 does not heat the free-flow filter 74 during smoking. Other lengths are suitable, for instance, if manufacturing tolerances permit, the void 91 might be configured as short as approximately 4 mm or less, or in the other extreme, extended well beyond 7 mm so as establish an elongate filler-free portion along the tobacco rod 60. The preferred range of lengths for the filler-free portion (the void 91) is from approximately 4mm to 13mm and more preferably 5 to 12 mm.

The base web 68 physically separates the heating elements 37 from the tobacco flavor material, transfers heat generated by the heater elements 37 to

the flavor material 70, and maintains physical cohesion of the tobacco rod during handling, insertion into the lighter 25 and removal of the cigarette after smoking.

In the description which follows, certain percentage levels and/or relative weights are set forth for the various components comprising the tobacco web 66. Unless otherwise expressed, or otherwise readily apparent to one of ordinary skill in the art to be to the contrary, recitations of weight percentage are on a dry weight basis, that is, the recited percentage levels and/or relative weights are adjusted for (do not include) moisture content.

The process for manufacturing the tobacco web 66 is preferably without the addition of carbon-fiber as will be described in paragraphs which follow. At the conclusion of the preferred manufacturing process, the base web 68 itself has a preferred total basis weight of approximately 35 to 45 g/m², more preferably approximately 40 g/m². At 40 g/m², the base web 68 preferably comprises approximately 28 g/m² tobacco fiber and approximately 12 g/m² cellulosic fiber such as from wood pulp or flax. The cellulosic fiber serves as a cellulosic strengthening agent in the composition of the base web 68. It is preferred to minimize the amount of cellulosic fiber in the base web for subjective reasons (to avoid establishing a papery note to the taste of the cigarette). Generally, the ratio of tobacco fiber to cellulosic fiber in the base web 68 on a dry weight basis should range from approximately 2:1 to 4:1. The preferred

cellulosic material is an unbleached, kraft softwood cellulose, although most wood and flax pulps are workable.

An alternative strengthening agent for the base web 68 is cellulosic fiber from produced tobacco stem.

Although it is not preferred, alginate may be coated along one side of the base web 68 at a level of approximately 1 g/m². If alginate is applied, it is preferred to be applied on a side of base web 68 opposite of the side receiving the tobacco favor material 70.

The tobacco material 70 is preferably applied to the base web 68 at dry weight levels of at least twice and more preferably about three to four times that of the base web 68. In the preferred embodiment, the tobacco material has a basis weight of approximately 130 g/m² so that preferably the grand total weight of the tobacco web 66 is approximately 170 g/m². On a dry weight basis, the tobacco material 70 comprises a portion of ground tobacco and extracted solids at a ratio in the range of approximately 3.5 to 1 (3.5:1) to five to one (5:1) by weight, although this ratio may be varied in a range from approximately 3:1 to 9:1. In the preferred embodiment, the ratio is approximately 4.1.

Glycerine is added to the tobacco material 70 as a humectant and as an aerosol precursor at levels of about 10-14%, most preferably approximately 12% by dry weight of the tobacco material 70, but this add-on level may be varied anywhere from approximately 5% to as high as 20% or more by

dry weight of the tobacco material 70. When glycerine is reduced to only about 5 to 7% dry weight of the composition, the tobacco web 66 may be somewhat stiffer and more resistive to collapse when rolled into a tubular form.

Pectin is also added to the tobacco material 70 at dry weight percentile levels ranging from about .5 to 2%, preferably about 1.4%. Pectin is added as a coating agent. In its absence, the tobacco material 70 may tend to drain into (penetrate) the base web 68 excessively during the coating operation, rendering a grainy surface texture on the coated side of the tobacco web 66. Too much pectin hampers penetration, and weakens the bond between the tobacco material 70 and the base web 68. At approximately 1%, the pectin promotes adequate penetration and bonding between the layers so that the base web 68 may withstand the rigors of automated cigarette making.

Most preferably, the tobacco material 70 on the base web 68 comprises approximately 16-20% by dry weight extracted tobacco solids, 66-71% by dry weight ground tobacco particles, 8-14% glycerine and approximately 1.4% pectin. For U.S. markets, the ground tobacco which is incorporated into the tobacco material 70 preferably comprises a blend of bright, burley and oriental tobaccos wherein almost half of the blend is bright tobacco, approximately 1/3 is burley and the remainder is oriental. The composition and relative amounts of the blend components

may be advantageously adjusted to meet consumer preferences in the U.S. or other markets.

Referring to Figs. 5A and 5B, the preferred method of manufacturing a stock of tobacco web 66 in a form suitable for the automated manufacture of the cigarettes 23 comprises a first series of steps 120 (shown in Fig. 5A) for the conversion of tobacco feedstock, preferably tobacco strip, into a continuous sheet of the tobacco web 66s and a second series of steps 122 (shown in Fig. 5B) of converting the continuous sheet of tobacco web 66s into one or more wound bobbins 66b of tobacco web that are in condition for use in the automated manufacture of the cigarettes 23.

Referring specifically to Fig. 5A, the process 120 of converting tobacco feedstock into a continuous sheet of tobacco web sheet 66s begins with subjecting tobacco feedstock to an extraction step 124 (preferably, with water) to separate tobacco fiber from tobacco solubles of the original feedstock. The tobacco feedstock preferably comprises tobacco strip, but other forms of tobacco and/or tobacco laminas are suitable for use in this process. Preferably the tobacco strip comprises a blend of bright and burley tobaccos, and may optionally include oriental or other varieties.

The tobacco fiber collected from the extraction process 124 is itself subjected to a paper-making type process 126 to form a continuous sheet 68s of the base web.

In the process 126, the tobacco fiber from the

extraction step 124 is dispersed in water with the addition of a predetermined amount of cellulosic fiber which serves as a strengthening agent in the composition of the base web 68. Preferably, the cellulosic fiber comprises pulped cellulose from wood, flax and/or tobacco stem. Once combined, the mixed dispersion of tobacco fiber and cellulosic fiber is refined so as to form a web slurry 128 suitable for casting in the casting step 130, wherein the web slurry 128 is directed to a casting box arrangement of a web forming machine and cast upon a fourdrinier wire or on an endless steel belt, preferably the former.

It is more expedient to refine the dispersed mixture of tobacco fiber and the strengthening agent after mixing the two components together. They may instead be refined separately and then combined.

After the casting step 130, the resultant web 132 is then directed through one or more driers at a drying step 134, which step preferably comprises passing the web over a Yankee drier and one or more can driers, although a host of alternative arrangements and devices are known in the pertinent art and available for executing the drying step 134. At the conclusion of the web drying step 134, a monitoring step 136 is executed to measure the moisture content and weight of the dried web. The output 138 regarding measurement of moisture content is used to adjust the drying operation 134 to achieve and maintain the desired final moisture level in the sheet of base web 68s for

purposes of the subsequent coating operation 144. The sheet of base web 68s is preferably at or about 15% moisture by weight at the coating operation 144.

Referring back to the monitoring step 136, the output 140 regarding the weight of the sheet of base web 68s is used to adjust operation of the casting step 130 so as to achieve the preferred basis weight in the base web 68 as previously described. Such adjustments include changes in the rate at which the web slurry 128 is introduced into the casting box of the web forming machine in the casting step 130.

The web forming step 126 may optionally further comprise a coating step 142 which coats one side of the base web 68s with alginate at levels previously described along one side of the base web 68s opposite of the side that receives the tobacco flavor material 70. However, it is the preferred practice to proceed without the application of alginate.

At the conclusion of the web forming process 126, the base web is in the form of a continuous sheet 68s that is conducive to undergoing the coating operation 144. In the alternative it may be collected for subsequent coating operations off-line. It is preferable, however to proceed immediately into the coating operation 144 upon the formation of the sheet of base web 68s.

Preferably, the base web 68s enters the coating operation 144 at a moisture content of approximately 12 to

17%, more preferably 14.5 to 15.5% moisture.

Referring back to the extraction step 124, the tobacco solubles leave the extraction step 124 in the form of a dilute solution comprising approximately 5 to 10 percent dissolved tobacco constituents (solubles), more preferably 7 to 8 percent dissolved tobacco constituents. Preferably, the dilute solution is not subjected to any evaporative treatment, so as to minimize the application of heat to the solution. The application of heat can have an impact on the flavor contributed by the tobacco solubles when smoked as part of the cigarette 23.

These solubles (also known as "extracted liquor") from the extraction step 124 are mixed at a mixing step 146 with additional, finely ground tobacco, glycerine and pectin, together with water, all in relative amounts that ultimately render the final proportional contents as previously described for the dried condition of the tobacco material to. In connection with the mixing step 146, water is added (or withheld) in amounts sufficient to render at the conclusion of the mixing step 124 a dispersion of approximately 20 to 35 percent solids content, more preferably approximately 24 to 26 percent solids content. The ground tobacco particles of the mixture are preferably in the range of 60 to 400 mesh, wherein the term "mesh" refers to a 95% passage rate of tobacco particles through a mesh having the given number of openings per square inch. More preferably, the additional ground tobacco particles are

in the range of approximately 100 to 200 mesh and most preferably approximately 120 mesh.

If the mesh size of the ground tobacco particles is established above 120 mesh, more specifically at or about 180 to 220 mesh, the solids content of the slurried tobacco material at the conclusion of the mixing step 146 may be elevated, such as to levels of approximately 28 to 31%.

Upon conclusion of the mixing step 146, the resultant slurried tobacco material is directed immediately into the coating operation 144, although the coating operation may be electively performed at some subsequent time on an off-line basis. At the coating operation 144, the slurried tobacco material should have a solids content of approximately 22 to 27% by weight, more preferably at or about 24 to 25%.

At the coating step 144, the slurried tobacco material has a target weight percent of tobacco solubles of 4 to 8 percent, more preferably 5.5 to 6.5 weight percent of tobacco solubles. Preferably, the slurried tobacco material enters the coating operation 144 at a temperature in the range of ap- proximately 70 to 130° F, more preferable at or about 90° F plus or minus 5° F.

The coating step 128 is preferably performed with a standard reverse-roll coater located after a Yankee dryer beyond the endless belt or fourdrinier wire. The coating step may be performed with other suitable coating devices that are known and available to those of ordinary skill in the art of web forming operations. The tobacco material 70

may instead be cast or extruded onto the base web 68. Alternatively, the application step 128 may be executed off-line separate from the production of the sheet of base web 66s. During or after the coating step 128, flavors that are conventional in the cigarette industry are added if desired.

At the conclusion of the coating operation 144, a continuous sheet of tobacco web 66s is produced.

Referring now to Fig. 5B, the process now proceeds through the steps 122 of converting the sheet of tobacco web 66s into a wound bobbin 66b of tobacco web which is suitable for the automated production of cigarettes 23. Preferably, the conversion steps 122 are executed on-line with the production of the continuous sheet of tobacco web 66s. During the execution of the conversion steps 122, the operator should avoid conditions which create breaks, tears or other imperfections in the tobacco web sheet 66s so that a continuous winding of tobacco web is obtained in the bobbin 66b with few or no splices. Additionally, the sheet of tobacco web 66s is to be conditioned such that at the conclusion of the converting steps 122 the tobacco web will not bind upon itself and may be rapidly wound and unwound from the bobbin 66b without breakage.

The conversion steps 122 initiate with a drying step 146, wherein preferably the sheet of tobacco web 66s is fed continuously through a gas-fired, hot-air impingement dryer such as the type obtainable from Airtech Systems Corp. of Stroughton, Maine or with a steam heated, hot air dryer.

Other driers that are known in the art of web forming may be employed instead. The drying step 146 should be executed with minimal application of heat but in amounts sufficient to dry the tobacco web 68s from its initial condition (approximately 15% moisture content in the base web and approximately a 75% moisture level in the coating itself) to about 8.5 to 12% moisture content overall at the conclusion of the drying step 146. More preferably, the dried tobacco web sheet 66d is in the range of approximately 10 to 11% moisture content. This final moisture content is preferred for several reasons: to facilitate slitter operations at a later stage in the conversion process 122; to set a moisture level which approximates where the material would equilibrate when stored and/or sent to a manufacturing facility; and to establish a moisture level which avoids tackiness and binding of the base web material upon itself in the bobbin 66b.

Subsequent to the drying step 126, the dried tobacco web sheet 66d is cooled to an ambient temperature, preferably that of its likely place of storage and/or associated manufacturing facility, usually in the range of 65 to 80° F. This cooling step 148 not only facilitates equilibration of the tobacco web 66 to operational environments, but also avoids the risk of heat being retained within a bobbin 66b which might otherwise initiate a self-heating process. If left unchecked, self-heating could lead to extreme temperatures and degradation of the

subjective character of the tobacco web 66. Preferably, the cooling step is performed with a chilled-water cooled, air impingement cooler available from Airtech Systems Corp. of Stroughton, Maine, although a host of alternate cooling systems are known to those of ordinary skill in the art of web forming.

After the web drying and cooling steps 146 and 148, the dried and cooled tobacco web sheet 66dc is passed though a decurler apparatus, such as those offered by Thermo Electron Web Systems, Inc. of Auburn, Maine or some other suitable web decurler device as would be readily known and available to one of ordinary skill in the pertinent art of web forming. At the conclusion of the decurling step 150, the tobacco web 66 is substantially free of thermally induced warping along its edges and is in condition for a subsequent winding and slitting steps 152 and 154. However, prior to the execution of those steps, it is preferable to monitor temperature, moisture level and total weight of the tobacco web sheet 66s as it leaves the decurling step 150 so as to provide feedback and control of the process to assure that the tobacco web sheet 66s is in condition for winding and slitting and will result in the desired target values of temperature and moisture, total weight for the bobbins 66b.

In particular, in monitoring the tobacco web sheet 66, the reading of its total weight are used to adjust the coating operation 144, such as in the feed rate of slurried tobacco material into the reverse-roll coater or the gap at

the nip of the coater. Readings of the moisture level at the monitoring step 151 are used to control drying operations so as to achieve the target moisture levels in the sheet as described previously. Likewise, the cooling step 148 is controlled responsively to readings of the temperature of the sheet of tobacco web 66 at the monitoring step 151.

Thereafter, the tobacco web sheet 66 is wound at a winding step 152, which is performed with web winding machines readily known and available to one of ordinary skill in the art of web processing. Subsequent thereto, the wound tobacco web sheet 68s is slit into individual bobbins 66b, wherein the cut-width for each bobbin is respective of the desired circumference of the cigarette 23.

At the conclusion of the conversion steps 122, the bobbin 66b is in condition for automated manufacturing processes of the cigarettes 23, such as in the combining operations disclosed with reference to Fig. 6 of commonly assigned, copending U.S. Serial No. 07/943,504, filed September 11, 1992, which application is hereby incorporated by reference in its entirety.

The glycerin in the tobacco material 70 serves as an aerosol precursor and facilitates formation of a visible aerosol during smoking of the cigarette 23. Additionally, as the glycerin is released in the atmosphere, it condenses and provides an appearance typically expected of cigarette

smoke. Other humectants, suitable for use in the tobacco industry may be used in its place.

Optionally, after the casting step 123, alginate may be coated along a side of the web 68 before, during or after the coating step 126. The alginate coating provides additional strength and film formation along one side of the base web 68. However, the base web 68 has sufficient strength without alginate, and it is the preferred practice to construct the base web 68 without it.

The present invention may be practiced with other types of base webs 68 (carriers), including the carbon-fiber mats or the metallic or screen mats described in copending, commonly assigned U.S. patent applications Serial No. 07/943,504 (PM 1550); Serial No. 07/943,747 (PM 1655); and commonly assigned U.S. Patent No. 5,388,594 (PM 1697); and ourtransmission o European Patent Application EP-A-0,615,411 all of which are incorporated herein by reference in their entireties.

With regard to carbon-fiber mats as disclosed in EP-A-0,615,411, and in commonly assigned U.S. Patent No. 5,388,594 (PM 1697), whose continuation is co-pending herewith as Serial No. 08/380,718, filed September 30, 1995 (PM 1697 Cont), a preferred composition of such mats comprises a base web 68 comprising tobacco fiber in the range of 20-30 g/m², more preferably approximately 24 to 28 g/m², most preferably 26 g/m²; carbon fiber in the range of 2-9 g/m², more preferably 2 to 4 g/m², and most preferably

approximately 3 g/m²; and pectin in the range of approximately .5 to 1.5 g/m², and most preferably approximately 1 g/m² pectin. Preferably, these constituents are balanced so as to establish a base web 68 having a total basis weight of approximately 30 g/m². It is also preferred to use carbon fiber of 1/4 inch strand length to facilitate its dispersion during the slurry forming portion of the process. Initiation of dispersion of the carbon fiber feedstock is facilitated when procedures are used such as those disclosed in U.S. Patent Nos. 4,007,083 and 4,234,379.

In the alternate embodiment of the tobacco base web 66 (i.e., the carbon fiber mat), the total finished dry sheet weight is preferably about 160 g/m², of which 30 g/m² comprises the base web 68 and 130 g/m² comprises the tobacco material 70. In contrast, the more preferred embodiment of the tobacco base web 66, which does not include carbon-fiber, has a dried sheet weight of approximately 170 g/m², of which 40 g/m² comprises the base web 68 and 130 g/m² comprises the tobacco material 70.

Whichever type of base web 68 (or carrier) is used, the tobacco material 70 is preferably disposed on the inner surface of the base web 68 and liberates a tobacco flavored aerosol (response) when heated. Such materials may also include continuous sheets, foams, gels, dried slurries or dried spray-deposited slurries of tobacco material.

Referring to Fig. 3 and in conjunction with the teachings incorporated by reference from commonly assigned

U.S. Patent No. 5,388,594 (PM 1697), when a cigarette 23 of the preferred embodiment is inserted into receptacle 27, it is guided into the heating fixture 39 until the free end 78 of the cigarette 23 abuts a stop 182 fixedly arranged at the base of the heater fixture 39. Once the cigarette is in place, smoking may commence, whereupon any puffing action on the cigarette by a smoker is detected by the puff sensor 45, which in cooperation with the control circuit 41, causes electric current to be delivered to a preselected one of the heaters 37. Power is delivered via an electrical circuit which includes leads 183 at one end of each heater 37, a common ring 184 at the opposite end of each heater 37 and a common lead 186 extending from the common ring 184 back to the proximity of the leads 183. As each heater 37 is activated, thermal energy is transferred through the overwrap 71 and the tobacco web 68 in sufficient amount to cause the tobacco flavor material 70 of the tobacco web 66 to release a tobacco aerosol within the confines of the tobacco rod 60, which is drawn from the cigarette 23 responsively to the puffing action of the smoker on the tipped end of the cigarette 23.

A smoker's draw on a cigarette typically endures approximately 1.5 to 2.0 seconds, while FTC cigarette testing procedures assume a 2.0 second puff duration.

Where the heater footprint 94 overlaps the void 91, aerosol is released directly from the heated tobacco flavor material 70 into the void 91 whereupon it is withdrawn into

and through the tipping 62 with very little pressure drop. On the other hand, where the heater footprint 94 overlaps the tobacco plug 80 (the heater/filler overlap 99), proximal portions of the tobacco plug 80 will become heated along with proximal portions of the tobacco web 66. Accordingly, the blended tobaccos of the tobacco plug 80 contribute their own fraction of the total aerosol so as to contribute their taste and other subjective attributes. The aerosol released from the tobacco plug 80 at or about the heater/filler overlap 99 undergoes some filtration and pressure drop as it is drawn through the tobacco plug 80 and into the void 91.

The aerosol produced from heating of the tobacco plug 80 has a character and taste that can be altered by the blend of tobaccos as well as by adjustments in how much of the heater footprint 94 overlaps the tobacco plug 80. The component of aerosol that is produced in the vicinity of the void 91 is released more instahtaneously from the cigarette, because there is less thermal inertia at the void 91 and because the thermally vaporized tobacco substance at the void 91 is not subject to the pressure drop of the tobacco plug 80 and is instead more immediately communicated to the tipping 62 through the free-flow filter 74. It however has a character different from that released from the tobacco plug 80, because it is released predominately from the tobacco flavor material 70 on the base web 68. As will be explained in greater detail below, it has been found that for smoker satisfaction, the aerosol delivered from a

cigarette 23 preferably includes both components of aerosol to assure immediate delivery to the smoker and to include the flavor notes attributable to blended cut filler tobaccos. As will also become apparent in the teachings which follow, the presence of the void 91 (and its immediacy of initial delivery) assures a consistent puff-to-puff smoking of the cigarette 23 and promotes consistency between cigarettes. This relationship bears out in the comparative puff-to-puff attributes of a partially filled cigarette 23 constructed in accordance with the preferred embodiment (having a plug of cut filler 80 and a void 91), in comparison with cigarettes 23' of a first alternate design (Fig. 6a) having no cut filler within its rolled tobacco web, and a second alternate design (Fig 7A) having a rolled tobacco web entirely filled with cut filler. In the depictions of these alternate designs, it is to be understood that the tobacco web 66' and 66" comprise a base web 68 and layer of tobaco material 70 as in the preferred embodiment. The tobacco rods 60' of these alternate designs also included on overwrap 71.

A serpentine type heater element at a 15 Joules energy setting was used to generate the comparative data as presented in Figs. 6B and 7B with the cigarettes shown in Figs. 6A and 7A, respectively.

In reference to Fig. 6A, a cigarette adapted for smoking in an electrical smoking system of the first alternate design comprises a tobacco rod 60' and a tipping

62', each which include components designated with prime numbers having correspondence with components of the preferred embodiment shown in Fig. 4A. However, the tobacco rod 60' of the cigarette 23' does not enclose any cut filler within its tobacco web 66' and the free end 78' of the tobacco rod 60' is provided with a back flow filter 200'. The base web 68' of the tobacco web 66' was the type including carbon fiber as previously described. The construction of cigarette 23' is also detailed in the commonly assigned U.S. Patent No. 5,388,594 (PM 1697), which is hereby incorporated by reference in its entirety. For purposes of the description which follows, reference will be made to this cigarette 23' as a filler-free cigarette 23'.

Referring now to Fig. 6C, experiments were conducted using a smoking machine in cooperation with a smoking system 21. The output of the smoking machine was directed during each puff through a smoke measuring device 6y having a transparent chamber 6v, where a beam of light 6u from a source 6w passes through the transparent chamber 6v to a photo detector 6z at the opposite of side of the transparent chamber 6v. The output of the photo sensor 6z is processed to resolve the intensity of the light beam 6u as its strikes the sensor 6z. Any tobacco aerosol that passes through the chamber 6v will have a light scattering effect upon the beam of light 6u, such that any resultant change in detected light intensity at the photo detector 6z will be inversely indicative of total particulate matter (TPM) in the aerosol.

In accordance with FTC cigarette testing practices, it is preferred that the smoking machine draws a standard two-second puff from the smoking system 21.

