April 29, 1969 B. T. WALL 3,441,028

APPARATUS FOR AND METHOD OF REMOVING CONDENSIBLE COMPOUNDS FROM TOBACCO SMOKE

Filed March 27, 1967

FIG. 1

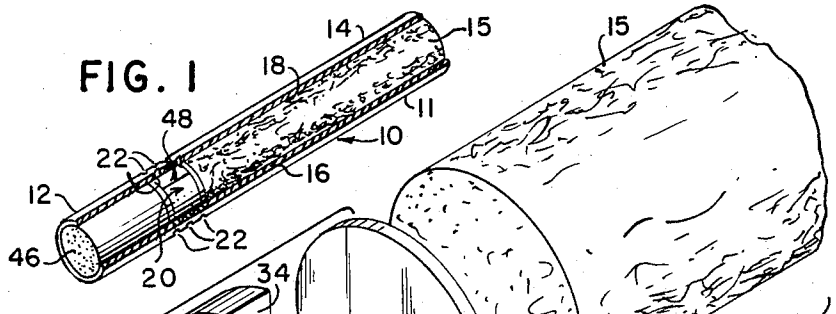


FIG. 2

FIG. 3

FIG. 7

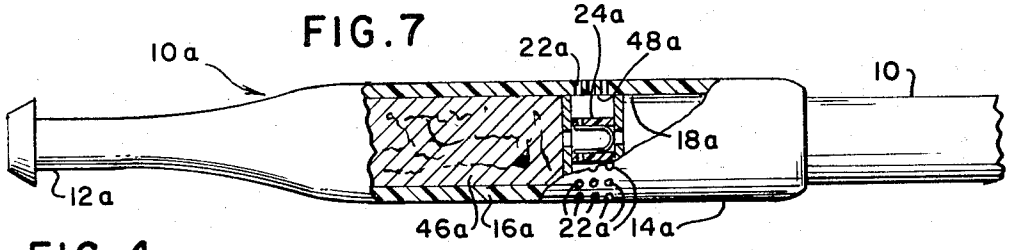


FIG. 4

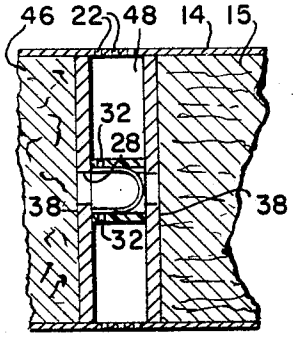


FIG. 5

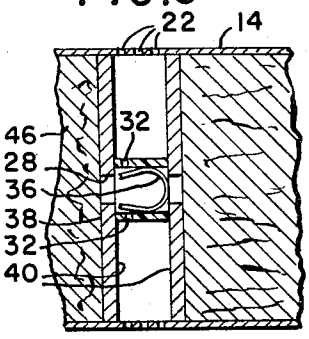
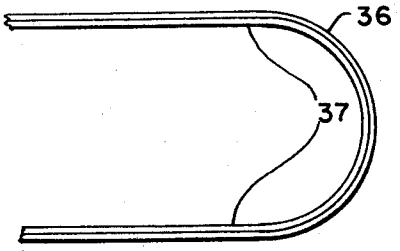


FIG. 6



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APPARATUS FOR AND METHOD OF REMOVING CONDENSIBLE COMPOUNDS FROM TOBACCO SMOKE

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U.S. Cl. 131—10.3 24 Claims

ABSTRACT OF THE DISCLOSURE

A smoking utensil such as a cigarette, a cigarette holder or a pipe stem having a smoke passage is provided with an insert in the passage having a smoke channel of smaller cross-section than the smoke passage and temperature responsive means, such as a bimetallic spring, for introducing air into the smoke as it passes through the smoke channel. A filter or other means for holding compounds which are condensed as a result of the cooling effect of the air is positioned in the smoke passage downstream from the insert to hold the tars and the like and thus remove them from the smoke leaving the utensil.

The present invention relates to apparatus for and a method of removing condensible compounds from tobacco smoke. The embodiment which is believed to have the greatest utility is a cigarette having the means built into it for removing the condensible compounds, but the invention also contemplates utilizing the means and method for removing such condensible compounds in the form of a cigarette and cigar holder and the stem of a pipe.

