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**Smoking article with carbon monoxide oxidation catalyst.**

The present invention relates to a cigarette-like smoking article which is capable of producing substantial quantities of aerosol, both initially and over the useful life of the product, without significant thermal degradation of the aerosol former and without the presence of substantial pyrolysis or incomplete combustion products or sidestream aerosol.

Embodiments of the present smoking article comprise a combustible fuel element, a physically separate CO oxidation catalyst attached adjacent to the fuel element, a physically separate aerosol-generating means including an aerosol forming material attached adjacent to the catalyst in conductive heat exchange relationship with the fuel element, and a means for delivering the generated aerosol to the user.

The articles of the present invention provide the user with the taste, feel, and aroma associated with the smoking of conventional cigarettes without burning tobacco. The CO oxidation catalyst substantially decreases the level of CO inhaled by the user of such an article, by oxidizing the CO created by the burning fuel element to CO<sub>2</sub>.

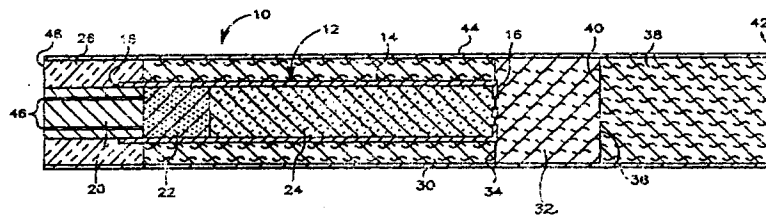


FIG. 1

EP 0 535 695 A2

Background of the Invention

The present invention relates generally to smoking articles, and more particularly, but not by way of limitation, to smoking articles comprising means for oxidation of CO.

5 Smoking articles have been disclosed which employ an aerosol-producing apparatus to simulate tobacco smoke. Generally, such articles comprise a small, high density combustible fuel element in conjunction with a physically separate aerosol-generating means. Generally, a heat conducting member is utilized, such as a metal conductor, which contacts both the fuel element and aerosol-generating means to transfer heat from the burning fuel element to the aerosol-generating means.

10 A problem with these articles is the high level of carbon monoxide which exists in the aerosol. This large amount of carbon monoxide is a result of incomplete combustion, which is caused by the burning carbonaceous fuel element. The level of carbon monoxide in the smoke of cigarettes and cigarette substitutes is a known concern in the tobacco industry.

15 Summary of the Invention

It is an object of this invention to provide a product, such as, for example, a smoking article which is capable of producing substantial quantities of aerosol, both initially and over the useful life of the product, while also producing significantly reduced quantities of carbon monoxide.

20 It is a further object of this invention to reduce potential health hazards in smoking.

In accordance with this invention there is provided an apparatus for producing aerosol comprising a combustible fuel element, a quantity of CO oxidation catalyst, and aerosol-generating means. In accordance with another aspect of this invention there is provided a cigarette-type smoking article comprising a combustible fuel element, a quantity of CO oxidation catalyst, aerosol-generating means, and means for delivering the generated aerosol to the user.

25 The present invention is described in greater detail in the accompanying drawings and in the detailed description of the invention which follow.

Brief Description of the Drawings

30 Figure 1 is a longitudinal cross-sectional view of a smoking article constructed in accordance with the invention.

Figure 2 is an enlarged, partial left side elevation view of the smoking article of Figure 1 more clearly illustrating the preferred fuel element passageway configurations.

35 Figure 3 is an elevation view similar to Figure 2 illustrating a second fuel element passageway configuration.

Figure 4 is an elevation view similar to Figure 2 illustrating a third fuel element passageway configuration.

40 Figure 5 is a longitudinal cross-sectional view of a smoking article constructed in accordance with a second embodiment of the invention.

Figure 6 is a longitudinal cross-sectional view of a smoking article constructed in accordance with a third embodiment of the invention.

Figure 7 is an enlarged partial longitudinal cross-sectional view more clearly illustrating the aerosol-production assembly employed in the embodiments of Figure 1, Figure 5 and Figure 6.

45 Figure 8 is an enlarged elevation view taken along line 8-8 of Figure 7.

Figure 9 is an enlarged longitudinal cross-sectional view of an alternative form of metallic containers suitable for use in the assembly of Figure 7.

Figure 10 is a cross-sectional view taken along line 10-10 of Figure 9.

50 Figure 11 is an enlarged partial longitudinal cross-sectional view illustrating an alternative form of aerosol-production assembly suitable for employment in the embodiments of Figure 1 and Figure 5.

Figure 12 is an enlarged cross-sectional view taken along line 12-12 of Figure 11.

Figure 13 is an enlarged elevation view taken along line 13-13 of Figure 11.

Figure 14 is an enlarged longitudinal cross-sectional view of an alternative form of metallic catalyst container suitable for use in the assembly of Figure 11.

55 Figure 15 is a cross-sectional view taken along line 15-15 of Figure 14.

Detailed Description of the Invention

Referring now to the drawings, and to Figure 1 in particular, there is illustrated a cigarette-like smoking article 10 constructed in accordance with one embodiment of the present invention. The smoking article 10 includes an aerosol production assembly 12 comprising a heat-conductive tubular metal container 14 having a partially closed, perforated first end portion 16 and an open second end portion 18, a combustible fuel element 20 fixedly secured in the second end portion 18, a quantity of CO oxidation catalyst 22 disposed within the metal container 14 adjacent to the fuel element 20, and a quantity of aerosol-generating material 24 disposed within the metal container 14 intermediate the first end portion 16 and the catalyst 22.

A CO oxidation catalyst can be any catalyst capable of the oxidation of carbon monoxide to carbon dioxide by reaction with oxygen. The process for oxidizing a carbon monoxide containing gas can be carried out at any suitable temperature and pressure conditions and any suitable volume ratio of CO an O<sub>2</sub>.

The periphery of the fuel element 20 is surrounded by a porous jacket of resilient heat insulating fibers 26, such as glass fibers. The portion of the tubular metal container 14 containing the catalyst 22 and aerosol-generating material 24 is surrounded by a jacket of tobacco-containing material 30. At the first end portion 16 of the container 14 is situated a tobacco paper filter 32 having a first end 34 contacting the first end portion 16 and the tobacco 30 and an opposite second end portion 36. At the second end portion 36 of the tobacco paper filter 32, a porous filter element 38 having a first end portion 40 contacting the second end portion 36 and having an opposite second end portion 42 defining the terminal or mouth-end of the smoking article 10. The entire length of the smoking article 10 is overwrapped with one or more layers of a suitable combustible wrapper 44 such as, for example, cigarette paper.

Preferably, the fuel element 20 is provided with one or more longitudinally extending passageways 46. The passageways 46 provide means for controlling transfer of heat from the fuel element 20 to the aerosol-generating material 24, which is important both in terms of transferring enough heat to produce sufficient aerosol and in terms of avoiding the transfer of so much heat that the aerosol-generating material 24 is degraded. Generally the passageways 46 provide porosity and increase early heat transfer to the aerosol-generating material 24 by increasing the amount of hot gases which reach the aerosol-generating material 24. The passageways 46 also tend to control the rate of burning of the fuel element 20.

Generally, a large number of passageways 46, e.g. about 5 to 9 or more, especially with a relatively close spacing between the passageways such that the passages grow together, at least at the lighting end 48 of the fuel element 20, during burning and produce high convective heat transfer which leads to high aerosol delivery from aerosol-generating material 24. A large number of passageways 46 also generally helps assure ease of lighting of the fuel element 20. Figure 2, Figure 3, and Figure 4 show several suitable alternative configurations for such passageways 46.

The most preferred fuel elements 20 useful in practicing this invention are carbonaceous materials (i.e. materials primarily comprising carbon). Combustible fuel elements 20 constructed of carbonaceous materials are particularly advantageous because they produce minimal ash, and have high heat generating capacity.

A preferred combustible fuel element 20 is formed of a pressed or extruded mass of carbon prepared from a powdered carbon and binder, by conventional pressure forming or extrusion techniques. Suitable non-activated carbons for pressure forming are prepared from pyrolyzed cotton or pyrolyzed papers, such as non-talc containing grades of Grande Prairie Canadian Kraft Paper, available from the Buckeye Cellulose Corporation of Memphis, Tennessee. A suitable activated carbon for combustible fuel elements 20 is sold under the designation PCB-G, and another suitable non-activated carbon is sold under the designation PXC, both of which are available from Calgon Carbon Corporation, Pittsburgh, Pennsylvania.

A suitable carbonaceous fuel can be prepared by admixing from about 50 to about 90 weight-%, most preferably from 80 to 95 weight-%, of the carbonaceous material based on the total weight of carbonaceous material and binder with from about 1 to about 50 weight-%, most preferably from 5 to 20 weight-%, of a suitable binder based on the total weight of carbonaceous material and binder with sufficient water to make a paste having a stiff dough-like consistency. Minor amounts, e.g. up to about 35 weight-%, preferably from about 10 to about 20 weight-%, based on the total weight of carbonaceous material and binder, of tobacco, tobacco extract, and the like can be added to the paste with additional water, if necessary, to maintain a stiff dough-like consistency.

The paste is then extruded, using any suitable extrusion apparatus such as a conventional ram or piston type extruder, into the desired shape with the desired number and configuration of passageways, and dried, preferably at a temperature in the range of from about 90 ° C to about 100 ° C to reduce the moisture content to about 2% to 7% by weight based on the total weight of paste. Alternatively, the passageways can be formed using conventional drilling techniques.