The information graphically presented in Fig. 6B shows the intensity registered at the smoke measuring device relative to time as the smoking machine progressed through each of a succession of puffs on a filler-free cigarette 23'. The data indicates the following trends: that with a filler-free cigarette 23', the first and second puffs are inconsistent with the remaining three puffs, which latter three puffs are much more consistent with each other; and that aerosol is delivered well before lapse of the two-second time period for each puff. The filler free cigarette 23' is less consistent in delivery at the first several puffs and consistency prevails only in the latter puffs. The data related to the first puff is fairly consistent with the general observation that machine smoking of a filler-free cigarette 23' delivers less aerosol during the first puff unless remedial measures are implemented such as perforating the tobacco rod 60' or other measures as taught in U.S. Patent No. 5,388,594 (PM 1697).

Referring now to Fig. 7A, another design of an electrically operative cigarette 23'' comprises a tobacco rod 60'' and a tipping 62'' having components and an arrangement similar to those of the preferred embodiment shown in Fig. 4A, with similar components being provided with double prime designations. However, the cigarette 23"

of Fig. 7A includes a back flow filter 200" at the free end 78'' and a column of cut filler 220" extending along the entire length of the tobacco rod 60" between the back flow filter 200" and the free-flow filter 74'' of the tobacco rod 60''. The tobacco column 220'' of the cigarette 23'' comprises the blend of burley, bright and oriental tobaccos at a rod density of .275 grams per cubic centimeter. The base web 68" of the tobacco web 66'' is the type including carbon fiber as previously described. In the discussion which follows, the cigarette 23'' will be referred to as a fully-filled, filler cigarette 23".

Referring now to Fig. 7B, the measurements in light intensity from the smoke measuring device 6y was correlated with the time lapse progression of each puff for a succession of puffs numbered one through seven on the fully-filled, filler cigarette 23". The data presented in Fig. 7B is representative of two recognizable trends in the performance of a cigarette constructed in accordance with the fully-filled, filler cigarette 23'': that the first several puffs provide significant aerosol delivery, but yet delivery thereafter declines to such an extent that the latter three puffs provide substantially less delivery than the first several puffs (unless corrective measures are taken); and with the fully-filled, filler cigarette 23'', aerosol delivery is delayed and the initial puffs (puffs one, two and three) do not achieve maximum delivery until after a substantial portion of a two-second period has

elapsed.

During the first several puffs, the fully-filled cigarette 23" tends to deliver a greater total volume of aerosol than the filler-free cigarette 23'. A comparison of the data presented in Figs. 7B and 6B substantiates this general observation in that the total areas above the first several puff-lines in Fig 7B for the fully-filled, filler cigarette 23'' are greater than the total areas above the first several puff-lines in Fig 6B for the filler-free cigarette 23'. The area above each puff-line in Figs. 7B and 6B is indicative of total delivery during that puff.

However, it is believed that the delay in delivery of the fully-filled, filler cigarette 23" induces a smoker to undertake a prolonged, more robust draw in reaction to his or her not obtaining an immediate flavor response from the cigarette 23". The more pronounced draw in turn can cause the heated portions of the overwrap 71'' and the tobacco web 66'' to become more fully consumed (oxidized) by the additional air drawn therethrough such that more significant breakage and perhaps localized collapse of the tobacco column 220'' occurs during the first several puffs. Additionally, it is believed that once pyrolysis is initiated in the fully-filled cigarette, it tends to be more self-sustaining, because of the presence of a greater mass of combustable tobacco and/or because of its more compacted state. In any event, because air may be drawn more readily into the tobacco rod through the breached "burn" situses of

the first several puffs, these localized breaches are believed to short circuit the desired air flow paths of subsequent puffs. Consequently, delivery declines during the latter puffs on the fully-filled, filler cigarette 23".

The data presented in Fig. 7B and the explanation above is consistent with a general observation that a fully-filled, filler cigarettes 23' or a traditional cigarette, when they are smoked with electrical lighters, tend to drop off in delivery as puffing thereon progresses.

With its delayed, yet more self-sustaining pyrolysis, the fully-filled cigarette 23' tends to generate a great amount of aerosol in the latter stages of the puff, and at times may continue to produce an amount of aerosol beyond the period of time that the smoker is actually drawing on the cigarette. The latter situation can result in the production of "post-puff" aerosol which may linger within the housing 33 of the lighter 25, particularly at or about the heater fixture 39. Some of such "post-puff" aerosol will problematically condense on the heater elements 33 or linger long enough to be drawn into the cigarette 23" during the next puff. Either consequence is inimical to the delivery of a pleasing and consistent taste.

Referring back to Fig. 6B, the puff lines of the filler-free cigarette 23' evidence that the delivery of aerosol maximizes (where the puff lines dip the most) well before the two (2) second duration of a standardized puff has elapsed, and delivery is minimal at the latter stages of

the puff, so that the production of "post puff" aerosol is not such a problem with the filler-free cigarette 23'. However as noted previously, the filler-free cigarette 23' delivers less total volume of aerosol than the fully-filled, filler cigarette 23", it suffers inconsistency at times in delivery during the first several puffs and it lacks the subjective attributes and flexibilities that would otherwise be enjoyed if blended (or even unblended) cut filler were included.

Fig. 8 is a presentation of data from comparative smoking on smoking machines using a smoke measuring device 6y as described above for cigarettes constructed in accordance with the filler-free cigarette 23'; the fully-filled, filler cigarette 23''; and the partially-filled, filler cigarette 23 constructed in accordance with teachings of the preferred embodiment (as shown in Fig. 4A) of the present invention. Carbon-fiber mat was used as the base web in all these cigarettes. As a discussion of the data of Fig. 8 will reveal, the partially-filled, filler cigarette 23 of the present invention provides more consistent delivery throughout a smoke. It avoids the drop in delivery that occurs in the latter puffs of the fully-filled, filler cigarette 23'' and is more consistent in delivery than the filler-free cigarette 23' during the first several puffs.

The partially-filled, filler cigarette 23 that was tested to collect data used in Fig. 8 was half-filled with cut filler such that the heater overlap over the void in the

cigarette design was relatively large, approximately 6mm. The heater elements 37 used for generating the data presented in Fig. 8 was a serpentine type at 15 Joules energy per heating cycle.

Referring to Fig. 8 in particular, the data presented therein is the amount of aerosol (in milligrams) generated during the first two seconds of each puff in a progression of puffs during the smoking of each particular type of cigarette. In relation to the data presented in Figs. 6B and 7B, an amount of aerosol indicated in Fig. 8 would analytically correspond to an integration of (the area defined above) each puff-line from 0 to 2 seconds in Figs. 6B and 7B.

The presentation of data in Fig. 8 clearly illustrates the drop in delivery that is experienced with a fully-filled, filler cigarette 23'' as one progresses from the first puff to subsequent puffs. In contrast, the filler-free cigarette did not suffer the drop in delivery as with the fully-filled, filler cigarette 23''.

The presentation of data in Fig. 8 also clearly illustrates that the partially-filled, filler cigarette 23 provides consistency in delivery comparable to that of the filler-free cigarette 23' throughout the six puffs. Furthermore, it does so with a contribution of cut-filler to its taste and subjective impact.

Referring to Table II, data was collected indicative of how changes in the amount of heater overlap at the void

in a cigarette constructed in accordance with cigarette 23 can affect delivery. The data presented in Table II was produced from machine smoking of partially filled cigarettes having a 32 mm tobacco rod, a 7 mm free-flow filter at the tipped end of the tobacco rod and a 30 mm long tipping, wherein the heater footprint was 12 cm long and centered at the midpoint of the tobacco rod of each cigarette.

Table II

Void Length (mm)	4	7	10
Heater overlap along the void (mm)	1	4	7
Heater overlap along the tobacco plug	11	8	5
Average TPM	4.9	5.5	7.0
Adjusted Average TPM (lowest reading omitted)	5.2	5.9	7.3
Standard Deviation of Adjusted Average	.34	.53	.50

Fig. 9 provides a graphical presentation of total particulate matter (TPM) delivered versus the amount of heater-filler overlap (in millimeters). The data shown therein was generated using standard testing techniques for determining FTC "tar" levels using Cambridge pads and two-second puff intervals on standard smoking machines. The tested cigarettes were partially-filled, filler cigarettes having a carbon fiber base web and a total length of 58 mm, except that the data appearing along the ordinate in Fig. 9

were obtained from a filler-free cigarette having a carbon fiber base web and the same total length. As the heater-tobacco overlap was varied, the heater footprint remained a constant length and remained centered upon the mid-point of the tobacco rod. Accordingly, any increase in heater-tobacco overlap created a proportional decrease in heater-void overlap. The heater was a serpentine type having a heater footprint of approximately 10 mm. All the data taken together indicates that a second order relationship exists in these circumstances between total particulate matter delivered and the amount of heater-filler overlap. The data presented in Fig. 9 and the separate set of data set forth in Table II show that the amount of heater-filler overlap may be adjusted to obtain a desired (target) level of delivery in a partially-filled, filler cigarette 23.

Adjusting the amount of heater-filler overlap is the preferred method of achieving a desired "tar" level in partially filled, filler cigarettes, for reasons including the finding that changes in heater-filler overlap have a more pronounced and controllable effect on delivery than do changes in rod density at the tobacco plug 80. Also, this approach allows one to select rod density in the tobacco plug 80 for purposes other than tar level, such as to control loose ends and/or to create a desired degree of pressure drop and/or filtration at the free end 78 of the tobacco rod 60, or otherwise facilitate manufacturing. It also provides the capacity to alter tar delivery amongst

related cigarette products without having to necessarily change either the tobacco web 66 or the tobacco plug 80.

It is also advantageous to configure the relative dimensions of the partially-filled, filler cigarette 23 and those of the heater fixture 39 of the lighter 21 such that upon insertion of the cigarette 23 into the lighter 21, each heater element 37 locates alongside the tobacco rod 60 such that at least some, if not all of the heater footprints superpose only the filled portion of the tobacco rod 60 (over the tobacco plug 80). In such configurations, the void 91 still facilitates aerosol formation and helps cool the smoke. It is believed that the free-flow filter 74 helps promote aerosol formation by its presenting a flow constriction to the aerosol constituents as they are being drawn from the wider void 91. In this regard, it is to be noted that the free-flow filter 74 of the tobacco rod 60 presents edges 73 and 75 at the transitions between it and the void 91 on one side and between it and the free-flow filter 102 on the other, respectively. These edges 73 and 75 are a consequence of the free-flow filter 74 having a smaller inside radius than either of the other two, adjacent regions (the void 91 and space enclosed within the free-flow filter 102). It is believed that these edges 73 and 75 (and possibly other, adjacent portions of the free-flow filter 74) promote turbulence and other flow conditions favorable to the formation of an aerosol from the gas-phase and particulate phase constituents released from the heated

tobacco portions of the tobacco rod 60.

Referring now to Fig. 10, a cigarette 23a is constructed in accordance with another preferred embodiment of the present invention having components and arrangements the same as set forth in the discussion of cigarette 23 in view of Fig. 4A, but with the addition of a back-flow filter 200a located at the free end 78a of the tobacco rod 60a. The back flow filter 200a prevents tobacco from the tobacco plug 80a from escaping at the free end 78a. The free flow filter 200a may as well be colored so as to indicate that the cigarette 23a is one for use in an electrical smoking device instead of one for being ignited with a match or a conventional cigarette lighter as with more traditional cigarettes. Although the back flow filter 200a is shown as a separate component of the wrapped tobacco plug 80a, one may for convenience in the manufacture of the cigarette 23a combine the tobacco plug 80a with the back flow filter 200a with a plug wrap (not shown). With the back flow filter plug, the cigarette 23a may be provided with a tobacco plug 80a having a low rod density without risking problems such as loose ends or tobacco falling out of the tobacco rod 60a. As revealed in EP-A-0,615,411, and in copending and commonly assigned, U.S. patent application Serial No. 07/943,504, filed September 11, 1992 (PM 1550) and in commonly assigned U.S. Patent No. 5,388,594 (PM 1697), the backflow filter 200a is configured to limit or wholly prevent the release of aerosol from the free end 78a of the tobacco rod 60a at the

conclusion of a puff and to create a pressure drop at the free end 78a so as to favorably limit the amount of air that is drawn into the cigarette 23a from the free end 78a in relation to the proportional amount of air admitted along the sides of the tobacco rod 60a.

With regard to design techniques for the partially filled, filler cigarette 23 of the preferred embodiment, heater energies and the amount of heater-filler overlap can be used to establish and/or adjust delivery to a desired "tar" level. Accordingly, in the course of designing a new partially filled, filler cigarette 23, a selection of rod density in the tobacco plug 80 is generally available for achieving a desired degree of pressure drop at the free end 78 and/or to control backflow, in the same manner as is achieved with a backflow filter 200a of the alternate embodiment 23a.

Referring now to Fig. 11, another cigarette 23b constructed in accordance with another preferred embodiment of the present invention includes a tobacco plug 80b which comprises a low density portion 310b adjacent the void 91b and a high density portion 320b adjacent the free end 78b of the cigarette rod 60b. The cigarette 23b is configured such that the heater footprint 94B overlaps the low density portion 310b of the tobacco plug 80b so as to obtain enhanced delivery achievable with the lower rod densities. The high density region of cut filler 320b is arranged to avoid loose ends and to limit transmission of air axially

through the rod 60b in a manner analogous to the backflow filter 200a.

Presently preferred heater embodiments are show in FIGs. 12-21. These heaters are suitable for any of the cigarette embodiments heretofore described; that is the fully filled, partially filled and filler free cigarettes of Figures 4a, 4b, 6a, 7a, 10 and 11, and modifications of these cigarettes.

These heaters provide improved mechanical strength for the repeated insertions, adjustments and removals of cigarettes 23 and significantly improve the generation of aerosols from a heated cigarette while maintaining energy requirements. It has been found that the generated aerosols tend to flow radially inward away from a pulsed heater.

Generally, there are preferably eight heater blades 121 to provide eight puffs upon sequential firing of the heater blades 121, thereby simulating the puff count of a conventional cigarette. Specifically, the heater blades 121 extend from hub 110 to form a cylindrical arrangement of heater blades to receive an inserted cigarette 23. Preferably, a gap 129 is defined between adjacent heater blades 121.

It may be desired to change the number of puffs, and hence the number of heater blades 121, achieved when a cigarette is inserted into the cylindrical receptacle CR. This desired number is achieved by forming a desired number

of heater blades 121. This can be achieved by providing equally or unequally sized blades.

The heater fixture is disposed in the orifice 27 in the lighter 25. The cigarette 23 is inserted, optional back-flow filter 200 first, in the orifice 27 in the lighter 25 into a substantially cylindrical space of the heater fixture 39 defined by a ring-shaped cap 83 having an open end for receiving the cigarette, a cylindrical air channel sleeve 87, a heater assembly 100 including the heater blades 121, an electrically conductive pin or common lead 104A, which serves as a common lead for the heater elements of the heater assembly, electrically conductive positive pins or leads 104B, and the spacer. The bottom inner surface 81 of the spacer stops the cigarette 23 in a desired position in the heater fixture 39 such that the heater blades 121 are disposed adjacent the cavity 79 in the cigarette, and in a preferred embodiment are disposed as described previously with respect to Figures 1 to 11.

Substantially all of the heater fixture 39 is disposed inside and secured in position by a snug fit with the housing 31 of the front 33 of the lighter 25. A forward edge 93 of the cap 83 is preferably disposed at or extending slightly outside the first end 29 of the lighter 25 and preferably includes an internally beveled or rounded portion to facilitate guiding the cigarette 23 into and out of the heater fixture 39. The pins 104A and 104B are preferably received in corresponding sockets (not shown), thereby

providing support for the heater fixture 39 in the lighter 25, and conductors or printed circuits lead from the socket to the various electrical elements. Other pins can provide additional support to strengthen the pin assembly. The pins 104A and 104B can comprise any suitable material and preferably comprise tinned phosphorous bronze. The passageway 47 in the spacer and the base 50 communicates with the puff-actuated sensor 45 and the light sensor 53 senses the presence or absence of a cigarette 23 in the lighter 25.

As seen in FIGs. 12 and 13, the heater assembly 100 is preferably a monolithic structure which comprises eight heater blades 121 extending from a central hub 1110 in a symmetrical arrangement or, as discussed below in reference to FIG 19, in a non-symmetrical arrangement. As best seen in FIG. 13, the heater assembly defines a generally circular insertion opening 360 having a throat 365 which directs the inserted cigarette toward the coaxially defined cylindrical receptacle CR having a diameter which is less than insertion opening 360. Insertion opening 360 is defined by respective end portions 118B of the connecting sections 118 of the heater blades 121, and the throat section 365 is defined by the portion of sections 118 between connecting edge 118A and end 118B. Insertion end 360 preferably has a diameter which is greater than the inserted cigarette 23 to guide the cigarette towards the receptacle CR, and the receptacle CR has a diameter approximately equal to cigarette 23 to ensure

a snug fit for a good transfer of thermal energy. Cigarette 23 preferably has a diameter which is approximately equal to the range of diameters known in the art. Given acceptable manufacturing tolerances for cigarette 23, the gradually narrowing area or throat 365 in the transition between the distal end and the receptacle CR can also serve to slightly compress the cigarette to increase the thermal contact with the surrounding blades 121 serving as an inner wall of the receptacle. By way of non-limiting example, insertion end 360 preferably has an internal diameter of approximately 0.356 in., ± 0.02 in. and receptacle CR preferably has an internal diameter of approximately 0.278 in., ± 0.02 in. The blades 120 can be bowed inward to increase thermal contact with the cigarette by constricting the diameter of the cylindrical receptacle.

Each U-shaped heater blade 121 comprises a first section or leg 116A extending at a first end from hub 111, a connecting section 118 connected to an opposite second end of the first section or leg 116A, and a second section or leg 116B extending at a first end from connecting section 118 toward hub 111. First and second legs 116A and 116B are separated by a gap 125 which can be relatively constant, are preferably substantially parallel in any unrolled state as in FIGs. 18 and 19 discussed below, are continuous in the direction of cigarette insertion to reduce undesired snagging of the cigarette and are oriented to define a cylindrical receptacle CR for the inserted cigarette 23.

Connecting section 118 has a curved joining edge 118A to join opposing inner edges of the blade legs 116A and 116B such that an elongated U-shaped resistive path is formed which is substantially parallel with the longitudinal axis of the inserted cigarette and extends alongside the cigarette, as discussed in greater detail below. Curved joining edge 118A preferably has a curvature of approximately 180° ±20° so that a U-shaped blade is formed and has a curvature which is concave toward the hub 111 and convex toward the insertion opening 360. The first end of first blade leg 116A at hub 111 can have an increased width, with the same approximate thickness, at portion 115 relative to the remainder of first leg 116A to lower the current density and the power density at portion 115 to reduce ohmic heating of portion 115. Also, this widening increases the mechanical integrity of the blade 121 at hub 111.

A second end 122 of second blade leg 116B is preferably elevated relative to the main portion of second blade section 116B in a step shape to facilitate electrical connection with a respective positive pin 104B. More specifically, as shown in FIGs. 12 and 13, end 122 comprises three sections, namely, a section 122A which is a substantially planar continuation of the main section of second blade leg 116B, a transition section 122B which rises at an angle as shown, and a connecting end section 122C which is generally parallel with section 122A. The sections

of end 122 can have a wider width than second blade leg 122B for increased strength, to provide an adequate contact area for a positive connection at connecting end section 122C, and to lower the current density and thus the ohmic heating of end 122. End section 122C is preferably tack welded or electrically and mechanically connected by any other technique to positive pin 104B.

Another embodiment for achieving the positive connections for the heater blades 121 is shown in FIGs. 14 and 15. The connecting end 122 is preferably not step-shaped as in FIGs. 12 and 13; rather, it is a substantially planar extension of second heater leg 116B, which simplifies the fabrication discussed below. To decrease the possibility of shorts arising from contact between the positive end 122 with the hub 111 and/or the section 115 of first leg 116A as, e.g., the inserted cigarette is twisted or otherwise adjusted by the smoker, an electrically insulating ceramic coating 300 is applied to end 122, hub 111 and section 115, especially to the respective facing edges of these elements.

Preferably, the ceramic coating is applied by any conventional technique, e.g., plasma spraying, to the hub 111, connecting end 122, and section 115 of first leg 116A. The ceramic preferably has a relatively high dielectric constant. Any appropriate electrical insulator can be employed such as alumina, zirconia, mulite, corderite, spinel, fosterite, combinations thereof, etc. Preferably,

zirconia or another ceramic is employed having a thermal coefficient of expansion which closely matches that of the underlying metal heater structure to avoid differences in expansion and contraction rates during heating and cooling, thereby avoiding cracks and/or delaminations during operation. The ceramic layer remains physically and chemically stable as the heater element is heated. A thickness of, e.g., approximately 0.1 to 10 mils, or approximately 0.5-6 mils, and more preferably 1-3 mils, is preferred for the electrical insulator. Preferably, a portion of end 122 is not coated. Positive pins 104B are then connected as discussed to this exposed portion. To simplify masking, a corresponding portion of section 115 is likewise not coated with ceramic.

The ceramic can also be applied, e.g., in the same plasma spraying step, in the gap 127 between the ends 122 and sections 115 of first legs 116A and in the gap 126 between the ends 122 and hub 110 to form a ceramic hub structure to increase the mechanical integrity of the heater assembly, as shown in Fig. 15. The size of this ceramic hub structure can be larger than shown. With or without this additional ceramic application, the ceramic coating electrically insulates the positive connecting ends 122, and the width gaps 127 and 125 can be decreased while protection against shorts is provided. Accordingly, the end section 122 and section 115 of first leg 116A can have an increased area, thereby further strengthening the receptacle, and, in

the case of the ceramic hub, increasing the skeletal structure and further strengthening the heater assembly. In addition, such a ceramic coating smooths sharp edges defining the gaps 125 and 127 to reduce the potential of snagging and damaging the cigarette, especially during insertion, removal and any adjustment by the smoker. Alternatively, the entire blade 121 and particularly first and second legs 116A and 116B are completely coated on one surface, e.g., the outer surface facing away from the cigarette, both the inner and outer surfaces, and/or the edges defining the gaps with a ceramic layer, e.g., approximately 2 mil. of zirconia, to strengthen the heater blades, maintaining gaps if desired. The blades 121 can accordingly be thinner, e.g., approximately 2 to approximately 6 mil., thereby increasing the resistance of the heater path and permitting the blades to be wider for increased thermal interface with the inserted cigarette 23 while maintaining the same overall blade resistance. This increased blade width, along with the ceramic layer, further strengthen the heater structure. Also, the ceramic coating on the outer surface of the blades 121 facing away from the inserted cigarette may prevent thermal losses from a heated blade to the ambient. The ceramic is preferably applied via plasma spraying or any other method described in the related applications and preferably is applied via electron beam physical vapor deposition to avoid inducement of residual stresses which may be induced during processing in plasma

spraying from surface treatment and/or particle impact.

Each blade 121 forms a resistive heater element. More specifically, the first end 115 of first blade section 116A is electrically connected to the negative terminal of the power supply, and more specifically is an integral extension of hub 111 or is mechanically and electrically connected to hub 111, which in turn is in electrical and mechanical connected to negative terminal pin 104A via tack welding or another technique such as brazing or soldering. Preferably, two terminal pins 104A are used to provide a balanced support since the negative and positive connections also serve to mechanically support the heater. The hub 111 thus functions as an electrical common for all of the heater blades 121. In any of the embodiments, the negative connection for each heater can be made individually by, e. g., an appropriate negative contact deposited on an end of the heater opposite the respective positive contact areas 122.