A large quantity of data has been accumulated which some scientists have interpreted as connecting lung cancer with tobacco smoke, particularly from cigarettes. Most scientists who hold this view are of the opinion that the carcinogens are in condensible compounds such as nicotine and tars that are volatilized when the tobacco is burned and travel in the smoke into the lungs where they are condensed. Since the publication of these data began, skilled workers in the tobacco art have proposed many ways and means of removing condensible compounds from tobacco smoke. Among these ways and means are various kinds of filters, absorbents, such as charcoal, metal baffles to cool and condense the compounds and hold them in the smoke passage of pipe stems, cigarette and cigar holders, and the like, and various means of blending air with the tobacco smoke for the purpose of cooling it and condensing out the tars and other condensible compounds. Among the aerating means proposed for cigarettes are the provisions of a plurality of holes along the length of the cigarette, the provisions of a plurality of holes located in a band adjacent to the interface between the tobacco filler and a filter which in one proposal are left open and in another proposal are closed by a slidable band or removable band so that the smoker can manually open these holes at a selected time during the smoking of the cigarette.

It has been established by reliable evidence that tars and other condensible solids precipitate out into the tobacco at the mouth end of the cigarette at the beginning of the burning of the tobacco at the other end. This is only a temporary deposit of the tars, however, because as the burning of the tobacco progresses down the cigarette, the temperature rises high enough to revolatilize the condensed tars and re-entrain them in the tobacco smoke entering the lungs of the smoker. Filters have been proposed for the mouth end of the cigarette which include various kinds of porous materials, e.g., cellulose,

charcoal, and the like, which are intended to cool and condense undesirable tars and the like and while they have some effectiveness, they are unable to cope with the problem adequately because as the tobacco burns nearer to the filter, the temperature of the smoke is too high to be cooled adequately in the filter to condense out and remove any substantial portion of the tars. It is also at this time that the concentration of these tars is highest for the reasons explained above.

The proposal to blend air with tobacco smoke for the purpose of cooling it has not been satisfactory. When air openings are distributed along the length of the cigarette, the greatest volume of air is drawn into the tobacco smoke at the beginning of the operation and it progressively decreases as the cigarette burns because more and more holes are eliminated by the burning of the wrapper. A cigarette constructed in accordance with the proposal to place the holes in a band adjacent to the interface between the tobacco and the filter suffers from a similar defect because the amount of air flowing through these openings is also a function of the length of the path of the smoke to the tobacco and as this length diminishes, the amount of air going through the holes in the band around the interface position also decreases. The proposal to cover holes in the wrapper arranged in a band adjacent to the tobacco filter interface, or if a filter is not used adjacent to the mouth end of the cigarette, is not satisfactory either, at least to most smokers, because it requires concentration of the smoker to open up the air passages at the appropriate time during the smoking operation which many smokers find objectionable and forget to do.

In its preferred form, the present invention overcomes these defects and disadvantages in smoking utensils, including cigarettes, which have means to hold a supply of tobacco, a mouthpiece and a wall forming a passage connecting said means and mouthpiece for smoke produced by burning the tobacco by providing heat-responsive means in the smoke passage of the utensil between the tobacco and the mouthpiece for introducing air into the tobacco smoke when the smoke in this region reaches a predetermined temperature, and means to catch and hold condensed tars and the like. This structure has the advantage of providing tobacco smoke of more uniform taste and low nicotine and tar content throughout the entire use of the cigarette, even when the tobacco is largely consumed. The present invention also contemplates such a smoking utensil having means to hold a supply of tobacco, a mouthpiece and a wall forming a passage connecting said means and mouthpiece in which temperature-responsive means are provided in the passage upstream from an air intake which is opened when the smoke reaches a predetermined temperature to admit air and mix it with the smoke downstream from the temperature-responsive means. The apparatus for and method of accomplishing these and other desirable and advantageous results will become apparent from the following description, taken in conjunction with the drawing in which:

FIG. 1 is an isometric view of a cigarette embodying the invention with part of the wrapper broken away to show the internal structure and arrangement of a tobacco filler, a filter and an intermediate aerating device;

FIG. 2 is an exploded view of the internal parts showing the tobacco filler and the filter with the elements of the aerating device located between them;

FIG. 3 is a cross-sectional view through the cigarette wrapper and the areating device;

FIG. 4 is a fragmentary longitudinal section along the line 4—4 of FIG. 3 showing the normal position of the arms of a U-shaped air control thermoresponsive spring;

FIG. 5 is a view similar to FIG. 4 showing the position

of the arms of the air control spring when the temperature of the smoke rises above the predetermined level;

FIG. 6 is an enlarged fragmentary side view of a preferred form of bimetallic thermoresponsive air control spring; and

FIG. 7 is a side view, partially in section, of a reusable holder for a cigarette or a cigar, or pipe stem.