In general, the combustible fuel elements 20 which are employed in practicing the invention are less than about 20 millimeters long. Preferably, the element 20 is about 15 millimeters or less, more preferably about 10 millimeters or less in length. Advantageously, the diameter of the fuel element 20 is about 8 millimeters or less, preferably between about 3 and 7 millimeters, and more preferably between about 4 to 6 millimeters. The density of the carbonaceous material forming the fuel elements 20 ranges generally from about 0.5 g/cc to about 1.5 g/cc as measured, e.g., by mercury displacement. Preferably, the density is greater than 0.7 g/cc, more preferably greater than 0.8 g/cc. The length and diameter of the fuel element 20, the density of the carbonaceous material from which it is formed, and the passageway patterns are selected to achieve a desired burning time for the fuel element 20. In most cases, a high density carbonaceous material is desired because it helps to ensure that the fuel element will burn long enough to simulate the burning time of a conventional cigarette and that it will provide sufficient heat energy to generate the required amount of aerosol from the aerosol-generating material 24.

Upon lighting the smoking article 10, the fuel element 20 burns, generating the heat used to volatilize the components of the aerosol-generating material 24. These thus volatilized components comprise the aerosol and are then drawn through the mouth-end 42 of the smoking article 10, especially during puffing, and into the users mouth, in a manner akin to the smoking of a conventional cigarette.

The aerosol-generating material 24 preferably includes one or more thermally stable components which carry one or more aerosol-forming substances. As used herein, a "thermally stable" material is defined as one capable of withstanding the high, albeit controlled, temperatures, e.g., generally from about 350 °C to about 600 °C, which may eventually exist near the burning fuel element 20, without significant decomposition or burning. The use of such thermally stable material is believed to help maintain the simple "smoke" chemistry of the aerosol.

Suitable aerosol-forming substances include polyhydric alcohols and mixtures of polyhydric alcohols. Preferred aerosol-forming substances are selected from the group consisting of glycerin, triethylene glycol, propylene glycol, and mixtures of any two or more thereof.

One particularly preferred aerosol-generating material 24 comprises a thermally stable alumina substrate containing sprayed, dried tobacco extract, and one or more tobacco flavored modifiers, such as levulinic acid, one or more flavoring materials, and one or more aerosol forming substances, such as glycerin. An especially useful alumina substrate is available from the Davison Chemical Division of W.R. Grace and Co. under the designation SMR-14-1896. Before use, this alumina is sintered at elevated temperatures, e.g. greater than 1000 °C, washed, and dried. In certain preferred embodiments, this alumina substrate can be mixed with densified tobacco particles, which particles may also be impregnated with an aerosol forming substance.

A significant improvement or advantage of the smoking article 10 over other similar smoking articles exists in the placement of the CO oxidation catalyst 22 between the combustible fuel element 20 and the aerosol-generating material 24. The CO oxidation catalyst 22 removes carbon monoxide produced by the burning carbonaceous material in the combustible fuel element 20. Such a removal results in a reduction in the amount of carbon monoxide inhaled by the user of the smoking article 10.

Non-limiting examples of suitable, effective CO oxidation catalysts are: CuO-MnO<sub>2</sub> catalysts such as, for example, catalysts sold under the trademark Hopcalite and available from Mine Safety Appliances; alumina or magnesia-supported Pt and/or Pd catalyst (preferably also containing iron oxide, described in U.S. Patent 4,818,745, the disclosure of which is hereby incorporated of reference); compositions comprising a ceramic honeycomb support, tin dioxide Pt and/or Pd, and optionally other copromoters (described in U.S. Patent 4,830,844, the disclosure of which is hereby incorporated of reference); titania or zirconia-supported platinum and iron oxide containing catalyst materials (optionally containing a ceramic honeycomb support which is coated with titania or zirconia); hydrotalcite-supported platinum/iron oxide; compositions comprising Pt and Fe-oxide on hydrotalcite; compositions comprising Pt and Fe-oxide on vanadium oxide; compositions which contain silver metal or oxide, manganese oxide, and an oxide of cobalt or iron; and many of the commercially available catalyst compositions used for purifying exhaust gases from combustion engines, and used in CO<sub>2</sub> lasers (for recombining CO and O<sub>2</sub>).

The CO oxidation catalyst materials used in the apparatus of this invention can have any suitable shape such as cylindrical, ring-shaped, honeycomb-shaped and the like. The materials can be of any suitable size, for instance a particle diameter of about 0.01 inches to about 0.1 inches for bead-shaped particles. The surface area of these catalyst materials generally is in the range of from about 10 to about 300 m<sup>2</sup>/g, preferably about 150 to about 250 m<sup>2</sup>/g. The shape, size, surface structure and area and other structural parameters of the catalyst particles can be selected by those having ordinary skill in the art so as to provide maximum conversion of CO to CO<sub>2</sub> and minimum resistance to the flow of the combustion gas exiting from the burning fuel element.

Preferably, the CO oxidation catalyst 22 and aerosol-generating material 24 are enclosed within a heat-conductive tubular metal container 14. The heat-conductive material preferably employed in constructing the preferred container is typically a metallic tube, strip, or foil, such as aluminum, which can vary in thickness from less than about 0.01 millimeters to about 0.1 millimeters, or more. The thickness and/or type of conducting material can be varied (e.g. other metals, or the material sold under the trademark Grafoil and available from Union Carbide) to achieve virtually any desired degree of heat transfer.

The fuel element heat insulating fibers 26 employed in practicing the invention are preferably formed into a porous resilient jacket from one or more layers of heat insulating material. Advantageously, this jacket is at least about 0.5 mm thick, preferably at least about 1 mm thick, more preferably between about 1.5 to 2 mm thick. Generally, the jacket extends over more than about half, if not all of the length of the fuel element 20.

The currently preferred heat insulating fibers 26 are ceramic fibers and glass fibers. Two suitable glass fibers are available from the Manning Paper Company of Troy, New York, under the designations, Manniglas 1000 and Manniglas 1200. When possible, glass fiber materials having a low softening point, e.g., below about 650 °C, are preferred. The preferred glass fibers include materials produced by Owens-Corning of Toledo, Ohio under the designations 6432 and 6537.

The CO oxidation catalyst 22 and aerosol-generating material 24, or at least a portion thereof, are circumscribed by a jacket of tobacco-containing material 30 through which gases and vapors may pass during smoking of the article. During smoking, hot vapors are swept through the tobacco to extract the volatile components from the tobacco, without combustion or substantial pyrolysis. Thus, the user receives an aerosol which contains the tastes and flavors of natural tobacco without the numerous combustion products produced by a conventional cigarette.

The jacket of tobacco-containing material 30 employed around the aerosol-generating material 24 may contain any tobacco available to the skilled artisan, such as Burley, Flue-Cured, Turkish, reconstituted tobacco, extruded tobacco mixtures, tobacco-containing sheets, and the like.

Advantageously, a blend of tobacco can be used to contribute a greater variety of flavors. The jacket of tobacco-containing material 30 can also include conventional tobacco additives, such as fillers, casings, reinforcing agents, humectants, and the like. Flavor agents can likewise be added to the jacket of tobacco-containing material 30, as well as flavor modifying agents.

The porous filter element 38 can be formed of any suitable material which can satisfactorily filter particulate or other forms of solids as well as liquids from combustion gases passing therethrough while passing filtered gases through the second end portion 42 of the filter element 38. It is presently preferred to construct the filter element 38 from polypropylene fibers in, for example, the form of non-woven fabric. Such filters can also include low efficiency cellulose acetate filters and hollow or baffled plastic filters, such as those made of polypropylene. Such filters do not appreciably interfere with the aerosol delivery. The embodiment of the invention in Figure 1 utilizes a filter comprised of two components. The first component is disposed adjacent the aerosol-generating material 24 and is comprised of a tobacco paper filter 32. The second component is disposed adjacent the tobacco paper filter 32 and is comprised of a porous filter element 38, preferably comprising polypropylene.

The entire length of the article, or any portion thereof, may be overwrapped with one or more layers of a suitable wrapper 44 such as cigarette paper, tobacco leaf, or tobacco paper. Generally, the wrapper 44 at the lighting end of the fuel element 48 should not openly flame during burning of the fuel element 20. In addition, the wrapper 44 should have controllable smolder properties and should produce a gray, cigarette-like or cigar-like ash.

In addition to the components described in Figure 1, the embodiment of smoking article 10A illustrated in Figure 5 also contains a second portion of CO oxidation catalyst 50 disposed between the heat conducting tubular metal container 14 and the wrapper 44. The second portion of CO oxidation catalyst 50 circumscribes either a portion of the fuel element 20 or a portion of the heat conducting tubular metal container 14, or a portion of both. The second portion of CO oxidation catalyst 50 is positioned between the heat insulating fibers 26 that surround the fuel element 20, and the jacket of tobacco-containing material 30 that surrounds the heat-conductive tubular metal container 14. The purpose of the second portion of CO oxidation catalyst 50 is to remove or substantially remove carbon monoxide from the vapor stream that passes around the heat-conductive tubular metal container 14 through the jacket of tobacco-containing material 30 to the first end portion 16 of the tubular metal container 14 by inducing the oxidation of CO to CO<sub>2</sub>.