A respective positive connection for each heater blade 121 is made at connecting end section 122C of the second blade section 116B as discussed. Connecting end section 122C is electrically isolated or insulated from common hub 111 by a gap 127; from first blade section 116A, and particularly first end 115, of the associated heater blade 121 by a gap 125; and from the adjacent heater blade by gap 131 to avoid shorts and to permit thermal expansion. In addition, the discussed ceramic coatings are optionally

applied. Alternatively, connecting end sections 122C are respectively connected to ground.

The discussed positive and negative connections provide a resistive path, and more specifically a circuit, for current applied from the source of electrical energy, e.g., via the control circuitry, to a particular blade(s) 120 upon activation of the smoking system by a smoker's draw. The primary heated area of the blade comprises first blade leg 116A, edge portion 118A and second blade leg 116B. Accordingly, a portion of the inserted cigarette 23 underlying and contacting the actuated blade 121 extending alongside will be heated in an outer surface pattern corresponding to the heated portion of the blade, i.e., in an elongated U-shape corresponding to the overlying blade, primarily via conduction and radiation, with some convection likely occurring. In addition, the portion of the inserted cigarette between the legs, i.e., underlying gap 125, is heated by overlapping or intersecting, cumulative radiative and conductive heat transfer from both leg 116A and leg 116B. If gap 125 is too large, desired overlapping will not occur and the portion of the inserted cigarette underlying gap 125 will not be adequately heated. Also, radiative and conductive heat will heat strip portions of the inserted cigarette slightly beyond the outer edges of heater blade legs 116A and 116B. The various heated portions together constitute a heated region of the cigarette 23 that extends from slightly beyond the outer

edge of leg 116A, beneath leg 116A, across gap 125, beneath leg 116B, and slightly beyond leg 116B of an actuated blade 121 and which correspond to a puff of generated tobacco flavor. The size of the heated portion is dependent upon the blade geometry and heating characteristics as well as the amount and duration of the energy pulse. Preferably, the heater blade is sized and thermally designed to ultimately heat a segment of the inserted cigarette having sufficient size, e.g., 18 square mm, to generate an acceptable puff to the smoker in response to a puff-actuated energy pulse.

Relatively larger blade end areas 115 and 122 forming a part of the current path are not heated to these operating temperatures since their relatively larger volumes lower the current density, and thus lower the ohmic heating. Also, a section of connecting end section 118 is not heated to these operating temperatures since the heating path tends to follow edge 118A and this section constitutes a relatively larger volume and accordingly has a lower current density, and thus has a lower ohmic heating, than the edge 118A and immediately adjacent sections. To further reduce undesired heating of the remainder of connecting portion 118, one can (1) increase the thickness of the monolithic material of portion 118 relative to curved edge 118A in a region 118C to further reduce current density and ohmic heating, as shown in FIG. 5, (2) perforate portion 118 to reduce ohmic and/or heat conduction paths, and/or (3) add an additional heat

sink material 119 onto portion 118 to reduce thermal transfer to the portion, as shown in FIG. 6. To achieve this heat sink function, a thermally non-conductive material, i..e., a thermal insulator such as a ceramic, is applied. Examples of suitable ceramics include alumina, zirconia, a mixture of alumina and zirconia, mulite, etc., as is the case with the heater blade coating. Any of these modifications should be evaluated for any adverse effect on the mechanical integrity of connecting portions 118 which support the heater assembly 100 and define an insertion and withdrawal opening for the cigarette.

After a heater blade 121 is pulsed, there is a predetermined minimum time before a subsequent puff is permitted. Premature heating of a portion of the cigarette could also result in undesired and/or partial aerosol generation or heat-induced degradation of the cigarette portion prior to the desired heating. Subsequent reheating of a previously heated portion can result in undesired flavors and tastes being evolved.

If a longer puff is desired than is obtained by a pulsing of a single heater blade, then the control logic is configured to fire another heater or additional heater blade(s) immediately after the pulsing of the initial heater blade, or during a final portion of the initial pulsing, to heat another segment of the cigarette. The additional heater blade can be a radially successive heater blade or another heater blade. The heater blades should be sized to

obtain the total desired number of puffs of a desired duration.

In one embodiment, the number of heater blades 121 corresponds to the number of desired puffs, e.g., eight. In another embodiment, the number of formed heater blades 121 is twice the number of puffs, e.g., there are sixteen portions with heaters for an eight puff cigarette. Such a configuration permits different firing sequences than the normal successive firing of approximately 2 seconds, and preferably the radially sequential firing sequence for an embodiment wherein the number of heating blades 121 corresponds to the puff count. For example, the logic circuit can dictate that two circumferentially opposite heater blades 121, i.e., heater blades separated by 180° on the tube, fire simultaneously to jointly heat an adequate amount of the cigarette to generate a puff. Alternatively, a first firing sequence of every other heater blade 121 for a cigarette is followed by a second firing sequence of the intervening heater blades 121 for the next cigarette. Alternatively, this first firing sequence can be repeated for a predetermined life cycle of numerous cigarettes and then the second firing sequence initiated. Any combination of heater blades can be employed. The number of heater blades can be less than, equal to, or greater than the number of puffs of a single employed cigarette. For example, a nine blade system can be employed for a six-puff cigarette, wherein a different set of six heaters is fired

for each subsequent cigarette and the associated set of remaining three heaters is not fired.

The heater assembly 100 is electrically and mechanically relatively fixed at one end via the welding of pin(s) 104A to hub 110 and of pins 104B to ends 122. Pins 104A and 104B are preferably pre-molded into plastic hub, or otherwise fixedly connected thereto, preferably in a manner to minimize air leakage. Preferably, this fixed end is opposite the insertion opening 360. The connecting sections 118, and specifically opposite ends 118B opposite connecting edges 118A, define the insertion opening 360. End sections 118B can flare outward to define a throat section 365. Blades 121 then narrow from this throat section to define an internal diameter which is slightly less than the outer diameter of the inserted cigarette 25 at, e.g., the blade midpoint to provide desired thermal contact, i.e. compressive forces, between the blades and the cigarette. End sections 118B are free to expand when heated, i.e., end sections 118B are not fixed. More specifically, each end 118B is positioned within a corresponding channel 210 located in inner wall 201 of lighter end cap 83. More specifically, the radially outward movement of end sections 118B of inwardly biased blades 121 are arrested by ends 118B contacting radially outward walls of channels 210, thereby establishing a boundary for the biasing and defining the inward bias. This inward bias may supplemented by the inward fabrication bias as discussed. As shown, inner wall 201 is

flared outward to permit insertion of a portion of blade ends 118B. The radially outward wall of channel 200 contacting end 118B is sized and shaped to permit insertion of an adequate amount of blade end 118B such that the blade end will not exit channel 210 during heating or cooling of the blade or insertion or withdrawal of the cigarette. If desired, this radially outward channel wall is provided with a rest, e.g., a trapezoid, which contacts the ends 118B. In an alternative embodiment, a portion 118D of blade end 118B is rounded, and more specifically elliptical, prior to the inserted end portion 118B. This rounded portion 118D permits the inserted portion to pivot within channel 210 in response to thermally or mechanically induced moments, thereby maintaining the inserted portion of the blade end within channel 210. Additonally or alternatively, blade ends 118B are more rounded.

In a first embodiment shown in FIG. 3, channel 210 is sized such that end 118B of the heater blade 121 can expand in a translating manner, i.e., toward end face 202 of channel 210, upon insertion of the cigarette 23 and/or heating of a blade, so that desired contact between the cigarette and the blades is achieved. Such an arrangement, wherein one end of the blade is free relative to the oppositely located hub, permits mechanical displacement and/or thermal expansion and contraction of the heater blades 121 in the longitudinal direction upon respective cigarette insertion/withdrawal and/or blade heating/cooling,

thereby reducing stresses. In a second embodiment shown in FIG. 14, an abutment 204, which may be trapezoidal, is located within the channel 210 such that as heater blade 121 expands thermally upon heating or displaced as cigarette 23 is inserted, end 118B contacts abutment 204 and establishes a pivot point to allow blade 121 to bias inward toward the inserted cigarette 23, thereby reducing stresses on the blade and increasing desired thermal contact, i.e., compressive forces, between the blade and the cigarette. By pivot point, it is meant that the blade 121 is free to rotate, but preferably not translate, at this abutment 204.

The heater assembly 100 is thus preferably a monolithic structure which optionally is coated with a ceramic as discussed. The hub 111 and heater blades 121 are fabricated from a material having desired electrical resistance and strength. For example, materials having electrical resistance in the range of approximately 50 to approximately 500 μohm.cm, and more preferably approximately 100 to approximately 200 μohm.cm are preferred, such that temperatures of approximately 200°C to approximately 1000°C, and preferably approximately 400°C to approximately 950°C, and more preferably approximately 300°C to approximately 850°C are reached by the activated blade 120 in approximately 0.2 to approximately 2.0 sec. with a pulse of approximately 10 to approximately 50 Joules, more preferably approximately 10 to approximately 25 Joules, and even more preferably approximately 20 Joules. The material

should be able to withstand approximately 1800 to approximately 10,000 such pulses without suffering failure, significant degradation, or undesired sagging of the blades 121.

The materials of which the heater blades 121 are made are preferably chosen to ensure reliable repeated uses of at least 1800 on/off cycles without failure. The heater fixture 39 is preferably disposable separately from the lighter 25 including the power source 37 and the circuitry, which is preferably disposed of after 3600 cycles or more. The heater materials and other metallic components are also chosen based on their oxidation resistance and general lack of reactivities to ensure that they do not oxidize or otherwise react with the cigarette 23 at any temperature likely to be encountered. If desired, the heater blades 121 and other metallic components are encapsulated in an inert heat-conducting material such as a suitable ceramic material to further avoid oxidation and reaction.

More preferably, however, the heater blades 121 and other metallic components are made from a heat-resistant alloy that exhibits a combination of high mechanical strength and resistance to surface oxidation, corrosion and degradation at high temperatures. Preferably, the heater blades 121 are made from a material that exhibits high strength and surface stability at temperatures up to about 80 percent of their melting points. Such alloys include those commonly referred to as super-alloys and are generally

based on nickel, iron, or cobalt. For example, alloys of primarily iron or nickel with aluminum and yttrium are suitable. Preferably, the alloy of the heater blades 121 includes aluminum to further improve the performance of the heater element, e.g., by providing oxidation resistance.

Preferred materials include iron and nickel aluminides and most preferably the alloys disclosed is commonly assigned, copending U.S. patent applications Serial No. 08/365,952 filed December 29, 1994, and especially Serial No. _____, filed concurrently herewith, entitled "Iron Aluminide Alloys Useful as Electrical Resistance Heating Elements" (Attorney Docket No. PM 1769), which are incorporated by reference in their entireties.

Several elements can be used as additions to the Ni_3Al alloys. B and Si are the principal additions to the alloy for heater layer 122. B is thought to enhance grain boundary strength and is most effective when the Ni_3Al is nickel rich, e.g., Al $\leq$ 24 at. %. Si is not added to the Ni_3Al alloys in large quantities since addition of Si beyond a maximum of 3 weight percent will form silicides of nickel and upon oxidation will lead to SiO_x. The addition of Mo improves strength at low and high temperatures. Zirconium assists in improving oxide spalling resistance during thermal cycling. Also, Hf can be added to improved high temperature strength. Preferred Ni_3Al alloy for use as the substrate 300 and resistive heater 122 is designated IC-50 and is reported to comprise approximately 77.92% Ni, 21.73%

A;. C.34% Zr and 0.01% B in "Processing of Intermetallic Aluminides", V. Sikka, Intermetallic Metallurgy and Processing Intermetallic Compounds, ed. Stoloff et al., Van Nestrand Reinhold, N. Y., 1994, Table 4. Various elements can be added to the iron aluminide. Possible additions include Nb, Cu, Ta, Zr, Ti, Mn, Si, Mo and Ni. The heater material can be the Haynes® 214 alloy (Haynes® Alloy No. 214, a nickel-based alloy containing 16.0 percent chromium, 3.0 percent iron 4.5 percent aluminum, traces of yttrium and the remainder (approximately 75 percent), commercially available from Haynes International of Kokomo, Indiana) , Inconel 702 alloy, MCrAlY alloy, FeCrAlY, Nichrome® brand alloys (54-80% nickel, 10-20% chromium, 7-27% iron, 0-11% copper, 0-5% manganese, 0.3-4.6% silicon, and sometimes 1% molybdenum, and 0.25% titanium; Nichrome I is stated to contain 60% nickel, 25% iron, 11% chromium, and 2% manganese; Nichrome II, 75% nickel, 22% iron, 11% chromium, and 2% manganese; and Nichrome III, a heat-resisting alloy containing 85% nickel and 15% chromium), as described in commonly assigned parent patent application Ser. No. 08/380,718, filed January 30, 1995 and U.S. Patent No. 5,388,594, or materials having similar properties.

As shown in FIG. 12, the heater blades 121 are arranged to extend symmetrically from hub 111. Alternatively, non-symmetric arrangements are employed. For example, the plurality, e.g., six or eight, of heater blades 121 can be subdivided into, e.g., two equally numbered

subgroups of, e.g., three or four, heater blades. The heater blades in each subgroup are separated by gaps 131 as discussed previously. The subgroups are separated by a wider gap 135, as shown in FIG. 19 in the unrolled flat state. Gap 135 is defined such that conductive and especially radiative heat transfer from adjacent blades 121 of adjacent subgroups is minimized to the portion of cigarette 23 underlying the gap 135. Accordingly, gap 135 provides a wider unheated and robust portion of the cigarette which is stronger than unheated portions of the cigarette underlying narrower gaps 131, whereby the column strength of cigarette 23 is improved to aid in removal of the cigarette after smoking and consequent heating, and weakening, of portions. If desired, the logic can activate more than one heater simultaneously in the symmetric or non-symmetric arrangement.

The present invention having two heater legs 116A and 116B separated by a gap 125 results in significant improvements in the amount of aerosol generated when compared to the amount generated by a solid heater element. A solid heater achieves good thermal transfer with the cigarette; however, mass transfer of aerosol into the drawn air flow is compromised by the solid structure blocking optimal entrainment of air located outside of the cigarette into the cigarette, especially if the enclosure of the smoking system housing is provided with perforations for communicating air outside of the enclosure to the cigarette

outer surface. A heater according to the present invention having the same volume as a solid heater but having a larger perimeter results in a higher opportunity for entrainment, e.g., due to gap 125, and accordingly results in an improved flavor delivery per unit of energy to the blade 121. As discussed, gap 125 should sized to provide optimal radiation overlap for a given blade geometry. Since a higher amount of aerosols are generated, the required mass of the blades can be decreased while generating the same desired amount of flavors, resulting in a lighter unit and a decrease in the energy required to adequately heat the heater blades 121 and inserted cigarette, which further reduces the weight of the unit since the power source, e.g., batteries, can be smaller. By way of non-limiting example, gap 125 can be approximately 0.020 in., ± approximately .005 in. wide; blade legs 116A and 116B can be approximately 0.0125 in. to approximately 0.017 in., ± approximately .005 in. wide and approximately 0.55 in., ± approximately .005 in. long; and approximately .008 in. to approximately .010 in. thick, ± approximately .005 in.; and the length from the hub 110 edge to the tip of connecting section 118 can be approximately 1.062 in., ± approximately .0625 in.

It has been found that a primarily transverse or radial air flow relative to the inserted cigarette results in a more desirable smoke generation than a primarily longitudinal flow. The gaps 125, 127 and 131 provide pathways for air to be drawn into contact with the inserted

cigarettes. Additional air passages are provided to optimize the transverse air flow by perforating sections of the heater blades.

Another embodiment of blade geometry is shown in FIG. 16, wherein both first leg 116A and second leg 116B are serpentine shaped. The serpentine shapes of legs 116A and 116B are parallel such that the legs are evenly spaced and gap 125 is also serpentine-shaped. Such a serpentine shape increases the blade perimeter, and thus improves the aerosol entrainment. This serpentine shape is described more fully in as described EP-A-0,615,411 and in commonly assigned parent patent application Ser. No. 08/380,718, filed January 30, 1995 and U.S. Patent No. 5,388,594.

A first preferred method of fabrication will now be described with reference to FIGs. 18 and 19. The fabrication steps defined herein may be performed in any desired order to achieve manufacturing speeds, materials savings, etc.

A sheet or strip of an appropriate material having a thickness of, e.g., approximately 2 to approximately 20 mil, e.g. approximately 10 mil, is formed to define a plurality of blades 121 extending generally perpendicularly via respective first blade sections 116A, and particularly via respective first end sections 115, from a generally straight section 111A in a comb-like arrangement. The blades 121 are substantially parallel to one another with gaps 131 located between the opposing edges second blade section 116B of one

blade and the first blade section 116A of an adjacent blade. As discussed, the blades 121 are either symmetrically arranged with equal gaps 131 therebetween as shown in FIG. 18, or are non-symmetrically arranged, e.g., with equal gaps 131 between adjacent blades 121 defining subgroups 121A and 121B of blades and a larger distance 133 between the two subgroups of width X as shown in FIG. 19. Note that straight section 111A has two end portions with a length of at least half the length of one half X to form a second distance 133 upon rolling. These end portions should be longer than X to provide an overlap for connection. By way of non-limiting example, gap 131 can be approximately 0.040 in., ± .005 in. wide in any of the embodiments and gap 135 can be approximately 0.125 in., ± .005 in. wide in the non-symmetrical embodiment.

The blades are configured as discussed previously to form connecting section 118 and the legs 116A and 116B.

This formation of the sheet or strip of material into the described configuration is performed by any conventional technique such as stamping or cutting, e.g., with a CO2 or Yag laser. If a strip format is employed, the number of heater blades 121 formed from the strip can exceed the required number for a single cylindrical heater arrangement. The straight strip is then cut, if necessary, to form sections 111A having the desired number of heater blades 121 extending therefrom. If employed, the step shape of sections 122A, 122B and 122C is formed via stamping.

If employed, ceramic coating 300 is then applied by masking the stamped profile and, e.g., thermally spraying the coating onto sections 111A, 115, 122 or the entire blade or any portion thereof to form the desired pattern as discussed. Alternatively, the ceramic coating is applied after the rolling step by this procedure or, if desired, prior to formation of the blades. As is known, appropriate maskings are applied prior to performing each of the steps of heater and ceramic deposition to define areas of application.

The section 111A is then rolled to form round hub 111. The section 111A can be rolled in either direction. Preferably, section 111A is rolled such that the positive contacts 122C at end section 122 are on the outer surface of the formed cylindrical heater, i.e., the side opposite the cigarette, to simplify connection with pins 104B and to avoid damage during insertion and removal of the cigarette. The rolled section can be rolled to a smaller diameter than its ultimate desired diameter and is inserted into the fixture. The rolled section then expands and is further held in shape by the electrical connections. Alternatively, the rolled section is joined, e.g., via any welding technique such as spot welding or laser welding, to form the hub 111.

Preferably a bias is imposed on each blade 121 such that legs 116A and 116B and connecting edge 118A will exert a compressive force on the inserted cigarette when the

heater assembly is formed, as shown in FIG 13. This biasing preferably occurs prior to rolling, but may be implemented after rolling. This biasing increases the thermal contact between the heater blade and the inserted cigarette to improve thermal transfer efficiency.

Thermal transfer efficiency is also improved by optimizing the amount of surface areas of the blade legs 116A and 116B which are in an efficient thermal relationship with the underlying cigarettes. As seen in FIG. 17A, the undersides 117 of legs 116A and 116B (leg 116A is shown by way of example) is planar, i.e., flat in a transverse direction of the blade leg in the discussed embodiments. To improve the thermal transfer relationship, the underside 117 is shaped in various non-planar geometries, e.g., an angle or curve to maximize the surface area of the heated leg relative to the cigarette without undesirably increasing the volume, and hence undesirably lowering the current density and resultant ohmic heating of the heater leg, as respectively depicted in FIGs. 17B and 17C. The shaped underside 117 preferably does not pierce any part of the cigarette 23 to avoid weakening and possibly ripping the cigarette during insertion, adjustment or removal. Rather, the midpoint or apex of the underside 117 contacts or is in close thermal proximity to cigarette 23, and the remainder of underside 117 is in a radiative thermal relationship with cigarette 23.

Preferably, this underside shape is achieved by

stamping the legs 116A and 116B of the blades 121 in an unrolled state. This stamping can occur at the same time as the stamping to achieve the bias discussed above. This stamping to shape the underside also increases the strength of legs 116A and 116B, thereby avoiding undesired shorts and deformations.

A second method of fabrication will now be described. A tube of appropriate material is provided. The blades 121 are then formed via any technique such as laser cutting. Alternatively, the blades are formed by a swaging technique wherein an internal mandrel is inserted into the tube to form the discussed blade profiles and then another swage, either internally or externally, is employed to cut the profile. A ceramic coating 300, if desired, is provided as discussed to the profiled tube.

The present invention also minimizes potentially damaging thermally induced stresses. Since the heater blades 121 and hub 111 are monolithic, stresses arising from interconnections of discrete portions of a heater element are avoided.

The various embodiments of the present invention are all designed to allow delivery of an effective amount of flavored tobacco response to the smoker under standard conditions of use. Particularly, it is presently understood to be desirable to deliver between 5 and 13 mg, preferably between 7 and 10 mg, of aerosol to a smoker for 8 puffs, each puff being a 35 ml puff having a two-second duration.

It has been found that, in order to achieve such delivery, the heater elements 121 should be able to convey a temperature as discussed when in a thermal transfer relationship with the cigarette 23. Further, the heater blades 121 should preferably consume the discussed energy. Lower energy requirements are enjoyed by heater blades 121 that are bowed inwardly toward the cigarette 23 to improve the thermal transfer relationship.

Of course, the heater resistance is also dictated by the particular power source 37 that is used to provide the necessary electrical energy to heat the heater blades 121. For example, the above heater element resistances correspond to embodiments where power is supplied by four nickel-cadmium battery cells connected in series with a total non-loaded power source voltage of approximately 4.8 to 5.8 volts. In the alternative, if six or eight such series-connected batteries are used, the heater blades 121 should preferably have a resistance of between about 3 Ω and about 5 Ω or between about 5 Ω and about 7 Ω, respectively.

Another embodiment 450 of the present invention is shown in FIG.s. 20 and 21 comprising a plurality of heating elements 451. Each heating element 451 is in the shape of an elongated "U", each having both of its ends 452, 453 of respective legs connected to the side wall of cavity 430 adjacent end wall 443 of cavity 430. Each respective end 452 is individually connected to the control circuitry, and ultimately to the source of electrical energy, for

individual actuation of heating elements 451, while ends 453 are connected in common to ground. While ends 454 adjacent the mouth end of cavity 430 are not electrically connected, and thus need not touch the side wall of cavity 430, they are nonetheless turned toward the side wall of cavity 430, as shown in both FIGS. 20 and 21, to provide a lead-in for the disposable portion, i.e., the inserted cigarette, as discussed above. It should be noted that in FIG. 21, the uppermost and lowermost elements 451 are shown cut through their U-shaped tips 454.

