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IN THE UNITED STATES DISTRICT COURT

DISTRICT OF ARIZONA

VPR BRANDS, L.P., a Delaware limited partnership, Plaintiff, v. Jupiter Research, LLC, an Arizona limited liability company, Defendant.	Case No. CV-20-02185-PHX-DJH **DEFENDANT'S SUPPLEMENTAL RESPONSE TO PLAINTIFF'S FIRST REQUEST FOR PRODUCTION OF DOCUMENTS TO DEFENDANT #20** [Assigned Hon. Diane J. Humetewa]

TO: VPR BRANDS, L.P. AND ITS ATTORNEYS:

Pursuant to Rule 34, Federal Rules of Civil Procedure, Defendant submits the following supplemental response to Plaintiff's First Request for Production of Documents to Defendant #20. Defendant Jupiter hereby incorporates, by reference, the Preliminary Statement, General Objections, and Objections to Definitions and Instructions set forth in Defendant's original response to Plaintiff's First Request for Production of Documents to Defendant.

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SPECIFIC OBJECTIONS AND RESPONSES

Subject to and without waiving its General Objections and Objections to Definitions and Instructions, Defendant provides this supplemental response (supplemental disclosure noted in ***bold italics***) to Plaintiff's First Request for Production of Documents to Defendant #20 as follows:

REQUEST FOR PRODUCTION NO. 20: All documents and ESI containing prior art to the patent-in-suit or that you contend would anticipate or otherwise render obvious any claim or claims of the patent-in-suit.

RESPONSE: Defendant provides Documents DEF000915-DEF001135 ***and DEF001239-DEF001640*** which are responsive to this request. Defendant continues to gather documents through the discovery process and will supplement this response as documents are gathered.

DATED this 5th day of October, 2021 (signing for the objections)

SCHMEISER, OLSEN & WATTS LLP

By:

/Sean K. Enos/

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ORIGINAL of the foregoing emailed this 5th day of October, 2021 to:

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Atomized electronic cigarette

Abstract

The utility model relates to an atomized electronic cigarette only containing methylpyrrolidine (nicotine) without tar, comprising a shell body and a suction nozzle. The outer wall of the shell body is provided with an air-in hole, and an electronic circuit board, a normal pressure cavity, a sensor, an air-liquid segregator, an atomizer and a liquid supplying bottle are arranged in the shell body in turn; wherein the electronic circuit board is composed of an electronic switching circuit and ahigh-frequency generator; one side of the sensor is provided with the airflow channel of the sensor, and a negative pressure cavity is arranged in the sensor; the atomizer is contacted with the liquid supplying bottle, and the inner part of the atomizer is provided with an atomized cavity; a retainer ring is arranged between one side of the liquid supplying bottle and the shell body for locking the liquid supplying bottle, and the other side of the liquid supplying bottle is provided with a smogless channel; the air-in hole, the normal pressure cavity, the air-liquid segregator, the atomizer, the smogless channel, an air guiding hole and the suction nozzle are communicated in turn. The atomized electronic cigarette has no tar, and can greatly reduce cancerogenic risks; users have the feel and excitement of smoking, and the atomized electronic cigarette needs not to light without the harm of fire hazard.

Classifications

A24F40/42 Cartridges or containers for inhalable precursors

View 28 more classifications

CN2719043Y
China

Download PDF Find Prior Art Similar

Other languages: Chinese

Inventor: 韩力

Worldwide applications

2004 ~~CN~~ 2005 ~~CA~~ BR *PT* ~~KR~~ ~~JP~~ *SI* ~~CN~~ ES EP US *AT* *UA* WO DK DE *PL* ~~AU~~ ~~EA~~ *MY* 2006 ~~IL~~ 2007 ~~HK~~ 2009 *CY* 2010 US 2012 US 2013 US 2014 US 2015 US ~~US~~ 2016 US 2017 US 2018 US US 2019 US 2020 US US US US

Application CN2004200311820U events

2004-04-14	Application filed by 韩力
2004-04-14	Priority to CN2004200311820U
2005-08-24	Application granted
2005-08-24	Publication of CN2719043Y
2008-12-29	First worldwide family litigation filed
2014-04-14	Anticipated expiration
Status	Expired - Lifetime

Info: Patent citations (238), Cited by (525), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (14)

Hide Dependent

1. Atmized electronic cigarrette, comprise housing and suction nozzle, it is characterized in that: have air admission hole (4) on the outer wall of described housing (14), be provided with electronic circuit board (3), common pressure chamber (5), sensor (6), gas-liquid separator (7), atomizer (9), supplying bottle (11) in the housing (14) successively; Wherein electronic circuit board (3) is made up of electronic switching circuit and radio-frequency generator; Side at sensor (6) has sensor gas channel (18), is provided with negative pressure cavity (8) in the sensor (6); Atomizer (9) contacts with supplying bottle (11), is provided with atomization chamber (10) in the inside of atomizer (9); Be provided with the back-up ring (13) of locking supplying bottle (11) between one side of supplying bottle (11) and the housing (14), the opposite side of supplying bottle (11) has mist vapour passage (12); Air admission hole (4), common pressure chamber (5), gas-liquid separator (7), atomizer (9), mist vapour passage (12), gas port (17), suction nozzle (15) are connected successively; Front end in the housing (14) also comprises a light emitting diode (1) and battery (2), constitutes the integral body of a cigarette holder shape, cigar shape or tobacco pipe shape jointly.

2. Atmized electronic cigarette as claimed in claim 1, it is characterized in that: in housing (14), atomizer (9) postposition, supplying bottle (11) is located between gas-liquid separator (7) and the atomizer (9), is equipped with at an end of supplying bottle (11) supplying bottle (11) is pressed on shell fragment (33) on the atomizer (9).

3. according to claim 1 or 2 described Atmized electronic cigarettes, it is characterized in that: on the inwall of housing (14), be equipped with display screen (32).

4. according to claim 1 or 2 described Atmized electronic cigarettes, it is characterized in that: be provided with in parallel with sensor (6) is used for the manually microswitch (16) of cleaning in housing (14).

5. according to claim 1 or 2 described Atmized electronic cigarettes, it is characterized in that: be provided with ripple film (22) between described sensor (6) and its inner negative pressure cavity (8), also be provided with first magnet steel (20), second magnet steel (21) in the sensor (6) and place between

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the two tongue tube (19), second magnet steel (21) is fixed on the ripple film (22).

6. according to claim 1 or 2 described Atmized electronic cigarrettes, it is characterized in that: described sensor (6) is built-in with silica gel spare non-return valve (31), is provided with the 3rd magnet steel (34) in the valve, and the outer side near magnet steel of valve is provided with tongue tube (19).

7. according to claim 1 or 2 described Atmized electronic cigarrettes, it is characterized in that: described gas-liquid separator has through hole on (7).

8. according to the described Atmized electronic cigarrette of claim 7, it is characterized in that: be with silica gel spare non-return valve (31) outside the through hole on gas-liquid separator (7).

9. according to claim 1 or 2 described Atmized electronic cigarrettes, it is characterized in that: have spout hole (29) on the atomization chamber wall (25) of described atomization chamber (10), atomization chamber (10) is provided with calandria (26) in the chamber, side at calandria (26) has long air-flow spray-hole (24), porous body (27) wraps in outside the atomization chamber wall (25), one side of atomizer (9) is provided with first piezoelectric patches (23), and opposite side is provided with projection (36).

10. according to claim 1 or 2 described Atmized electronic cigarrettes, it is characterized in that: add second piezoelectric patches (35) in the described atomizer (9).

11. according to the described Atmized electronic cigarrette of claim 9, it is characterized in that: the available nickel foam of porous body (27), stainless steel fibre felt, macromolecule polymer foaming body and foamed ceramics in the described atomizer (9) are made; The available platinum filament of calandria (26), nichrome or the Aludirome silk that contains rare earth element are made, and also can be made into plates; Available aluminium oxide of atomization chamber wall (25) or pottery are made.

12. according to the described Atmized electronic cigarrette of claim 7, it is characterized in that: available plastics of described gas-liquid separator (7) or silicon rubber are made.

13., it is characterized in that according to claim 1 or 2 described Atmized electronic cigarrettes: storage liquid porous body (28) is housed in the described supplying bottle (11), its available poly-third fiber, polyster fibre or nylon fiber filling, or with plastic foamed formed body filling; Also available polyvinyl chloride, polypropylene, polycarbonate injection moulded become multiple-plate column.

14. according to the described Atmized electronic cigarrette of claim 5, it is characterized in that: tongue tube (19), first magnet steel (20), second magnet steel (21), ripple film (22) is available has the semiconductor gauge of closing membrane to replace, and is installed in sensor ripple film position.

Description

Atmized electronic cigarrette

Technical field

The utility model relates to a kind of electronics cigarette, does not particularly a kind ofly contain tar, only contains the Atmized electronic cigarrette of nicotine (nicotine).

Background technology

Become under the situation of general knowledge current " Smoking is harmful to your health ", the whole world still has 1,000,000,000 people's smokings at present, and annual this numeral is also enlarging.The international ban on opium-smoking and the opium trade agreement of first that on March 1st, 2003, The World Health Organization (WHO) passed through " Framework Convention on Tobacco Control ", the numeral that provides according to WHO shows, smoking causes 4,900,000 people's death every year, although smoking can cause serious respiratory disease and cancer, allowing the smoker give up smoking fully is extremely difficult thing.

The active ingredient of cigarette is nicotine (being nicotine); after entering alveolar, a large amount of tar droplets that nicotine produces along with cigarette combustion during smoking absorbed rapidly; nicotine acts on the acceptor of central nervous system after being absorbed into blood; cause similar anti-depressant " euphoria ", as having a dizzy spell or smug sensation that the smoker experienced.

Nicotine is little molecular biosciences alkali, and is harmless substantially to human body under low dose, and the half-life in blood is extremely short.The harmful substance of tobacco mainly is a tar, and tobacco tar is to become to be grouped into by thousands of kinds, and it is carcinogenic substances that tens of kinds of compositions are wherein arranged.Confirm that at present passive smoking is bigger to non-smoker's harm.

In order to seek the cigarette substitute that only contains nicotine and do not contain harmful tar, it is to make such as " smoking cessation is pasted " with purer nicotine that many inventions are arranged, " nicotine rinse water ", " be packaged in the high pressure gas holder spray of propellant ", " nicotinamide chewing gum ", products such as " nicotine beverages ", though these products do not have the harm of tar, but because of nicotine absorbs slowly, in blood, can not set up effective peak concentration, can not solve the sensation of demand nicotine " enjoyable ", also deprived simultaneously " taking out " that the smoker has formed, the custom of " suction ", thereby the conduct that similar products like can not be real smoking cessation articles for use or cigarette substitute.

The utility model content

In order to overcome above-mentioned deficiency, the purpose of this utility model is to provide a kind of Atmized electronic cigarrette with smoking cessation and cigarette substitute effect.

The purpose of this utility model is achieved through the following technical solutions:

The utility model comprises housing and suction nozzle, has air admission hole on the outer wall of housing, is provided with electronic circuit board, common pressure chamber, sensor, gas-liquid separator, atomizer, supplying bottle in the housing successively; Wherein electronic circuit board is made up of electronic switching circuit and radio-frequency generator; Side at sensor has the sensor gas channel, is provided with negative pressure cavity in the sensor; Atomizer contacts with supplying bottle, is provided with atomization chamber in the inside of atomizer; Be provided with the back-up ring of locking supplying bottle between one side of supplying bottle and the housing, the opposite side of supplying bottle has mist vapour passage; Air admission hole, common pressure chamber, gas-liquid separator, atomizer, mist vapour passage, gas port, suction nozzle are connected successively; Front end in the housing also comprises a light emitting diode and battery, constitutes the integral body of a cigarette holder shape, cigar shape or tobacco pipe shape jointly.

Wherein: on the inwall of housing, be equipped with display screen; Be provided with in parallel with sensor is used for the manually microswitch of cleaning in housing; Be provided with ripple film between sensor and its inner negative pressure cavity, also be provided with first magnet steel, second magnet steel in the sensor and place between the two tongue tube, second magnet steel is fixed on the ripple film; Sensor is built-in with silica gel spare non-return valve, is provided with the 3rd magnet steel in the valve, and the outer side near magnet steel of valve is provided with tongue tube; Have through hole on the gas-liquid separator, be with silica gel spare non-return valve outside the through hole on gas-liquid separator; Have spout hole on the atomization chamber wall of atomization chamber, atomization chamber is provided with calandria in the chamber, has long air-flow spray-hole in a side of calandria, and porous body wraps in outside the atomization chamber wall, and a side of atomizer is provided with first piezoelectric patches, and opposite side is provided with projection; Add second piezoelectric patches in the atomizer; Porous body in the atomizer can be made with nickel foam, stainless steel fibre felt, macromolecule polymer foaming body and foamed ceramics; Calandria can be made with platinum filament, nichrome or the Aludirome silk that contains rare earth element, also can be made into plates; The atomization chamber wall can be made with aluminium oxide or pottery; Gas-liquid separator can be made with plastics or silicon rubber; Storage liquid porous body is housed in the supplying bottle, its available poly-third fiber, polyster fibre or nylon fiber filling, or with plastic foamed formed body filling; Also available polyvinyl chloride, polypropylene, polycarbonate injection moulded become multiple-plate column; Tongue tube, first magnet steel, second magnet steel, ripple film can replace with the semiconductor gauge that closing membrane is arranged, and are installed in sensor ripple film position.

The invention also discloses the Atmized electronic cigarette of another kind of structure, in housing, the atomizer postposition, supplying bottle is located between gas-liquid separator and the atomizer, is equipped with at an end of supplying bottle supplying bottle is pressed on shell fragment on the atomizer.

The utility model has the advantages that: smoking does not have tar, reduces carcinogenic risk greatly, and the user still has the feeling and excitement of smoking, need not to light no fire hazard.

Device of the present utility model and syndeton can be packed conventional medicine into for the feeding drug into pulmones apparatus after liquid reservoir is changed a little.

Description of drawings

Fig. 1 is a kind of overall structure schematic diagram of the present utility model;

Fig. 2 is an another kind of overall structure schematic diagram of the present utility model;

Fig. 3 is the overall structure schematic diagram of the utility model band display screen;

Fig. 4 is the structure chart of the utility model sensor;

Fig. 5 has the sensor construction figure of silica gel spare non-return valve for the utility model;

Fig. 6 is the structure chart of a kind of atomizer of the utility model;

Fig. 7 is the structure chart of ceramic member in the utility model atomizer;

Fig. 8 is the structure chart of the another kind of atomizer of the utility model;

Fig. 9 is the structure chart of a kind of gas-liquid separator of the utility model;

Figure 10 is the structure chart of the another kind of gas-liquid separator of the utility model;

Figure 11 is the johning knot composition of the utility model supplying bottle and suction nozzle;

Figure 12 is circuit theory diagrams of the present utility model.

The specific embodiment

The utility model is described in further detail below in conjunction with accompanying drawing.