The embodiment of smoking article 10B illustrated in Figure 6 also includes, in addition to the elements depicted in Figure 5, a slightly modified aerosol production assembly 12A which differs from the aerosol production assembly 12 by additionally including an elongated heat-conductive member 52 that is in direct

heat-conductive contact with both the fuel element 20 and at least a portion of the aerosol-generating material 24. The heat-conductive member 52 is generally comprised of a thin metallic wire. The wire is preferably comprised of copper. The wire can be of any suitable length and diameter for effectively transferring heat from the fuel element 20 to at least a portion of the aerosol-generating material 24. The wire preferably has a diameter of about 0.05 cm. The wire is preferably about 2.0 cm or less in length. More preferably, the wire is about 1.0 cm in length. The heat-conductive member 52 is anchored in the center hole of the fuel element 20 and extends axially through the center of the heat-conductive tubular metal container 14. The heat-conductive member 52 reaches completely through the CO oxidation catalyst 22 and extends into the aerosol-generating material 24.

The purpose of such a heat-conductive member 52 is to promote more effective transfer of heat from the burning tip of the fuel element 20 to the aerosol-generating material 24. This is necessary because the CO oxidation catalyst 22 inside the heat-conductive tubular metal container 14 can act as a heat sink, delaying the warmup of the aerosol-generating material 24 which in turn delays the appearance or generation of aerosol. Additionally, the heat-conductive member 52 heats up the CO oxidation catalyst 22 more quickly, resulting in better conversion of carbon monoxide to carbon dioxide during the initial puffs from the cigarette-like smoking article 10B.

Figure 7 more clearly illustrates the configuration for the aerosol production assembly 12 comprising the heat-conductive tubular metal container 14 having a partially closed perforate first end portion 16 and the open second end portion 18, the combustible fuel element 20 fixedly secured in the second end portion 18, the quantity of CO oxidation catalyst 22 disposed within the metal container 14 adjacent the fuel element 20, and the quantity of aerosol-generating material 24 disposed within the metal container 14 intermediate the first end portion 16 thereof and the CO oxidation catalyst 22. The metal container 14 is cylindrically shaped with the open second end portion 18 adjacent to the fuel element 20. Preferably, several slot-like openings 54 are provided in the closed perforate first end portion 16 of the metal container 14. A preferred configuration for such slot-like openings 54 is shown in Figure 8. The purpose of these slot-like openings 54 is to allow the aerosol created to escape from the metal container 14.

While the metal container 14 could be of any suitable length and material thickness, generally, the thickness of the metal container 14 ranges from about 0.01 mm or less to about 0.1 mm or more, and ranges from about 10 mm or less to about 50 mm or more in length. Preferably, the metal container 14 ranges in length from about 20 mm to about 40 mm, more preferably from about 25 to about 35 mm. Advantageously, the diameter of metal container 14 is about 8 mm or less, preferably between about 3 and 7 mm, and more preferably between about 4 to 6 mm.

Generally, the diameter of the heat-conductive metal container 14 and the fuel element 20 are such that one end of the fuel element 20 will fit tightly within the open second end portion 18 of the metal container 14. Generally, the heat-conductive metal container 14 extends over no more than about one half the length of the fuel element 20. Preferably, the heat-conductive metal container 14 overlaps or otherwise contacts no more than about the rear 5 mm of the fuel element. This contact is sufficient to hold the fuel element 14 in place while not substantially interfering with the burning of the fuel element 14.

In Figure 9 and Figure 10, a slightly modified version of the heat-conductive metal container 14 is shown as is designated by the reference character 14A. This embodiment contains a plurality of circumferentially spaced pin-like holes 15 formed in the metal container 14A along a circumferential line near the juncture of the combustible fuel element 20 and the CO oxidation catalyst 22 to be disposed therein. The purpose of the holes 15 is to increase the amount of oxygen available to the CO oxidation catalyst 22. A higher oxygen concentration will increase the carbon monoxide conversion to carbon dioxide that can be obtained.

Generally the pin-like holes 15 are of such size and number so as to allow a sufficient amount of oxygen to reach the catalyst in order to provide a maximum conversion of carbon monoxide to carbon dioxide. While the pin-like holes 15 can be of any suitable number, generally there are about 8 pin-like holes 15 formed in the metal container 14A. Generally, the pin-like holes 15 are evenly spaced around the circumference of the metal container element 14A. Preferably, the pin-like holes 15 are positioned so that they circumscribe the juncture between the fuel element 20 and the CO oxidation catalyst 22 disposed within the metal container element 14A. Preferably, this position is about 5 mm from the open end of the metal container element 14A. While the pin-like holes 15 can be of any suitable size, generally the pin-like holes 15 are less than about 1 mm in diameter. Preferably, the pin-like holes 15 are less than about 0.5 mm in diameter.

Figure 11 illustrates an alternate configuration for the aerosol production assembly which is designated by the reference character 12B. This aerosol production assembly 12B is characterized by physically separate container elements. The CO oxidation catalyst 22 is contained within a heat-conductive catalyst

container element 56, while the aerosol-generating material 24 is contained within a heat-conductive aerosol-generating material container element 58.

5 Generally, the catalyst container element 56 is cylindrically shaped with an open end adjacent to the fuel element 20 and closed at the other perforated end. Generally, several slot-like openings 60 are provided in the perforate closed end of the catalyst container element 56 as shown in Figure 12. The purpose of these slot-like openings 60 is to allow the flow of hot gases and vapors from the fuel element 20 to the aerosol-generating material 24.

10 While the catalyst container element 56 can be of any suitable length and material thickness, generally, the thickness of the catalyst container element 56 ranges from about 0.01 mm or less to about 0.1 mm, or more, and is less than about 30 mm in length. Preferably, the catalyst container element 56 is about 20 mm or less, more preferably about 15 mm or less in length. Advantageously, the diameter of the catalyst container element 56 is about 8 mm or less, preferably, from about 3 mm to about 7 mm, and more preferably from about 4 mm to about 6 mm.

15 Generally, the diameters of the catalyst container element 56 and the fuel element 20 are such that one end of the fuel element 20 will fit tightly within the open end of the catalyst container element 56. Generally, the catalyst container element 56 extends over no more than about one half the length of the fuel element 20. Preferably, the catalyst container element 56 overlaps or contacts no more than about the rear 5 mm of the fuel element 20. This will allow the catalyst container element 56 to hold the fuel element 20 securely while not interfering substantially with the burning of the fuel element 20.

20 Generally, the aerosol-generating material container element 58 is cylindrically shaped with an opened end adjacent to the closed perforate end of the catalyst container element 56 and closed at the other perforated end. Preferably, several slot-like openings 62 are provided in the perforate closed end of the aerosol-generating material container element 58 as shown in Figure 12. The purpose of these slot-like openings 62 is to allow the aerosol created to escape from the aerosol-generating material container element 58.

25 While the aerosol-generating material container element 58 could be of any suitable length and material thickness, generally the thickness of the aerosol-generating material container element 58 ranges from about 0.01 mm or less to about 0.1 mm, or more, and the element ranges from about 10 mm to about 50 mm in length. Preferably, the aerosol-generating material container element 58 is about 40 mm or less, more preferably about 30 mm or less in length. Advantageously, the diameter of the container element 58 is about 8 mm or less, preferably, from about 3 mm to about 7 mm, and more preferably from about 4 mm to about 6 mm. Generally, the diameter of the aerosol-generating material container element 58 and the catalyst container element 56 are such that the closed end of the catalyst container element 56 will fit tightly within the open end of the aerosol-generating material container element 58. Generally, the aerosol-generating material container element 58 extends over a sufficient portion of the catalyst container element 56 so that the catalyst container element 56 is securely held adjacent to the aerosol-generating material container element 58.

30 In Figure 14 and Figure 15, a slightly modified version of heat-conducting catalyst container element 56 is shown and is designated by the reference character 56A. This embodiment contains a plurality of circumferentially spaced pin-like holes 64 formed in the catalyst container element 56A along a circumferential line near the juncture of the combustible fuel element 20 and the CO oxidation catalyst 22 to be disposed therein. The purpose of the holes 64 is to increase the amount of oxygen available to the CO oxidation catalyst 22. A higher oxygen concentration will increase the carbon monoxide conversion to carbon dioxide that can be obtained.

35 Generally, the pin-like holes 64 are of such size and number so as to allow a sufficient amount of oxygen to reach the catalyst in order to provide a maximum conversion of carbon monoxide to carbon dioxide. While the pin-like holes 64 can be of any suitable number, generally there are about 8 pin-like holes 64 formed in the catalyst container element 56A. Generally, the pin-like holes 64 are evenly spaced around the circumference of the catalyst container element 56A. Preferably, the pin-like holes 64 are positioned so that they circumscribe the juncture between the fuel element 20 and the CO oxidation catalyst 22 disposed within the catalyst container element 56A. Preferably, this position is about 5 mm from the open end of the catalyst container element 56A. While the pin-like holes 64 can be of any suitable size, generally the pin-like holes 64 are less than about 1 mm in diameter. Preferably, the pin-like holes 64 are less than about 0.5 mm in diameter.

40 The aerosol produced by the articles constructed in accordance with the present invention is chemically simple, consisting essentially of air, water, oxides of carbon, the aerosol former, any desired flavors or other desired volatile materials, and trace amounts of other materials.

The wet total particulate matter (WTPM) produced by articles of this invention has no measurable mutagenic activity as measured by the Ames Test, i.e., there is no significant dose response relationship between the WTPM produced by articles of the present invention and the number of revertants occurring in standard test microorganisms exposed to such products. According to the proponents of the Ames Test, a significant dose dependant response indicates the presence of mutagenic materials in the products tested. See Ames et al, Mutation Research, 31:347-364 (1975); Nagas et al, Mutation Research, 42:335 (1977).

A further benefit from the present invention is a relative lack of ash produced during use in comparison to ash from a conventional cigarette. As the carbon fuel element is burned, it is essentially converted to oxides of carbon, with relatively little ash generation, and thus there is no need to dispose of ashes while using the article.