Referring now to FIGS 1–6, the apparatus for removing condensible compounds from tobacco smoke is in the form of a cigarette **10** which is the most common type of smoking utensil used. The cigarette includes a wrapper **11** of any desired material. One end of the cigarette wrapper **11** serves as a mouthpiece **12** for holding the same between the lips of the smoker and the other end **14** constitutes the tobacco-holding means of the cigarette for a tobacco filler **15**. The wrapper also constitutes a wall **16** forming a smoke passage **18** connecting the tobacco-holding means with the mouthpiece. Generally speaking, the cross-section of the cigarette is circular so that the tobacco filler **15**, the smoke passage **18** and other enclosed parts are cylindrical in shape, but other rounded cross-sections such as ovals and ellipses are equally contemplated by the invention and included in the term "rounded cross-section" as used in the description and claims.

Aerating means **20** are provided in the smoke passage **18** of the cigarette. The aerating means includes at least one air inlet or opening **22** in the wrapper **11** and preferably a plurality of such air inlets or openings **22** located in a band around it. While the invention contemplates the use of a thermostatic or temperature-responsive means for opening and closing these openings directly, in the preferred embodiment of the invention, means **24** are provided for concentrating or converging the smoke into a channel of very much smaller cross-sectional area than the smoke passage **18**, which greatly increases the velocity of the smoke in this zone. At the point of high velocity, when the temperature of the smoke reaches a predetermined level, air is blended with the smoke which is then passed into the holding means for the tar which is located in the smoke passage of the larger diameter. The effect of the air so blended with the smoke, alone or in combination with a temperature drop resulting from the expansion of the air-smoke blend as it leaves the zone of high velocity, is to cool the smoke and precipitate out tars and other condensible compounds which are then caught and held in the holding means.

The means **24** preferably comprises a closed end cylinder or rounded insert **26** having an air channel **28** of smaller cross-section than the air passage **18**. In a preferred embodiment, the air channel is provided with one or more inner grooves **30** which have in the bottom thereof at least one air opening **32** which communicates either directly or preferably through a peripheral groove **34** with one or more of the openings **22** in the cigarette wrapper. By providing a plurality of openings **22** in a band around the wrapper having a width generally corresponding to the length of insert **26**, there is no problem of aligning openings **22** and **32** in assembling the parts because regardless of the angular orientation of the insert in relation to the smoke passage, a sufficient number of the openings **22** will be in communication with openings **32**. A heat-responsive element **36** is provided in the air channel **28** upstream from the openings **32** which has an arm normally covering the openings **32**. In the preferred embodiment, it is shown as a U-shaped spring with its arms **37** loosely lying in grooves **30** so that the free ends are adapted to open and close the air openings **32** in response to temperature changes. FIG. 6 shows that spring **36** in a preferred embodiment may be made of two layers of material, e.g., metal, plastic and the like, having different coefficients of expansion with temperature rise which are so chosen as to effect contraction of the ends or arms **37** thereof away from the openings **32** when the smoke passing the spring reaches a predetermined temperature. The particular predetermined temperature at which the arms **37** pull away from the bottom of the groove and uncover the openings **32** as shown in FIG. 5 is a matter of choice on the part of the manufacturer to obtain an optimum balance of taste and removal of condensibles. Means **38** are provided to hold the spring **36** in the air channel, preferably a disc **40** at the tobacco side, and desirably also at the other side, of the cylinder **26** each of which is provided with an opening **42** smaller than the spring **36** so that it is positively held in the channel **28** with an arm **37** covering each air opening **32**. The fit of the arms **37** in the grooves **30** is sufficiently loose and the lengths of the spring **36** and the groove **30** are so related as to permit easy movement of the arms in the grooves in response to temperature changes in the smoke flowing through the channel **28** but tight enough to hold the arms **37** aligned with and covering, or adapted to cover, the openings **32** when the temperature is below, or falls below, a predetermined level. It will be noted that spring **36** is not riveted or otherwise fastened to the insert **24** but is loosely positioned therein. This is of great advantage in automatic assemblage of parts of the aerating means and the mounting thereof in a cigarette or other smoking utensil.