In another embodiment 470 shown in FIGS. 22 and 23, heating elements 471 are spaced somewhat further from the wall of cavity 430, and each is provided with a somewhat sharper "V" tip 472, as well as with fold 473 to increase their rigidity. In this way, heating elements 471 actually pierce and extend into the disposable portion to provide the desired intimate thermal contact. The open-cell foam structure described above is particularly well-suited for such an embodiment. In this embodiment, because heating elements 471 are spaced further from the side wall of cavity 430, ends 452, 453 are not attached to the side wall of cavity 430, but to its end wall 443. Preferably, the connections of ends 452, 453 to end wall 443 are made through spacers 480 which are not conductive of either heat or electricity. In this way, a wiping action wipes residue past ends 452, 453 and onto spacers 480, where the residues are not reheated, as described more fully in U.S. Patent No.

5,249,586. Perforations 412 are provided in the wall to allow outside air to be drawn through portion 420, as described more fully in U.S. Patent No. 5,249,586, which is incorporated by reference in its entirety.

Many modifications, substitutions and improvements may be apparent to the skilled artisan without departing from the spirit and scope of the present invention as described and defined herein and in the following claims. For example, the decurling step may be performed before the cooling step in a modification of the portion of the process described above with reference to FIG. 5B.

Claims :-

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1. A cigarette (23) comprising a tobacco rod, said tobacco rod (60) comprising a tubular tobacco web (66) and a plug of tobacco (80) disposed within said tubular tobacco web, said tobacco rod having a free end (78) and an opposite end (72), said tubular tobacco web comprising a base web (68) and a layer (70) of tobacco flavour material supported by said base web, said base web adapted to transfer heat from an electrical heating element (37) to said tobacco flavour material, said tobacco rod (60) adapted to operatively receive an electrical heating element (37) alongside said tobacco rod (60) at a location between said free end (78) and said opposite end (72), said plug of tobacco (80) located adjacent said free end, said plug of tobacco being spaced apart from said opposite end so as to define an unfilled space (91) between said plug of tobacco and said opposite end.

2. The cigarette as claimed in claim 1, wherein said location alongside said tobacco rod is such that said location overlaps at least a portion of said unfilled space (91) and overlaps at least a portion of said plug of tobacco (80).

3. The cigarette as claimed in claim 1 or 2, wherein said tobacco rod includes a free-flow filter (74) adjacent said opposite end, said free-flow filter being spaced apart from said plug of tobacco (80) so as to define said unfilled space (91) between said free-flow filter and said plug of tobacco.

4. A cigarette and lighter adapted to cooperate as an

electrical smoking system, said cigarette comprising a tube of tobacco web, partially filled with cut filler tobacco so as to define a filled tobacco rod portion and an unfilled tobacco rod portion (91), said cigarette (23) and said lighter (25) being mutually arranged so that an electrical heater element of the lighter at least partially superposes at least one of the filled and unfilled tobacco rod portions when the cigarette is in an operative position in said lighter.

5. The cigarette as claimed in claim 4, wherein said filled tobacco rod portion includes a plug of tobacco, and said electrical heater superposes at lease a portion of said unfilled space and superposes at least a portion of said plug of tobacco when the cigarette is in said operative position in the lighter..

6. The cigarette as claimed in claim 4 or 5, wherein said cigarette has a free end, said tobacco plug being located adjacent said free end, said cigarette including a tubular element spaced apart from said plug of tobacco so as to define said unfilled tobacco rod portion between said free-flow filter and said plug of tobacco.

7. The cigarette as claimed in any preceding claim, wherein said tubular element (74) is a filter.

8. The cigarette as claimed in claim 7, wherein said tubular element (74) is constructed from a plasticized tow material.

9. The cigarette as claimed in claim 7, wherein said free-flow filter (74) is constructed from a molded material.

10. The cigarette as claimed in any preceding claim, further comprising filter tipping (62) adjacent said opposite end.

11. The cigarette as claimed in claim 10, wherein said tipping (62) comprises a second free-flow filter (102) adjacent said opposite end, said cigarette further comprising tipping paper (64) attaching said second free-flow filter (102) to said opposite end.

12. The cigarette as claimed in claim 11, wherein said tipping further comprises a mouthpiece filter plug (104) adjacent said second free-flow filter (102).

13. The cigarette as claimed in claim 12, wherein said free-flow filter (74) of said tobacco rod (66) includes a first passage (75) and said second free-flow filter (102) of said tipping includes a second passage, said first and second passages communicating said unfilled space (91) of said tobacco rod with said mouthpiece filter plug (104), said second passage having a second inside radius greater than a first inside radius of said first passage (75).

14. The cigarette as claimed in claim 12, wherein said tobacco rod further comprises a backflow filter (200") at said free end.

15. The cigarette as claimed in claim 12, wherein said plug of tobacco (80b) includes a first portion (320b) adjacent said free end (78b) which has a higher density than a second portion (310b) of said plug of tobacco distal from said free end.

16. A cigarette (23) comprising a tobacco rod (60) having a back-flow resistive free end (78) and an opposite end (72), said tobacco rod comprising a tubular tobacco (66) web including a layer of tobacco material (78) a flow constriction (74) operative at said opposite end of said tubular web and tobacco (78,80) operatively situated adjacent said free end and spaced from said flow constriction, the tobacco comprising cut filler partially filling said tobacco rod so as to define a filled tobacco rod portion and an unfilled tobacco rod portion, said unfilled portion being located adjacent said flow constriction, said tubular web arranged to communicate heat received by said tubular web to said tobacco, said tobacco rod (60) being arranged such that during a puff on said cigarette with an application of heat along a region of said tubular web, at least a portion of the tobacco is caused to release tobacco aerosol which is drawn through said flow constriction.

17. The cigarette as claimed in claim 16, wherein said flow constriction (74) is defined by a tubular element.

18. The cigarette as claimed in claim 17, wherein said tubular element comprises a first free-flow filter (74), said first free-

flow filter defining a first passage (75) therethrough, said cigarette further comprising tipping (62), said tipping including a second tubular free-flow filter (102) located adjacent said first free-flow filter of said tobacco rod, said second tubular free-flow filter defining a second passage therethrough, said first passage of said first free-flow filter being narrower than said unfilled portion (91) of said tobacco rod and narrower than said second passage of said second free-flow filter (102).

19. The cigarette as claimed in claim 18, wherein said cut filler tobacco forms a back-flow resistive plug.

20. The cigarette as claimed in claim 19, wherein said portion of said cut filler tobacco (80) is located at said free end (78) and has a density greater than a remainder of said cut filler tobacco distal from said free end.

21. The cigarette as claimed in claim 20, wherein said tipping (62) further comprises a mouthpiece filter (104) adjacent said second free-flow filter (102).

22. The cigarette as claimed in claim 20, wherein said tubular web includes a cigarette wrapper (71) about said tobacco rod (60), said tipping attached to said tobacco rod with a tipping paper (64).

23. The cigarette as claimed in any preceding claim, wherein

said tobacco or plug of tobacco (80) comprises a cut filler tobacco.

24. The cigarette as claimed in claim 23, wherein said tobacco or plug of tobacco (80) comprises a blend of cut filler tobacco, said blend comprising a combination of at least two of bright, burley and oriental tobaccos.

25. The cigarette as claimed in claim 23 or 24, wherein said plug of tobacco includes a plug wrap (84) disposed about said cut filler tobacco (80).

26. The cigarette as claimed in claim 23 or 24, wherein said tobacco (70) is located along an inside surface of said tubular tobacco web (66).

27. The cigarette as claimed in claim 26, wherein said tobacco rod comprises an overwrap (71) disposed about an outside surface of said tubular tobacco rod or rod portion.

28. A method of improving delivery of smoke from a cigarette (23) operated with an electronic lighter, said cigarette comprising a tubular web (66) having a free end (78), and an opposite end (72), smoke being withdrawable from said opposite end, said method comprising the steps of:

establishing an unfilled portion along said tubular web at a location adjacent said opposite end and a tobacco filled

portion along said tubular web at a location adjacent said free end; and

superposing an electrical heater element of said electronic lighter at least partially over said filled portion of said tubular web while activating said electrical heater element so as to cause release of smoke constituents from said tobacco.

29. The method of claim 28, wherein said superposing step includes superposing said electrical heater element partially over both said filled portion of said tubular web and said unfilled portion of said tubular web while activating said electrical heater element.

30. The method of claim 28 or 29 further comprising the step of passing said released tobacco constituents through a construction located adjacent said opposite end.

31. A tobacco web adapted to be rolled into a tubular tobacco rod (60) of a cigarette (23) operative with an electrical cigarette lighter (25), said tobacco web comprising a base web (68) and a tobacco material (70) disposed along a first side of said base web;

said base web comprising a combination of tobacco fiber and cellulosic fiber, said tobacco fiber and said cellulosic fiber combined at a ratio in the range of approximately 2:1 to 4:1, said base web having a basis weight in a range of approximately 35 to 45 g/m^2;

said tobacco material having at least twice the basis weight of said base web, said tobacco material comprising finely ground tobacco and extracted tobacco solids at a ratio in a range of approximately 3:1 to 9:1, and a humectant at a level of approximately 5% to 20% by weight of said material.

32. The tobacco web as claimed in claim 31, wherein said tobacco material has a basis weight of approximately three to four times that of said base web.

33. The tobacco web as claimed in claim 31 or 32, wherein said tobacco material further comprises pectin at a level of up to approximately 2% by weight of said tobacco material.

34. The tobacco web as claimed in claim 33, wherein said base web comprises approximately 28 g/m^2 tobacco fiber and approximately 12 g/m^2 cellulosic fiber of a wood pulp or flax pulp, or tobacco stem pulp.

35. The tobacco web as claimed in claim 34, wherein said tobacco material comprises approximately 66 to 71% by weight tobacco particles, approximately 16 to 20% by weight extracted tobacco solids, approximately 10 to 14% by weight glycerine and approximately 1-2% pectin.

36. A tobacco web adapted to rolled into a tubular tobacco rod (60) of a cigarette (23) operative with an electrical cigarette

lighter (25), said tobacco web comprising a base web (68) and a tobacco material (70) disposed along a first side of said base web;

said base web comprising a combination of tobacco fiber at a component basis weight of approximately 20 to 30 g/m² and carbon fiber at a component basis weight of approximately 2-9 g/m², and pectin at a component basis weight of approximately 1 g/m²

said tobacco material having a basis weight three to four times that of said base web, said tobacco material comprising finely ground tobacco and extracted tobacco solids at a ratio in a range of approximately 3:1 to 9:1, and a humectant at a level in the range of approximately 5% to 20% by weight of said tobacco material.

37. A cigarette operative with an electrical cigarette lighter, said cigarette comprising a tubular tobacco rod (6) constructed from a tobacco web according to any of claims 31 to 36.

38. The cigarette as claimed in claim 37 further comprising a plug of cut filler (80) adjacent a free end (78) of said tobacco rod (60), at least one tubular free-flow filter (74) adjacent an opposite end (72) of said tobacco rod and a filler-free void (91) located between said plug of cut filler and said tubular free-flow filter.

39. A method of manufacturing a tobacco web (66) comprising a base web (68) and a layer of tobacco material (70), said tobacco web being foldable into a tubular form as part of a cigarette (22) operative with an electrical cigarette lighter (25), said method comprising the steps of:

separating solubles (124) from fibers of tobacco feedstock, said solubles being in solution comprising 5 to 10% by weight dissolved tobacco constituents;

producing (128) said base web by forming a slurry of said separated tobacco fiber, mixing said slurried tobacco-fiber with a slurry strengthening agent to form a slurried mixture and casting (130) said slurried mixture onto a web forming apparatus;

producing (146) said tobacco material by mixing said 5 to 10% solution of tobacco constituents with additional tobacco particles, glycerin and pectin so as to form a dispersion of tobacco material and adjusting water content so as to achieve in said dispersion a solids content in the range of approximately 20 to 30%;

applying (144) said dispersion of tobacco material along said base web to form a sheet of said tobacco web;

drying (146) said sheet of said tobacco web to a moisture content in the range of approximately 8.5 to 12%;

cooling (148) said sheet of said tobacco web;

decurling (150) said sheet of said tobacco web;

winding (152) said sheet of said tobacco web so as to form a roll of tobacco web; and

slitting (154) said roll of tobacco web so as to produce a bobbin of tobacco web.

40. The method as claimed in claim 39, wherein said solution of tobacco solubles comprises approximately 7 to 8% by weight dissolved tobacco constituents.

41. The method as claimed in claim 40, wherein the amount of water is adjusted to achieve at the conclusion of the mixing step a dispersion of approximately 24 to 25% solids content.

42. The method as claimed in claim 41, wherein the tobacco particles are in the range of approximately 100 to 220 mesh.

43. The method as claimed in claim 42, wherein the tobacco particles are approximately 120 mesh.

44. The method as claimed in any of claims 40 to 43 wherein said slurry strengthening agent comprises at least one of wood pulp, flax pulp and tobacco stem pulp.

45. The method as claimed in any of claims 40 to 44, wherein said applying step includes applying said dispersion of tobacco material to said base web at dry weight ratio of at least 2:1.

46. The method as claimed in any of claims 40 to 45, wherein said applying step includes applying said dispersion of tobacco material to said base web at dry weight ratio of at least 3:1.

47. The tobacco web as claimed in claim 36, wherein said tobacco fibre is at a component basis weight of approximately 24 to 28 g/m², carbon fibre is at a component basis weight of approximately 2 to 4 g/m² and pectin is at a component basis weight of 2.5 to 1.5 g/m².

48. A heater (39) for use in a smoking system having a source of electrical energy for heating a cigarette, the heater comprising:

a plurality of electrically resistive heater blades (121) defining a receptacle to receive an inserted cigarette and extending alongside the inserted cigarette, each blade comprising a first heater blade leg (116A) having a first end and a second end, a second heater blade leg (116B) having a first end and a second end (122), and a connecting section (118) connecting the second end of said first heater blade leg and the first end of said second heater blade leg;

wherein said first and second heater blade legs of each heater blades are separated by a respective gap (125); and

wherein the first ends of said first heater blade leg are adapted to be in electrical contact with the source of electrical energy, wherein respective resistive heating paths are formed comprising said first heater blade leg, said connecting section, and said second heater blade leg to respectively heat each of said electrically resistive heater blades along said first and second blades, which in turn heat the inserted cigarette, said first ends of said first blades having a common connection.

49. The heater according to claim 48, wherein the first ends of said first heater blade legs (116A) are grounded.

50. The heater according to claim 48 or 49, wherein the common connection of the first ends of said first heater blade legs is a hub.

51. The heater according to any of claims 48 to 50 wherein the gap (125) separating said first and second heater blade legs is sized to permit entrainment of air flow into the heated cigarette upon drawing by a smoker.

52. The heater according to any of claims 48 to 51 further comprising a supporting hub (110), the first ends of each of said first heater blade legs (116A) extending from said supporting hub;

wherein said supporting hub is adapted to be in electrical contact with the source of electrical energy to form a common for the first ends of said first heater blade legs.

53. The heater according to claim 52, wherein the second ends of said second heater blade legs (116B) are adapted to be in respective electrical contact with the source of electrical energy, wherein respective resistive heating circuits are formed comprising said first heater blade leg, said connecting edge section, and said second heater blade to respectively heat each of said electrically resistive heater blades (121), which in turn heats the inserted cigarette.

54. The heater according to claim 52 or 53, wherein the second ends (122) of said second heater blade legs (116B) extend toward said supporting hub (111) and are electrically insulated therefrom.

55. The heater according to claim 52 or 53, wherein the second ends (122) of said second heater blade legs (116B) are separated from said hub by a gap.

56. The heater according to claim 52, further comprising an electrical insulator applied to at least one of said hub and the second ends of said second heater blade legs.

57. The heater according to claim 52, further comprising an electrical insulator applied to at least one of the second ends of said second heater blade legs and the first ends of said first heater blade legs.

58. The heater according to claim 52, further comprising an electrical insulator (300) forming a ceramic hub support structure around said supporting hub (111), the second ends (122) of said second heater blade legs (116B) and the first ends of said first heater blade legs (116B).

59. The heater according to any of claims 52 to 58, wherein

said supporting hub and said blades are monolithic.

60. The heater according to any of claims 48 to 59, wherein said connecting section (118) further comprises a free end (118B) to compensate for thermal expansion when the heater element is heated.

61. The heater according to claim 60, further comprising a support structure (83) stationarily located within the smoking system and defining channels (210) to receive the free ends (118B) of said connecting sections of said blades (121).

62. The heater according to claim 61, wherein said channels (210) are arranged to permit translational thermal expansion and contraction of said heater blades.

63. The heater according to claim 61 or 62 further comprising a pivot point (204) located in each of said channels, said pivot point located such that the associated free end (118B) of said connecting section pivots about said pivot points to bias said first and second heater blade legs (116A,B) inward toward the inserted cigarette upon heating of the associated heater blade.

64. The heater according to any of claims 48 to 63, wherein portions of at least one of said first heater blade leg (116A) and said second heater blade leg (116B) are coated with a ceramic (300) to strengthen and electrically insulate the at least one

of said first heater blade leg and said second heater blade leg.

65. The heater according to claim 64, wherein a portion of said second heater blade leg (116B) adjacent said ceramic is adapted to be in electrical contact with the source of electrical energy.

66. The heater according to any of claims 48 to 65, wherein said blades (121) are arranged to slidingly receive the inserted cigarette.

67. The heater according to any of claims 48 to 66 wherein the second end of said second heater blade leg is a step shape, said step shape comprising an end section (122C) adapted to be in electrical contact with the source of electrical energy.

68. The heater according to any of claims 48 to 67 wherein said first and second heater blade legs (116A,B) of a respective heater blade (121) are substantially parallel.

69. The heater according to any of claims 48 to 68, wherein said connecting edge has a curvature between approximately 160° and 200°.

70. The heater according to any of claims 48 to 69 wherein an underside of at least one of said first and second heater blade legs (116A,B) facing the inserted cigarette is substantially non-planar in a transverse direction of said heater blade leg.

71. The heater according to claim 70, wherein said underside is curved.

72. The heater according to claim 70, wherein said underside is angled.

73. The heater according to any of claims 48 to 72, wherein said plurality of electrically resistive heater blades (121) are arranged in groups, wherein gaps (133) between the groups are sized to provide unheated portions of the inserted cigarette providing strength to facilitate removal of the cigarette after smoking.

74. The heater according to any of claims 48 to 73, wherein at least one of said first and second heater blade legs (116A,B) is serpentine shaped.

75. The heater according to claim 74, wherein both said first and second blade legs are serpentine and mutually parallel such that space between the legs is serpentiginous.

76. The heater according to claim 48, wherein at least one end of at least one blade (121, 122) is wider than an adjacent active portion of said at least one leg, wherein the end of said leg has a lower current density and a lower ohmic heating than the active portion of said leg.

77. The heater according to any of claims 48 to 76, wherein said connecting section (119) is perforated.

78. The heater according to any of claims 48 to 77, wherein said first and second heater blade legs (116A,B) are biased inwardly toward the inserted cigarette.

79. The heater according to any of claims 48 to 78, wherein said first and said second heater blade legs (116A,B) and said connecting edges have a resistance of approximately 100 to approximately 200 μohm.cm.

80. The heater according to any of claims 48 to 79, wherein said first and said second heater blade legs (116A,B) and said connecting edges have a resistance of approximately 50 to approximately 500 μohm.cm.

81. The heater according to any of claims 48 to 80, wherein said first and said second heater blade legs (116A,B) and said connecting edges are capable of reaching temperatures of approximately 200°C to approximately 1000°C in approximately 0.2 to approximately 2.0 sec. with a pulse of approximately 10 to approximately 50 Joules.

82. The heater according to claim 81, wherein said first and second legs (116A,B) and said connecting edges are capable of being pulsed to these temperatures for approximately 1800 to

approximately 10,000 such pulses.

83. The heater according to claim 48, wherein the gap (125) separating said first and second heater blade legs (116A,B) is sized to maximize cumulative radiative heating from each of said first and second heater blade legs of an associated heater blade to a portion of the inserted cigarette underlying the gap.

84. The heater according to any of claims 48 to 83, wherein said first and second heater blade legs (116A,B) and said connecting edge section comprise an electrically resistive material selected from the group consisting of iron aluminides and nickel aluminides.

85. An electrical smoking system comprising a cigarette according to any of claims 1 to 37 and a lighter, the lighter having a plurality of resistive heater blades defining a receptacle for receiving the heater blades, whereby the blades at least partially overlap said tobacco plug when said cigarette is inserted into said receptacle.

86. An electrical smoking system according to claim 85, wherein said heater blades extend along the length of said tobacco plug and partially overlap said unfilled space.

87. An electrical smoking system according to claim 85 or 86, wherein the lighter includes a heater according to any of claims

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48 to 84.

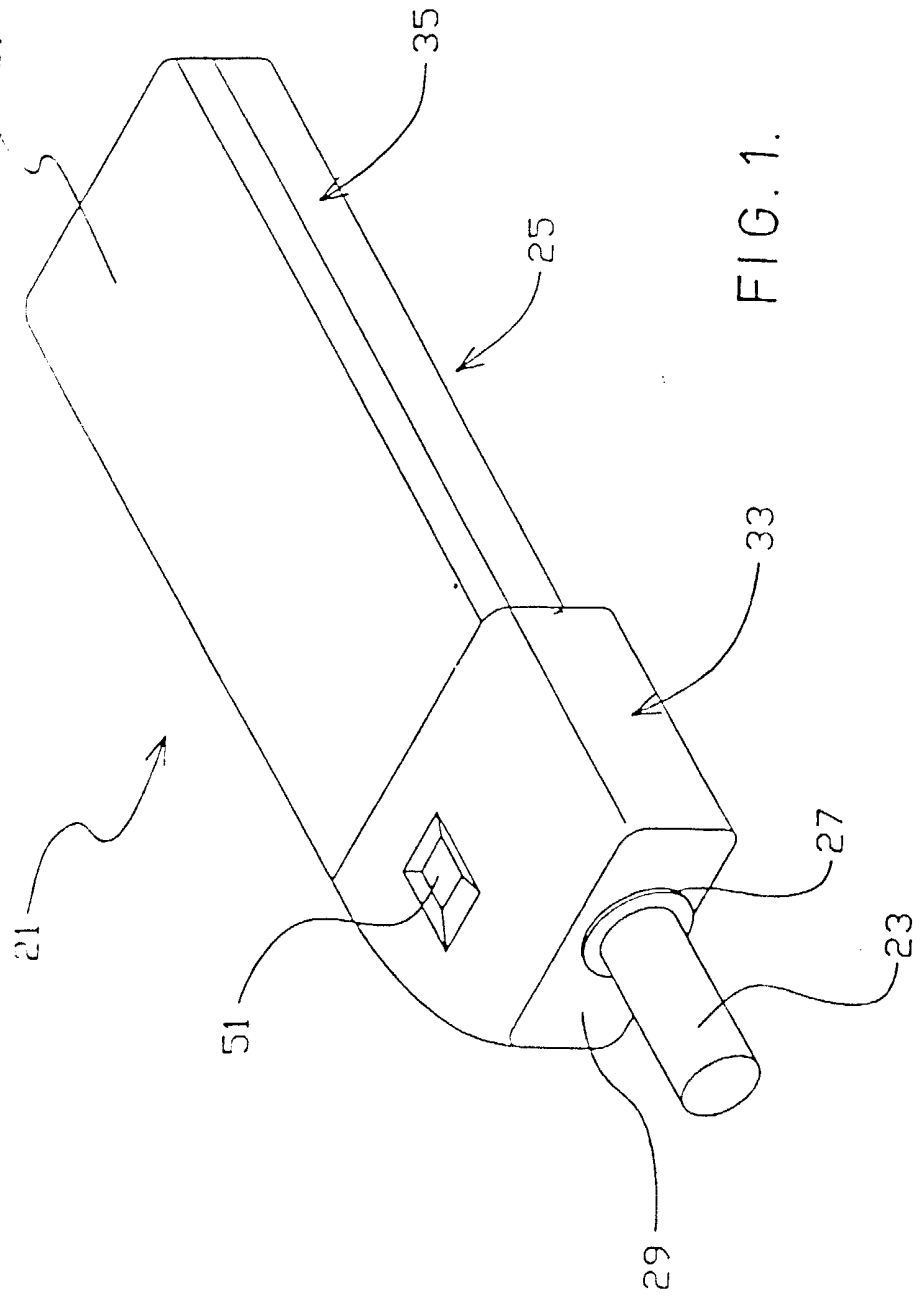

FIG. 1.