Embodiment one

As shown in Figure 1, the utility model can constitute the integral body of a cigarette holder shape, cigar shape or tobacco pipe shape.Have air admission hole 4 on the outer wall of housing 14, be sequentially set with light emitting diode 1, battery 2, electronic circuit board 3, common pressure chamber 5, sensor 6, gas-liquid separator 7, atomizer 9, supplying bottle 11, suction nozzle 15 in the housing 14.Electronic circuit board 3 is made up of electronic switching circuit and radio-frequency generator.As shown in Figure 4, be provided with negative pressure cavity 8 in the sensor 6, separate by ripple film 22 and sensor 6.Also be provided with first magnet steel 20, second magnet steel 21 in the sensor 6 and place tongue tube 19, the second magnet steel 21 between the two to be fixed on the ripple film 22.Atomizer 9 contacts with supplying bottle 11 by protruding 36, and atomizer 9 inside are provided with atomization chamber 10.As Fig. 6, shown in Figure 7, have spout hole 29 on the atomization chamber wall 25 of atomization chamber 10, be provided with calandria 26 in the chamber, available platinum filament, nichrome or the Aludirome silk that contains rare earth element are made, and also can be made into plates.Side over against calandria 26 has spray-hole, and spray-hole can be selected long air-flow spray-hole 24 for use or lose heart stream spray-hole

30 according to the material of atomization chamber wall 25.Long air-flow spray-hole 24 can adopt the single hole and the loose structure of 0.1mm ~ 1.3mm narrow slit structure or Φ 0.2mm ~ 1.3mm circular hole; Lose heart stream spray-hole 30 diameter at 0.3mm ~ 1.3mm.Be surrounded by porous body 27 outside the atomization chamber wall 25, available nickel foam, stainless steel fibre felt, macromolecule polymer foaming body and foamed ceramics are made.On atomizer 9, also be provided with first piezoelectric patches 23.Atomization chamber wall 25 can be made with aluminium oxide or pottery.As shown in Figure 9, have through hole on the gas-liquid separator 7, available plastics or silicon rubber are made.As shown in figure 11, be provided with the back-up ring 13 of locking supplying bottle 11 between one side of supplying bottle 11 and the housing 14, opposite side has mist vapour passage 12, storage liquid porous body 28 is housed in the bottle, available poly-third fiber, polyster fibre or nylon fiber filling, or with plastic foamed formed body such as Polyurethane Thysanophyllum or the poly-third Thysanophyllum filling, also available polyvinyl chloride, polypropylene, polycarbonate injection moulded become multiple-plate column.Air admission hole 4, common pressure chamber 5, gas-liquid separator 7, atomizer 9, mist vapour passage 12, gas port 17, suction nozzle 15 are connected successively.

Shown in Figure 12 circuit theory diagrams; K1 is that tongue tube 19, RL are that calandria 26, LED1 are that light emitting diode 1, U2 are first piezoelectric patches 23 for over, the M1 that the low-voltage detection lug is used for lithium battery, and C1, C2, R3, L1, C3, BG, M1 constitute bikini electric capacity oscillator.Its circuit theory is: when K1 was closed, U1 was that the field-effect power tube is opened, RL work, and bikini electric capacity oscillator starting of oscillation simultaneously, M1 reaches atomizing effect for atomizer 9 provides the high-frequency mechanical vibration ripple.

When smoker's smoking, suction nozzle 15 is in negative pressure state, and draught head between common pressure chamber 5 and the negative pressure cavity 8 or high velocity air cause sensor 6 output enabling signals, is attached thereto electronic circuit board 3 work that connect.This moment, sensor 6 interior ripple films 22 were out of shape, drive second magnet steel 21 away from tongue tube 19, tongue tube 19 is closed (being the K1 closure) under the excessive magnetic line of force effect of first magnet steel 20, start fet power pipe electronic switch (being that U1 opens), high-frequency generator adopts bikini electric capacity oscillator, and frequency is at 550KHz to 8MHz, first piezoelectric patches, 23 resonance of the automatic fine tuning of circuit medium frequency and annular, to the fluid molecule energy supply, light emitting diode 1 is luminous under rechargeable battery 2 power supplies simultaneously.Atmosphere is entered in the common pressure chamber 5 by air admission hole 4, through sensor gas channel 18, the through hole on gas-liquid separator 7 flows to the atomization chamber 10 in the atomizer 9 again.The tobacco juice that drives in the porous body 27 through the high velocity air of spray-hole sprays in the atomization chamber 10 with the droplet form, ultrasonic atomizatio by first piezoelectric patches 23, further atomizing under the effect of calandria 26 again, major diameter droplet after the atomizing attached wall under the effect of eddy current is heavily absorbed by porous body 27 through spout hole 29, and the minor diameter droplet is suspended in the air-flow and forms aerosol and be sucked out through mist vapour passage 12, gas port 17, suction nozzle 15.Storage liquid porous body 28 in the supplying bottle 11 contacts with the projection 36 on the atomizer 9 realizes capillary infiltration feed flow.

Be shaped on screw thread on the suction nozzle 15, when the tobacco juice in the supplying bottle 11 was used up, rotatable suction nozzle 15 was backed out it, takes out supplying bottle 11, and tobacco juice is injected in the supplying bottle 11, reloads in the housing 14, tightens suction nozzle 15.

Tongue tube 19, first magnet steel 20, second magnet steel 21, ripple film 22 is also available has the semiconductor gauge of closing membrane to replace, and is installed in sensor ripple film position.

For simplified design, first piezoelectric patches 23 on the desirable atomizer 9 that disappears only depends on calandria 26 that tobacco juice is atomized.It is less that the size of this atomizer can be done, and the syndeton of whole Atmized electronic cigarrette is identical with embodiment one.In addition, also can be as shown in Figure 8, with first piezoelectric patches 23 in the atomizer 9, calandria 26 cancellations, in atomization chamber, add individual layer or many laminations, plate shaped second piezoelectric patches 35, by the air-flow heart vibration therein focus point atomizing of spray-hole, reach the effect of powerful ultrasonic atomization.

As shown in figure 10, the through hole of gas-liquid separator 7 also can be with silica gel spare non-return valve 31 outward.During smoking, air-flow arrives through hole, because the air pressure in the through hole raises, makes silica gel spare non-return valve 31 open the air communication mistake; During non-smoking, silica gel spare non-return valve 31 is closed.

As shown in Figure 5, sensor 6 also can be designed to have the structure of silica gel spare non-return valve 31.During smoking, air-flow converges in the silica gel spare non-return valve 31, and air pressure raises, gas expands, and the 3rd magnet steel 34 in the valve is gradually near tongue tube 19, and until tongue tube closure, open circuit, along with draught head continues to increase, open the gas outlet of silica gel spare non-return valve 31.Tongue tube 19 also can replace with hall device or magnetodiode or magnetic sensitive transistor.

Embodiment two

As shown in Figure 2, in order to improve the feed flow state, in housing 14, atomizer 9 postposition, supplying bottle 11 is located between gas-liquid separator 7 and the atomizer 9, is equipped with at an end of supplying bottle 11 supplying bottle 11 is pressed on shell fragment 33 on the atomizer 9, and miscellaneous part and operation principle and embodiment are together.

On the inwall of the housing 14 of embodiment one, embodiment two described Atmized electronic cigarrettes, also can add digital display screen 32, be used for showing number of times, the battery capacity of smoking every day.Sensor 6 adopts linear signal output, and be directly proportional with the power of suction (being that the suction time big more, work is long more), atomizer 9 is pressed linear mode work, with the more real hommization cigarette of simulation.

In housing 14, also be parallel with the microswitch 16 that is used for manual cleaning with sensor 6.When non-smoking, press microswitch 16, sensor 6 work in parallel with it, or residue and other contaminant removals in the housing 14 is clean.

The tobacco juice that is used to atomize contains 0.4 ~ 3.5% nicotine, flavouring essence for tobacco 0.05 ~ 2%, and organic acid 0.1 ~ 3.1%, antioxidant 0.1 ~ 0.5%, surplus is 1, the 2-propane diols.

Patent Citations (238)

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[51] Int. Cl[7]
A24D 1/18
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[12] 实用新型专利说明书

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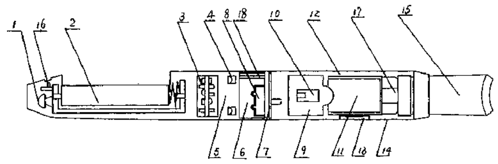
权利要求书2页 说明书5页 附图5页

[54] 实用新型名称 雾化电子烟

[57] 摘要

本实用新型涉及一种不含有焦油、只含烟碱(尼古丁)的雾化电子烟，包括壳体及吸嘴，壳体的外壁上开有进气孔，壳体内依次设有电子线路板、常压腔、传感器、气液分离器、雾化器、供液瓶；其中电子线路板由电子开关电路及高频发生器组成；在传感器的一侧开有传感器气流通道，传感器内设有负压腔；雾化器与供液瓶相接触，在雾化器的内部设有雾化腔；供液瓶的一侧与壳体之间设有锁定供液瓶的挡圈，供液瓶的另一侧开有雾汽通道；进气孔、常压腔、气液分离器、雾化器、雾汽通道、导气孔、吸嘴依次相连通。本实用新型无焦油，大大降低致癌风险，使用者仍有吸烟的感觉和兴奋，无需点燃，无火灾危害。



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1. 一种雾化电子烟，包括壳体及吸嘴，其特征在于：所述壳体（14）的外壁上开有进气孔（4），壳体（14）内依次设有电子线路板（3）、常压腔（5）、传感器（6）、气液分离器（7）、雾化器（9）、供液瓶（11）；其中电子线路板（3）由电子开关电路及高频发生器组成；在传感器（6）的一侧开有传感器气流通道（18），传感器（6）内设有负压腔（8）；雾化器（9）与供液瓶（11）相接触，在雾化器（9）的内部设有雾化腔（10）；供液瓶（11）的一侧与壳体（14）之间设有锁定供液瓶（11）的挡圈（13），供液瓶（11）的另一侧开有雾汽通道（12）；进气孔（4）、常压腔（5）、气液分离器（7）、雾化器（9）、雾汽通道（12）、导气孔（17）、吸嘴（15）依次相连通；壳体（14）内的前端还包括一个发光二极管（1）和电池（2），共同构成一个烟嘴形、雪茄形或烟斗形的整体。

2. 一种如权利要求1所述的雾化电子烟，其特征在于：在壳体（14）内，雾化器（9）后置，供液瓶（11）设在气液分离器（7）和雾化器（9）之间，在供液瓶（11）的一端加设有将供液瓶（11）压紧在雾化器（9）上的弹片（33）。

3. 按照权利要求1或2所述的雾化电子烟，其特征在于：在壳体（14）的内壁上加设有显示屏（32）。

4. 按照权利要求1或2所述的雾化电子烟，其特征在于：在壳体（14）内与传感器（6）并联设有用于手动清洁的微动开关（16）。

5. 按照权利要求1或2所述的雾化电子烟，其特征在于：所述的传感器（6）与其内部的负压腔（8）之间设有波纹膜（22），传感器（6）内还设有第一磁钢（20）、第二磁钢（21）及置于两者之间的干簧管（19），第二磁钢（21）固接在波纹膜（22）上。

6. 按照权利要求1或2所述的雾化电子烟，其特征在于：所述的传感器（6）内置有硅胶件逆止阀（31），阀内设有第三磁钢（34），阀外靠近磁钢的一侧设有干簧管（19）。

7. 按照权利要求1或2所述的雾化电子烟，其特征在于：所述的气液分离器（7）上开有通孔。

8. 按照权利要求7所述的雾化电子烟，其特征在于：在气液分离器（7）上的通孔外套有硅胶件逆止阀（31）。

9. 按照权利要求1或2所述的雾化电子烟，其特征在于：所述雾化腔（10）的雾化腔壁（25）上开有溢流孔（29），雾化腔（10）腔内设有加热体（26），在加热体（26）的一侧开有长气流喷射孔（24），多孔体（27）包

在雾化腔壁（25）外，雾化器（9）的一侧设有第一压电片（23），另一侧设有凸起（36）。

10. 按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述的雾化器（9）中加设第二压电片（35）。

11. 按照权利要求 9 所述的雾化电子烟，其特征在于：所述的雾化器（9）中的多孔体（27）可用泡沫镍、不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成；加热体（26）可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体；雾化腔壁（25）可用氧化铝或陶瓷制成。

12. 按照权利要求 7 所述的雾化电子烟，其特征在于：所述的气液分离器（7）可用塑料或硅橡胶制成。

13. 按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述供液瓶（11）内装有贮液多孔体（28），其可用聚丙纤维、涤纶纤维或尼龙纤维充填，或用塑料发泡成形体充填；也可用聚氯乙烯、聚丙烯、聚碳酸酯注塑成多层板的柱状物。

14. 按照权利要求 5 所述的雾化电子烟，其特征在于：干簧管（19）、第一磁钢（20）、第二磁钢（21）、波纹膜（22）可用有封闭膜的半导体应变片来代替，安装在传感器波纹膜位置。

雾化电子烟

技术领域

本实用新型涉及一种电子烟，特别是一种不含有焦油、只含烟碱（尼古丁）的雾化电子烟。

背景技术

在当今“吸烟有害健康”已成为常识的情况下，全世界目前仍有10亿人吸烟，而且每年这个数字还在扩大。2003年3月1日世界卫生组织(WHO)通过的第一个国际禁烟协定《烟草控制框架公约》，据WHO提供的数字表明，吸烟每年造成490万人死亡，尽管吸烟可导致严重的呼吸系统疾病和癌症，让吸烟者完全戒烟是极其困难的事。

香烟的有效成分是烟碱（即尼古丁），吸烟时烟碱随着香烟燃烧产生的大量焦油雾滴进入肺泡后被迅速吸收，烟碱被吸收入血后作用于中枢神经系统的受体上，引起类似兴奋剂的“陶醉感”，如吸烟者所经历的头晕目眩或飘飘然的感觉。

烟碱是小分子生物碱，在小剂量下对人体基本无害，而且在血液中的半衰期极短。烟草的有害物质主要是焦油，烟草焦油是由数千种成分组成，其中有数十种成分是致癌物。目前证实被动吸烟对不吸烟者的危害更大。

为了寻找只含烟碱而不含有害焦油的香烟代用品，有许多发明是用较纯的烟碱制成诸如“戒烟贴”、“烟碱含漱水”、“包装在有抛射剂的高压气罐喷雾剂”、“烟碱口香糖”、“烟碱饮料”等产品，这些产品虽然没有焦油的危害，但因烟碱吸收缓慢，在血液中不能建立有效的高峰浓度，不能解决需求烟碱“过瘾”的感觉，同时也剥夺了吸烟者已经养成的“抽”、“吸”的习惯，因而类似的产品不能真正的作为戒烟用品或香烟代用品。

实用新型内容

为了克服上述不足，本实用新型的目的在于提供一种具有戒烟和香烟代用品作用的雾化电子烟。

本实用新型的目的是通过以下技术方案来实现的：

本实用新型包括壳体及吸嘴，壳体的外壁上开有进气孔，壳体内依次设有电子线路板、常压腔、传感器、气液分离器、雾化器、供液瓶；其中电子线路板由电子开关电路及高频发生器组成；在传感器的一侧开有传感器气流通道，传感器内设有负压腔；雾化器与供液瓶相接触，在雾化器的内部设有雾化腔；供液瓶的一侧与壳体之间设有锁定供液瓶的挡圈，供液瓶的另一侧开有雾汽通道；进气孔、常压腔、气液分离器、雾化器、雾汽通道、导气孔、

吸嘴依次相连通；壳体内的前端还包括一个发光二极管和电池，共同构成一个烟嘴形、雪茄形或烟斗形的整体。

其中：在壳体的内壁上加设有显示屏；在壳体内与传感器并联设有用于手动清洁的微动开关；传感器与其内部的负压腔之间设有波纹膜，传感器内还设有第一磁钢、第二磁钢及置于两者之间的干簧管，第二磁钢固接在波纹膜上；传感器内置有硅胶件逆止阀，阀内设有第三磁钢，阀外靠近磁钢的一侧设有干簧管；气液分离器上开有通孔，在气液分离器上的通孔外套有硅胶件逆止阀；雾化腔的雾化腔壁上开有溢流孔，雾化腔腔内设有加热体，在加热体的一侧开有长气流喷射孔，多孔体包在雾化腔壁外，雾化器的一侧设有第一压电片，另一侧设有凸起；雾化器中加设第二压电片；雾化器中的多孔体可用泡沫镍、不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成；加热体可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体；雾化腔壁可用氧化铝或陶瓷制成；气液分离器可用塑料或硅橡胶制成；供液瓶内装有贮液多孔体，其可用聚丙纤维、涤纶纤维或尼龙纤维充填，或用塑料发泡成形体充填；也可用聚氯乙烯、聚丙烯、聚碳酸酯注塑成多层板的柱状物；干簧管、第一磁钢、第二磁钢、波纹膜可用有封闭膜的半导体应变片来代替，安装在传感器波纹膜位置。