The insert **26** is preferably a molded plastic piece which can readily be made by injection molding individual pieces in a die or preferably by extruding a long rod of the configuration shown and cutting it into the desired short lengths. Insert **26** is of rounded form in cross section, preferably cylindrical, having an outer shape and size equal to the inner cross-section of the smoke passage in the smoking utensil. The channel **28** through the insert may be and preferably is axially located therein. This molded piece preferably has weight reducing holes **44** extending from end to end to reduce cost and, with the discs **40**, to provide a closed cylinder that concentrates or converges the smoke against the bight of the U-shaped spring in the smoke channel **28**. It is to be noted that the major portion of the spring **36** is upstream from the air openings **32** so that the response of the spring to temperature depends almost entirely on the smoke entering channel **28** which is not diluted with incoming air through openings **32** until it has largely passed by the thermoresponsive element **36**. This makes for accurate introduction of controlled proportions of air with the smoke depending on its temperature.

Adjacent to the insert **26** on the side opposite the tobacco filler **15** is the means **46** for removing and holding the condensible compounds precipitated from the smoke. This may be, and in cigarettes preferably is, a filter of any desired form and construction, e.g., a preshaped cylinder made of cellulosic material. The tobacco filler **15** and filter **46** are spaced apart a distance equal to the length of the insert **26** and this space is enclosed by the wrapper **14** to form a chamber **48** to house the aerating device **24**.

Referring now to FIG. 7, the reusable holder **10*a***, which is shown as a cigarette holder but which may be a cigar holder or the stem of a pipe, comprises a mouthpiece **12*a***, tobacco holding means **14*a***, e.g., a cylinder to receive the end of a cigarette **10**, a wall **16*a*** forming a smoke passage **18*a*** connecting the tobacco holding means **14*a*** with the mouthpiece **12*a***, and openings **22*a*** in the wall **16*a*** around the chamber **48*a*** in which the aerating means **24*a*** lies. The aerating means **24*a*** may, and preferably does, have the same structure described above for means **24**. On the downstream side of the aerating device is a means **46*a*** to receive and hold condensed compounds in the smoke produced by the burning of the tobacco, e.g., a filter such as described above.

In both embodiments of the invention described above and illustrated in the drawing, the tobacco smoke produced by burning the tobacco when it is first lighted travels through the smoke passage without being admixed with air because the spring **36** has each arm **37** covering

the opening or openings **32** in the bottom of the channels **30** in the smoke channel **28** and the path of travel of the smoke through the unburned tobacco is long enough to cool it and condense and catch condensible impurities largely in the tobacco. When the distance of travel of the smoke through the tobacco has been reduced by the burning away of the tobacco so that the temperature of the smoke heats the spring above the temperature which has been predetermined by choice of the material of which it is formed to cause the arms **37** to move toward each other, the openings **32** are first slightly opened and then more fully opened as the smoke temperature at the bight of the spring rises, permitting air to flow from the atmosphere in these controlled proportions into the channel **28** through openings **22**, peripheral grooves **34** and openings **32**. The introduction of the air takes place in the zone of highest velocity and turbulence of the smoke-laden air assures good mixing and cooling to precipitate condensibles. The confluence of the two streams of air flowing from opposite directions through openings **32** into the smoke-laden air stream flowing through channel **28** produces, by application of the principles of fluidics, optimum conditions for effecting precipitation of condensibles. The smoke-laden stream carrying the condensed compounds flows next into the means **46** for catching and holding them while permitting the smoke, thus purified, to pass out of the smoke passage.

Technical reports on tar and nicotine content of commercial brands of cigarettes typically report on the average tar and nicotine content per cigarette as determined in a cigarette smoking machine under controlled conditions and procedures. Recently, some data on tar and nicotine yields per puff and per gram of tobacco consumed have been reported. While scientists are not agreed on the significance of these data in relation to cancer and other diseases that appear to be related to cigarette smoking, it appears likely that the high proportion of condensibles in later puffs on a cigarette when the butt is short may be more detrimental than the average weight of these condensibles per cigarette. Thus, even in a cigarette having a low average weight of tar and nicotine per cigarette, the proportion of tar and nicotine in late puffs with a short butt could be higher than in the last puffs from a cigarette of higher average tar and nicotine content which is thrown away before the butt is as short. The technology of cigarette manufacture has developed to the stage where cigarettes of very low average tar and nicotine yield per cigarette can be produced but smokers appear to prefer brands of higher average yield of tars and nicotine per cigarette for taste and systemic effects regardless of possible long-range health hazards. The present invention has particular benefits in respect to the amount of tars and nicotine that pass from the cigarette over the entire use thereof. Thus, instead of having the amount of tars and nicotine per puff go from an initial relatively low value in the first puff to a maximum value in the last puff at a constantly increasing rate as in conventional cigarettes of both filter and non-filter types, cigarettes made and used in accordance with the present invention follow the same upward curve from the initial relative low value until the temperature of the smoke at the spring **36** is high enough to let air bleed past the opening arms **37**, but from that point on, the rate of increase in tars and nicotine per puff decreases asymptotically. The net effect is to make the average yield of tars and nicotine from a cigarette much lower and more uniform throughout its consumption for any given tobacco and thus enable a manufacturer to use a tobacco filler of high enough tar and nicotine content to be acceptable to smokers without subjecting them to higher proportions of tars and nicotine in later puffs than a smoker would get from other cigarettes of much lower average yield of tars and nicotine per cigarette.