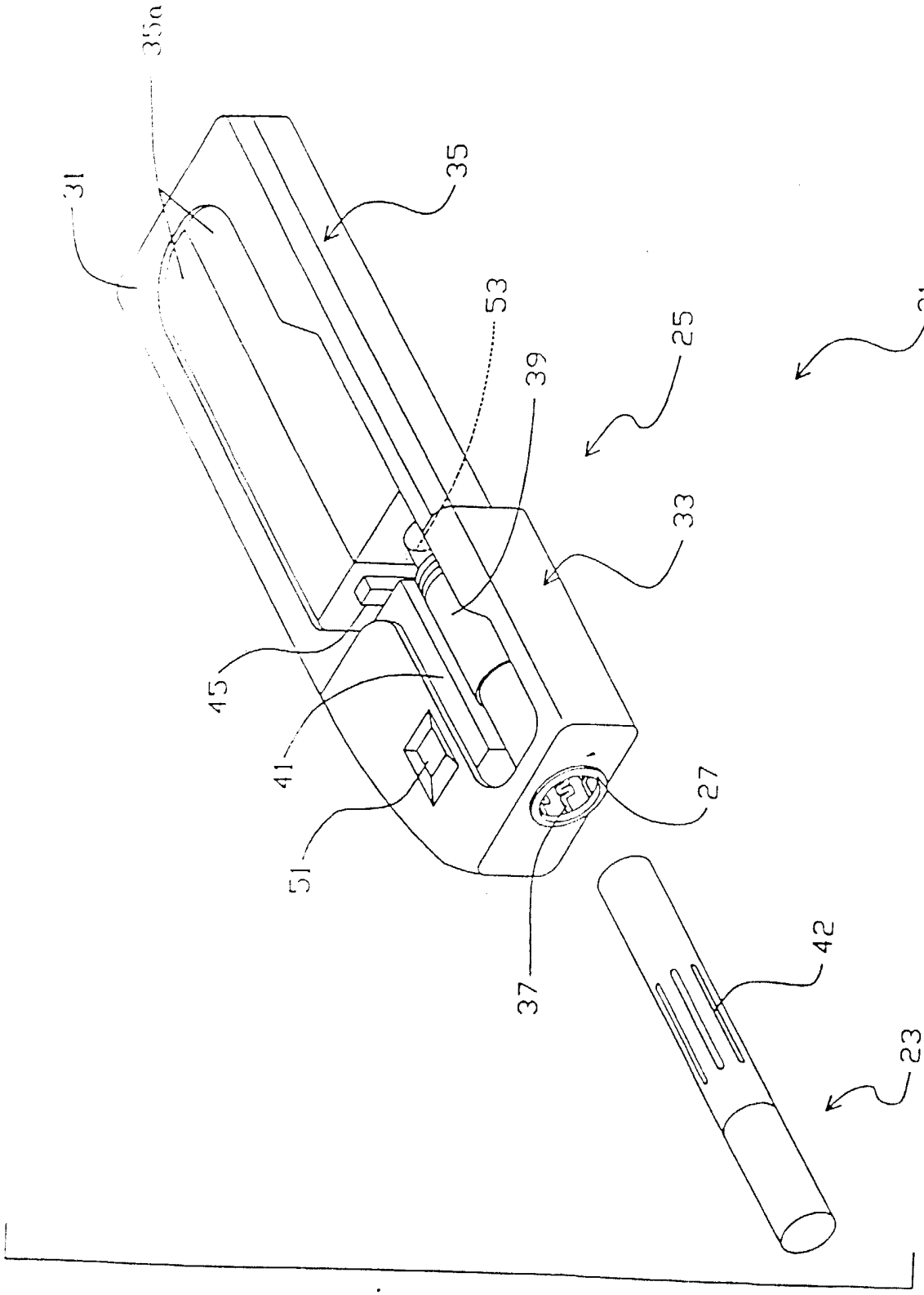

FIG. 2.

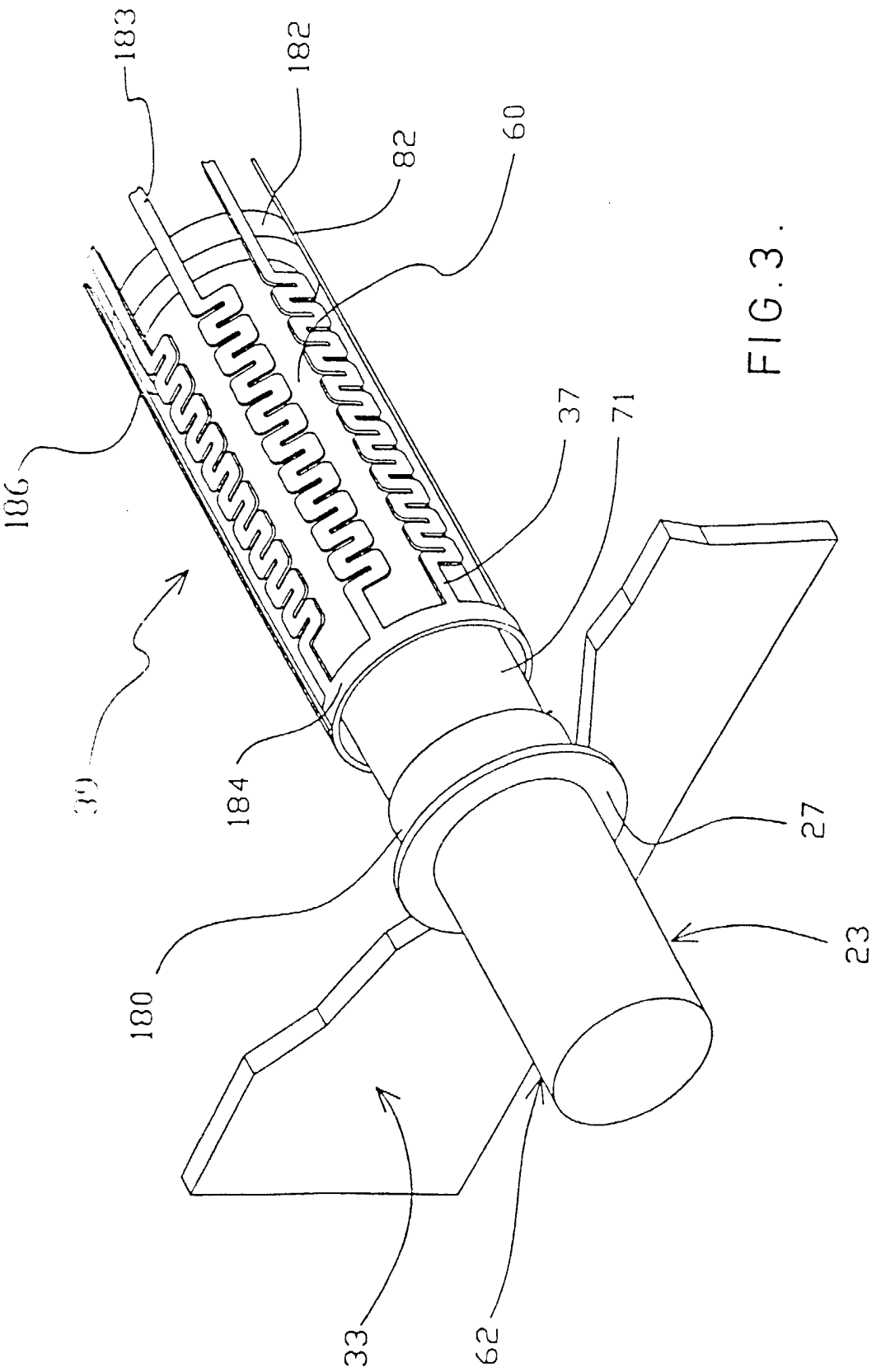

FIG.3.

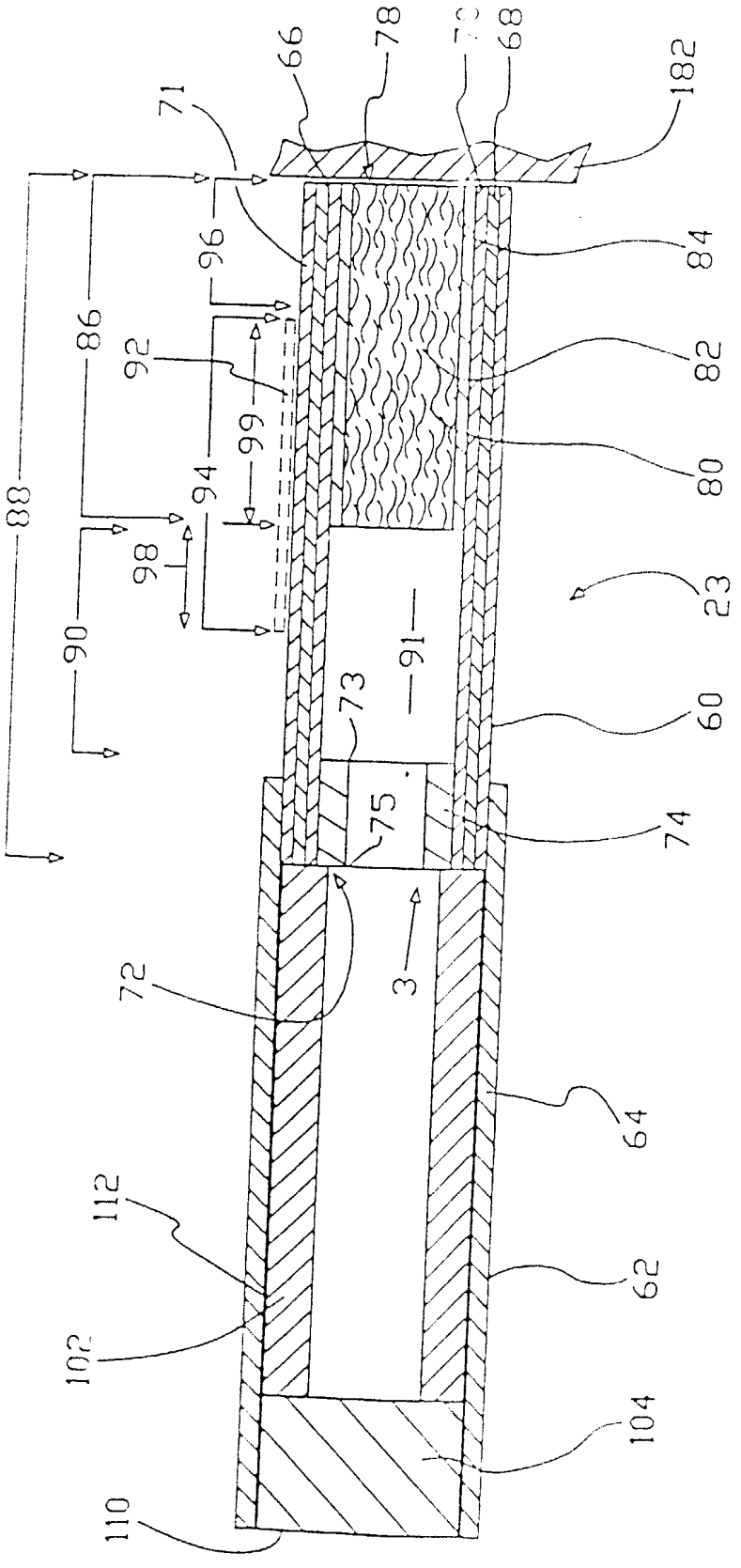
66
78
68
182
71
96
84
86
92
82
99
80
88
94
98
23
90
91
73
60
75
74
72
3
64
112
62
102
104
110

FIG. 4A.

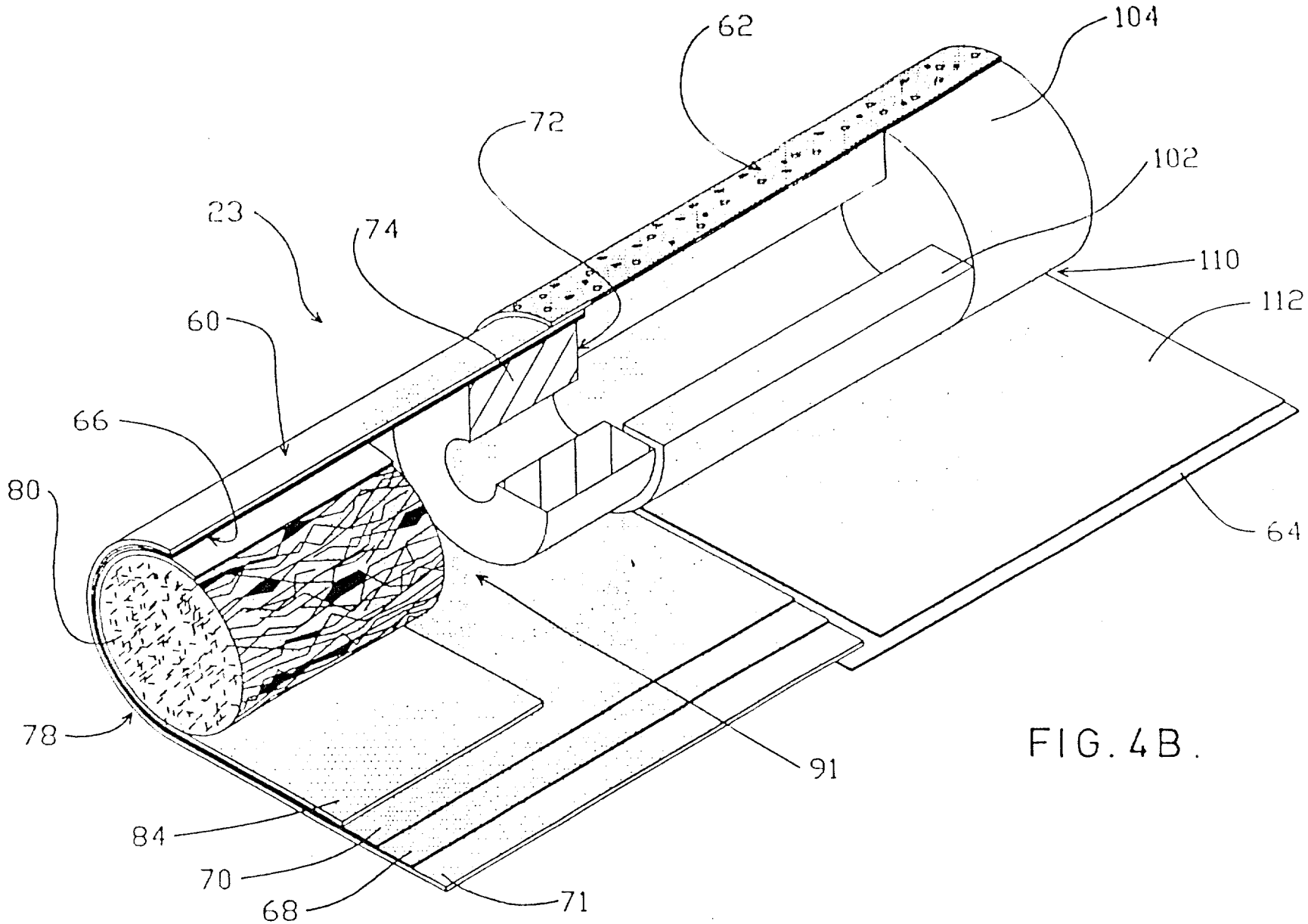

FIG. 4B.

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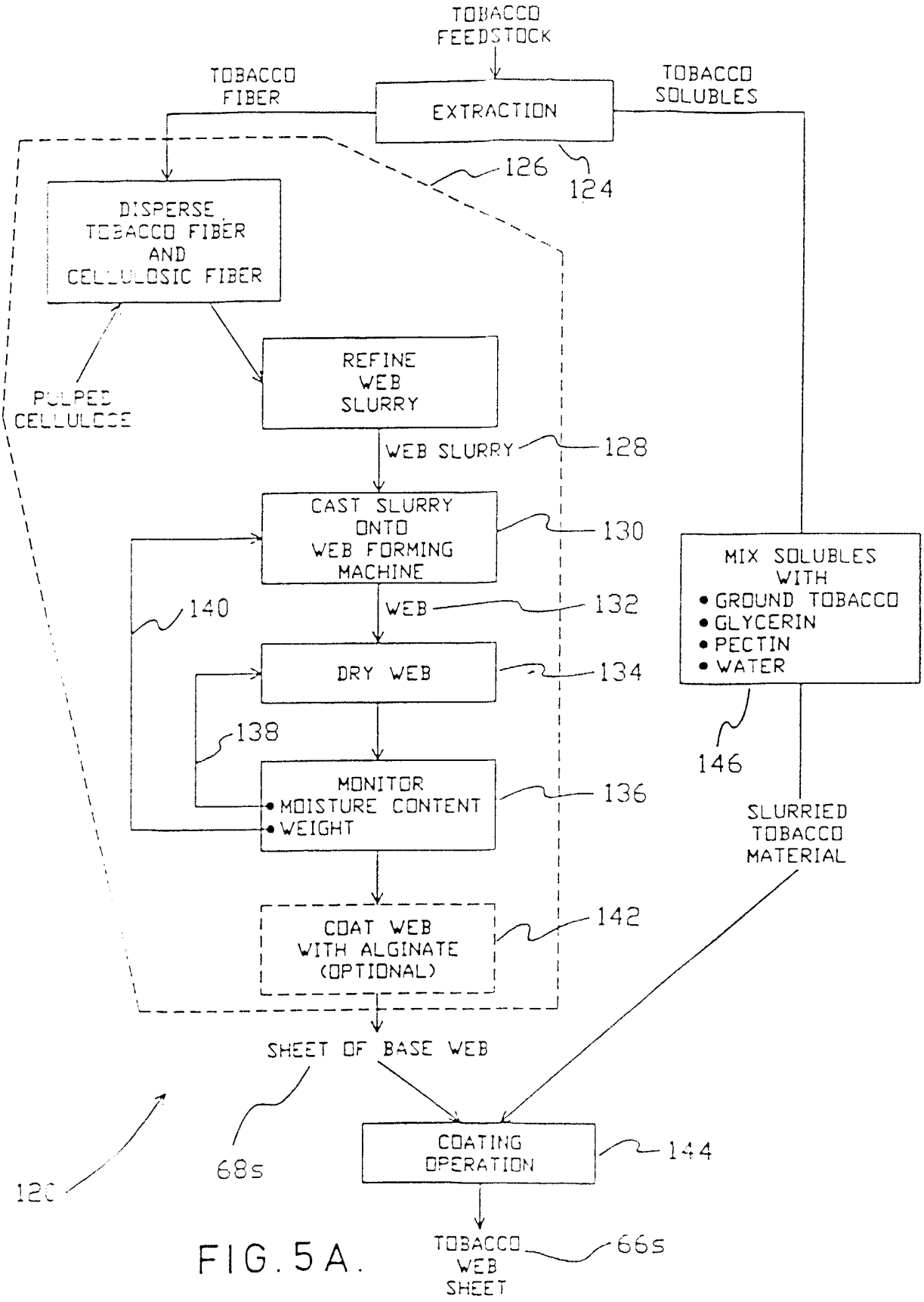
TOBACCO FEEDSTOCK
TOBACCO FIBER
EXTRACTION
TOBACCO SOLUBLES
126
124
DISPERSE TOBACCO FIBER AND CELLULOSIC FIBER
PULPED CELLULOSE
REFINE WEB SLURRY
WEB SLURRY
128
CAST SLURRY ONTO WEB FORMING MACHINE
130
MIX SOLUBLES WITH
• GROUND TOBACCO
• GLYCERIN
• PECTIN
• WATER
140
WEB
132
DRY WEB
134
138
MONITOR
• MOISTURE CONTENT
• WEIGHT
136
146
SLURRIED TOBACCO MATERIAL
COAT WEB WITH ALGINATE (OPTIONAL)
142
SHEET OF BASE WEB
68s
120
COATING OPERATION
144
TOBACCO WEB SHEET
66s

FIG. 5A.