本实用新型还公开了另一种结构的雾化电子烟，在壳体内，雾化器后置，供液瓶设在气液分离器和雾化器之间，在供液瓶的一端加设有将供液瓶压紧在雾化器上的弹片。

本实用新型的优点是：吸烟无焦油，大大降低致癌风险，使用者仍有吸烟的感觉和兴奋，无需点燃，无火灾危害。

本实用新型的装置和连接结构在贮液器稍加改动后可装入常规药物供肺内给药器械。

附图说明

图 1 为本实用新型的一种整体结构示意图；

图 2 为本实用新型的另一种整体结构示意图；

图 3 为本实用新型带显示屏的整体结构示意图；

图 4 为本实用新型传感器的结构图；

图 5 为本实用新型带有硅胶件逆止阀的传感器结构图；

图 6 为本实用新型一种雾化器的结构图；

图 7 为本实用新型雾化器中陶瓷件的结构图；

图 8 为本实用新型另一种雾化器的结构图；

图 9 为本实用新型一种气液分离器的结构图；

图 10 为本实用新型另一种气液分离器的结构图；

图 11 为本实用新型供液瓶及吸嘴的连接结构图；

图 12 为本实用新型的电路原理图。

具体实施方式

下面结合附图对本实用新型作进一步详述。

实施例一

如图 1 所示，本实用新型可构成一个烟嘴形、雪茄形或烟斗形的整体。壳体 14 的外壁上开有进气孔 4，壳体 14 内顺序设置有发光二极管 1、电池 2、电子线路板 3、常压腔 5、传感器 6、气液分离器 7、雾化器 9、供液瓶 11、吸嘴 15。电子线路板 3 由电子开关电路及高频发生器组成。如图 4 所示，传感器 6 内设有负压腔 8，由波纹膜 22 与传感器 6 隔开。传感器 6 内还设有第一磁钢 20、第二磁钢 21 及置于两者之间的干簧管 19，第二磁钢 21 固接在波纹膜 22 上。雾化器 9 通过凸起 36 与供液瓶 11 相接触，雾化器 9 内部设有雾化腔 10。如图 6、图 7 所示，雾化腔 10 的雾化腔壁 25 上开有溢流孔 29，腔内设有加热体 26，可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体。正对加热体 26 的一侧开有喷射孔，喷射孔可根据雾化腔壁 25 的材料而选用长气流喷射孔 24 或短气流喷射孔 30。长气流喷射孔 24 可采用 0.1mm ~ 1.3mm 狭缝结构或Φ0.2mm ~ 1.3mm 圆孔的单孔及多孔结构；短气流喷射孔 30 的直径在 0.3mm ~ 1.3mm。雾化腔壁 25 外包有多孔体 27，可用泡沫镍、不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成。在雾化器 9 上还设有第一压电片 23。雾化腔壁 25 可用氧化铝或陶瓷制成。如图 9 所示，气液分离器 7 上开有通孔，可用塑料或硅橡胶制成。如图 11 所示，供液瓶 11 的一侧与壳体 14 之间设有锁定供液瓶 11 的挡圈 13，另一侧开有雾汽通道 12，瓶内装有贮液多孔体 28，可用聚丙纤维、涤纶纤维或尼龙纤维充填，或用塑料发泡成形体如聚胺酯泡沫柱或聚丙泡沫柱充填，也可用聚氯乙烯、聚丙烯、聚碳酸酯注塑成多层板的柱状物。进气孔 4、常压腔 5、气液分离器 7、雾化器 9、雾汽通道 12、导气孔 17、吸嘴 15 依次相连通。

如图 12 电路原理图所示，K1 为干簧管 19、RL 为加热体 26、LED1 为发光二极管 1、U2 为低电压检测片用于对锂电池的过放电保护、M1 为第一压电片 23，C1、C2、R3、L1、C3、BG、M1 构成三点式电容振荡器。其电路原理为：当 K1 闭合时，U1 即场效应功率管开启，RL 工作，同时三点式电容振荡器起振，M1 为雾化器 9 提供高频机械振动波，达到雾化效果。

当吸烟者吸烟时，吸嘴 15 处于负压状态，常压腔 5 与负压腔 8 之间的气压差或高速气流导致传感器 6 输出启动信号，与之相连接的电子线路板 3 工作。此时传感器 6 内的波纹膜 22 变形，带动第二磁钢 21 远离干簧管 19，干簧管 19 在第一磁钢 20 的过量磁力线作用下闭合（即 K1 闭合），启动场效应功率管电子开关（即 U1 开启），高频振荡器采用三点式电容振荡器，

频率在 550KHz 至 8MHz，电路中频率自动微调与环形的第一压电片 23 谐振，对液体分子供能，同时发光二极管 1 在可充电电池 2 供电下发光。大气由进气孔 4 进到常压腔 5 内，经传感器气流通道 18、再经气液分离器 7 上的通孔流到雾化器 9 内的雾化腔 10。经过喷射孔的高速气流带动多孔体 27 中的烟液以微滴形式喷射进雾化腔 10 内，通过第一压电片 23 的超声雾化，再在加热体 26 的作用下进一步雾化，雾化后的大直径微滴在涡流的作用下附壁经溢流孔 29 被多孔体 27 重吸收，小直径微滴悬浮在气流中形成气溶胶经雾汽通道 12、导气孔 17、吸嘴 15 被吸出。供液瓶 11 中的贮液多孔体 28 与雾化器 9 上的凸起 36 接触实现毛细浸润供液。

吸嘴 15 上制有螺纹，当供液瓶 11 中的烟液用尽时，可旋转吸嘴 15 将其拧下，取出供液瓶 11，将烟液注入供液瓶 11 内，重新装入壳体 14 内，拧紧吸嘴 15。

干簧管 19、第一磁钢 20、第二磁钢 21、波纹膜 22 还可用有封闭膜的半导体应变片来代替，安装在传感器波纹膜位置。

为了简化设计，可取消雾化器 9 上的第一压电片 23，仅靠加热体 26 将烟液雾化。这种雾化器的尺寸可做的较小，整支雾化电子烟的连接结构与实施例一相同。此外，还可如图 8 所示，将雾化器 9 中的第一压电片 23、加热体 26 取消，在雾化腔内加设单层或多叠层、平板形的第二压电片 35，通过喷射孔的气流在其中心振动聚焦点雾化，达到强超声雾化的效果。

如图 10 所示，气液分离器 7 的通孔外还可套有硅胶件逆止阀 31。吸烟时，气流到达通孔，由于通孔内的气压升高，使硅胶件逆止阀 31 开启，气流通过；不吸烟时，硅胶件逆止阀 31 关闭。

如图 5 所示，传感器 6 还可设计成带有硅胶件逆止阀 31 的结构。吸烟时，气流汇聚在硅胶件逆止阀 31 内，气压升高、气体膨胀，阀内的第三磁钢 34 逐渐靠近干簧管 19，直至干簧管闭合、开启电路，随着气压差继续增大，硅胶件逆止阀 31 的出气口开启。干簧管 19 也可以用霍尔器件或磁敏二极管或磁敏三极管代替。

实施例二

如图 2 所示，为了改善供液状态，在壳体 14 内，雾化器 9 后置，供液瓶 11 设在气液分离器 7 和雾化器 9 之间，在供液瓶 11 的一端加设有将供液瓶 11 压紧在雾化器 9 上的弹片 33，其他部件及工作原理与实施例一同。

在实施例一、实施例二所述的雾化电子烟的壳体 14 的内壁上，还可加设数字显示屏 32，用来显示每天吸烟的次数、电池容量。传感器 6 采用线性信号输出，与吸力的强弱成正比（即吸力越大、工作的时间越长），雾化器 9 按线性方式工作，以模拟更真实的人性化香烟。