Another important benefit from the various embodiments of the present invention is the decrease in carbon monoxide produced in comparison to that produced by other known cigarette-like smoking articles.

Preferred embodiments of this invention are capable of delivering at least 0.6 milligrams of aerosol, measured as wet total particulate matter (WTPM), in the first three puffs, when smoked under FTC smoking conditions, which consist of a 35 cc puff volume of 2 seconds duration, separated by 58 seconds of smolder. More preferably, embodiments of the invention are capable of delivering 1.5 milligrams or more of aerosol in the first three puffs. Most preferably, embodiments of the invention are capable of delivering 3.0 milligrams or more of aerosol in the first three puffs when smoked under FTC smoking conditions. Moreover, preferred embodiments of the invention deliver an average of at least about 0.8 milligrams of WTPM per puff for at least about 6 puffs, preferably at least about 10 puffs under FTC smoking conditions. More preferably, preferred embodiments deliver 20 to 30 milligrams, or more, of WTPM over at least 10 puffs, under FTC smoking conditions.

A presently preferred smoking article of the present invention also delivers very low levels of carbon monoxide, preferably less than about 10 milligrams total CO delivery over the life of the smoking article, more preferably, less than about 5 milligrams total CO delivery (e.g., about 0.01-4.5 milligrams), most preferably less than about 3 milligrams total CO delivery (e.g., about 0.1-2 milligrams).

As used herein, and only for the purposes of this application, "aerosol" is defined to include vapors, gases, particles, and the like, both visible and invisible, and especially those components perceived by the user to be "smoke-like", generated by action of the heat from the burning fuel element upon substances contained within the aerosol-generating means, or elsewhere in the article. As so defined, the term "aerosol" also includes volatile flavoring agents and/or pharmacologically or physiologically active agents, irrespective of whether they produce a visible aerosol.

As used herein, the term "conductive heat exchange relationship" is defined as a physical arrangement of the aerosol-generating means and the fuel element whereby heat is transferred by conduction from the burning fuel element to the aerosol-generating means substantially throughout the burning period of the fuel element. Conductive heat exchange relationships can be achieved by locating the aerosol-generating means in close proximity to the burning portion of the fuel element, and/or by utilizing a conductive member to transfer heat from the burning fuel to the aerosol-generating means. Preferably, both methods of providing conductive heat transfer are used.

Advantages of the cigarette-like smoking article of the present invention will be further illustrated with reference to the following examples which aid in the understanding of the present invention, but which are not to be construed as limitations thereof.

#### Example I

In this example the preparation and properties of several CO oxidation catalysts are described. These catalysts were tested in the smoking article of this invention, as is described in subsequent examples.

A CuO-MnO<sub>2</sub> catalyst was prepared in R&D laboratories of Phillips Petroleum Company in Bartlesville, Oklahoma as follows: To 150 ml of water (having been heated to 75 °C) were added 20.7 g of MnSO<sub>4</sub> • H<sub>2</sub>O and 6.2 g of CuSO<sub>4</sub> • 5 H<sub>2</sub>O. Upon complete dissolution of the copper and manganese sulfates, air was bubbled through the solution at a fast rate. Then 40 ml of an aqueous 25 weight-% NaOH solution was added with stirring to the solution of copper and manganese sulfates. A coprecipitate of copper oxides/hydroxides and manganese oxides/hydroxides was formed, which was filtered, washed with water, air dried and then heated for 3 hours at 200 °C in an oven. A brown, dry solid was obtained, which is labeled Lab CuO-MnO<sub>2</sub> catalyst. Its composition is shown in Table 1.

Several commercial CuO-MnO<sub>2</sub> catalysts were obtained from Callery Chemical Co. These materials are labeled "Callery A", "Callery B", and "Callery C". These CuO-MnO<sub>2</sub> contain approximately 60 weight-% MnO<sub>2</sub> and about 40% CuO (as per disclosure in J. Am. Chem. Soc. 43, 1921, page 1982). The exact



compositions of the above-described CuO-MnO<sub>2</sub> catalysts are shown in Table 1.

Table 1

Element	Lab CuO-MnO <sub>2</sub> Catalyst	Callery A CuO-MnO <sub>2</sub> Catalyst	Callery B CuO-MnO <sub>2</sub> Catalyst	Callery C CuO-MnO <sub>2</sub> Catalyst
Ag	64 ppm	70 ppm	88 ppm	88 ppm
Ba	14 ppm	12 ppm	14 ppm	27 ppm
Ca	2440 ppm	200 ppm	3690 ppm	1440 ppm
Co	42 ppm	---	23 ppm	---
Cr	125 ppm	123 ppm	132 ppm	151 ppm
Cu	11.4%	11.8%	15.0%	12.9%
Fe	741 ppm	576 ppm	893 ppm	825 ppm
K	1.9%	2.3%	1.8%	2.7%
Mn	55.1%	50.4%	48.0%	48.9%
Mo	319 ppm	297 ppm	319 ppm	378 ppm
Na	6040 ppm	3250 ppm	2770 ppm	5560 ppm
Ni	430 ppm	538 ppm	115 ppm	118 ppm
Pb	730 ppm	821 ppm	744 ppm	508 ppm
Sr	10 ppm	11 ppm	36 ppm	18 ppm
Ti	452 ppm	---	13 ppm	---
V	42 ppm	33 ppm	58 ppm	92 ppm

(Note: "%" means weight percent; "ppm" means parts by weight per million parts by weight of CuO-MnO<sub>2</sub> catalyst)

An Ag-Mn-Co oxide catalyst (1:3:8 atomic ratio) was prepared in the following manner. A solution as prepared by dissolving 127.1 g Na<sub>2</sub>CO<sub>3</sub> in 500 ml H<sub>2</sub>O. When fully dissolved, 12.6 g KMnO<sub>4</sub> were then added to the solution and dissolved. This solution was stirred while a second solution was slowly added, comprised of 8.5 g AgNO<sub>3</sub>, 28.0 g 50% Mn(NO<sub>3</sub>)<sub>2</sub> solution, and 113.4 g Cu(NO<sub>3</sub>)<sub>2</sub>•6H<sub>2</sub>O dissolved in 500 ml H<sub>2</sub>O. The mixture was stirred, filtered, and washed in 1 liter of H<sub>2</sub>O containing 30 g NH<sub>4</sub>NO<sub>3</sub> in order to remove the Na and K from the sample. This mixture was then washed in a like manner an additional three times using distilled water. The sample was dried at 110 °C for 3 hours, and then calcined at 400 °C for 20 hours. The resulting material was ground and sieved to 8-10 mesh. This catalyst is labeled Ag-Mn-Co oxide catalyst.

A titania-supported catalyst with platinum metal and iron oxide as promoters was prepared by impregnating titania (provided by Degussa Corporation, Teterboro, New Jersey) with an aqueous solution containing both Pt(NH<sub>3</sub>)<sub>4</sub>(NO<sub>3</sub>)<sub>2</sub> and Fe(NO<sub>3</sub>)<sub>2</sub>•9H<sub>2</sub>O. Concentrations of Pt and Fe in the solution and the weight ratio of the solution to titania were chosen such as to obtain a final catalyst loading of about 1 weight-% Pt and about 0.5 weight-% Fe. The Pt/Fe-impregnated titania was dried at about 125 °C, calcined in air for several hours at 350 °C, and heated in a stream of hydrogen gas at about 200-300 °C for several hours. This catalyst is labeled 1% Pt, .5% Fe/TiO<sub>2</sub>.

Several other Pt/Fe/TiO<sub>2</sub> catalysts were prepared substantially in accordance with the above-described procedure except that Pt and Fe loadings were different. These promoter loadings will be identified when tests are described in the examples below.

#### Example II

This example illustrates the carbon monoxide output for the preferred smoking articles of the present invention. These articles were substantially those illustrated in Figure 1. For the tests in this example, the articles were prepared by modifying the RJR Premier smokeless cigarette.

The Premier unmodified cigarette was comprised of a carbonaceous fuel element in direct contact with an aerosol-generating material. The aerosol-generating material was enclosed within a metal container having a length of approximately 30 mm and a diameter of approximately 5 mm. The carbonaceous fuel element was of approximately 10 mm in length and 5 mm in diameter, with longitudinal channels or passageways running through the length of the element. The fuel element was inserted into the open end of the aerosol-generating material container.

The fuel element was circumscribed by a layer of heat-insulating glass fiber of approximately 1.5 mm in thickness. The aerosol-generating material container was circumscribed by a layer of tobacco of approximately 1.5 mm in thickness. The mouthpiece end of the aerosol-generating material container was adjacent to a filter consisting of a cigarette paper filter adjacent to a nonwoven polypropylene filter. The entire article was wrapped in cigarette paper, and it had the overall size and appearance of a conventional cigarette.

The Premier cigarette was modified by removing a portion of the aerosol-generating material from its container and replacing it with a CO oxidation catalyst at the fuel element end of the container. This modification was accomplished by cutting through the outer paper and tobacco one inch from the cigarette tip. The canister was then opened at the partially perforated end. All the aerosol-generating material was then removed from the canister. The desired amount of CO oxidation catalyst was loaded into the canister so as to be in direct contact with the fuel source. The remaining space in the canister was refilled with the aerosol-generating material, and the perforated end of the canister was then reclosed.

For testing, tygon® polymer tubing was fitted directly onto the exposed end of the metal container. Smoke was drawn through the tubing, through a particulate filter and into the cylinder of a smoking machine. The particulate filter was utilized to remove H<sub>2</sub>O, glycerine and particulates prior to the gas chromatograph sampling. The smoke was then exhaled from the cylinder into an HP 3890 gas chromatograph. Finally the smoke passed through an Anarad AR 400 Series infrared CO analyzer and then to vent.