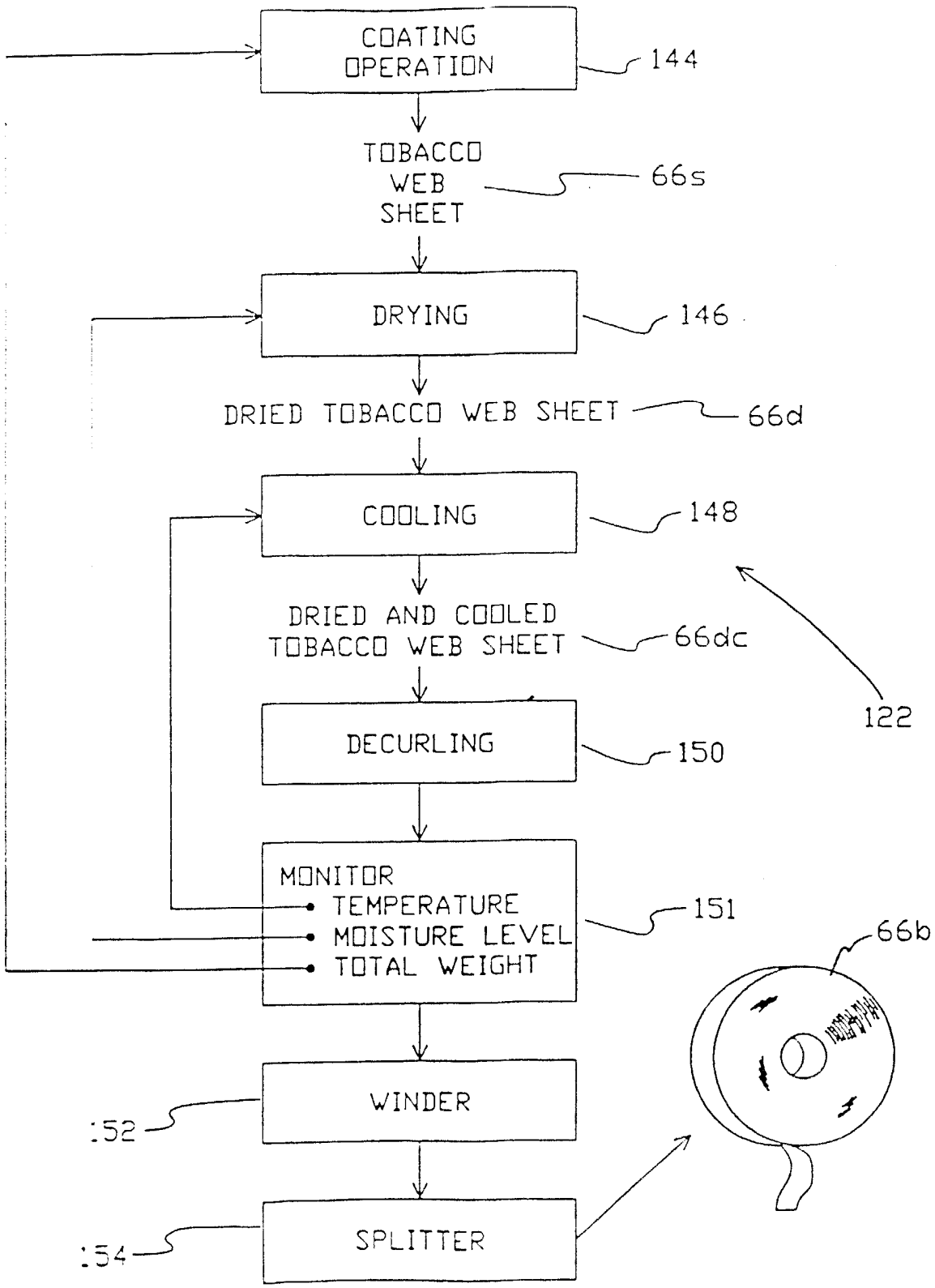
COATING OPERATION
144
TOBACCO WEB SHEET
66s
DRYING
146
DRIED TOBACCO WEB SHEET
66d
COOLING
148
DRIED AND COOLED TOBACCO WEB SHEET
66dc
122
DECURLING
150
MONITOR
TEMPERATURE
MOISTURE LEVEL
TOTAL WEIGHT
151
66b
WINDER
152
SPLITTER
154

FIG. 5B.

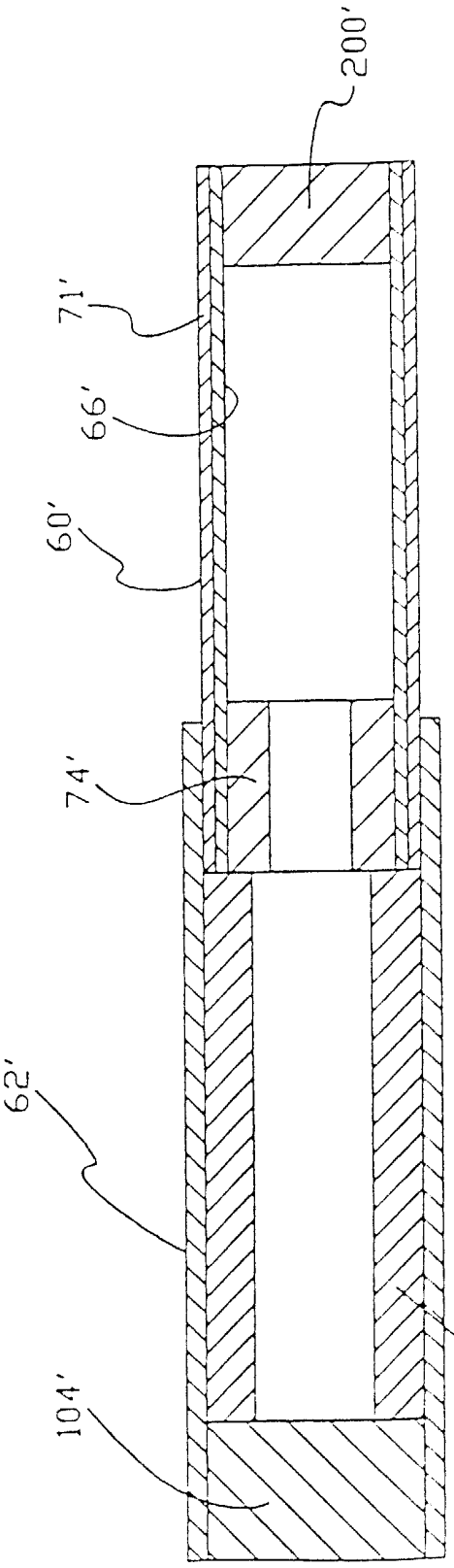

FIG. 6A.

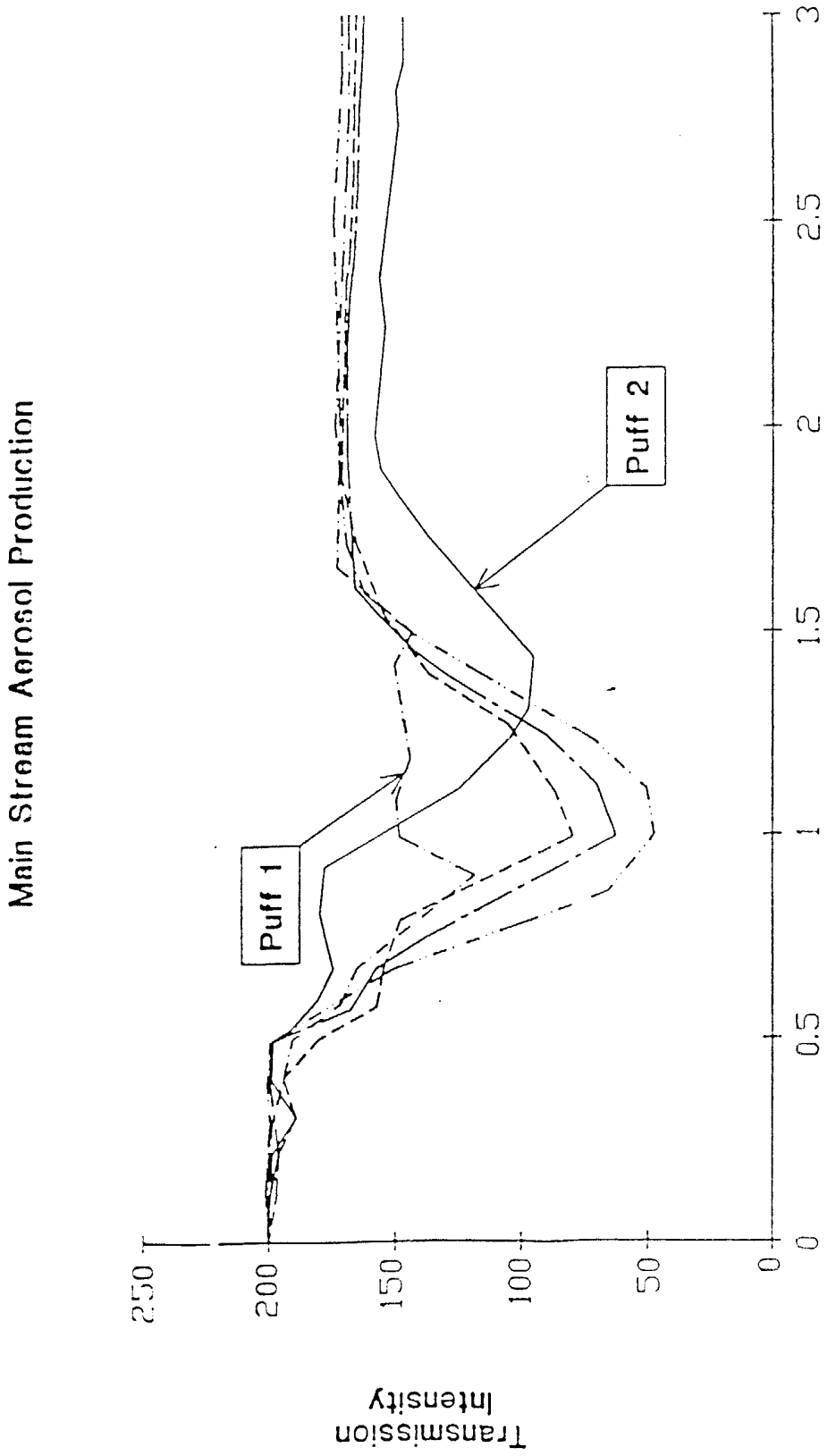
Main Stream Aerosol Production
Puff 1
Puff 2
Transmission Intensity
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
Time (sec)

FIG. 6B.

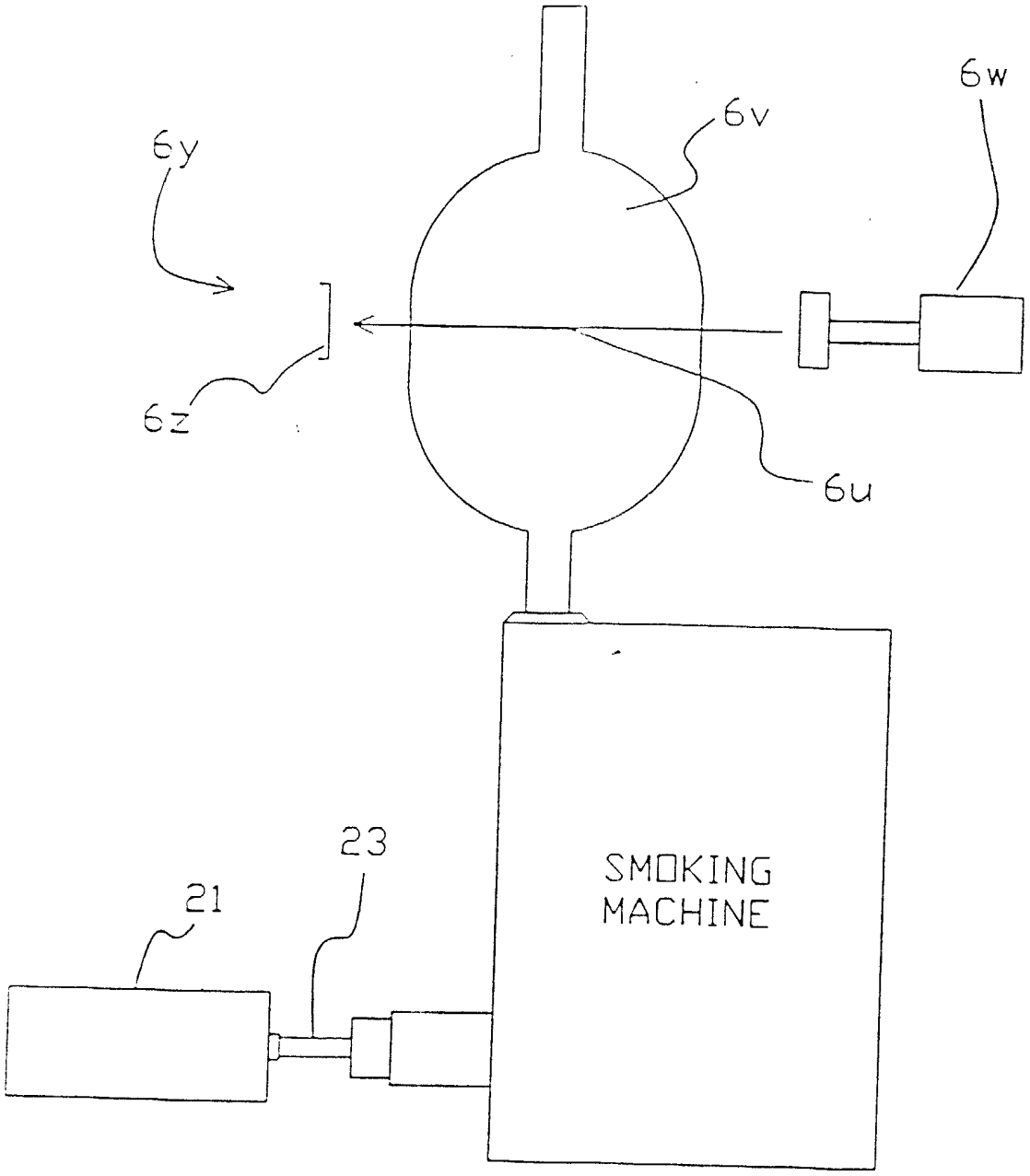

FIG. 6C.

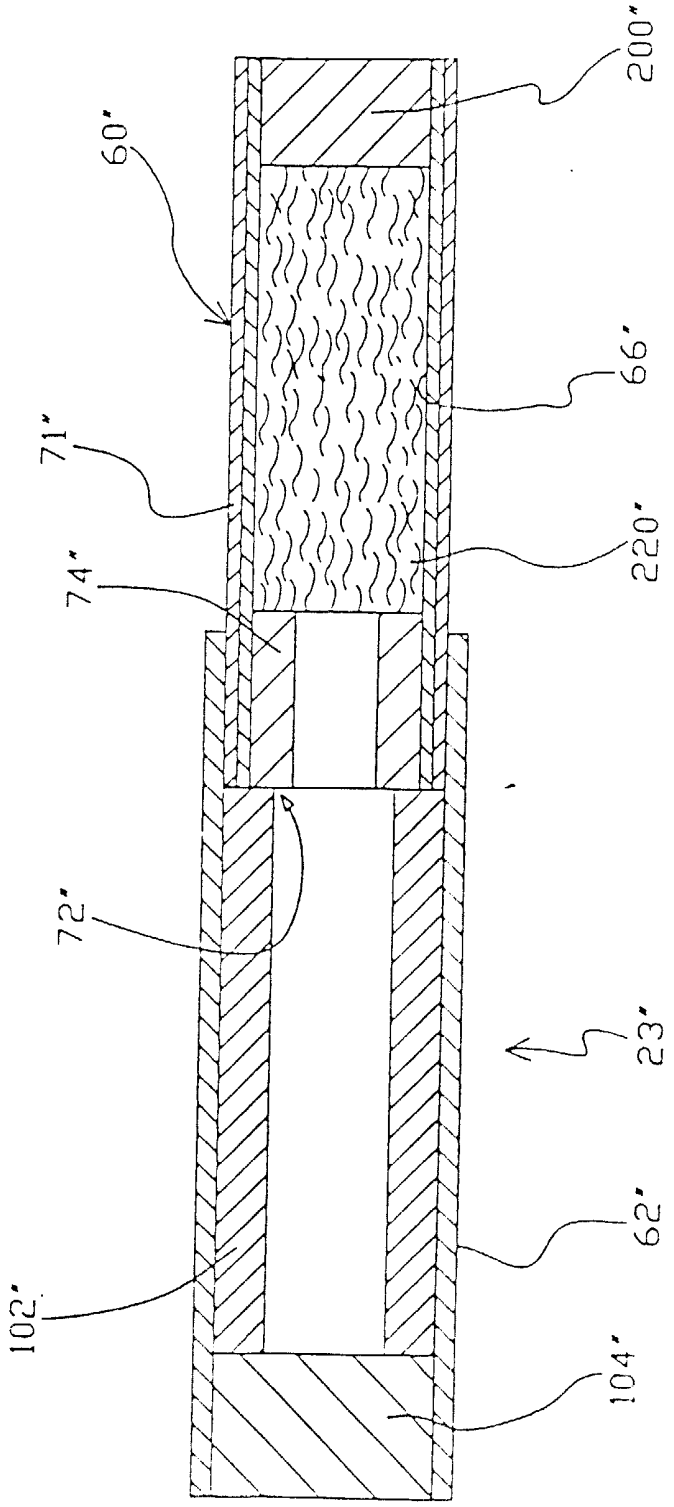

FIG. 7A.

Main Stream Aerosol Production
0.275 g/cc cut filler, base mat, backflow filter

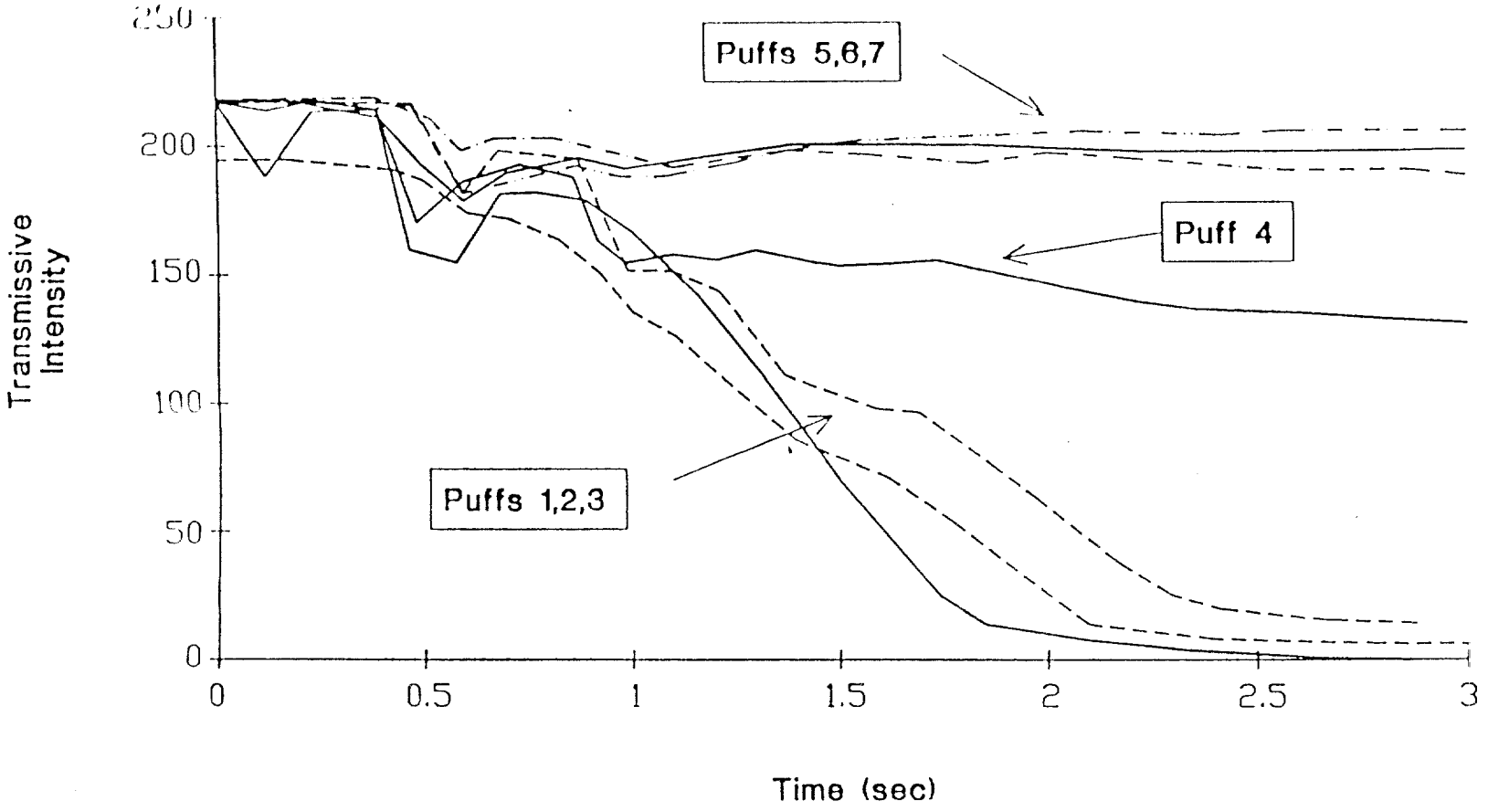

FIG. 7B.

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MAIN STREAM AEROSOL VOLUME
CONSTRUCTION COMPARISON
Serpentine Heater, 15 Joules

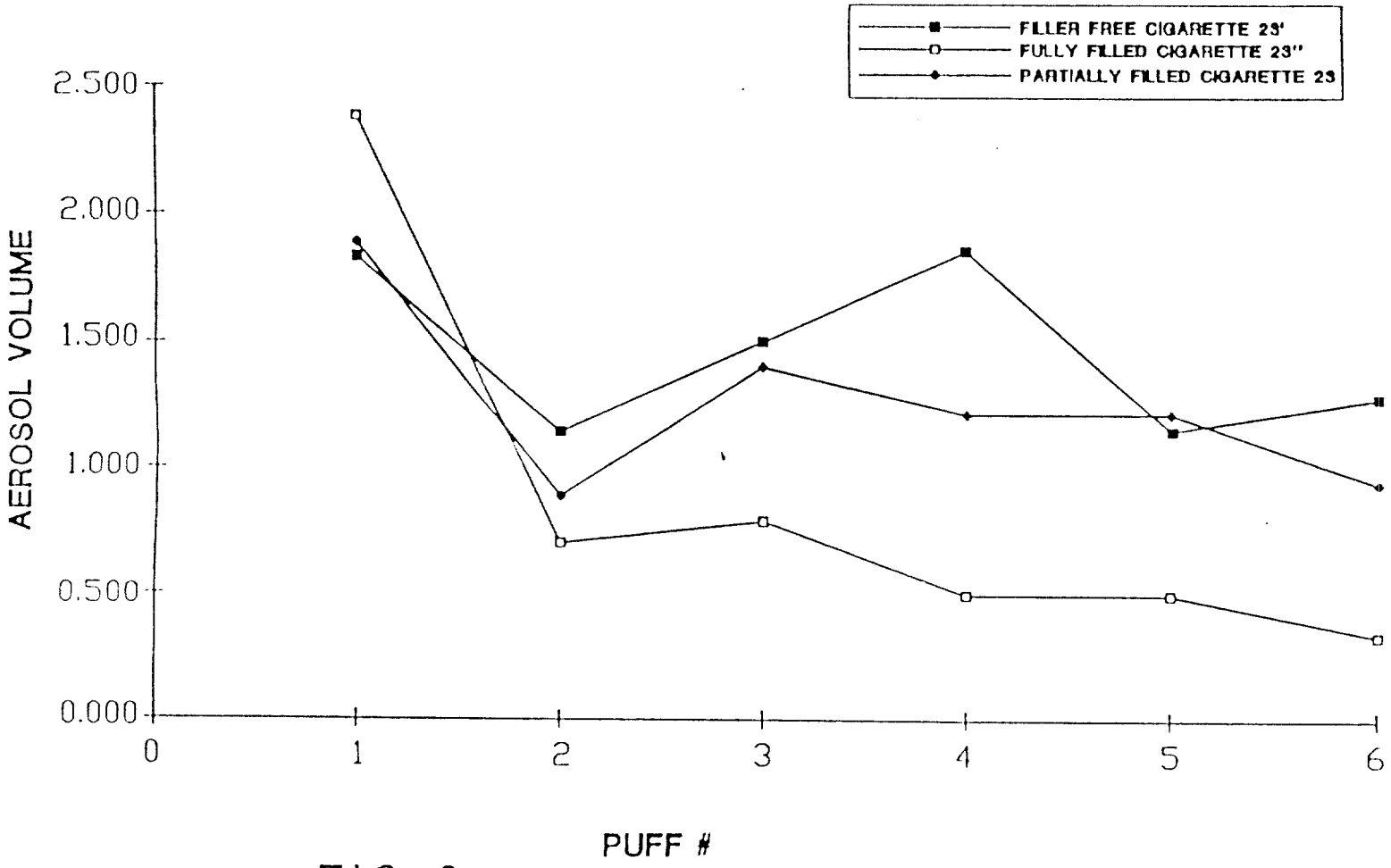

FIG. 8.