在壳体 14 内与传感器 6 还并联有用于手动清洁的微动开关 16。在不吸

烟时，按下微动开关16，与其并联的传感器6工作，或将壳体14内的残留物及其他杂质清除干净。

用于雾化的烟液含有 0.4～3.5％的烟碱，烟用香精 0.05～2％，有机酸 0.1～3.1％，抗氧剂 0.1～0.5％，余量为1，2-丙二醇。

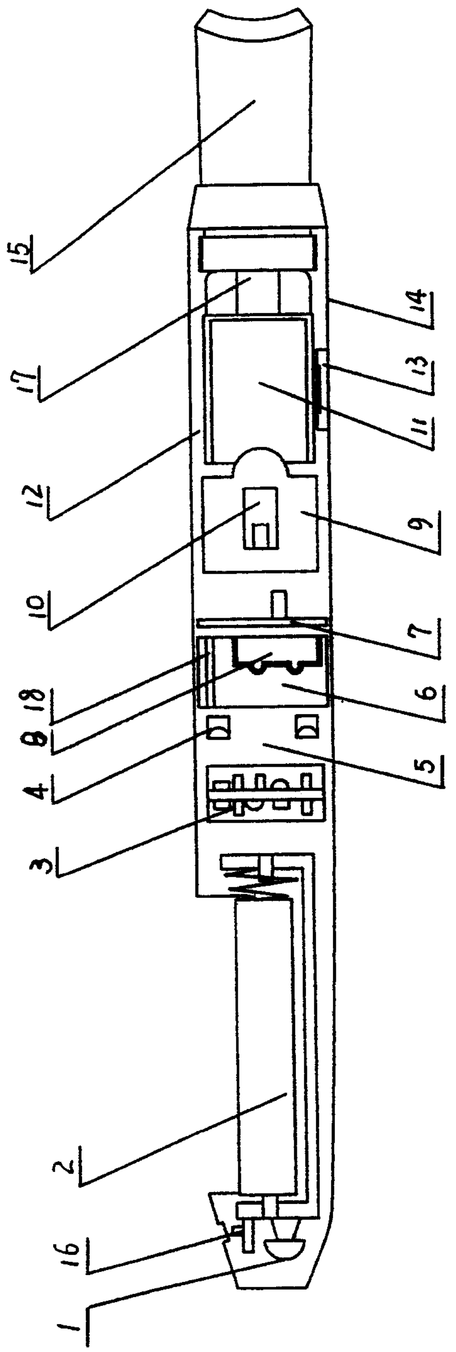

图 1

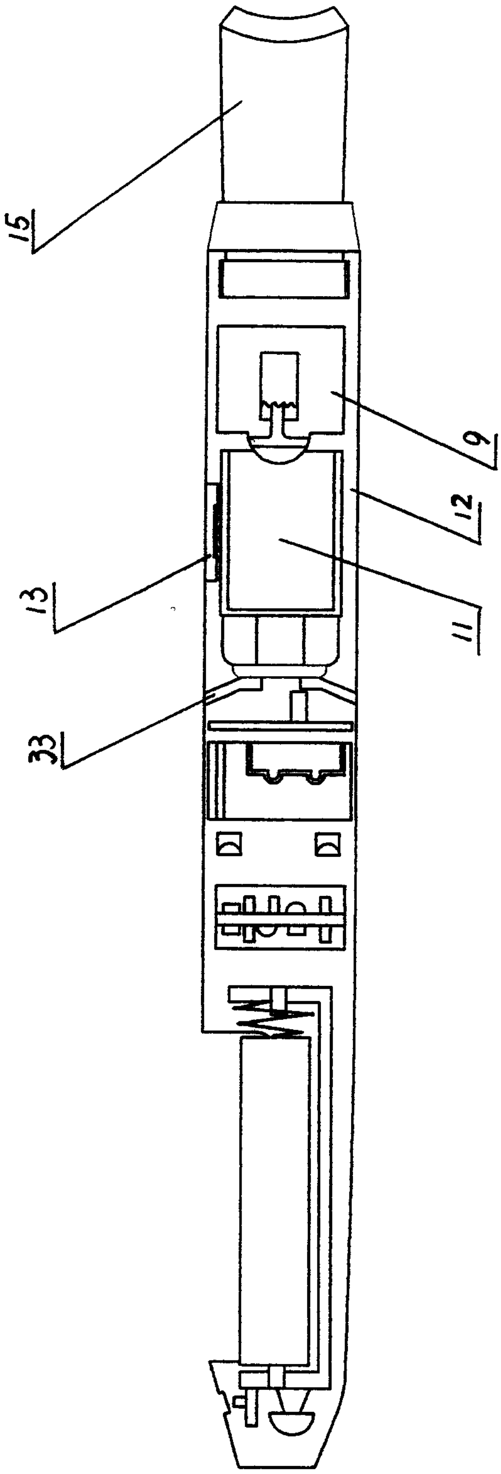

图 2

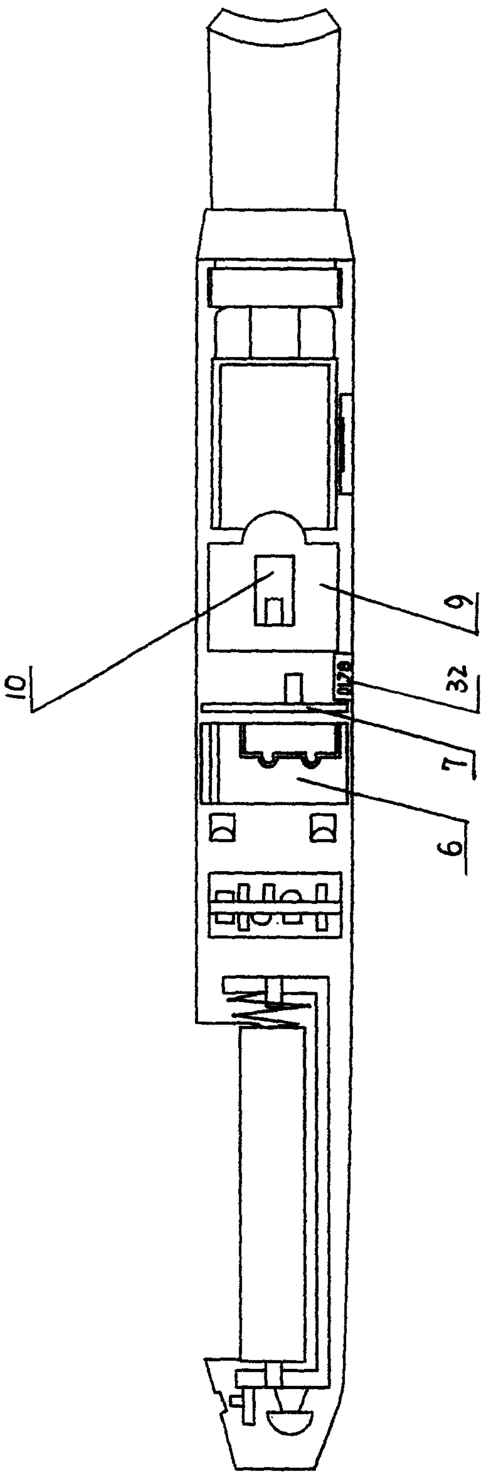

图 3

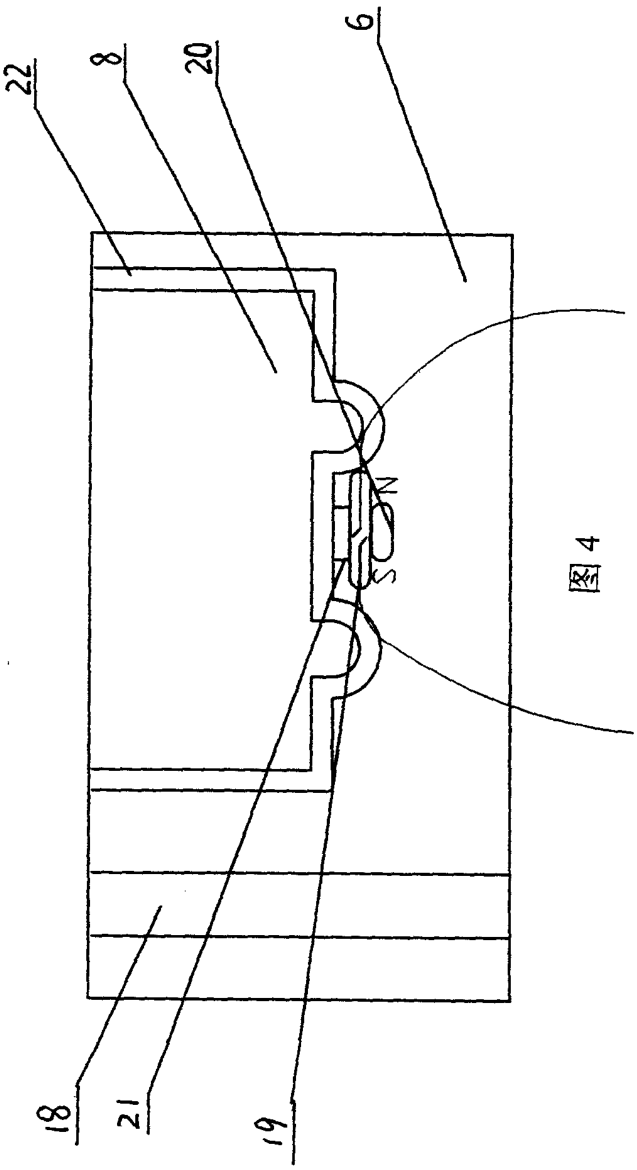

图 4

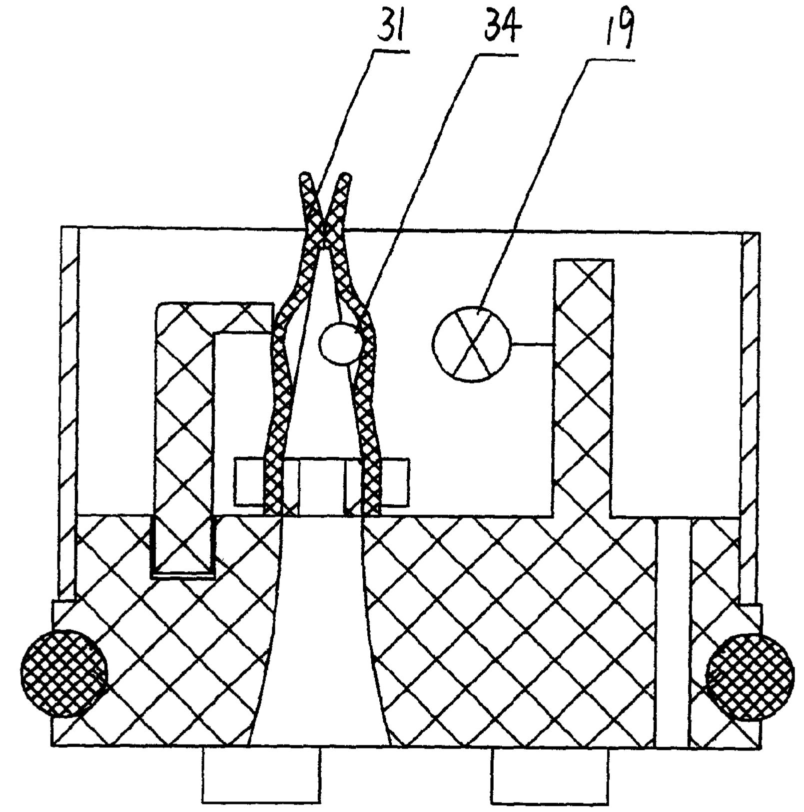

图 5

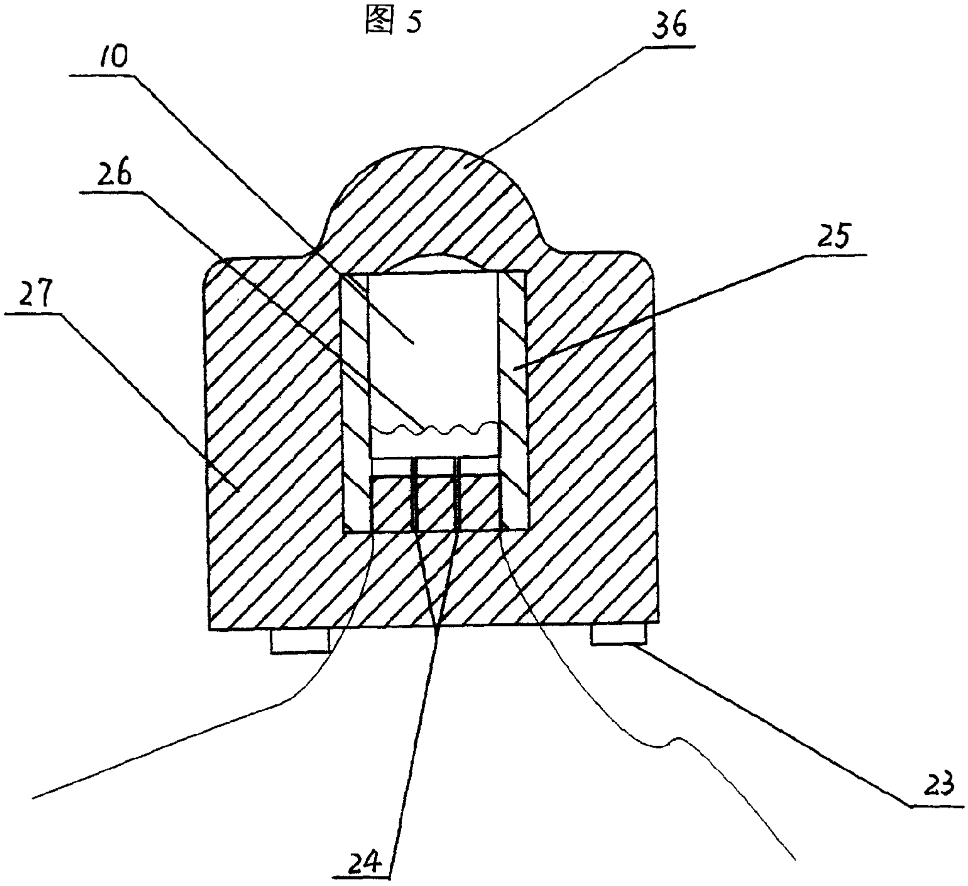

图 6

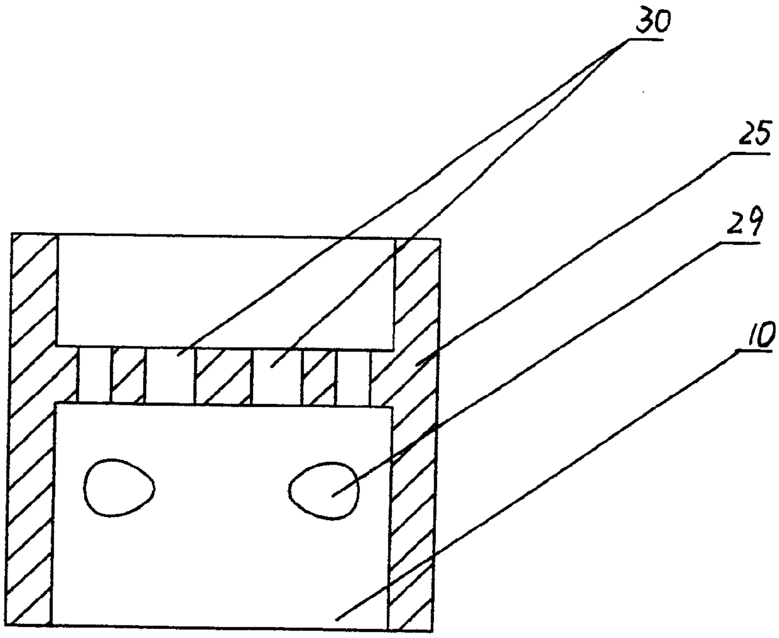

图 7

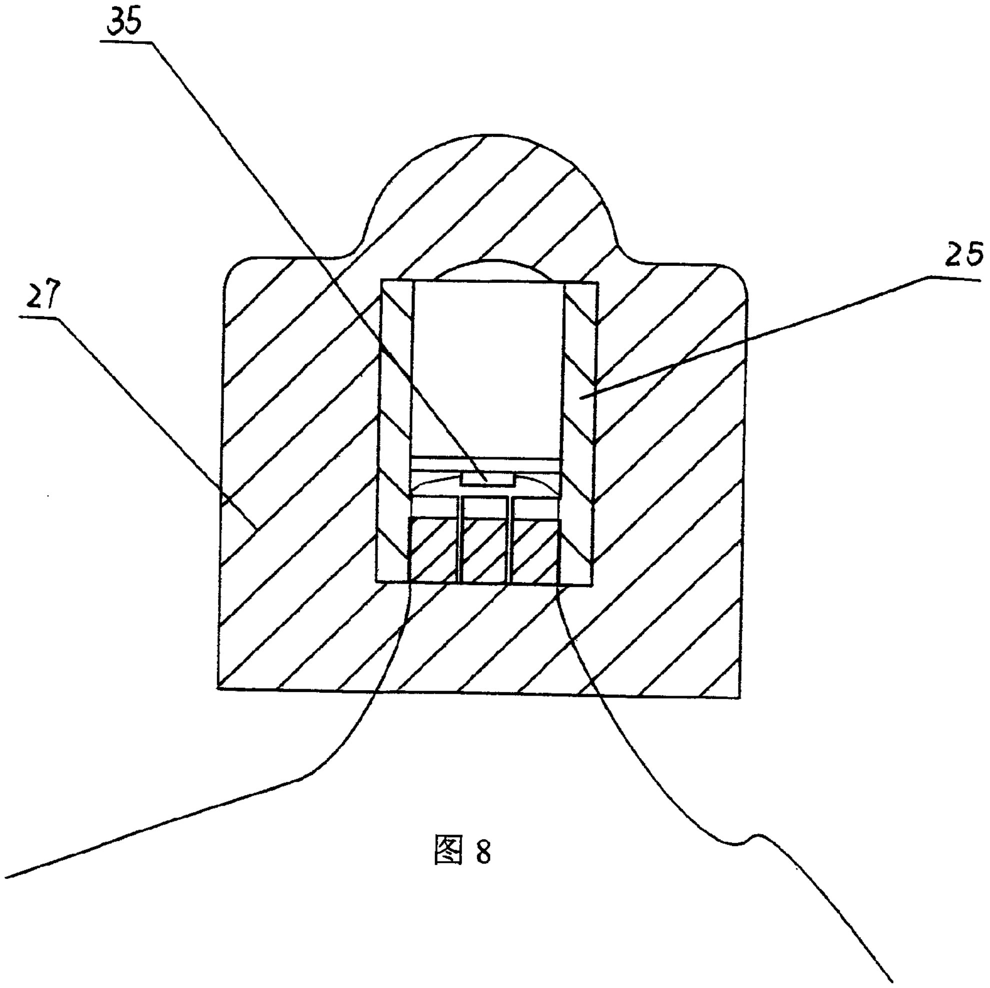

图 8

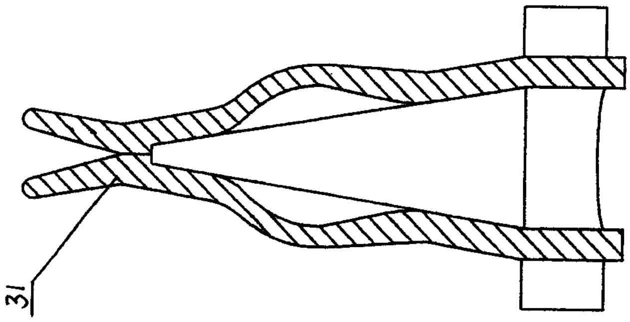

图 10

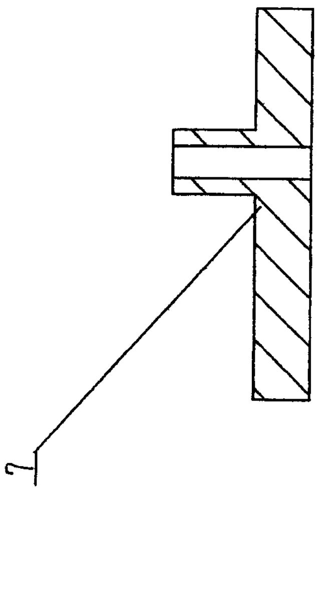

图 9

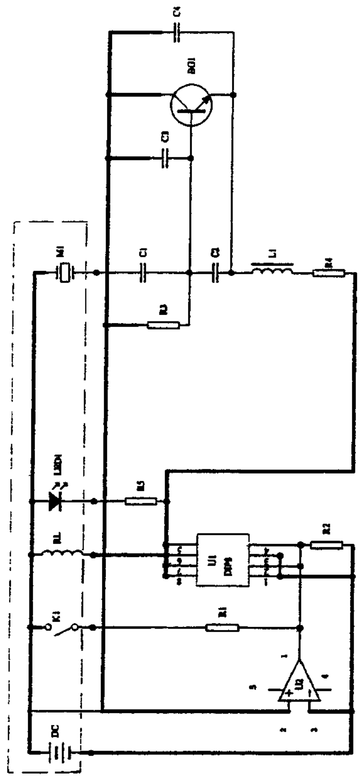

图 12

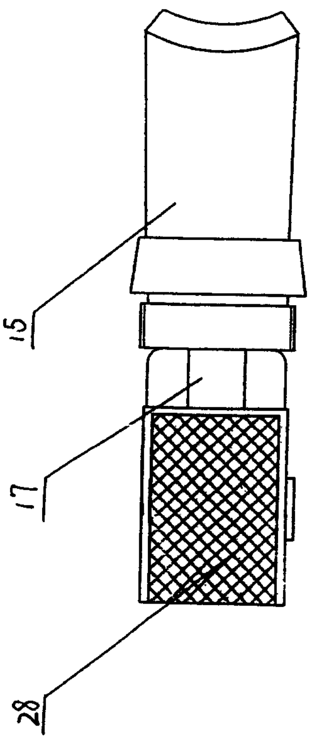

图 11

Patents CN201067079Y

Simulation aerosol inhaler

Abstract

The utility model relates to an electronic suction apparatus, in particular to an emulated aerosol inhalator which contains only nicotine without tar and comprises a battery component, an atomizer component and a cigarette bottle component, and an electrode with an outer thread is arranged at one end of the battery component, an electrode with an inner thread is arranged at one end of the atomizer component, and the electrode with the outer thread and the electrode with the inner thread are connected through a thread electrode; furthermore, the cigarette bottle component is plugged into the other end of the atomizer component, thus being combined together into a whole cigarette-typed or cigar-typed body. The utility model contains no tar for smokers, greatly reduces carcinogenic risks, and leads users to have usual smoking feeling and excitement; the utility model does not need ignition and have fire hazard. The apparatus and the connection structure of the utility model can be taken as a drug delivery device of pulmonary suction medicines with routine medicines loaded.