According to FTC smoking conditions, a "standard puff" consists of a 35 cc draw in 2 seconds, with one minute rest between puffs. Because the tygon® tubing in this experiment was fitted directly onto the exposed end of the metal container rather than to the mouth-end of the smoking article, no air was drawn around the outside of the container during the test. There was approximately 30% bypass around the container in the unmodified Premier cigarette. For this reason, the 35 cc/2 sec. standard puff was adjusted to 25 cc/2 sec. for the canister only experiments. The results are shown in Table 2. The values shown in Table 2, as well as the values shown in all subsequent tables, are the average values for three runs.

Table 2

Run	Catalyst	CO/CO <sub>2</sub> <sup>(1)</sup>	Total mg CO <sup>(2)</sup>
1	No catalyst	0.96	14.4
2	1% Pt, .5% Fe/TiO <sub>2</sub> (100 mg)	0.37	7.7
3	LAB CuMnO <sub>2</sub> (100 mg)	0.01	2.8
4	CALLERY A CuMnO <sub>2</sub> (100 mg)	0.14	5.4
5	CALLERY B CuMnO <sub>2</sub> (100 mg)	0.01	2.3
6	CALLERY B CuMnO <sub>2</sub> (80 mg)	0.11	4.0
7	CALLERY B CuMnO <sub>2</sub> (50 mg)	0.27	7.2
8	CALLERY C CuMnO <sub>2</sub> (100 mg)	0.06	4.2

Notes: (1) "CO/CO<sub>2</sub>" in this and subsequent Tables means molecular ratio of CO to CO<sub>2</sub> in the filtered smoke, taken on the third puff.

(2) "Total mg CO" in this and subsequent Tables means the total amount (in milligrams) of CO produced during one entire test using one Premier cigarette until complete exhaustion of the fuel source.

The CO/CO<sub>2</sub> ratio is used as a measure of the completeness of the combustion to CO<sub>2</sub>. Test results in Table 2 clearly demonstrate the CO reducing effect of the tested catalysts (Runs 2-8) when compared to the unmodified Premier cigarette canister (Run 1). The CuO-MnO<sub>2</sub> catalysts (Runs 3-8) were generally more effective than the Pt/Fe/TiO<sub>2</sub> catalyst (Run 2).

Example III

The articles utilized in this example were substantially those described in Figure 1. The articles were prepared and tested in the same manner as those in Example II. Additionally, however, some of the articles were provided with eight pin-like holes in the outer surface of the container, as shown in Figure 14 and Figure 15. The holes were made with the sharp point of a #1 insect pin. The purpose of the holes was to provide additional oxygen to the catalyst in the container for more complete combustion of the carbon monoxide to carbon dioxide. Table 3 shows the carbon monoxide output for the articles with holes in the container, as compared to articles without such holes.

Table 3

Run	Test Description	O/C	CO/CO <sub>2</sub>	Total mg CO
9	No catalyst, no holes	2.1	0.96	14.4
10	1% Pt, 0.5% Fe/TiO <sub>2</sub> (100 mg), no holes	2.1	0.37	7.7
11	1% Pt, 0.5% Fe/TiO <sub>2</sub> (100 mg), 8 holes	2.8	0.03	2.5
12	Lab CuO/MnO <sub>2</sub> (100 mg), no holes	2.3	0.01	2.8
13	Lab CuO/MnO <sub>2</sub> (100 mg), 8 holes	2.8	0.01	2.1

The O/C ratio clearly shows the holes are effective for increasing the amount of oxygen available for combustion of the carbon fuel. The additional oxygen significantly increases the CO removal by the noble metal type catalysts, such as the 1% Pt, 0.5% Fe/TiO<sub>2</sub> catalyst. The additional oxygen only slightly effects the CO removal by the CuO/MnO<sub>2</sub> catalysts.

#### Example IV

The articles used in this example were substantially identical to those described in Figure 1. The articles were prepared and tested in the same manner as those in Example III, with 8 holes in the metal container to provide additional oxygen for the reaction. The effects of using 100 mg of catalyst with different promoter levels were investigated in an effort to reduce the cost of the catalyst while maintaining a high activity. Data with various Pt and Fe weight percentages on TiO<sub>2</sub> support are given in Table 4.

Table 4

Run		% Pt	% Fe	Total O/C Ratio	Total mg CO
14	Blank	no	catalyst	2.7	13.4
15	Group 1	1.0	0.5	2.7	2.5
16		0.5	0.25	2.8	4.7
17		0.3	0.15	2.8	9.5
18	Group 2	0.5	0.0	2.7	11.2
19		0.5	0.25	2.8	4.7
20		0.5	0.5	3.0	6.6
21		0.5	1.0	2.8	9.7
22	Group 3	0.3	0.0	2.5	12.1
23		0.3	0.15	2.8	9.5
24		0.3	1.5	2.9	12.4

In the utilization of the preferred smoking articles of the present invention, carbon monoxide passes to the user by flow around the outside of the metal container as well as flow through the metal container. Test results in Group I of Table IV demonstrate that as the Pt level decreases, the CO conversion decreases. Test results in Groups 2 and 3 demonstrate that the addition of a small amount of Fe (Runs 18, 19, 22 and 23) results in a substantial increase in the CO conversion over the same catalyst without Fe (Run 14). Furthermore, these results show that too much Fe can have a detrimental effect on the activity of a low level Pt catalyst (Runs 19-21, 23 and 24).

#### Example V

This example illustrates the additional benefit that is incurred when catalyst is positioned outside the metal container as well as inside the metal container. Additionally, this example illustrates that the positioning of the catalyst inside the metal container in close proximity to the aerosol-generating material for a substantial period of time will not result in a reduction of the catalyst activity. The articles utilized in this example were substantially those described in Figure 5. The articles were prepared by modifying the RJR Premier smokeless cigarette. The cigarette was modified by removing a portion of the aerosol-generating material from its container and replacing it with a CO oxidation catalyst at the fuel element end of the

container, as described in Example II. Additionally, a portion of catalyst was placed outside the metal container so that it circumscribed a portion of the container near the fuel element, as shown in Figure 5. This was accomplished by removing a portion of the tobacco adjacent to the glass fiber jacket that surrounds the fuel element and replacing it with catalyst so that the catalyst was positioned between the glass fiber jacket and the tobacco jacket of the cigarette.

In order for this experiment to account for air flow around the outside of the canister as well as through the inside, the cigarette was completely reassembled, and tygon® tubing was fitted to the mouth end of the cigarette. Standard FTC smoking conditions were employed, i.e. a 35 ml puff of 2 seconds duration, once every minute. The amount of catalyst inside and outside the metal container was varied. Additionally, the effect of aging on the newly prepared cigarettes was tested. The results are shown in Table 5.

Table 5

Run	Test Description	O/C	CO/CO <sub>2</sub>	Total mg CO
25	no catalyst (unmodified Premier)	3.2	0.92	13.0
	Lab CuO-MnO <sub>2</sub> catalyst			
26	100 mg inside canister, none outside	4.3	0.10	5.3
27	100 mg inside canister, 50 mg outside	4.2	0.03	3.0
28	80 mg inside canister, 50 mg outside	3.2	0.06	5.8
	Aging tests for Lab CuO-MnO <sub>2</sub> catalyst: 100 mg inside, 50 mg outside			
29	aged for 24 hrs before testing	3.6	0.02	3.4
30	aged for 48 hrs	4.6	0.02	3.1
31	aged for 120 hrs	3.4	0.02	3.6
32	aged for 48 hrs at 50°C	4.5	0.02	2.7

Addition of catalyst outside the metal container decreased the total carbon monoxide (Run 27). Test results on aging of the cigarettes from Table 5 show that aging up to 120 hours had no detrimental effect on the catalyst performance.

#### Example VI

The articles utilized in this example were substantially those described in Figure 6. The articles were prepared by modifying the RJR Premier smokeless cigarette. The cigarette was modified by removing a portion of the aerosol-generating material from its container and replacing it with a CO oxidation catalyst at the fuel element end of the container, as described in Example II. Also, in all articles, 50 mg of 28-48 mesh Callery CuO-MnO<sub>2</sub> B catalyst were placed outside the container, as described in Example V. Additionally, a short piece of 0.020 inch diameter copper wire was anchored in the center hole of the carbon fuel element extending axially through the center of the container. The length of the wire reached completely through the catalyst bed and extended into the aerosol-generating material.

The cigarettes were completely reassembled and tygon® tubing fitted to the mouth end of the cigarettes. Standard FTC smoking conditions were employed, i.e. a 35 ml puff of 2 seconds duration, once every minute. The amount of catalyst inside the container was varied from 25 to 100 mg. Control tests without the copper wire were run for each trial for comparison.

The amount of aerosol emitted from the cigarette was recorded by carefully watching the clear tygon® tube attached to the mouthpiece of the cigarette. A numerical value for the amount of aerosol was designated for each puff on a scale from 0.0 to 1.0 (in increments of 0.25), where 0.0 is for no aerosol, 0.5 is for moderate aerosol, and 1.0 is for full aerosol. Of course, these numerical assignments for the amount of aerosol are subjective and imprecise. Nevertheless, this gives a useful (though approximate) method of quantifying the amount of aerosol. As before, the total mg of CO is determined for each cigarette using the IR CO meter. The tabulated aerosol and total mg CO data for all trials are given in Table 6 and Table 7. Puff #1 designates the puff that is utilized to light the cigarette. Puffs #9 and #10 show no aerosol because

the fuel source has completely burned.