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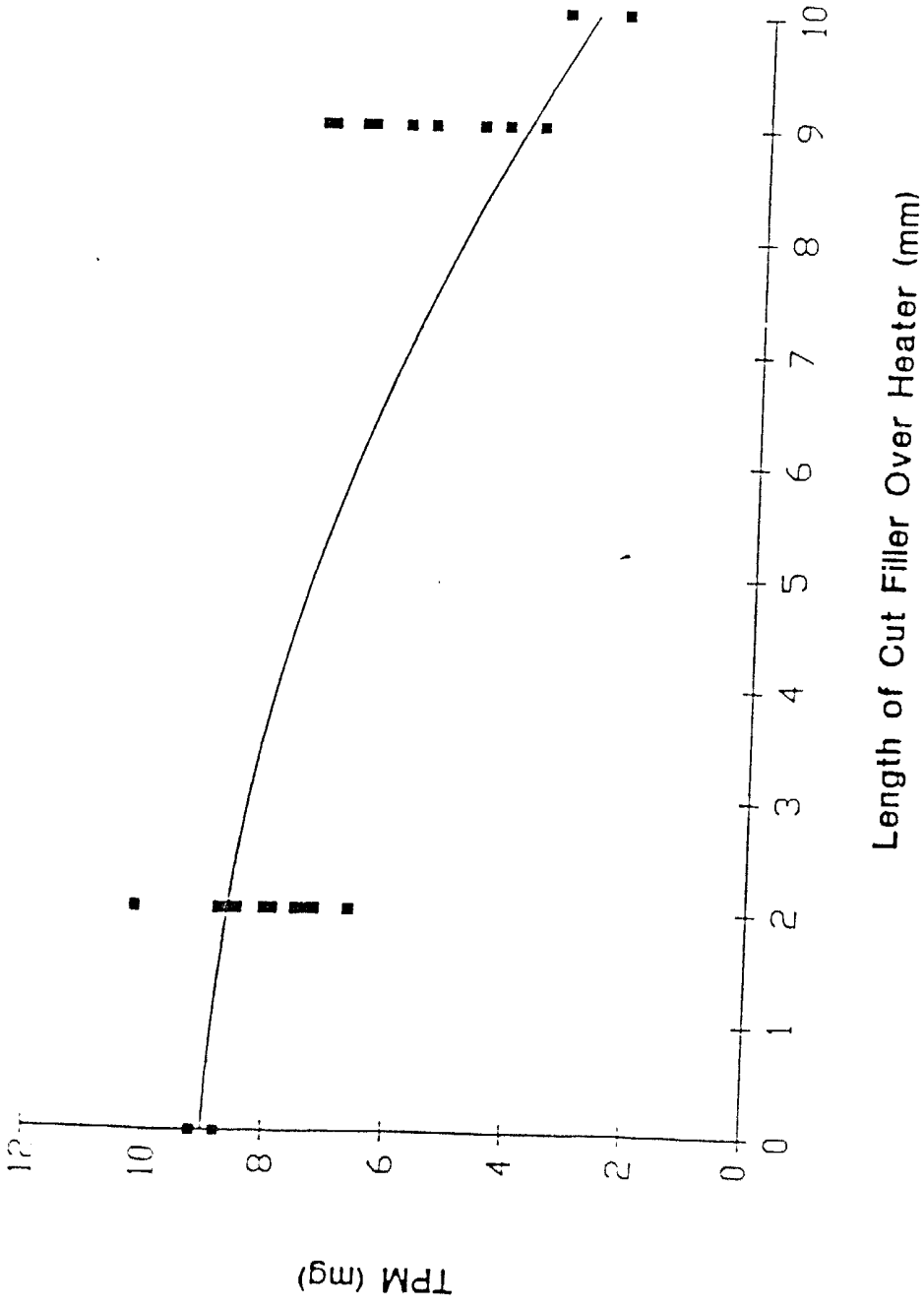

TPM (mg)
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
10
Length of Cut Filler Over Heater (mm)

FIG. 9.

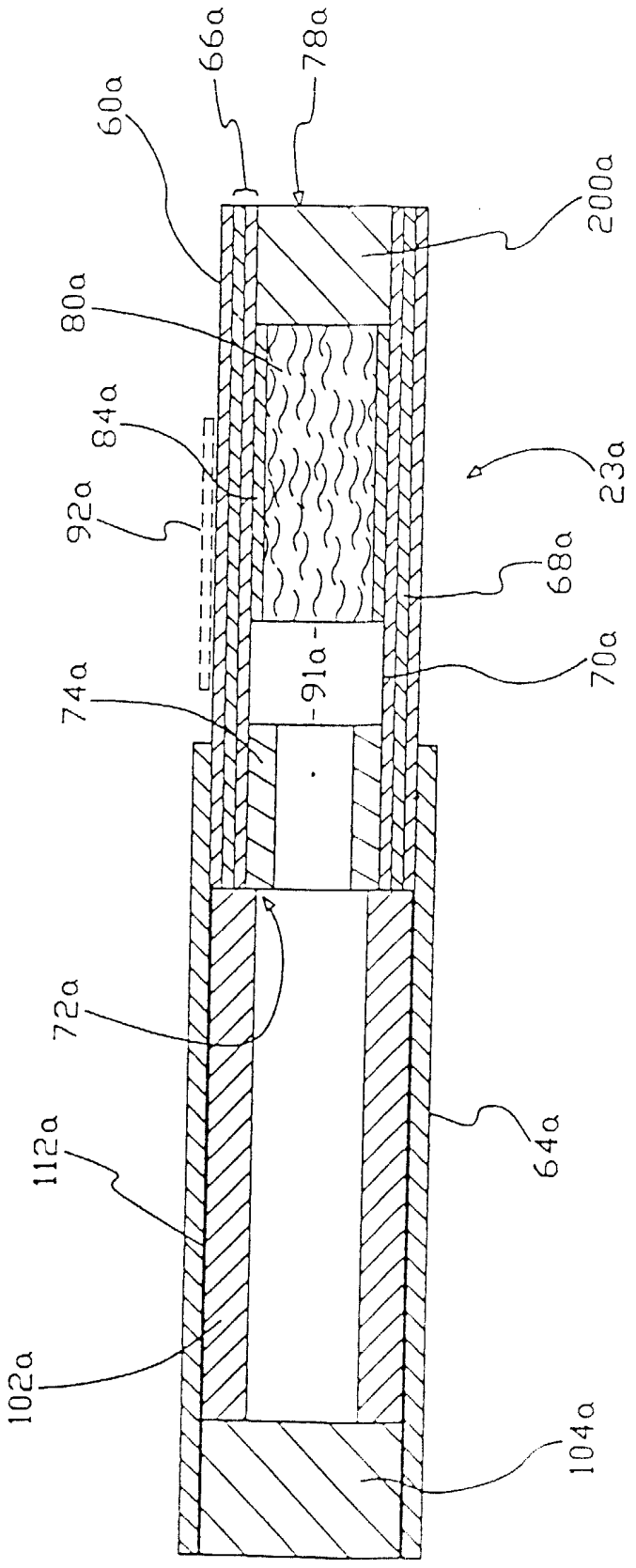

60a
66a
78a
200a
80a
84a
23a
92a
68a
91a
70a
74a
72a
112a
64a
102a
104a

FIG. 10.

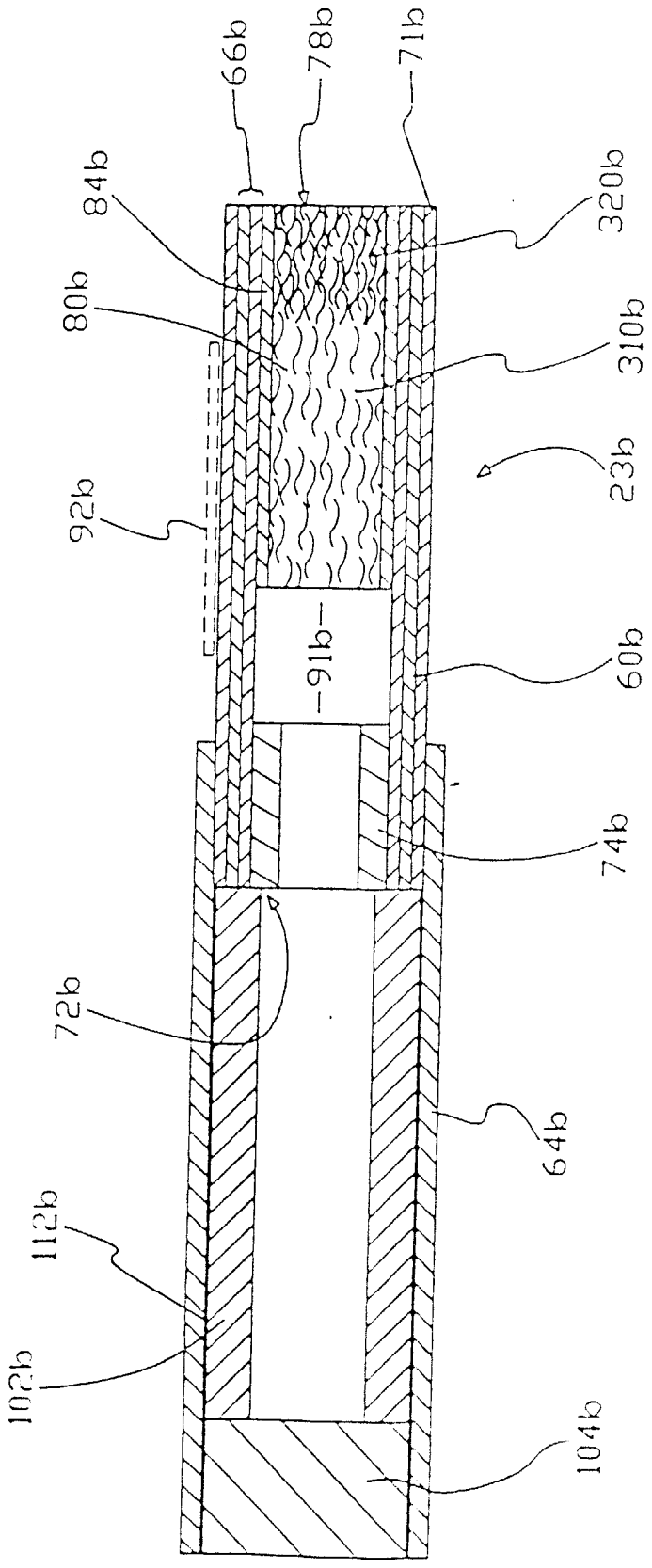

66b
78b
71b
84b
320b
80b
310b
23b
92b
91b
60b
74b
72b
64b
112b
102b
104b

FIG. 11.

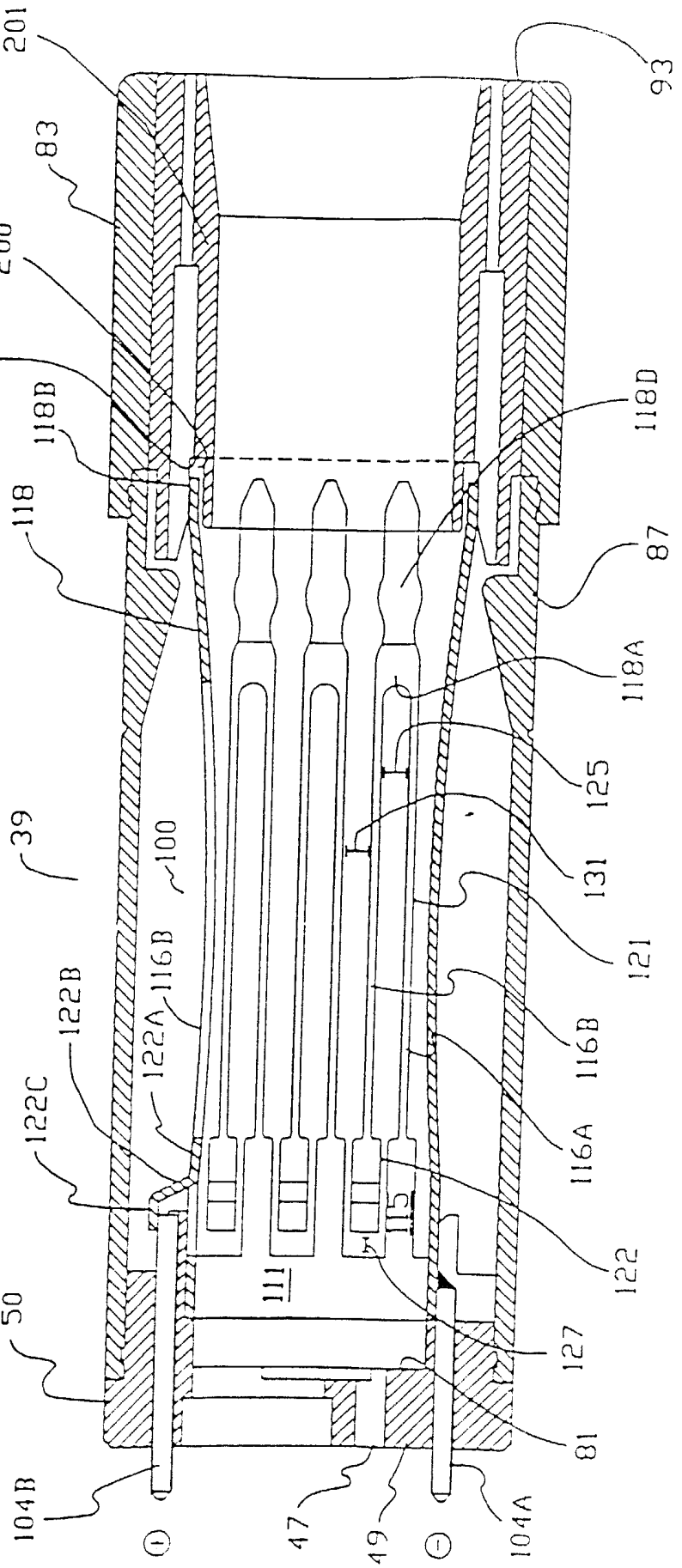

201
93
83
200
202
118B
118D
118
87
118A
125
131
121
39
100
116B
122B
122A
122C
116B
116A
115
111
122
127
50
81
104B
47
49
104A

FIG.12.

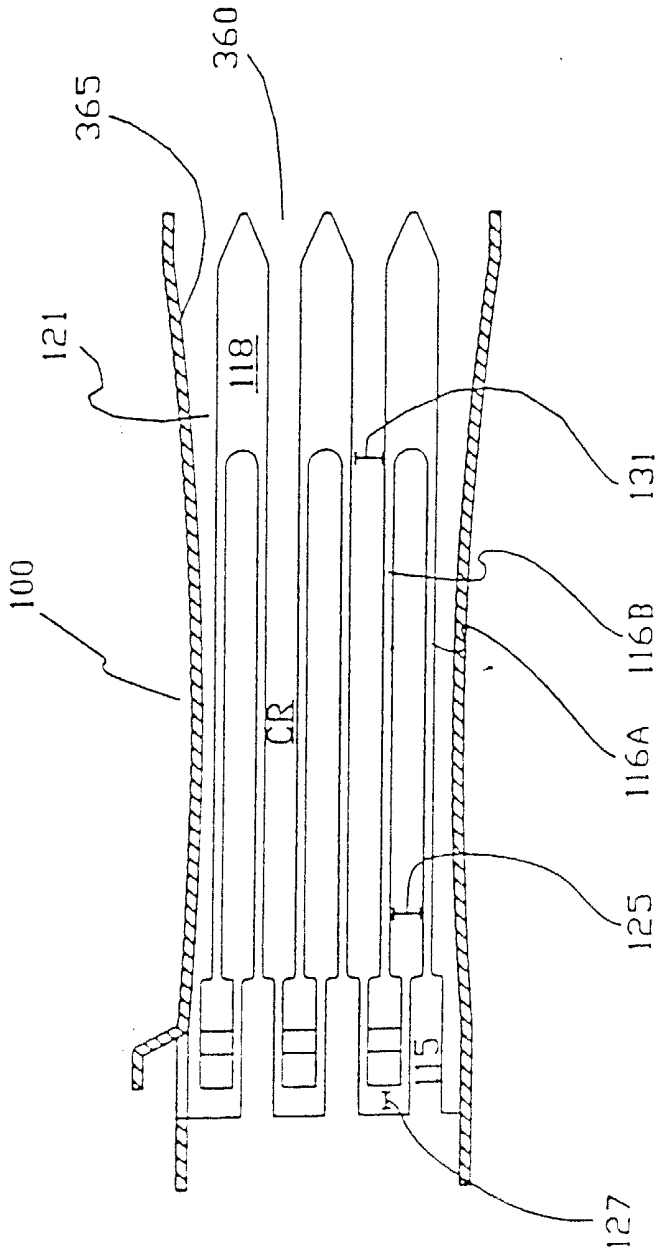


FIG. 13.

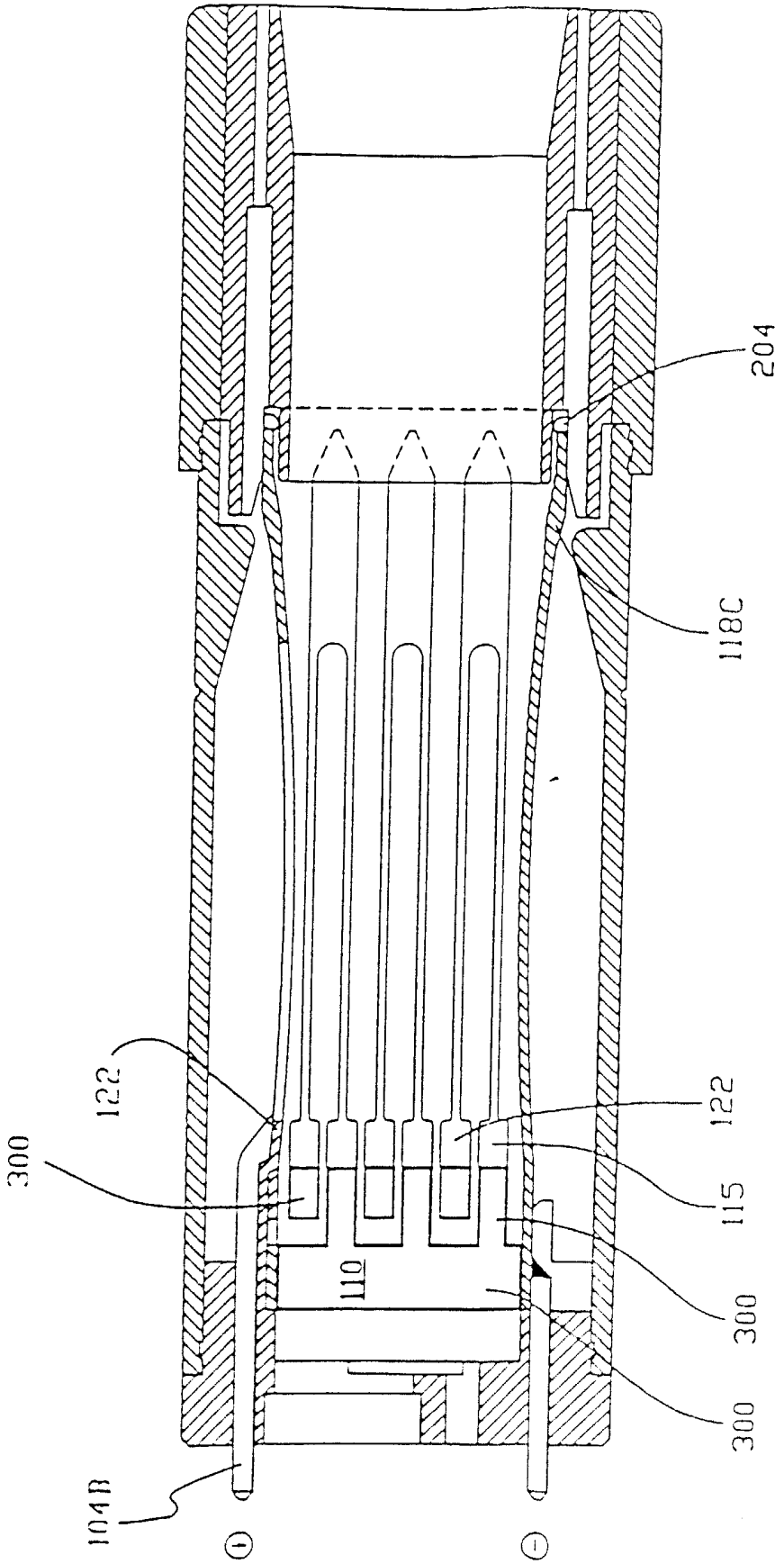


FIG. 14.

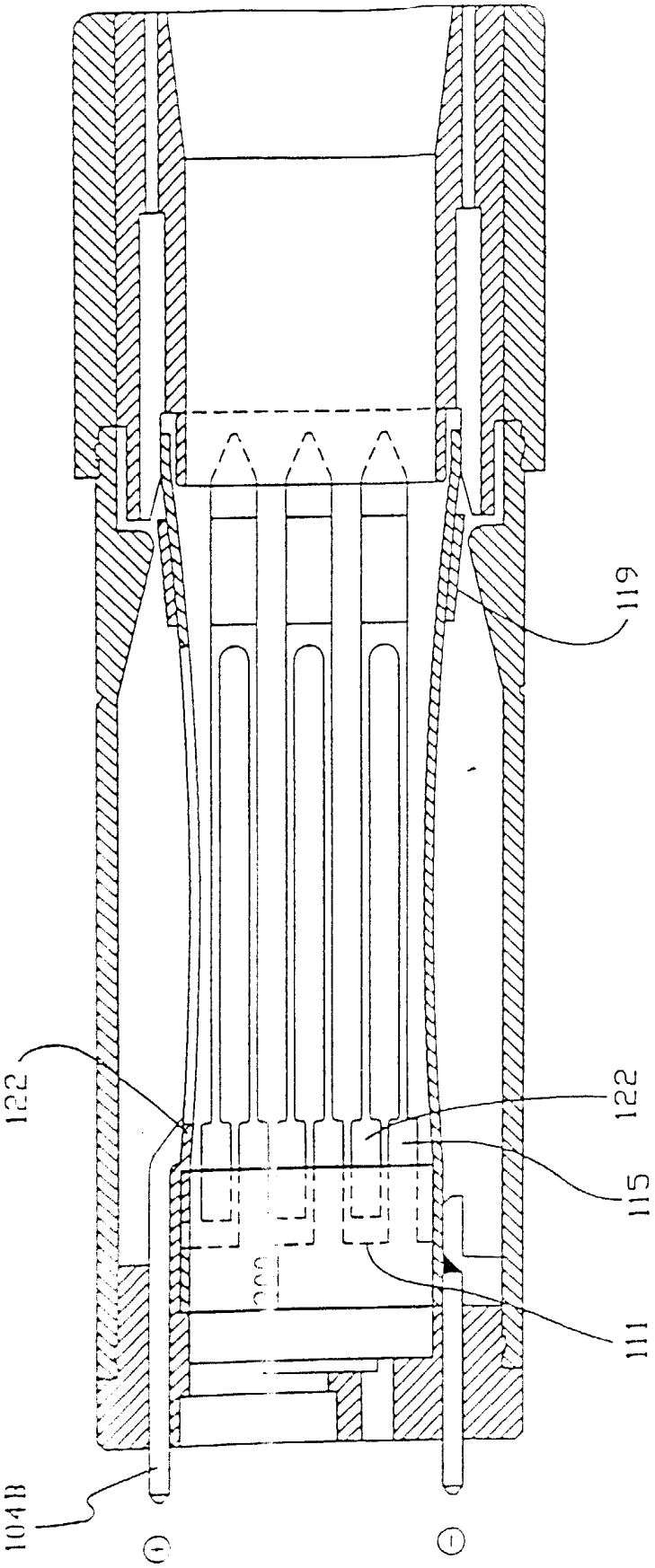


FIG. 15.