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Other languages: Chinese

Inventor: 韩力

Worldwide applications

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External links: Espacenet, Global Dossier, Discuss

Classifications

A24F40/40 Constructional details, e.g. connection of cartridges and battery parts

View 24 more classifications

Claims (20)

Hide Dependent

1. emulation aerosol inhalator, it is characterized in that comprising battery component, atomizer assembly and cigarette bottle assembly, described cigarette bottle assembly comprises the tobacco juice bottle, described atomizer assembly comprises atomizer, its cigarette bottle modular connector constitutes the integral body of a cigarette type or cigar type jointly at an end of atomizer assembly.

2. emulation aerosol inhalator according to claim 1 is characterized in that an end of described battery component is provided with the external screw thread electrode, and an end of atomizer assembly is provided with the internal thread electrode, and both are connected by the screw thread electrode.

3. emulation aerosol inhalator according to claim 1 and 2, it is characterized in that battery component comprises lithium battery, MOSFET circuit board, sensor, the first screw thread electrode, the first negative pressure lumen pore and first housing, one end of first housing is provided with the external screw thread electrode, opposite side connects lithium battery and MOSFET circuit board successively, and the MOSFET circuit board is provided with sensor.

4. emulation aerosol inhalator according to claim 3, it is characterized in that described battery component also comprises silicon rubber ripple barrier film, silicon rubber ripple barrier film is installed between the first screw thread electrode and sensor, have the first negative pressure lumen pore on it, sensor is connected with silicon rubber ripple barrier film by affixed reed switch thereon.

5. emulation aerosol inhalator according to claim 3 is characterized in that described battery component comprises that also the other end of indicator lamp, first housing is equipped with indicator lamp, and the one side is covered with indicator-lamp cover, has micropore on the indicator-lamp cover; Between MOSFET circuit board and sensor, be equipped with MCU; First surface of shell is equipped with display screen.

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6. emulation aerosol inhalator according to claim 5 is characterized in that described MCU is the battery saving mode scanning sensor with pulse, realizes with frequency the integral function of single working time being done the restriction of atomizing dosage according to the signal parameter of sensor; Simultaneously, MCU finishes and the pulsewidth modulation of the permanent power output of electric current and over, thousands of automatic cleaning functions of every work, indicator lamp gradually bright is put out gradually control, work number of times and battery capacity show, the sensor misoperation is shut down and recovered automatically to control; Described indicator lamp is the light emitting diode of two redness.

7. emulation aerosol inhalator according to claim 3 is characterized in that described sensor is the switching regulator sensor made from the elastic alloy sheet, hall device, the quick chip of semiconductor power, semiconductor matrix thermal bridge chip or the electric capacity and the inductance type transducer of linear output.

8. emulation aerosol inhalator according to claim 4 is characterized in that described silicon rubber ripple barrier film makes with fluorubber, acrylonitrile-butadiene rubber or elastic alloy film.

9. emulation aerosol inhalator according to claim 3 is characterized in that described external screw thread electrode is that the gold-plated mesopore of opening of stainless steel or brass spare is made; Described lithium battery is chargeable poly-lithium battery or chargeable lithium ion battery.

10. emulation aerosol inhalator according to claim 1 and 2, it is characterized in that described atomizer assembly comprises internal thread electrode, atomizer and second housing, one end of second housing and cigarette bottle assembly plug, and the other end is provided with the internal thread electrode, which is provided with the second negative pressure lumen pore.

11. emulation aerosol inhalator according to claim 3, it is characterized in that described atomizer assembly comprises internal thread electrode, atomizer and second housing, one end of second housing and cigarette bottle assembly plug, and the other end is provided with the internal thread electrode, which is provided with the second negative pressure lumen pore.

12. emulation aerosol inhalator according to claim 11 is characterized in that described atomizer assembly comprises gas-liquid separator, gas-liquid separator is connected with the internal thread electrode successively with atomizer; On second housing, have the air inlet duct.

13. emulation aerosol inhalator according to claim 12 is characterized in that described internal thread electrode is that the gold-plated mesopore of opening of stainless steel or brass spare is made; Described gas-liquid separator is to make with stainless steel or plastics perforate.

14. emulation aerosol inhalator according to claim 10 is characterized in that described atomizer is capillary infiltration type atomizer or injecting type atomizer, is provided with calandria in the atomizer; Have spray-hole on the injecting type atomizer.

15. emulation aerosol inhalator according to claim 11 is characterized in that described atomizer is capillary infiltration type atomizer or injecting type atomizer, is provided with calandria in the atomizer; Have spray-hole on the injecting type atomizer.

16. emulation aerosol inhalator according to claim 15 is characterized in that described spray-hole is to make with foamed ceramics, micropore ceramics, foaming metal, stainless steel fibre felt or chemical fibre moulding perforate.

17. emulation aerosol inhalator according to claim 15, it is characterized in that described calandria is to make with being wound with nichrome wire, Aludirome silk or platinum filament thermo electric material on the micropore ceramics skeleton, or the porous body of the band sintered electrode of directly making with conductivity ceramics or PTC ceramic material; The surface of calandria sinters high-temperature glaze into fixing zeolite granular, and zeolite granular is made by natural zeolite, artificial inorganic micropore ceramics or alumina particle.

18. emulation aerosol inhalator according to claim 3, it is characterized in that described cigarette bottle assembly comprises tobacco juice bottle, fiber and suction nozzle, the fiber that has tobacco juice is contained in an end of tobacco juice bottle, this end is plugged in second housing, is connected on the atomizer, suction nozzle is positioned at the other end of tobacco juice bottle, leaves air-breathing duct between the inwall of fiber and tobacco juice bottle.

19. emulation aerosol inhalator according to claim 11, it is characterized in that described cigarette bottle assembly comprises tobacco juice bottle, fiber and suction nozzle, the fiber that has tobacco juice is contained in an end of tobacco juice bottle, this end is plugged in second housing, is connected on the atomizer, suction nozzle is positioned at the other end of tobacco juice bottle, leaves air-breathing duct between the inwall of fiber and tobacco juice bottle.

20. emulation aerosol inhalator according to claim 18, it is characterized in that described tobacco juice bottle, suction nozzle are to make with non-toxic plastic: described fiber is to make with polypropylene fibre or nylon fiber.

Description

Emulation aerosol inhalator

Technical field

The utility model relates to the electronics suction apparatus, does not specifically a kind ofly contain tar, only contains the emulation aerosol inhalator of nicotine (nicotine).

Background technology

Become under the situation of general knowledge current " Smoking is harmful to your health ", the whole world still has 1,000,000,000 people's smokings at present, and annual this numeral is also enlarging.First international ban on opium-smoking and the opium trade agreement " Framework Convention on Tobacco Control " that on March 1st, 2003, The World Health Organization (WHO) passed through, the numeral that provides according to WHO shows, smoking causes 4,900,000 people's death every year, although smoking can cause serious respiratory disease and cancer, allowing the smoker give up smoking fully is extremely difficult thing.

The active ingredient of cigarette is nicotine (being nicotine); after entering alveolar, a large amount of tar droplets that nicotine produces along with cigarette combustion during smoking absorbed rapidly; nicotine acts on the acceptor of central nervous system after being absorbed into blood; cause similar anti-depressant " euphoria ", as having a dizzy spell or smug sensation that the smoker experienced.

Nicotine is little molecular biosciences alkali, and is harmless substantially to human body under low dose, and the half-life in blood is extremely short.The harmful substance of tobacco mainly is a tar, and tobacco tar is to become to be grouped into by thousands of kinds, and it is carcinogenic substances that tens of kinds of compositions are wherein arranged.Confirm that at present passive smoking is bigger to non-smoker's harm.

In order to seek the cigarette substitute that only contains nicotine and do not contain harmful tar, it is to make such as " smoking cessation is pasted " with purer nicotine that many inventions are arranged, " nicotine rinse water ", " be packaged in the high pressure gas holder spray of propellant ", " nicotinamide chewing gum ", products such as " nicotine beverages ", though these products do not have the harm of tar, but because of nicotine absorbs slowly, in blood, can not set up effective peak concentration, can not solve the sensation of demand nicotine " enjoyable ", also deprived simultaneously " taking out " that the smoker has formed, the custom of " suction ", thereby the conduct that similar products like can not be real smoking cessation articles for use or cigarette substitute.

The utility model content

The utility model purpose is to provide a kind of emulation aerosol inhalator that smoking cessation and cigarette substitute effect are arranged.

The technical solution of the utility model is the inventor: 200420031182.0 international application no are: the utility model of PCT/CN2005/000337 " Atmized electronic cigarrette " patent innovative.

The purpose of this utility model is achieved through the following technical solutions:

The utility model comprises battery component, atomizer assembly and cigarette bottle assembly, one end of battery component is provided with the external screw thread electrode, one end of atomizer assembly is provided with the internal thread electrode, both are connected by the screw thread electrode, cigarette bottle modular connector constitutes the integral body of a cigarette type or cigar type jointly at the other end of atomizer assembly.

Wherein: battery component comprises indicator lamp, lithium battery, the MOSFET circuit board, sensor, silicon rubber ripple barrier film, the first screw thread electrode, the first negative pressure lumen pore and first housing, one end of first housing is provided with the external screw thread electrode, the other end is equipped with indicator lamp, the one side is covered with indicator-lamp cover, have micropore on the indicator-lamp cover, opposite side connects lithium battery and MOSFET circuit board successively, the MOSFET circuit board is provided with sensor, silicon rubber ripple barrier film is installed between the first screw thread electrode and sensor, have the first negative pressure lumen pore on it, sensor is connected with silicon rubber ripple barrier film by affixed reed switch thereon; Between MOSFET circuit board and sensor, be equipped with MCU; First surface of shell is equipped with display screen; Described MCU is the battery saving mode scanning sensor with pulse, realizes with frequency the integral function of single working time being done the restriction of atomizing dosage according to the signal parameter of sensor; Simultaneously, MCU finishes and the pulsewidth modulation of the permanent power output of electric current and over, thousands of automatic cleaning functions of every work, indicator lamp gradually bright is put out gradually control, work number of times and battery capacity show, controls such as automatic recovery are shut down in the sensor misoperation; Described sensor can be the switching regulator sensor made from the elastic alloy sheet, hall device, the quick chip of semiconductor power, semiconductor matrix thermal bridge chip or the electric capacity and the inductance type transducer of linear output; Described indicator lamp is the light emitting diode of two redness; The also available fluorubber of described silicon rubber ripple barrier film, acrylonitrile-butadiene rubber or elastic alloy film are made; Described external screw thread electrode is that the gold-plated mesopore of opening of stainless steel or brass spare is made; Described lithium battery can be chargeable poly-lithium battery or chargeable lithium ion battery; Described atomizer assembly comprises internal thread electrode, gas-liquid separator, atomizer and second housing, one end of second housing and cigarette bottle assembly plug, the other end is provided with the internal thread electrode, which is provided with the second negative pressure lumen pore, and gas-liquid separator is connected with the internal thread electrode successively with atomizer; On second housing, have the air inlet duct; Described internal thread electrode is that the gold-plated mesopore of opening of stainless steel or brass spare is made; Described gas-liquid separator is to make with stainless steel or plastics perforate; Described atomizer can be capillary infiltration type atomizer or injecting type atomizer, is provided with calandria in the atomizer; Have spray-hole on the injecting type atomizer; Described spray-hole is to make with foamed ceramics, micropore ceramics, foaming metal, stainless steel fibre felt or chemical fibre moulding perforate; Described calandria is to make with being wound with thermo electric materials such as nichrome wire, Aludirome silk or platinum filament on the micropore ceramics skeleton, the porous body of the band sintered electrode of also can be directly making with conductivity ceramics or PTC ceramic material; The surface of calandria sinters high-temperature glaze into fixing zeolite granular, and zeolite granular is made by natural zeolite, artificial inorganic micropore ceramics or alumina particle; Described cigarette bottle assembly comprises tobacco juice bottle, fiber and suction nozzle, the fiber that has tobacco juice is contained in an end of tobacco juice bottle, this end is plugged in second housing, is connected on the atomizer, and suction nozzle is positioned at the other end of tobacco juice bottle, leaves air-breathing duct between the inwall of fiber and tobacco juice bottle; Described tobacco juice bottle, suction nozzle are to make with non-toxic plastic; Described fiber is to make with polypropylene fibre or nylon fiber; The tobacco juice that is used to atomize in the described fiber contains 0.1 ~ 3.5% nicotine, 0.05 ~ 5% flavouring essence for tobacco, and 0.1 ~ 3% organic acid, 0.1 ~ 0.5% stabilizing agent, surplus is a propane diols; Described inhalator and syndeton thereof can be packed conventional medicine into as inhalation-type drug administration apparatus in the lung.

Advantage of the present utility model and good effect are:

The utility model smoking does not have tar, greatly reduces carcinogenic risk, and the user still has the feeling and excitement of smoking, need not to light no fire hazard.Device of the present utility model and syndeton can be packed conventional medicine into as inhalation-type drug administration apparatus in the lung.

Description of drawings

Fig. 1 is the schematic appearance of the utility model cigarette type;

Fig. 2 A is a kind of structural representation of the utility model battery component;

Fig. 2 B is the another kind of structural representation of the utility model battery component;

Fig. 3 is the schematic diagram of the utility model atomizer assembly;

Fig. 4 is the schematic diagram of the utility model cigarette bottle assembly;

Fig. 5 A is a kind of internal structure schematic diagram of the present utility model;

Fig. 5 B is an another kind of internal structure schematic diagram of the present utility model;

Fig. 6 is the structural representation of the utility model charger;

Fig. 7 is the circuit theory diagrams of the utility model MCU and MOSFET;

Fig. 8 is the structural representation of the utility model capillary infiltration type atomizer;

Fig. 9 is the left view of Fig. 8;

Figure 10 is the structural representation of the utility model injecting type atomizer;

Figure 11 is the left view of Figure 10;

Figure 12 is the structural representation of the utility model cigar formula profile.

The specific embodiment

The utility model is described in further detail below in conjunction with accompanying drawing.

Embodiment 1

As shown in Figure 1, outward appearance of the present utility model and the cigarette appearance similar that inserts cigarette holder, comprise battery component, atomizer assembly and cigarette bottle assembly, one end of battery component is provided with external screw thread electrode 209, one end of atomizer assembly is provided with internal thread electrode 302, both link to each other by the screw thread electrode and are connected into the simulation smoke, and cigarette bottle modular connector constitutes a cigarette type emulation aerosol inhalator jointly at the other end of atomizer assembly.

Shown in Fig. 2 A, battery component comprises indicator lamp 202, lithium battery 203, MOSFET circuit board 205, sensor 207, silicon rubber ripple barrier film 208, the first screw thread electrode 209, the first negative pressure lumen pore 210 and first housing 211, one end of first housing 211 is provided with external screw thread electrode 209, the other end is equipped with indicator lamp 202, the one side is covered with indicator-lamp cover 201, have micropore 501 on the indicator-lamp cover 201, opposite side connects lithium battery 203 and MOSFET (metal oxide semiconductor field effect tube) circuit board 205 successively, MOSFET circuit board 205 is provided with sensor 207, silicon rubber ripple barrier film 208 is installed between the first screw thread electrode 209 and sensor 207, have the first negative pressure lumen pore 210 on it, sensor 207 is connected with silicon rubber ripple barrier film 208 by affixed reed switch 212 thereon.

Wherein: sensor 207 can be the switching regulator sensor made from the elastic alloy sheet, hall device, the quick chip of semiconductor power, semiconductor matrix thermal bridge chip or the electric capacity and the inductance type transducer of linear output.Indicator lamp 202 is the light emitting diode of two redness.Lithium battery 203 can be chargeable poly-lithium battery or chargeable lithium ion battery.External screw thread electrode 209 is made for stainless steel or the gold-plated mesopore of opening of brass spare.Silicon rubber ripple barrier film 208 also available fluorubber, acrylonitrile-butadiene rubber or elastic alloy film are made.