The method of the invention comprises burning tobacco to produce smoke, passing this smoke through unburned tobacco and through means for holding condensed compounds and selectively introducing air into the smoke between the tobacco and holding means when the smoke in that zone reaches a predetermined temperature. Preferably, the velocity of this smoke is greatly increased as it leaves the tobacco by providing a smoke channel at the point of introduction of the air which is much smaller in cross-section than the smoke passage through the tobacco. It is also desirable again to decrease the velocity of the smoke as it passes into the holding means such as the filter **46**. The provision of the channel of reduced cross-section area through the air blending means as compared to the area of the smoke passage on each side thereof, produces a sort of venturi effect. As those skilled in the art of air flow know, decreasing the volume of the gas in the constricted passage of a venturi results in perhaps a small increase in pressure but a substantial increase in temperature and velocity. The use of this method brings the atmospheric cooling air into the smoke-laden stream where its temperature and velocity are at the highest and thus gives the greatest opportunity for proper blending of the air and smoke to effect maximum condensation of condensible compounds present in the smoke. Then, as the smoke leaves the constricted passage and expands again into the larger smoke passage through the filter or other holding means there is a corresponding decrease in temperature, velocity and possibly pressure, which causes further cooling and condensation while giving added time for the smoke to pass through the holding means to remove condensed compounds from the smoke which leaves the smoking implement.

Although the present invention has been described and illustrated in connection with two specific embodiments of the invention, it is understood that other embodiments, variations and modifications are within the contemplation of the invention as defined in the following claims.

Having thus described the invention, what is claimed is:

1. A smoking utensil having a mouthpiece, means for holding a supply of tobacco, a wall forming a passage connecting said means with said mouthpiece for smoke produced by burning said tobacco, aerating means including a thermostat in said smoke passage for excluding the admixing of air with said smoke until it reaches a predetermined temperature, and means downstream to catch and hold condensed compounds.

2. A smoking utensil having a mouthpiece and means for holding a supply of tobacco, a wall forming a smoke passage connecting said mouthpiece and tobacco holding means for smoke produced by burning said tobacco, and means for aerating smoke flowing through said passage comprising at least one opening in the wall of said passage connecting it to the atmosphere and temperature responsive means loosely positioned in said passage for normally closing said opening when cold but opening it when heated above a predetermined temperature by said smoke.

3. A smoking utensil having a mouthpiece, means for holding a supply of tobacco, a wall forming a smoke passage connecting said means with said mouthpiece for smoke produced by burning said tobacco, said wall having an air inlet connecting said smoke passage with the atmosphere, and temperature responsive means in said smoke passage largely upstream from said air inlet having only the end of an arm extending downstream from said air inlet for normally closing it when the smoke around said temperature responsive means is below a predetermined temperature and for opening said air inlet as the temperature of the smoke around said temperature responsive means rises above said predetermined temperature to admit air to be admixed with said smoke downstream from said air inlet.

4. A smoking utensil comprising means for holding a supply of tobacco, a filter, a wall surrounding said filter and forming a smoke passage from said means to said filter, means between said filter and tobacco for converg-

ing the smoke passage, and temperature responsive means in said passage for introducing air into smoke in the converged portion of the passage when the smoke therein reaches a predetermined temperature.

5. A smoking utensil as set forth in claim **1** which includes means for concentrating smoke on said thermostat.

6. A smoking utensil as set forth in claim **5** in which said concentrating means comprises an insert having a channel of smaller cross-section than said passage and said thermostat is a U-shaped spring in said channel.

7. A smoking utensil as set forth in claim **1** in which said utensil is a reusable holder.

8. A smoking utensil as set forth in claim **1** in which said utensil is a cigarette having a paper wrapper that constitutes the mouthpiece, the wall of the passage and the tobacco holding means.