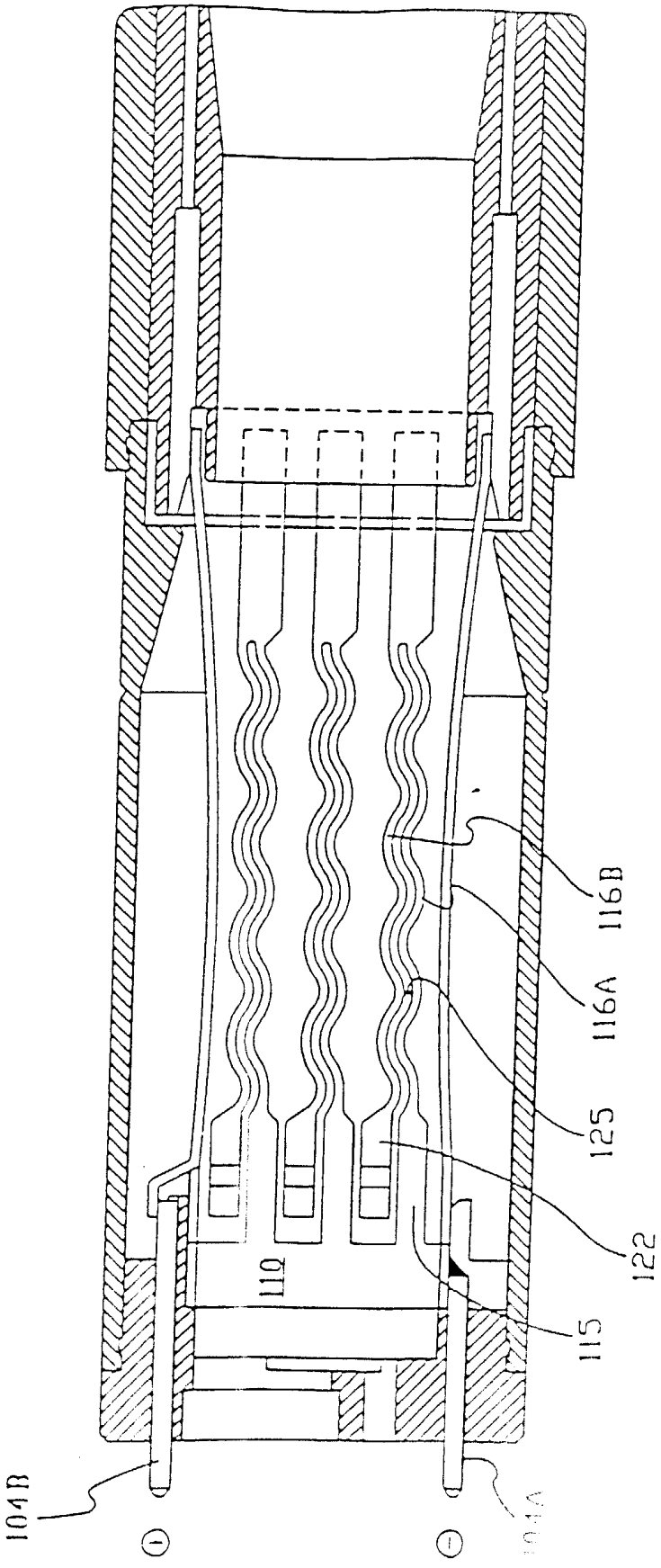


FIG.16.

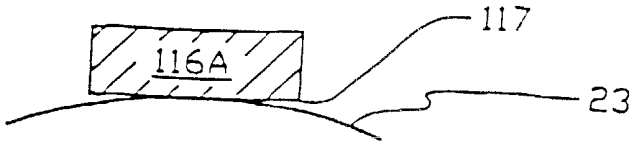


FIG. 17A

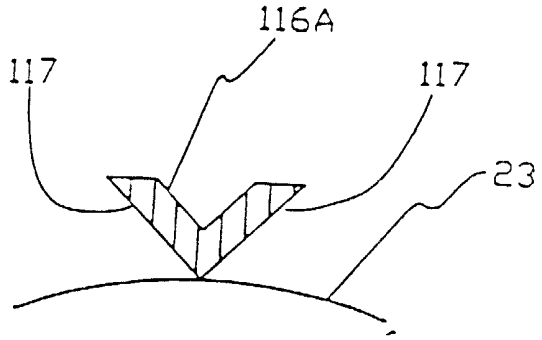


FIG. 17B

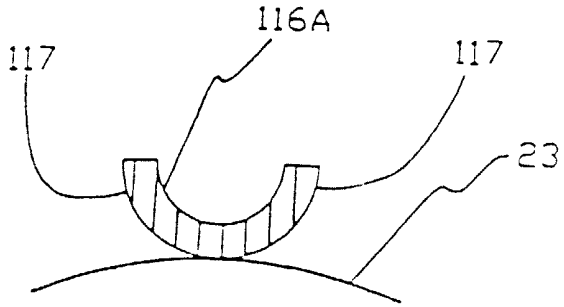
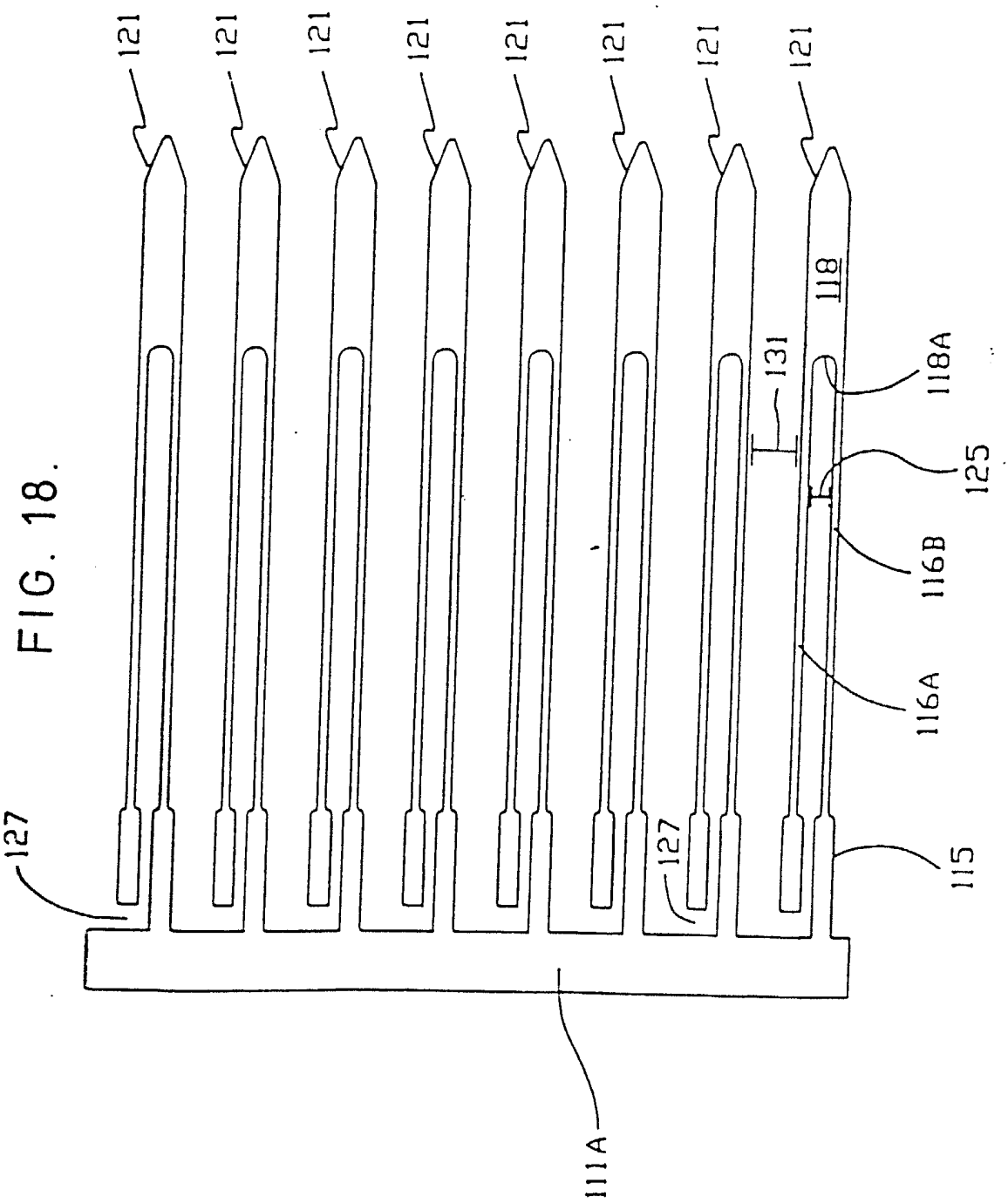


FIG. 17C.

FIG. 18.


121
121
121
121
121
121
121
121
118
131
118A
125
116B
116A
127
127
115
111A

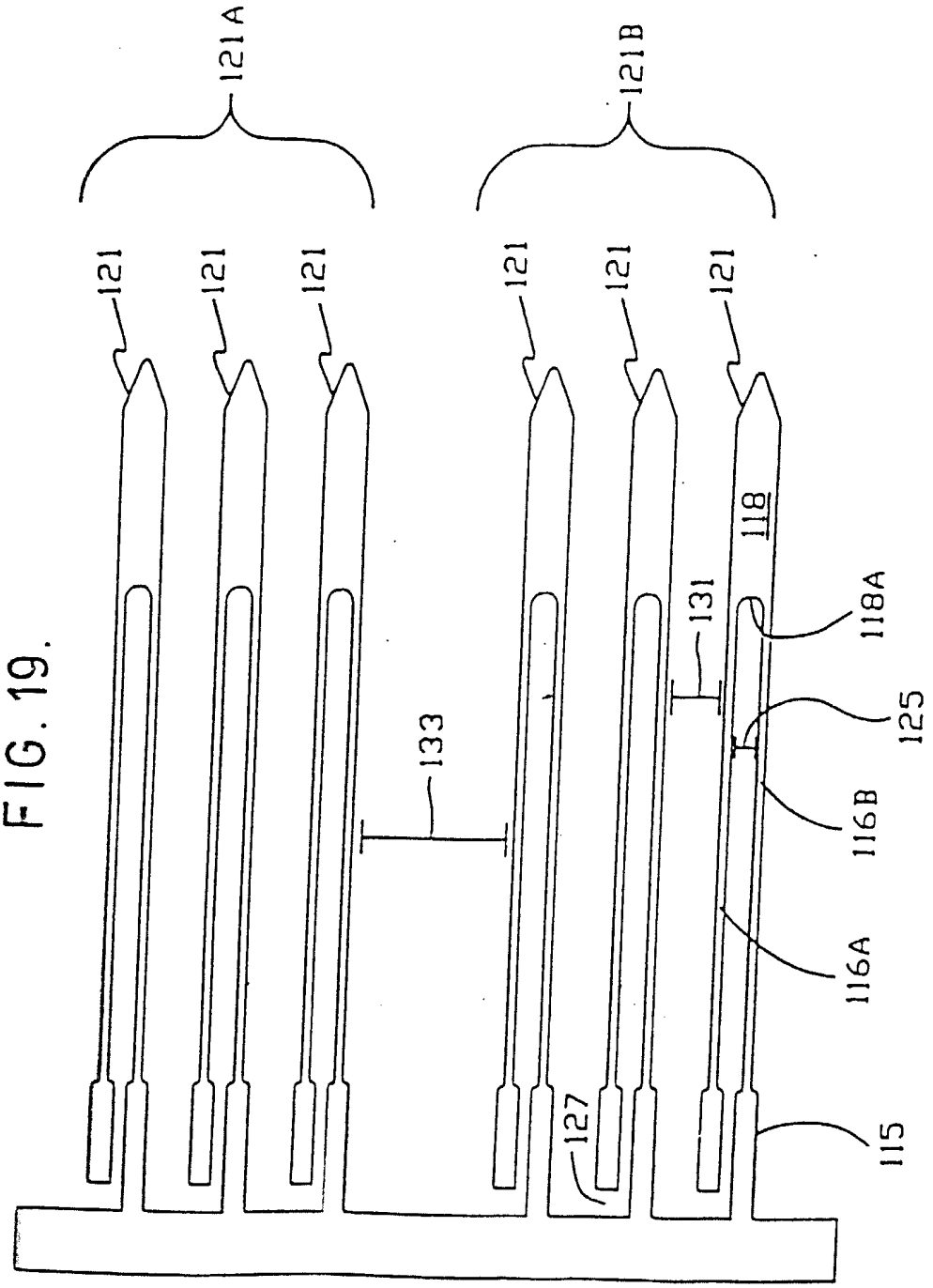

121A
121B
121
121
121
121
121
121
118
131
118A
125
133
116B
116A
127
115

FIG. 19.

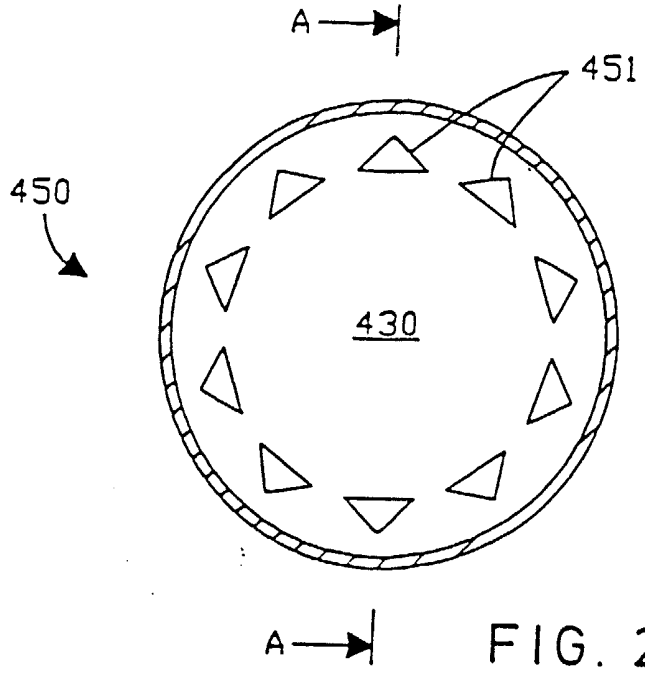

A
451
450
430
A

FIG. 20.

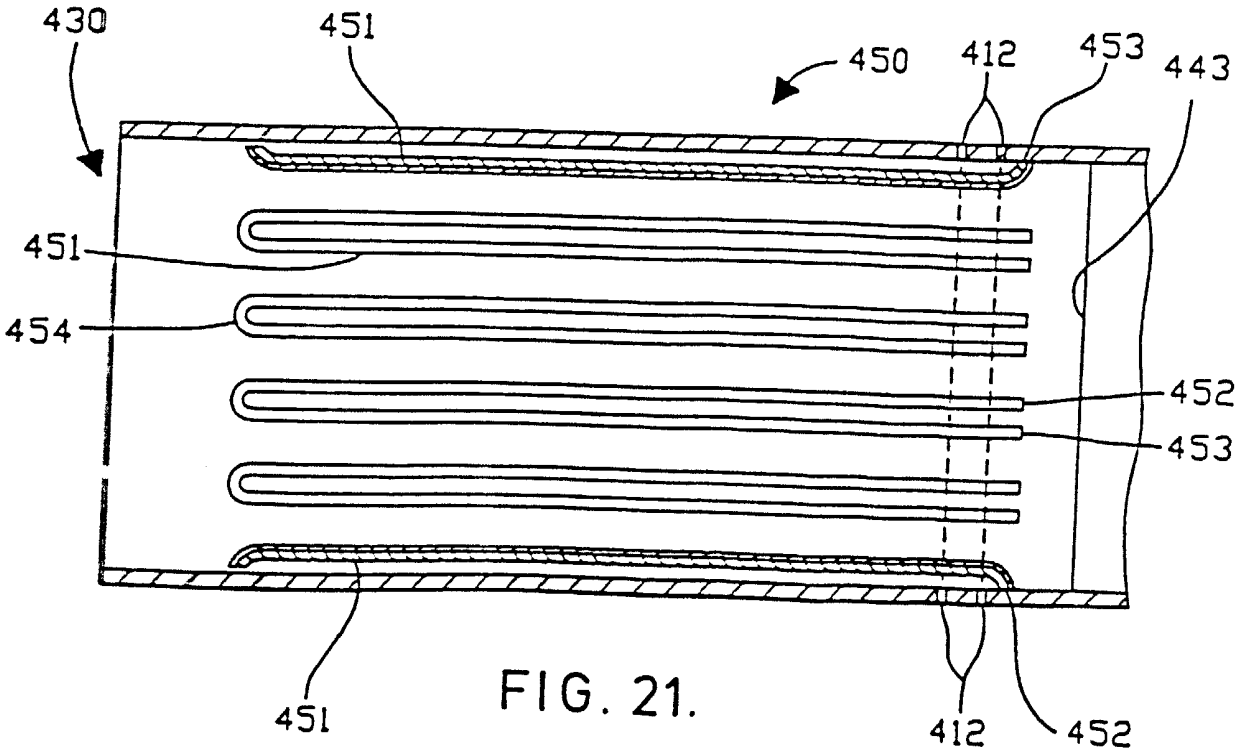

430
451
450
412
453
443
451
454
452
453
451
412
452

FIG. 21.

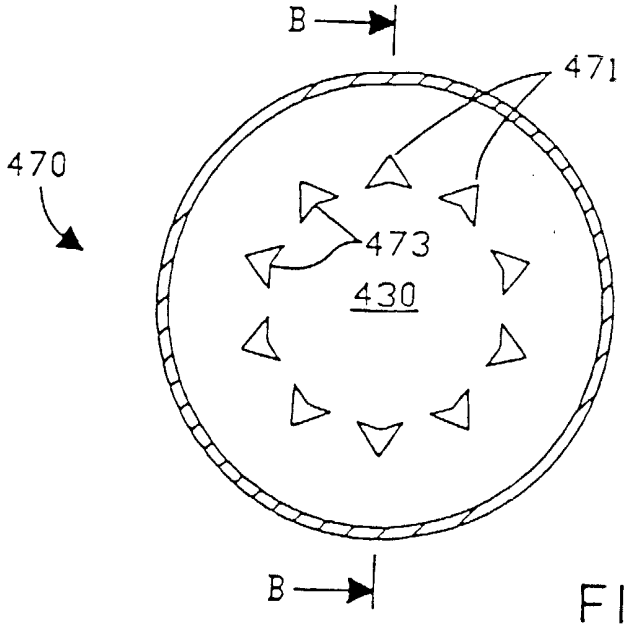

B
471
470
473
430
B

FIG. 22.

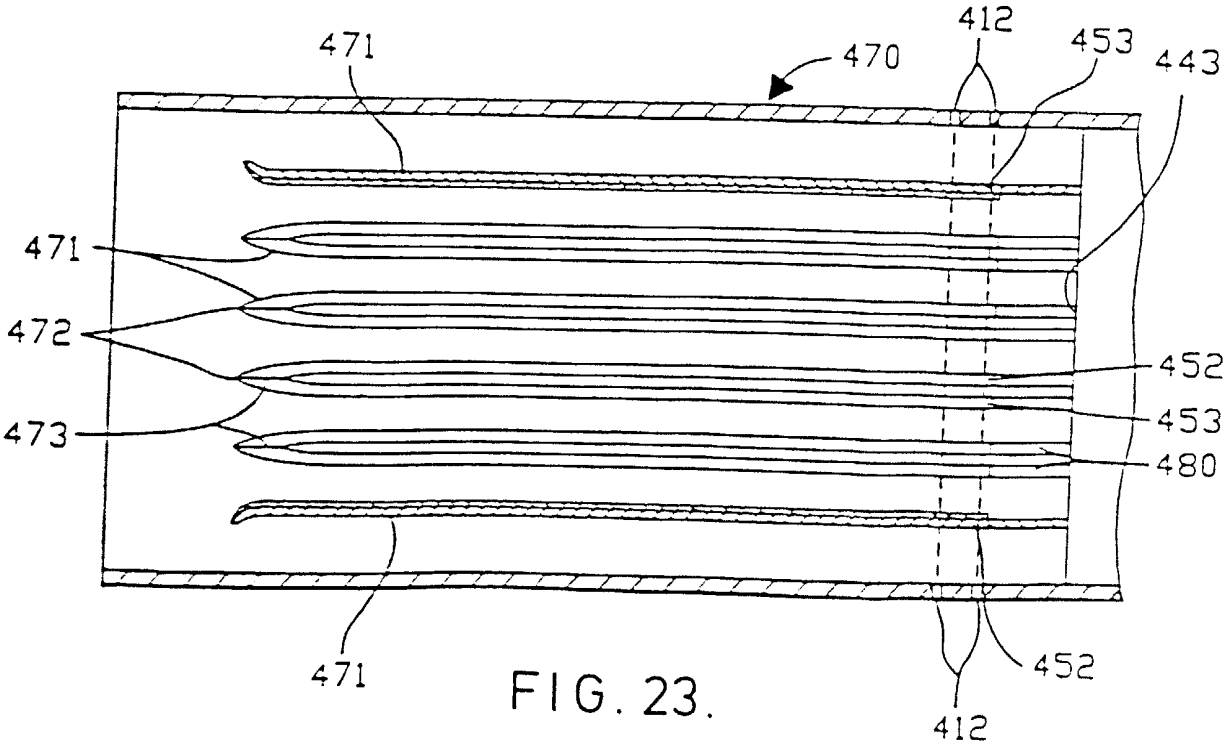

471
470
412
453
443
471
472
473
452
453
480
471
452
412

FIG. 23.