As shown in Figure 3, atomizer assembly comprises internal thread electrode 302, gas-liquid separator 303, atomizer 307 and second housing 306, one end of second housing 306 and cigarette bottle assembly plug, the other end is provided with internal thread electrode 302, which is provided with the second negative pressure lumen pore 301, gas-liquid separator 303 is connected with internal thread electrode 302 successively with atomizer 307; On second housing 306, have air inlet duct 502.Wherein: gas-liquid separator 303 is to make with stainless steel or plastics perforate.Internal thread electrode 302 is made for stainless steel or the gold-plated mesopore of opening of brass spare.

Atomizer 307 can be capillary infiltration type atomizer as Fig. 8, shown in Figure 9, or as Figure 10, shown in Figure 11, is the injecting type atomizer.Present embodiment is the injecting type atomizer.

As shown in Figure 4, cigarette bottle assembly comprises tobacco juice bottle 401, fiber 402 and suction nozzle 403, the fiber 402 that has tobacco juice is contained in an end of tobacco juice bottle 401, this end is plugged in second housing 306, is connected on the atomizer 307, suction nozzle 403 is positioned at the other end of tobacco juice bottle 401, leaves air-breathing duct 503 between the inwall of fiber 402 and tobacco juice bottle 401.

Shown in Fig. 5 A, of the present utility model treat duty with shown in Fig. 2 A, charge the electricity battery component be tightened on the atomizer assembly shown in Figure 3, insert cigarette bottle assembly shown in Figure 4 again.As user during with suction suction nozzle 403 fond of food that is not salty, on silicon rubber ripple barrier film 208, form negative pressure through air-breathing duct 503 and first and second negative pressure lumen pore 210,301, silicon rubber ripple barrier film 208 is Zona transformans movable contact spring switch 212 and sensor 207 under the effect of air-breathing pressure reduction, starts MOSFET circuit board 205.At this moment, indicator lamp 202 lights gradually, and lithium battery 203 calandria 305 power supplies in atomizer 307 by MOSFET circuit board 205 and internal and external screw thread electrode 302,209 make the calandria 305 in the atomizer 307 produce heat.Contain tobacco juice in the fiber 402 in the tobacco juice bottle 401, the micropore ceramics 801 that tobacco juice soaks in the atomizer through fiber 402; Air is entered by air inlet duct 502, in the passage on the gas-liquid separator 303, spray-hole 304, form gas-liquid mixture at atomizer 307, gas-liquid mixture is ejected into vaporization on the calandria 305, and be inhaled into rapidly in the air-flow of gas and be condensed into aerosol, become white vaporific aerosol through air-breathing duct 503 by suction nozzle 403 sucking-offs.

When air-breathing stopping, reed switch 212 and sensor 207 reset, and atomizer 307 quits work, indicator lamp 202 extinguishes gradually, when the work number of times reaches default numerical value, atomizer 307 work time-delays 5 to 20 seconds once, with the micro-incrustation on the cleaning calandria 305.

The feed flow material of atomizer 307 also can be selected foamed ceramics, micropore glass, foaming metal, stainless steel fibre felt, polyster fibre, nylon fiber, acrylic fiber, aramid fiber or hard porous plastics for use except that micropore ceramics.Calandria 305 can adopt thermo electric materials such as being wound with nichrome wire, Aludirome silk, platinum filament on the micropore ceramics skeleton, the porous body of the band sintered electrode of also can be directly making with conductivity ceramics or PTC (positive temperature coefficient thermal sensitive ceramic) material.The surface of calandria 305 sinters high-temperature glaze into fixing zeolite granular, and zeolite granular is made by natural zeolite, artificial inorganic micropore ceramics or alumina particle.Tobacco juice bottle 401 usefulness in the cigarette bottle assembly, suction nozzle 403 are to make with non-toxic plastic, in be stained with the fiber 402 made with polypropylene fibre or nylon fiber with the absorption tobacco juice.In battery component, have micropore 501 on the indicator-lamp cover 201, be used for the pressure reduction of balance silicon rubber ripple barrier film 208 both sides.

The tobacco juice that is used to atomize contains 0.1 ~ 3.5% nicotine, 0.05 ~ 5% flavouring essence for tobacco, and 0.1 ~ 3% organic acid, 0.1 ~ 0.5% stabilizing agent, surplus is a propane diols.

First and second shell of the present utility model 211,306 is made the baking vanish color of exterior trim emulation cigarette by stainless steel tube or copper alloy tube.

As shown in figure 12, also can the scale up diameter of battery component of the utility model makes it consistent with the diameter of atomizer assembly, and be decorated with plant leaf vein texture and the pale brown look baking vanish of inferior light on shell, becomes cigar type emulation aerosol inhalator.

Lithium battery 203 of the present utility model recharge available shown in Figure 6 have with battery component on the screw thread electrode 601 that is complementary of external screw thread electrode 209 do the interface charging.

Embodiment 2

Shown in Fig. 2 B, present embodiment is with embodiment 1 different heres: be equipped with MCU206 between MOSFET circuit board 205 and sensor 207; First housing, 211 surfaces are equipped with display screen 204, are used to show the electric weight of lithium battery 203 and the number of times of smoking.

Shown in Fig. 5 B, of the present utility model treat duty with shown in Fig. 2 B, charge the electricity battery component be tightened on the atomizer assembly shown in Figure 3, insert cigarette bottle assembly shown in Figure 4 again.As user during with suction suction nozzle 403 fond of food that is not salty, on silicon rubber ripple barrier film 208, form negative pressure through air-breathing duct 503 and first and second negative pressure lumen pore 210,301, silicon rubber ripple barrier film 208 is Zona transformans movable contact spring switch 212 and sensor 207 under the effect of air-breathing pressure reduction, starts MCU206 and MOSFET circuit board 205.At this moment, indicator lamp 202 lights gradually, and lithium battery 203 calandria 305 power supplies in atomizer 307 by MOSFET circuit board 205 and internal and external screw thread electrode 302,209 make the calandria 305 in the atomizer 307 produce heat.Contain tobacco juice in the fiber 402 in the tobacco juice bottle 401, the micropore ceramics 801 that tobacco juice soaks in the atomizer through fiber 402; Air is entered by air inlet duct 502, in the passage on the gas-liquid separator 303, spray-hole 304, form gas-liquid mixture at atomizer 307, gas-liquid mixture is ejected into vaporization on the calandria 305, and be inhaled into rapidly in the air-flow of gas and be condensed into aerosol, become white vaporific aerosol through air-breathing duct 503 by suction nozzle 403 sucking-offs.

As shown in Figure 7, when aspiratory action caused that sensor starts, MCU206 realized with frequency the integral function of single working time being done the restriction of atomizing dosage according to the signal parameter of sensor 207 with the battery saving mode scanning sensor 207 of pulse.Simultaneously, MCU206 finishes and the pulsewidth modulation of the permanent power output of power supply and over, thousands of automatic cleaning functions of every work, indicator lamp gradually bright is put out gradually control, work number of times and battery capacity show, control functions such as recovery are certainly shut down in the sensor misoperation.

Device of the present utility model and syndeton also can be packed conventional medicine into as inhalation-type drug administration apparatus in the lung.

Patent Citations (209)

Publication number	Priority date	Publication date	Assignee	Title
Family To Family Citations				
US2057353A		1936-10-13		Vaporizing unit fob therapeutic
US705919A	1901-11-15	1902-07-29	Edwin R Gill	Electric battery.
US1147416A	1912-01-25	1915-07-20	Udolpho Snead	Vaporizing device.

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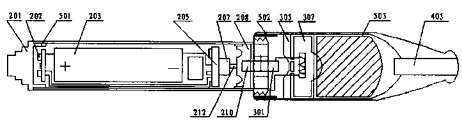
权利要求书 3 页 说明书 6 页 附图 10 页

[54] 实用新型名称

仿真气溶胶吸入器

[57] 摘要

本实用新型涉及电子吸入装置，具体地说是一种不含有焦油、只含烟碱(尼古丁)的仿真气溶胶吸入器，包括电池组件、雾化器组件及烟瓶组件，电池组件的一端设有外螺纹电极，雾化器组件的一端设有内螺纹电极，两者通过螺纹电极相连接，烟瓶组件插接在雾化器组件的另一端，共同构成一个香烟型或雪茄型的整体。本实用新型吸烟无焦油，大大降低了致癌风险，使用者仍有吸烟的感觉和兴奋，无需点燃，无火灾危害。本实用新型的装置和连接结构可装入常规药物作为肺内吸入式给药器械。



1．一种仿真气溶胶吸入器，其特征在于包括电池组件、雾化器组件及烟瓶组件，所述烟瓶组件包括烟液瓶，所述雾化器组件包括雾化器，其烟瓶组件插接在雾化器组件的一端，共同构成一个香烟型或雪茄型的整体。

2、根据权利要求 1 所述的仿真气溶胶吸入器，其特征在于所述的电池组件的一端设有外螺纹电极，雾化器组件的一端设有内螺纹电极，两者通过螺纹电极相连接。

3、根据权利要求 1 或 2 所述的仿真气溶胶吸入器，其特征在于电池组件包括锂电池、MOSFET 电路板、传感器、第一螺纹电极、第一负压腔孔及第一壳体，第一壳体的一端设有外螺纹电极，另一侧依次连接锂电池及 MOSFET 电路板，MOSFET 电路板上设有传感器。

4、根据权利要求 3 所述的仿真气溶胶吸入器，其特征在于所述电池组件还包括硅橡胶波纹隔膜，在第一螺纹电极与传感器之间安装有硅橡胶波纹隔膜，其上开有第一负压腔孔，传感器通过固接在其上的簧片开关与硅橡胶波纹隔膜相连接。

5、根据权利要求 3 所述的仿真气溶胶吸入器，其特征在于所述电池组件还包括指示灯、第一壳体的另一端安装有指示灯，其一侧罩有指示灯罩，指示灯罩上开有微孔；在 MOSFET 电路板与传感器之间加设有 MCU；第一壳体表面加设有显示屏。

6、根据权利要求 5 所述的仿真气溶胶吸入器，其特征在于所述 MCU 是以脉冲的省电模式扫描传感器，根据传感器的信号参数实现以频率对单次工作时间的积分函数做雾化剂量限制；同时，MCU 完成对电流恒功率输出的脉宽调制及过放电保护、每工作数千次自动清洗功能、指示灯的渐亮渐熄控制、工作次数及电池容量显示、传感器误动作停机自动恢复控制；所述指示灯为两只红色的发光二极管。

7、根据权利要求 3 所述的仿真气溶胶吸入器，其特征在于所述传感器为用弹性合金片制成的开关式传感器、线性输出的霍尔器件、半导体力敏芯片、半导体矩阵热电桥芯片或电容及电感式传感器。

8、根据权利要求 4 所述的仿真气溶胶吸入器，其特征在于所述硅橡胶

波纹隔膜用氟橡胶、丁腈橡胶或弹性合金膜制成。

9、根据权利要求 3 所述的仿真气溶胶吸入器，其特征在于所述外螺纹电极为不锈钢或黄铜件镀金开中孔制成；所述锂电池为可充电的聚合物锂电池或可充电的锂离子电池。

10、根据权利要求 1 或 2 所述的仿真气溶胶吸入器，其特征在于所述雾化器组件包括内螺纹电极、雾化器及第二壳体，第二壳体的一端与烟瓶组件相插接，另一端设有内螺纹电极，其上设有第二负压腔孔。

11、根据权利要求 3 所述的仿真气溶胶吸入器，其特征在于所述雾化器组件包括内螺纹电极、雾化器及第二壳体，第二壳体的一端与烟瓶组件相插接，另一端设有内螺纹电极，其上设有第二负压腔孔。

12、根据权利要求 11 所述的仿真气溶胶吸入器，其特征在于所述雾化器组件包括气液分离器，气液分离器与雾化器依次与内螺纹电极相连接；在第二壳体上开有进气孔道。

13、根据权利要求 12 所述的仿真气溶胶吸入器，其特征在于所述内螺纹电极为不锈钢或黄铜件镀金开中孔制成；所述气液分离器是用不锈钢或塑料开孔制成。

14、根据权利要求 10 所述的仿真气溶胶吸入器，其特征在于所述雾化器为毛细浸润式雾化器或喷射式雾化器，雾化器内设有加热体；喷射式雾化器上开有喷射孔。

15、根据权利要求 11 所述的仿真气溶胶吸入器，其特征在于所述雾化器为毛细浸润式雾化器或喷射式雾化器，雾化器内设有加热体；喷射式雾化器上开有喷射孔。

16、根据权利要求 15 所述的仿真气溶胶吸入器，其特征在于所述喷射孔是用泡沫陶瓷、微孔陶瓷、发泡金属、不锈钢纤维毡或化学纤维成型开孔制成。

17、根据权利要求 15 所述的仿真气溶胶吸入器，其特征在于所述加热体是用微孔陶瓷骨架上绕有镍铬合金丝、铁铬铝合金丝或铂丝电热材料制成，或直接用导电陶瓷或 PTC 陶瓷材料制成的带烧结电极的多孔体；加热体的表面烧结成高温釉以固定沸石颗粒，沸石颗粒由天然沸石、人造无机微孔陶瓷或氧化铝颗粒制成。

18、根据权利要求3所述的仿真气溶胶吸入器，其特征在于所述烟瓶组件包括烟液瓶、纤维及吸嘴，带有烟液的纤维容置在烟液瓶的一端，该端插接在第二壳体内、抵接在雾化器上，吸嘴位于烟液瓶的另一端，在纤维与烟液瓶的内壁间留有吸气孔道。

19、根据权利要求11所述的仿真气溶胶吸入器，其特征在于所述烟瓶组件包括烟液瓶、纤维及吸嘴，带有烟液的纤维容置在烟液瓶的一端，该端插接在第二壳体内、抵接在雾化器上，吸嘴位于烟液瓶的另一端，在纤维与烟液瓶的内壁间留有吸气孔道。

20、根据权利要求18所述的仿真气溶胶吸入器，其特征在于所述烟液瓶、吸嘴是用无毒塑料制成：所述纤维是用聚丙烯纤维或尼龙纤维制成。

仿真气溶胶吸入器

技术领域

本实用新型涉及电子吸入装置，具体地说是一种不含有焦油、只含烟碱（尼古丁）的仿真气溶胶吸入器。

背景技术

在当今“吸烟有害健康”已成为常识的情况下，全世界目前仍有10亿人吸烟，而且每年这个数字还在扩大。2003年3月1日世界卫生组织（WHO）通过了的第一个国际禁烟协定《烟草控制框架公约》，据WHO提供的数字表明，吸烟每年造成490万人死亡，尽管吸烟可导致严重的呼吸系统疾病和癌症，让吸烟者完全戒烟是极其困难的事。

香烟的有效成分是烟碱（即尼古丁），吸烟时烟碱随着香烟燃烧产生的大量焦油雾滴进入肺泡后被迅速吸收，烟碱被吸收入血后作用于中枢神经系统的受体上，引起类似兴奋剂的“陶醉感”，如吸烟者所经历的头晕目眩或飘飘然的感觉。

烟碱是小分子生物碱，在小剂量下对人体基本无害，而且在血液中的半衰期极短。烟草的有害物质主要是焦油，烟草焦油是由数千种成分组成，其中有数十种成分是致癌物。目前证实被动吸烟对不吸烟者的危害更大。