Table 6

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	<u>No Catalyst</u>	<u>100 mg Catalyst</u>	<u>75 mg Catalyst</u>	<u>50 mg Catalyst</u>	<u>25 mg Catalyst</u>
Total mg CO	12.15	2.62	2.79	4.80	7.72
Puff #	<u>Aerosol</u>				
0	0.00	0.00	0.00	0.00	0.00
1	0.50	0.00	0.00	0.25	0.33
2	1.00	0.33	0.42	0.75	0.75
3	1.00	0.50	0.67	1.00	1.00
4	1.00	1.00	0.92	1.00	1.00
5	1.00	0.75	1.00	1.00	1.00
6	1.00	0.58	0.83	1.00	1.00
7	0.50	0.50	0.67	0.75	0.66
8	0.00	0.16	0.33	0.16	0.00
9	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00

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Table 7

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	<u>No Catalyst</u>	<u>100 mg Catalyst</u>	<u>75 mg Catalyst</u>	<u>50 mg Catalyst</u>	<u>25 mg Catalyst</u>	<u>25 mg Catalyst</u>
	<u>No Wire</u>	<u>2.0 cm Wire</u>	<u>2.0 cm Wire</u>	<u>2.0 cm Wire</u>	<u>1.0 cm Wire</u>	<u>2.0 cm Wire</u>
Total Mg CO	12.15	2.28	2.10	2.70	4.86	5.39
Puff #	<u>Aerosol</u>					
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.50	0.16	0.25	0.13	0.25	0.42
2	1.00	0.66	0.58	0.38	0.72	0.92
3	1.00	0.91	1.00	0.88	0.92	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	0.83	1.00	0.96	1.00	1.00
6	1.00	0.66	0.91	0.79	0.88	0.83
7	0.50	0.42	0.58	0.50	0.50	0.17
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00

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Test results in Table 6 show the effect of varying the amount of catalyst inside the container in the absence of a copper wire. This data illustrates that adding catalyst inside the container reduces the amount of aerosol produced, especially during the initial puffs. Test results in Table 7 show the effect of varying the amount of catalyst inside the container with the addition of the copper wire described above. Comparing the wire and no-wire data shows that the addition of the copper wire increased the observed aerosol in all cases except the 50 mg case. Additionally, comparison of the wire and no-wire data shows that the addition of the copper wire increased the CO conversion rate in all cases. The increased CO conversion is apparently due to the copper wire heating up the catalyst more quickly, resulting in better conversion of CO during the initial puffs than is observed in the absence of the copper wire.

Example VII

The articles utilized in this example were substantially those illustrated in Figure 5. The articles were prepared by modifying the RJR Premier smokeless cigarette as described in Example V. The portion of the catalyst placed outside the metal container comprised 50 mg of the Ag-Mn-CO oxide catalyst described in Example I. The portion of the catalyst placed inside the metal container comprised 100 mg of the Ag-Mn-CO oxide catalyst described in Example I. Standard FTC smoking conditions were employed, i.e. a 35 ml puff of 2 seconds duration, once every minute. Also, unmodified Premier cigarettes were tested for comparison. The results are shown in Table 8.

Table 8

Run	Test Description	O/C	CO/CO <sub>2</sub>	Total mg CO
32	No catalyst (unmodified Premier)	3.2	0.92	13.0
33	Ag-Mn-Co Oxide Catalyst 100 mg inside container, 50 mg outside	4.0	0.3	6.1

The results of Table 8 clearly indicate that the addition of the Ag-Mn-CO oxide catalyst significantly increases the CO conversion for the Premier cigarette.

Reasonable variations, modifications and adaptations for various usages and conditions can be made within the scope of the disclosure and the appended claims, without departing from the scope of this invention.

**Claims**

1. Apparatus for producing aerosol, which comprises:
  - a combustible fuel element;
  - a quantity of CO oxidation catalyst having a first end portion and an opposite second end portion and disposed with the first end portion thereof adjacent said fuel element;
  - aerosol-generating means including an aerosol-forming substance and disposed adjacent the second end portion of said catalyst for forming an aerosol in response to the application of heat thereto; and
  - heat-conductive means interconnecting said combustible fuel element and said aerosol-generating means for transferring heat from said combustible fuel element to said aerosol-generating means.
2. Apparatus in accordance with claim 1,
  - wherein said CO oxidation catalyst comprises CuO and MnO<sub>2</sub>;
  - or wherein said CO oxidation catalyst comprises titania-supported platinum and iron oxide;
  - or wherein said CO oxidation catalyst comprises a silver-manganese-cobalt oxide.
3. Apparatus in accordance with claim 1, wherein said CO oxidation catalyst is selected from the group consisting of a CuO and MnO<sub>2</sub> catalyst, a titania-supported platinum and iron oxide catalyst, and a silver-manganese-cobalt oxide catalyst and combinations of any two or more thereof.
4. A cigarette-type smoking article comprising:
  - a combustible hollow tube having a first end portion, an opposite second end portion and an intermediate portion;
  - filter means disposed within said hollow tube adjacent the second end portion thereof;
  - apparatus for producing aerosol disposed within said hollow tube intermediate the first end portion thereof and said filter means, said apparatus comprising
    - a combustible fuel element;
    - a quantity of CO oxidation catalyst, in particular one as defined in one of the preceding claims, having a first end portion and an opposite second end portion and disposed with the first end portion thereof adjacent said fuel elements;
    - aerosol-generating means including an aerosol-forming substance adjacent the second end portion of said catalyst for forming an aerosol in response to application of heat thereto;
    - heat-conducting means interconnecting said combustible fuel element and said aerosol-generating means for conducting heat from said combustible fuel element to said aerosol-generating means; and
    - said combustible fuel element being disposed within the first end portion of said hollow tube and said

aerosol-generating means being disposed within said hollow tube adjacent said filter means.

- 5
5. A smoking article in accordance with claim 4 wherein said hollow tube and said apparatus for producing aerosol defines an annular space therebetween and wherein said smoking article further comprises:  
a quantity of tobacco disposed within said annular space adjacent said catalyst and said aerosol-generating means; and  
a quantity of porous heat insulation material disposed within said annular space adjacent said combustible fuel element.
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6. A smoking article in accordance with claim 4 or 5 wherein said heating conducting means comprises:  
an elongated metallic member having a first end portion and an opposite second end portion with the first end portion thereof in heat-conductive contact with at least a portion of said combustible fuel element and with the second end portion thereof in heat-conductive contact with at least a portion of said aerosol-generating means, more particularly wherein said elongated member extends through said  
15 quantity of CO oxidation catalyst.
7. A smoking article of one of claims 4-6 wherein the fuel element comprises combustible carbon.
8. A smoking article of one claims 4-7 wherein the aerosol-generating means comprises glycerin-impregnated alumina particles.
- 20
9. A smoking article in accordance with one of claims 4-8 further comprising a heat-conductive metal container which encloses at least a first portion of the CO oxidation catalyst and at least a portion of the aerosol-generating means.
- 25
10. A smoking article in accordance with one of claims 4-9 wherein said heat-conductive container is provided with a plurality of pin-like holes through the surface of said heat-conductive container so as to circumscribe said CO oxidation catalyst enclosed within said heat-conductive metal container.
- 30
11. A smoking article in accordance with one of claims 4-10 further comprising a first heat-conductive metal container having a first end portion, an opposite second end portion, and an intermediate portion wherein said CO oxidation catalyst is enclosed within said first heat-conductive metal container, and a second heat-conductive metal container having a first end portion adjacent to said second end portion of said first heat-conductive metal container, an opposite second end portion and an intermediate  
35 portion, wherein said aerosol-generating means is enclosed within said second heat-conductive metal container.
- 40
12. A smoking article in accordance with one of claims 4-11 wherein said hollow tube and said apparatus for producing aerosol defines an annular space therebetween and wherein said smoking article further comprises:  
a quantity of tobacco disposed within said annular space adjacent said catalyst and said aerosol-generating means;  
a quantity of porous heat insulation material disposed said annular space adjacent said combustible fuel element; and  
45 a second portion of CO oxidation catalyst within said annular space between said quantity of tobacco and said quantity of porous heat insulation material so as to circumscribe at least a portion of said heat-conductive metal container.
- 50
13. A smoking article in accordance with one of claims 4-12 wherein said elongated member comprises a thin metallic wire, preferably wherein said thin metallic wire has a diameter not greater than 0.020 inches.