9. A smoking utensil as set forth in claim **8** in which the means to catch and hold condensed compounds is a filter and said aerating means is between the tobacco and filter.

10. An aerating device for a smoking utensil having a smoke passage of uniform rounded cross-section comprising a closed rounded insert having an outer size and shape corresponding in cross-section to the inner surface of said smoke passage, a smoke channel from end to end thereof, and at least one opening from said smoke channel adapted to admit air thereinto from the atmosphere through an opening in the wall of said smoke passage and temperature responsive means in said channel normally covering said air opening when cold but opening it when heated above a predetermined temperature.

11. An aerating device for a smoking utensil as set forth in claim **10** in which said temperature responsive means is a U-shaped spring having the bight upstream from said air opening and an arm extending over said opening and means to position said spring loosely in said channel.

12. An aerating device for a smoking utensil as set forth in claim **11** in which said positioning means includes an inner groove in the smoke channel to receive the arm of said spring that normally covers the air opening and an annulus at one end of said rounded insert having a hole aligned with said smoke channel which is smaller than said spring.

13. An aerating device for a smoking utensil as set forth in claim **12** in which said rounded insert is a molded plastic piece having a peripheral groove communicating with said air opening.

14. An aerating device for a smoking utensil as set forth in claim **13** in which said rounded insert has a second groove opposed to said inner groove, each groove being adapted loosely to receive one of the arms of said spring and having at least one air opening in the bottom normally covered by said arms, and an annulus at each end of said rounded insert.

15. An aerating device for a smoking utensil as set forth in claim **12** in which said rounded insert has weight reducing cavities and means to prevent passage of smoke through said cavities.

16. A cigarette comprising a tobacco filler at one end; a filter at the other end spaced from said tobacco and a wrapper surroundiing said tobacco filler, said filter and the space between them, said space surrounded by said wrapper being a rounded chamber, said wrapper having a plurality of air openings into said chamber; and an aerating device in said chamber comprising a closed insert having an outer cross-section corresponding in size and shape to the inner cross-section of said chamber, a smoke channel from end to end of said insert and at least one opening from said channel to the periphery of said insert in communication with at least one opening in said wrapper, temperature responsive means in said channel, and means for positioning said temperature responsive means with a part thereof normally covering said air opening when said temperature responsive means is below a predetermined temperature but opening it when heated above said predetermined temperature.

17. A cigarette as set forth in claim **16** in which said insert has a peripheral groove communicating with the air openings in said wrapper and said insert.

18. A cigarette as set forth in claim **16** in which said temperature responsive means is a U-shaped spring and said positioning means includes an inner groove in the smoke channel to receive an arm of said spring that normally covers the air opening and an annulus having a hole aligned with said smoke channel which is smaller than said spring.

19. A cigarette as set forth in claim **18** in which said smoke channel has two opposed inner grooves, each having at least one air opening in the bottom thereof, said insert has two peripheral grooves, each adjacent to one of said inner grooves, and communicating with air openings in said insert and said wrapper, and said spring has its arms normally covering the air openings in the bottoms of the grooves.

20. A cigarette as set forth in claim **16** in which said insert is a molded plastic piece having weight reducing cavities and means to close said weight reducing cavities to passage of smoke while leaving said channel open.

21. A cigarette comprising a tobacco filler at one end, a filter at the other end, a wrapper surrounding said tobacco and filter forming a smoke passage, means between said filter and said tobacco for converging the smoke passage, an air passage connecting said smoke passage with the atmosphere, and temperature responsive means in said smoke passage for controlling the introduction of air into the converged portion of the passage when smoke therein reaches a predetermined temperature.

22. A method of removing tars and other condensible compounds from tobacco smoke which comprises burning tobacco to produce smoke, passing said smoke first through tobacco, then through an aerating zone, and thereafter through separate means for holding condensed compounds, and utilizing the temperature of the smoke in said aerating zone directly for controlling the introduction of air into said smoke in said zone before it enters said holding means.

23. A method as set forth in claim **22** in which the confluence of the streams of the smoke and the air is utilized to effect precipitation of condensibles.

24. A method of controlling the precipitation and removal of condensible compounds in a stream of tobacco smoke by introduction of air streams from opposite directions into said smoke stream in proportions regulated by direct response to the temperature of said smoke stream and filtering the mixed streams, said proportions being predetermined to obtain desired balance between taste and content of condensible compounds remaining in the mixed streams after filtering to effect removal of condensed compounds.

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