为了寻找只含烟碱而不含有害焦油的香烟代用品，有许多发明是用较纯的烟碱制成诸如“戒烟贴”、“烟碱含漱水”、“包装在有抛射剂的高压气罐喷雾剂”、“烟碱口香糖”、“烟碱饮料”等产品，这些产品虽然没有焦油的危害，但因烟碱吸收缓慢，在血液中不能建立有效的高峰浓度，不能解决需求烟碱“过瘾”的感觉，同时也剥夺了吸烟者已经养成的“抽”、“吸”的习惯，因而类似的产品不能真正的作为戒烟用品或香烟代用品。

实用新型内容

本实用新型目的在于提供一种有戒烟和香烟替代品作用的仿真气溶胶吸入器。

本实用新型的技术方案是发明人于2000年4月14日在中国知识产权局申请的申请号为：200420031182.0 国际申请号为：PCT/CN2005/000337 的实用新型“雾化电子烟”专利的创新型。

本实用新型的目的是通过以下技术方案来实现的：

本实用新型包括电池组件、雾化器组件及烟瓶组件，电池组件的一端设有外螺纹电极，雾化器组件的一端设有内螺纹电极，两者通过螺纹电极相连接，烟瓶组件插接在雾化器组件的另一端，共同构成一个香烟型或雪茄型的整体。

其中：电池组件包括指示灯、锂电池、MOSFET电路板、传感器、硅橡胶波纹隔膜、第一螺纹电极、第一负压腔孔及第一壳体，第一壳体的一端设有外螺纹电极，另一端安装有指示灯，其一侧罩有指示灯罩，指示灯罩上开有微孔，另一侧依次连接锂电池及MOSFET电路板，MOSFET电路板上设有传感器，在第一螺纹电极与传感器之间安装有硅橡胶波纹隔膜，其上开有第一负压腔孔，传感器通过固接在其上的簧片开关与硅橡胶波纹隔膜相连接；在MOSFET电路板与传感器之间加设有MCU；第一壳体表面加设有显示屏；所述MCU是以脉冲的省电模式扫描传感器，根据传感器的信号参数实现以频率对单次工作时间的积分函数做雾化剂量限制；同时，MCU完成对电流恒功率输出的脉宽调制及过放电保护、每工作数千次自动清洗功能、指示灯的渐亮渐熄控制、工作次数及电池容量显示、传感器误动作停机自动恢复等控制；所述传感器可为用弹性合金片制成的开关式传感器、线性输出的霍尔器件、半导体力敏芯片、半导体矩阵热电桥芯片或电容及电感式传感器；所述指示灯为两只红色的发光二极管；所述硅橡胶波纹隔膜还可用氟橡胶、丁腈橡胶或弹性合金膜制成；所述外螺纹电极为不锈钢或黄铜件镀金开中孔制成；所述锂电池可为可充电的聚合物锂电池或可充电的锂离子电池；所述雾化器组件包括内螺纹电极、气液分离器、雾化器及第二壳体，第二壳体的一端与烟瓶组件相插接，另一端设有内螺纹电极，其上设有第二负压腔孔，气液分离器与雾化器依次与内螺纹电极相连接；在第二壳体上开有进气孔道；所述内螺纹电极为不锈钢或黄铜件镀金开中孔制成；所述气液分离器是用不锈钢或塑料开孔制成；所述雾化器可为毛细浸润式雾化器或喷射式雾化器，雾化器内设有加热体；喷射式雾化器上开有喷射孔；所述喷射孔是用泡沫陶瓷、微孔陶瓷、发泡金属、不锈钢纤维毡或化学纤维成型开孔制成；所述加热体是用微孔陶瓷骨架上绕有镍铬合金丝、铁铬铝合金丝或铂丝等电热材料制成，也可直接用导电陶瓷或PTC陶瓷材料制成的带烧结电极的多孔体；加热体的表面烧结成高温釉以固定沸石颗粒，沸石颗粒由天然沸石、人造无机微孔陶瓷或氧化铝颗粒制成；所述烟瓶组件包括烟液瓶、纤维及吸嘴，带有烟液的纤维容置在烟液瓶的一端，该端插接在第二壳体内、抵接在雾化器上，吸嘴位于烟液瓶的另一端，在纤维与烟液瓶的内壁间留有吸气孔道；所述烟液瓶、吸嘴是

用无毒塑料制成；所述纤维是用聚丙烯纤维或尼龙纤维制成；所述纤维中用于雾化的烟液含有 0.1～3.5%的烟碱，0.05～5%的烟用香精，0.1～3%的有机酸，0.1～0.5%的稳定剂，余量为丙二醇；所述吸入器及其连接结构可装入常规药物作为肺内吸入式给药器械。

本实用新型的优点与积极效果为：

本实用新型吸烟无焦油，大大降低了致癌风险，使用者仍有吸烟的感觉和兴奋，无需点燃，无火灾危害。本实用新型的装置和连接结构可装入常规药物作为肺内吸入式给药器械。

附图说明

图 1 为本实用新型香烟型的外观示意图；

图 2A 为本实用新型电池组件的一种结构示意图；

图 2B 为本实用新型电池组件的另一种结构示意图；

图 3 为本实用新型雾化器组件的示意图；

图 4 为本实用新型烟瓶组件的示意图；

图 5A 为本实用新型的一种内部结构示意图；

图 5B 为本实用新型的另一种内部结构示意图；

图 6 为本实用新型充电器的结构示意图；

图 7 为本实用新型 MCU 及 MOSFET 的电路原理图；

图 8 为本实用新型毛细浸润式雾化器的结构示意图；

图 9 为图 8 的左视图；

图 10 为本实用新型喷射式雾化器的结构示意图；

图 11 为图 10 的左视图；

图 12 为本实用新型雪茄式外形的结构示意图。

具体实施方式

下面结合附图对本实用新型作进一步详述。

实施例 1

如图 1 所示，本实用新型的外观与插入烟嘴的卷烟外形相似，包括电池组件、雾化器组件及烟瓶组件，电池组件的一端设有外螺纹电极 209，雾化器组件的一端设有内螺纹电极 302，两者通过螺纹电极相连接成模拟烟体，烟瓶组件插接在雾化器组件的另一端，共同构成一个香烟型仿真气溶胶吸入器。

如图 2A 所示，电池组件包括指示灯 202、锂电池 203、MOSFET 电路板 205、传感器 207、硅橡胶波纹隔膜 208、第一螺纹电极 209、第一负压腔孔 210 及第一壳体 211，第一壳体 211 的一端设有外螺纹电极 209，另一端安装有指示灯 202，其一侧罩有指示灯罩 201，指示灯罩 201 上开有微孔 501，另一侧依次连接锂电池 203 及 MOSFET

（金属氧化物半导体场效应管）电路板 205，MOSFET 电路板 205 上设有传感器 207，在第一螺纹电极 209 与传感器 207 之间安装有硅橡胶波纹隔膜 208，其上开有第一负压腔孔 210，传感器 207 通过固接在其上的簧片开关 212 与硅橡胶波纹隔膜 208 相连接。

其中：传感器 207 可为用弹性合金片制成的开关式传感器、线性输出的霍尔器件、半导体力敏芯片、半导体矩阵热电桥芯片或电容及电感式传感器。指示灯 202 为两只红色的发光二极管。锂电池 203 可为可充电的聚合物锂电池或可充电的锂离子电池。外螺纹电极 209 为不锈钢或黄铜件镀金开中孔制成。硅橡胶波纹隔膜 208 还可用氟橡胶、丁腈橡胶或弹性合金膜制成。

如图 3 所示，雾化器组件包括内螺纹电极 302、气液分离器 303、雾化器 307 及第二壳体 306，第二壳体 306 的一端与烟瓶组件相插接，另一端设有内螺纹电极 302，其上设有第二负压腔孔 301，气液分离器 303 与雾化器 307 依次与内螺纹电极 302 相连接；在第二壳体 306 上开有进气孔道 502。其中：气液分离器 303 是用不锈钢或塑料开孔制成。内螺纹电极 302 为不锈钢或黄铜件镀金开中孔制成。

雾化器 307 可如图 8、图 9 所示，为毛细浸润式雾化器，或如图 10、图 11 所示，为喷射式雾化器。本实施例为喷射式雾化器。

如图 4 所示，烟瓶组件包括烟液瓶 401、纤维 402 及吸嘴 403，带有烟液的纤维 402 容置在烟液瓶 401 的一端，该端插接在第二壳体 306 内、抵接在雾化器 307 上，吸嘴 403 位于烟液瓶 401 的另一端，在纤维 402 与烟液瓶 401 的内壁间留有吸气孔道 503。

如图 5A 所示，本实用新型的待工作状态是将图 2A 所示的、充完电的电池组件旋紧在图 3 所示的雾化器组件上，再插入图 4 所示的烟瓶组件。当使用者用口轻吸吸嘴 403 时，经吸气孔道 503 和第一、二负压腔孔 210、301 在硅橡胶波纹隔膜 208 上形成负压，硅橡胶波纹隔膜208在吸气压差的作用下变形带动簧片开关212及传感器207，启动 MOSFET 电路板 205。此时，指示灯 202 逐渐亮起，锂电池 203 通过 MOSFET 电路板 205 及内、外螺纹电极 302、209 向雾化器 307 内的加热体 305 供电，使雾化器 307 内的加热体 305 产生热量。烟液瓶 401 内的纤维 402 中含有烟液，烟液经纤维 402 浸润雾化器中的微孔陶瓷 801；空气由进气孔道 502 进入，经气液分离器 303 上的通气孔、在雾化器 307 的喷射孔 304 中形成气液混合物，气液混合物喷射到加热体 305 上汽化，并迅速被吸入气体的气流中冷凝成气溶胶，经吸气孔道 503 由吸嘴 403 吸出成白雾状气溶胶。

当吸气停止时，簧片开关 212 及传感器 207 复位，雾化器 307 停

止工作，指示灯202逐渐熄灭，在工作次数达到预设的数值时，雾化器307工作延时5至20秒一次，以清洁加热体305上的微量积垢。

雾化器307的供液材料除微孔陶瓷外还可选用泡沫陶瓷、微孔玻璃、发泡金属、不锈钢纤维毡、涤纶纤维、尼龙纤维、腈纶纤维、芳伦纤维或硬质多孔塑料。加热体305可采用微孔陶瓷骨架上绕有镍铬合金丝、铁铬铝合金丝、铂丝等电热材料，也可直接用导电陶瓷或PTC（正温度系数热敏陶瓷）材料制成的带烧结电极的多孔体。加热体305的表面烧结成高温釉以固定沸石颗粒，沸石颗粒由天然沸石、人造无机微孔陶瓷或氧化铝颗粒制成。烟瓶组件中的烟液瓶401用、吸嘴403是用无毒塑料制成，内粘有用聚丙烯纤维或尼龙纤维制成的纤维402以吸附烟液。在电池组件中，指示灯罩201上开有微孔501，用于平衡硅橡胶波纹隔膜208两侧的压差。

用于雾化的烟液含有0.1～3.5%的烟碱，0.05～5%的烟用香精，0.1～3%的有机酸，0.1～0.5%的稳定剂，余量为丙二醇。

本实用新型的第一、二外壳211、306由不锈钢管或铜合金管制成，外饰仿真卷烟的烤漆颜色。

如图12所示，本实用新型还可按比例加大电池组件的直径，使之与雾化器组件的直径一致，并在外壳上饰以植物叶脉纹理及亚光棕黄色烤漆，成为雪茄型仿真气溶胶吸入器。

本实用新型的锂电池203的再充电可用图6所示的带有与电池组件上外螺纹电极209相匹配的螺纹电极601做接口充电。

实施例2

如图2B所示，本实施例与实施例1不同这处在于：在MOSFET电路板205与传感器207之间加设有MCU206；第一壳体211表面加设有显示屏204，用于显示锂电池203的电量以及吸烟的次数。

如图5B所示，本实用新型的待工作状态是将图2B所示的、充完电的电池组件旋紧在图3所示的雾化器组件上，再插入图4所示的烟瓶组件。当使用者用口轻吸吸嘴403时，经吸气孔道503和第一、二负压腔孔210、301在硅橡胶波纹隔膜208上形成负压，硅橡胶波纹隔膜208在吸气压差的作用下变形带动簧片开关212及传感器207，启动MCU206及MOSFET电路板205。此时，指示灯202逐渐亮起，锂电池203通过MOSFET电路板205及内、外螺纹电极302、209向雾化器307内的加热体305供电，使雾化器307内的加热体305产生热量。烟液瓶401内的纤维402中含有烟液，烟液经纤维402浸润雾化器中的微孔陶瓷801；空气由进气孔道502进入，经气液分离器303上的通气孔、在雾化器307的喷射孔304中形成气液混合物，气液混

合物喷射到加热体 305 上汽化，并迅速被吸入气体的气流中冷凝成气溶胶，经吸气孔道 503 由吸嘴 403 吸出成白雾状气溶胶。

如图 7 所示，在吸气动作引致传感器启动时，MCU206 以脉冲的省电模式扫描传感器 207，根据传感器 207 的信号参数实现以频率对单次工作时间的积分函数做雾化剂量限制。同时，MCU206 完成对电源恒功率输出的脉宽调制及过放电保护、每工作数千次自动清洁功能、指示灯的渐亮渐熄控制、工作次数及电池容量显示、传感器误动作停机自恢复等控制功能。