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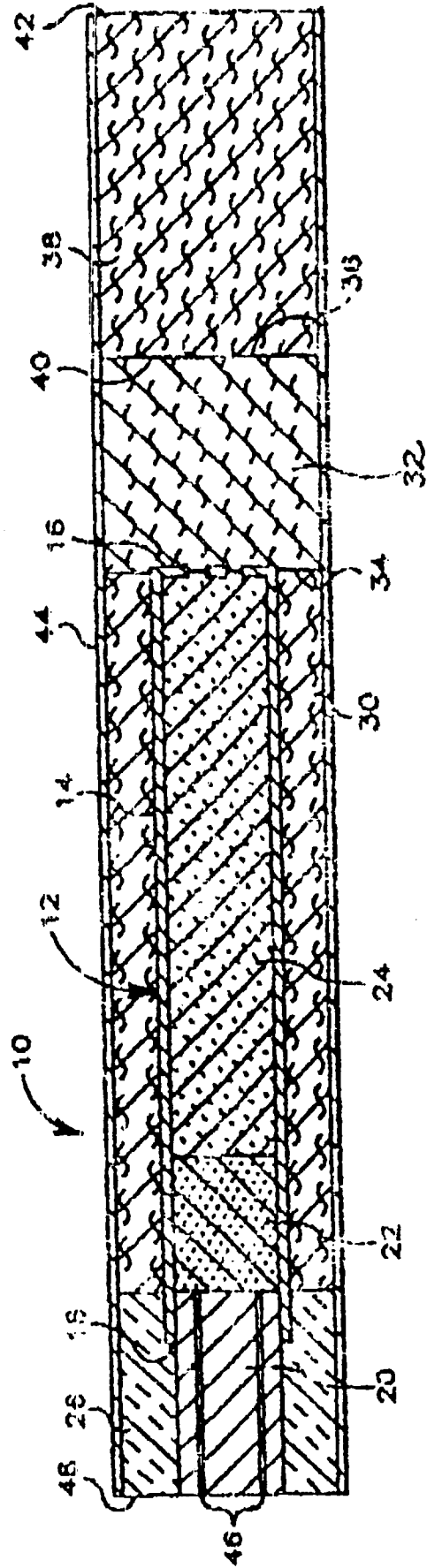


FIG. 1



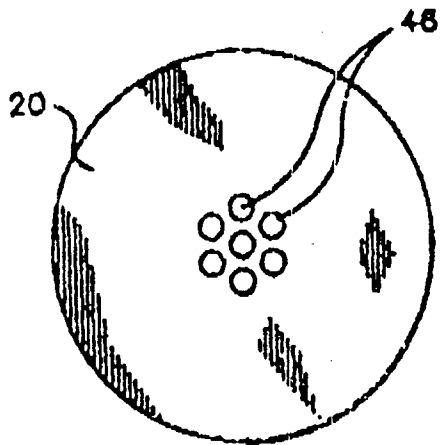


FIG. 2

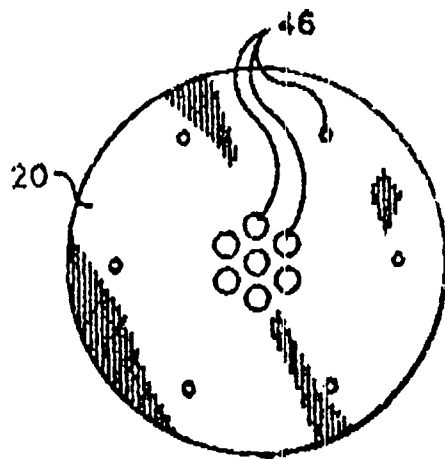


FIG. 3

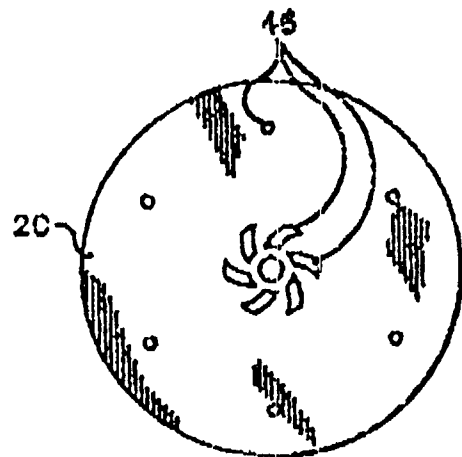


FIG. 4

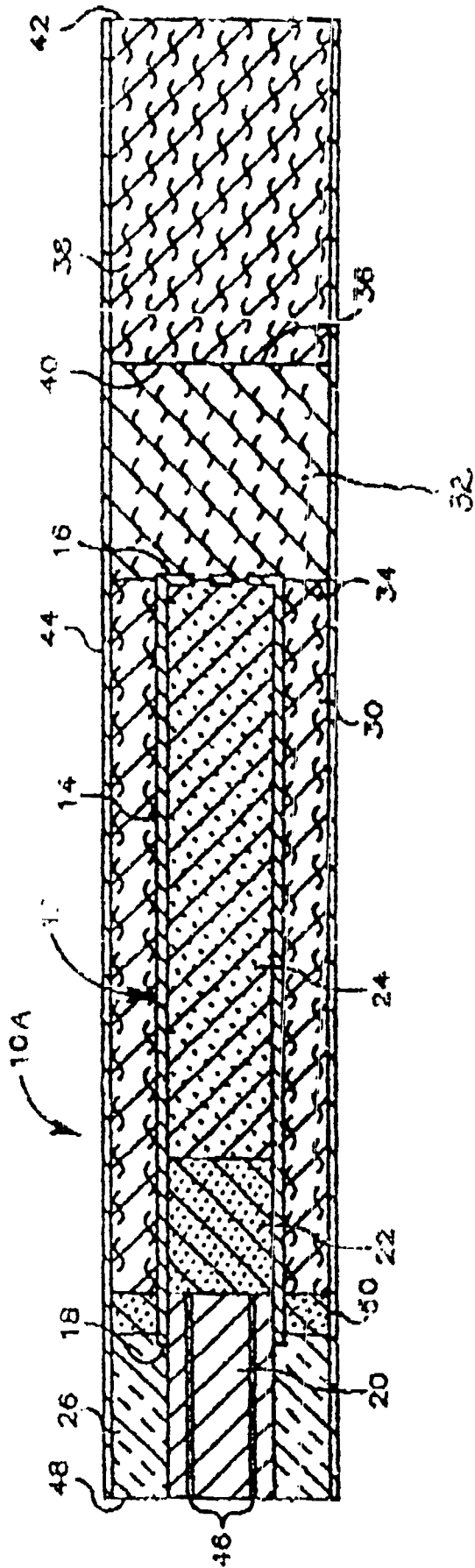


FIG. 5

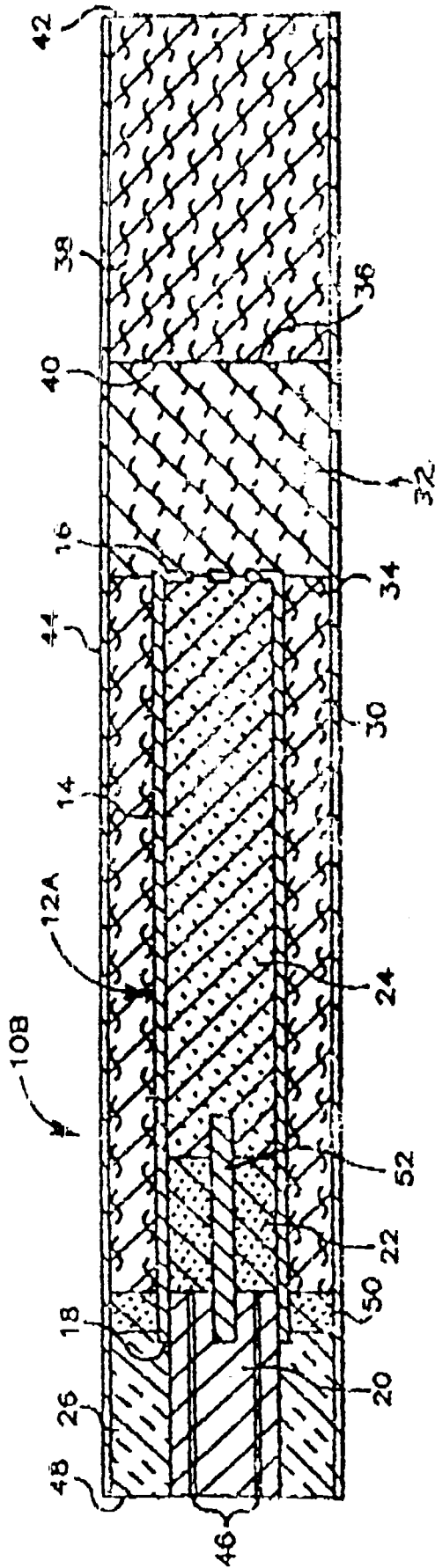


FIG. 6

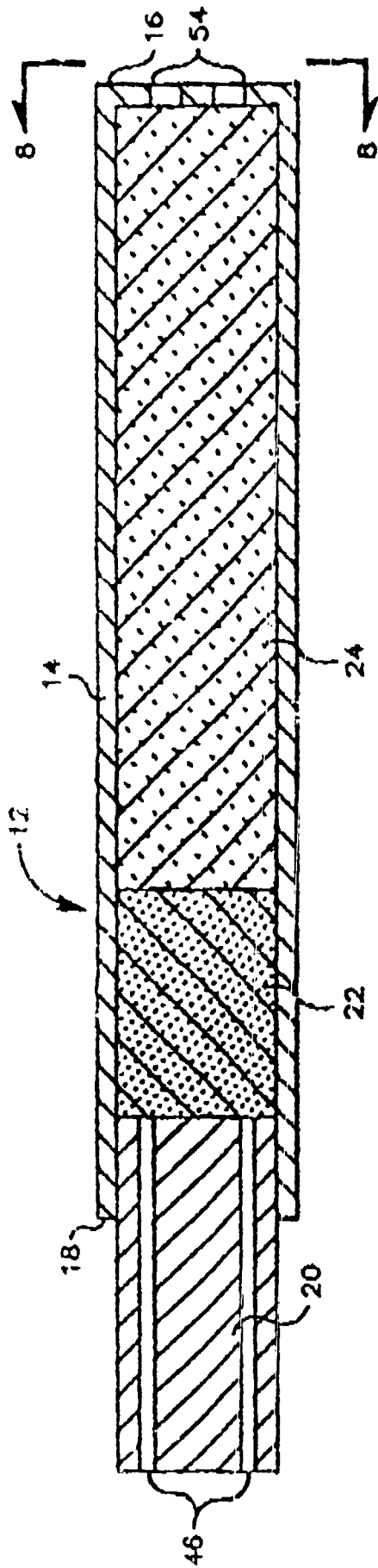


FIG. 7

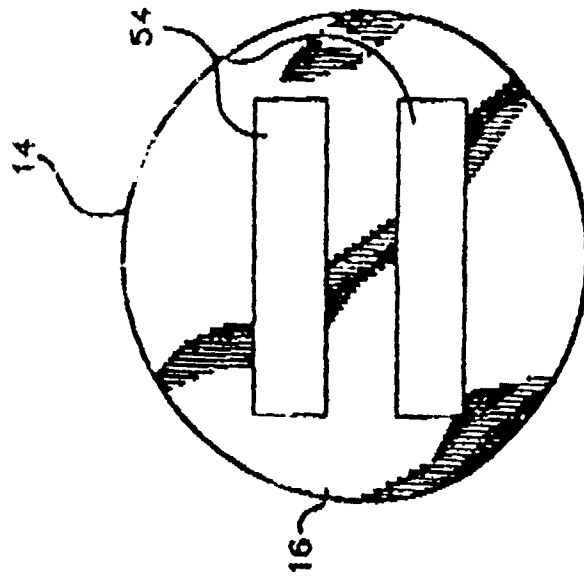


FIG. 8

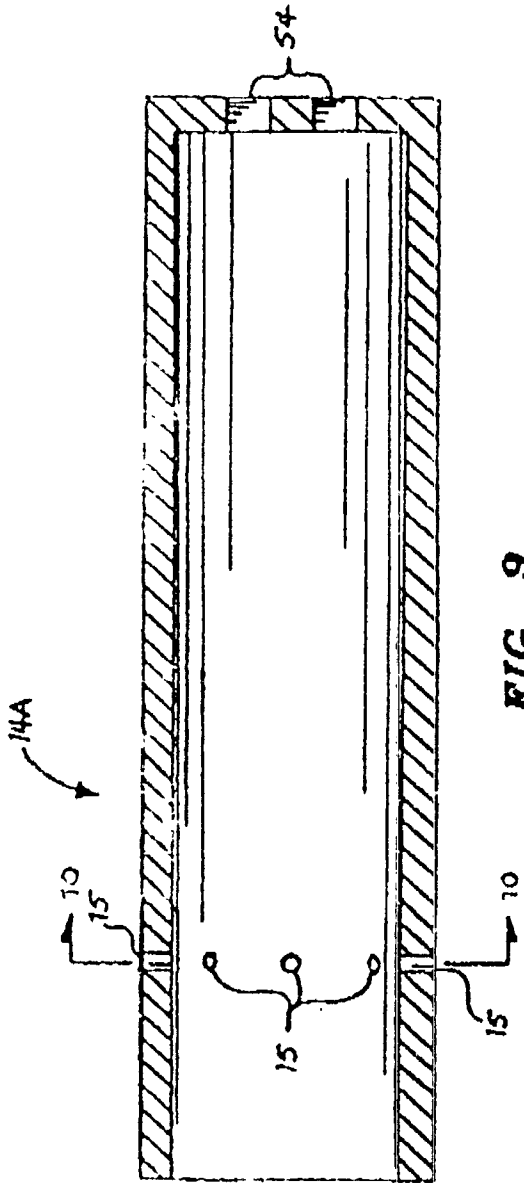


FIG. 9

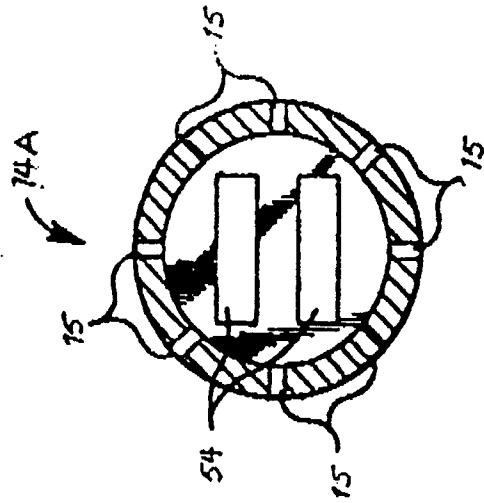


FIG. 10

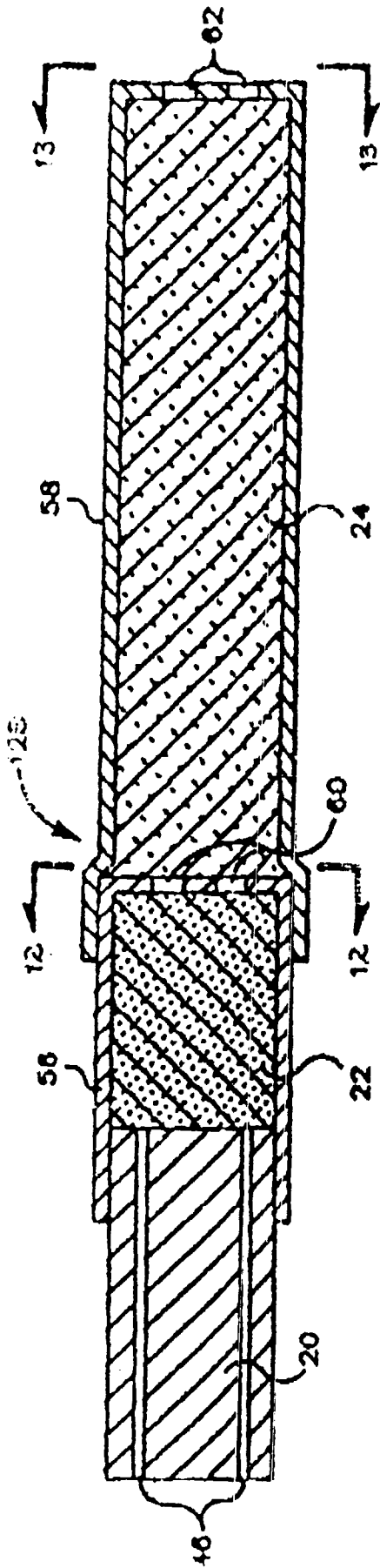


FIG. 11

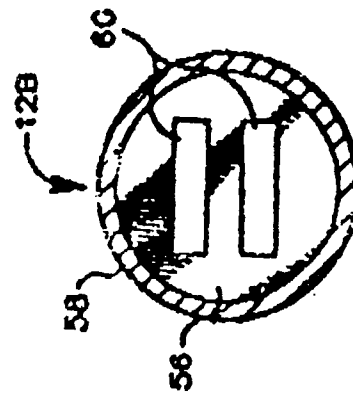


FIG. 12

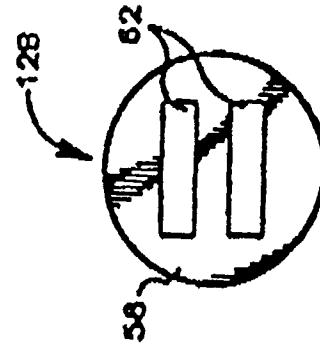


FIG. 13

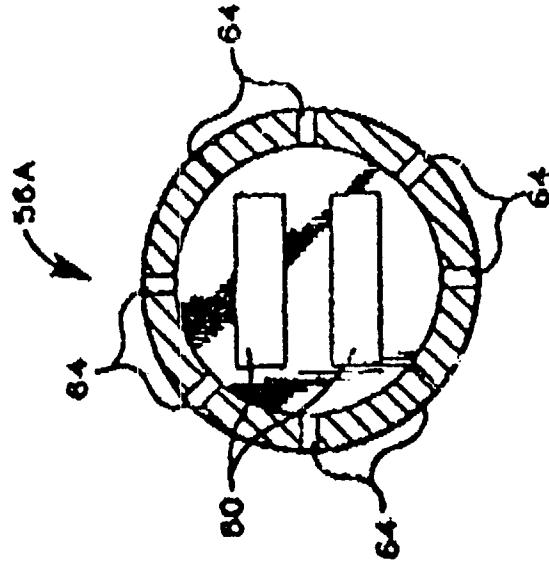


FIG. 14

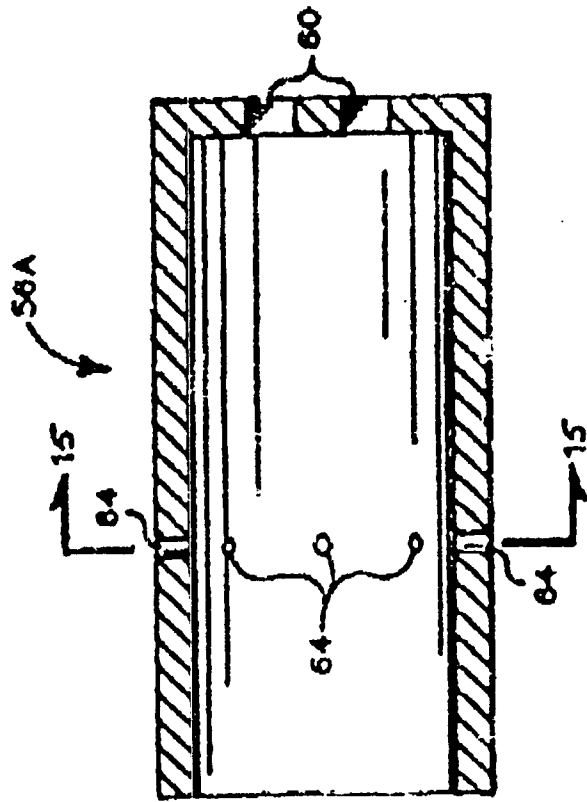


FIG. 15