本实用新型的装置和连接结构还可装入常规药物作为肺内吸入式给药器械。

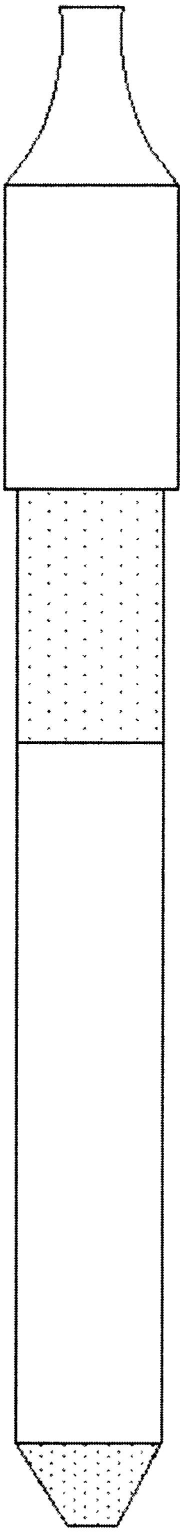


图 1

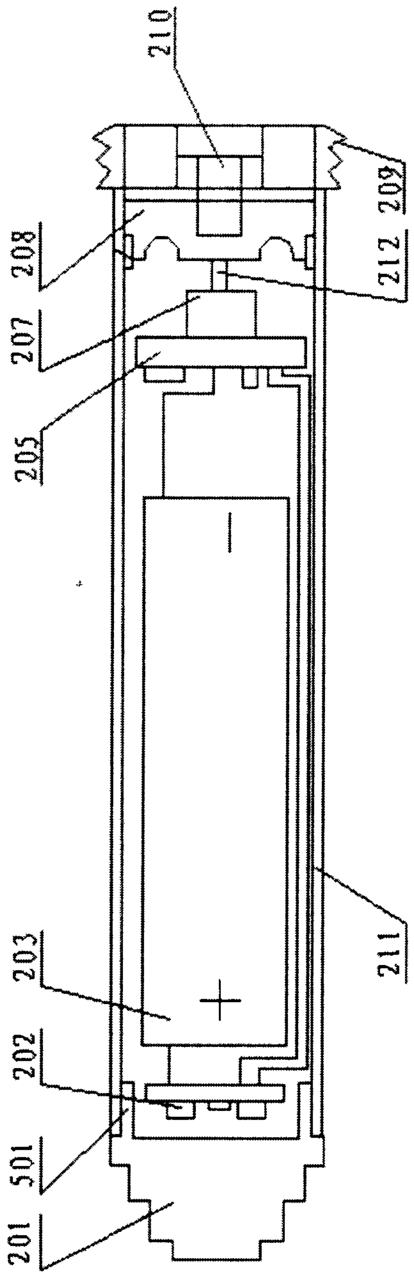


图 2A

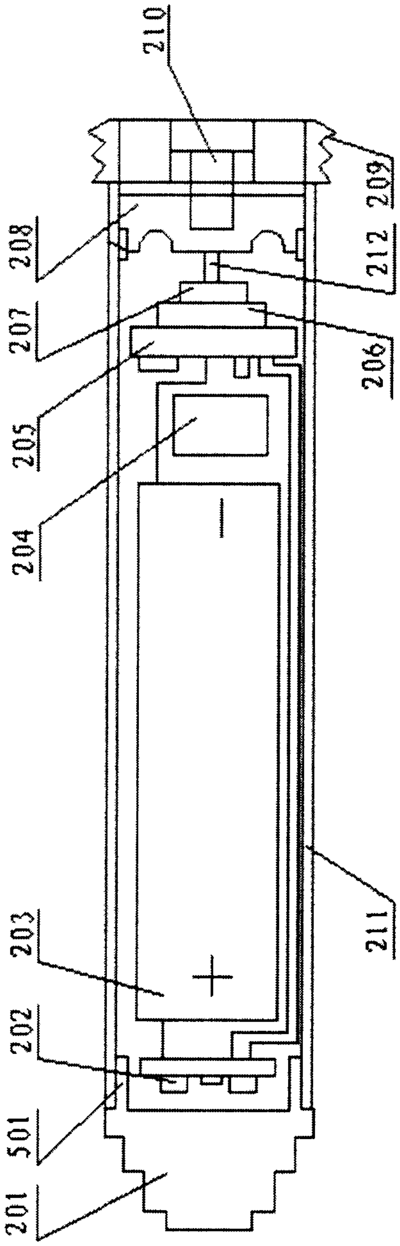


图 2B

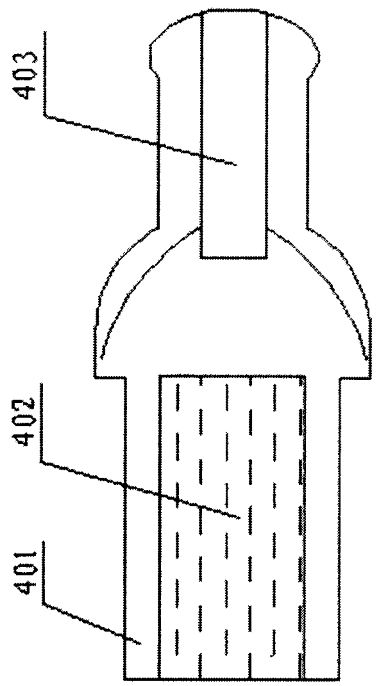


图 4

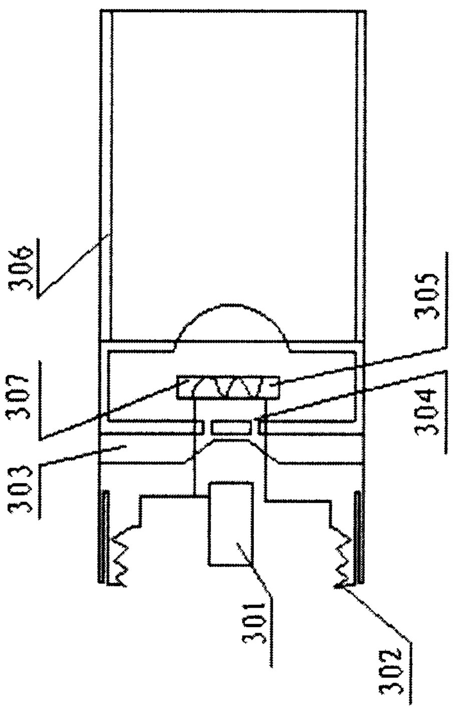


图 3

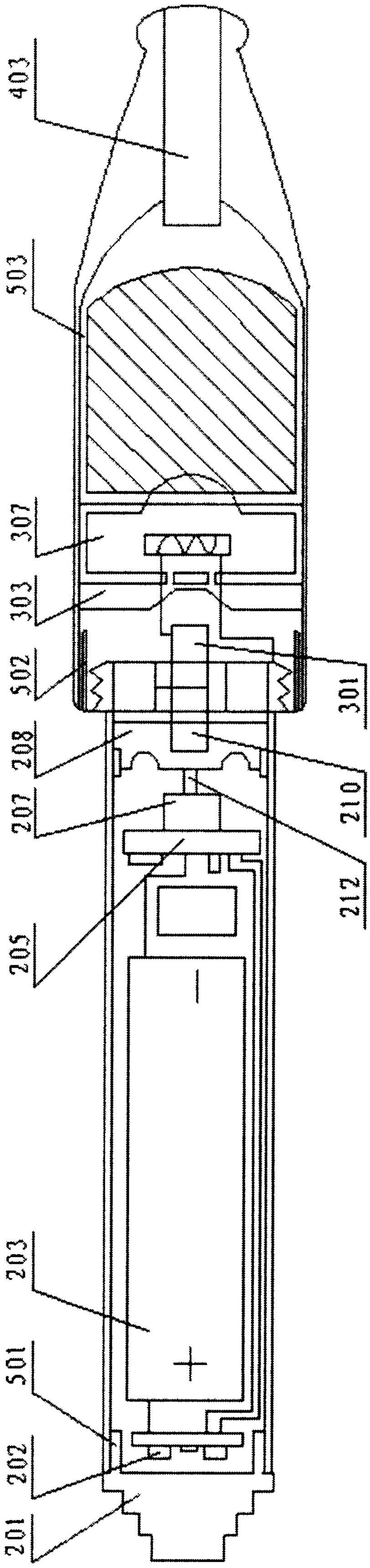


图 5A

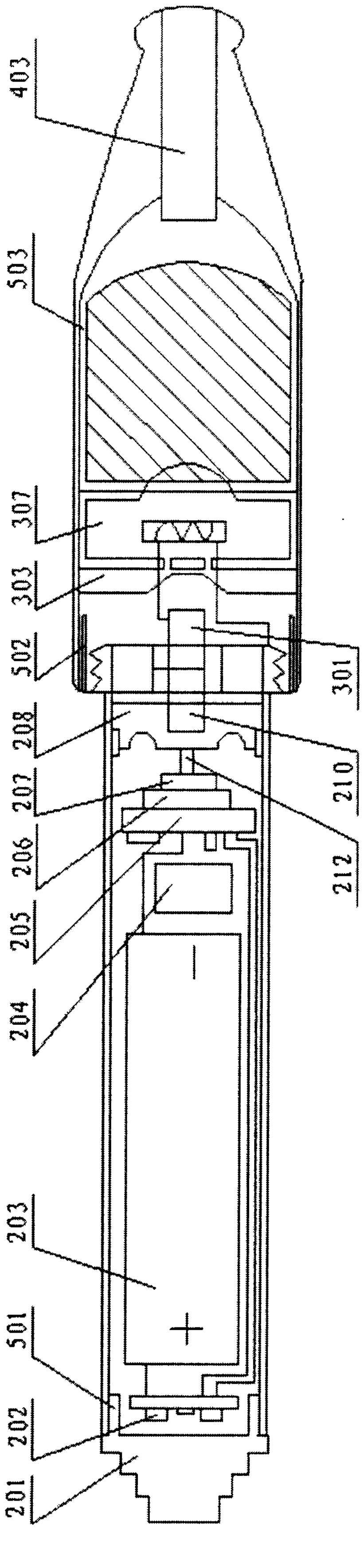

403
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图 5B

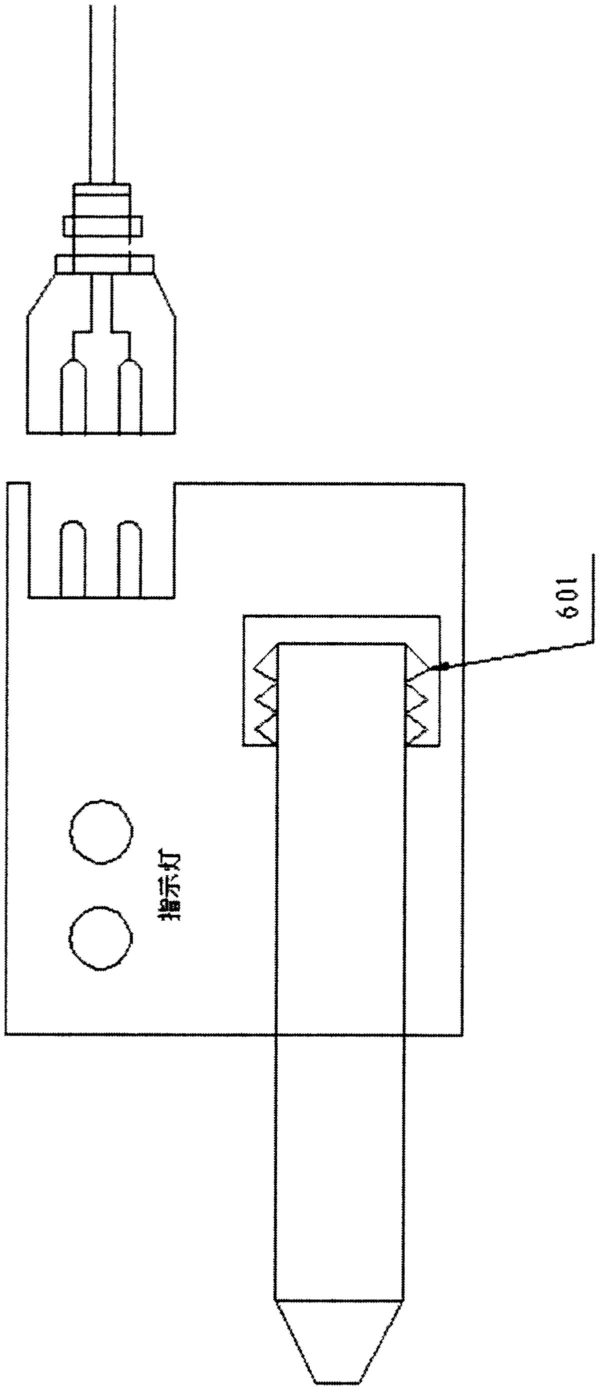

图 6

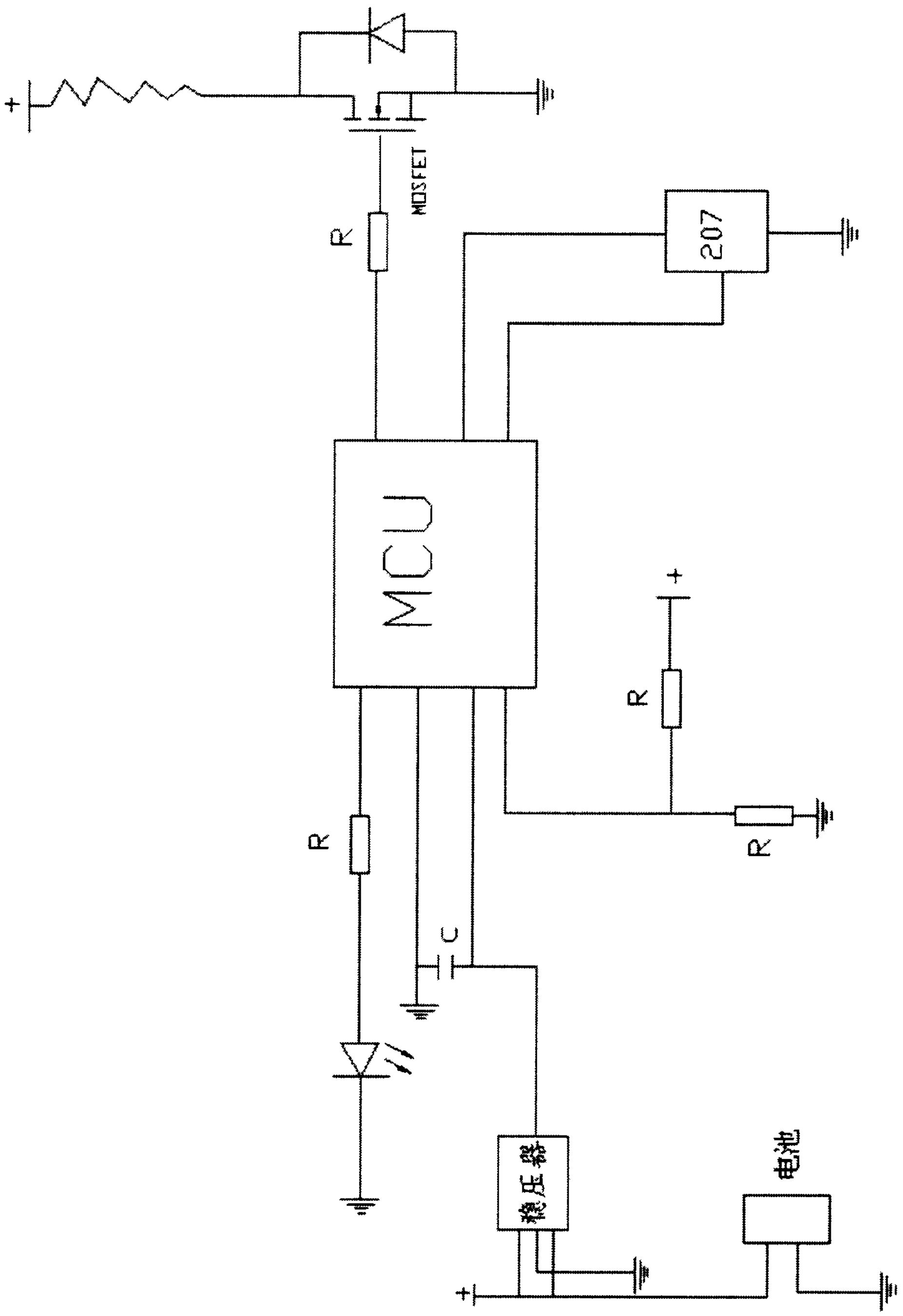

图 7

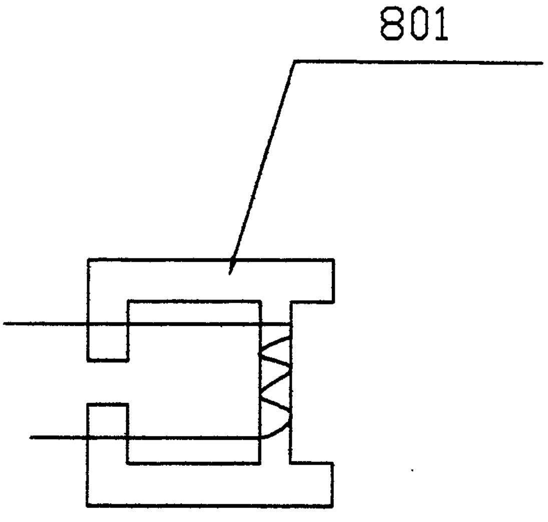

图8

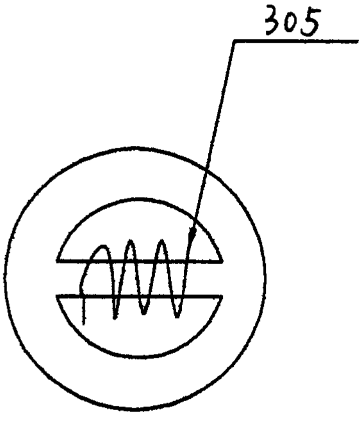

图9

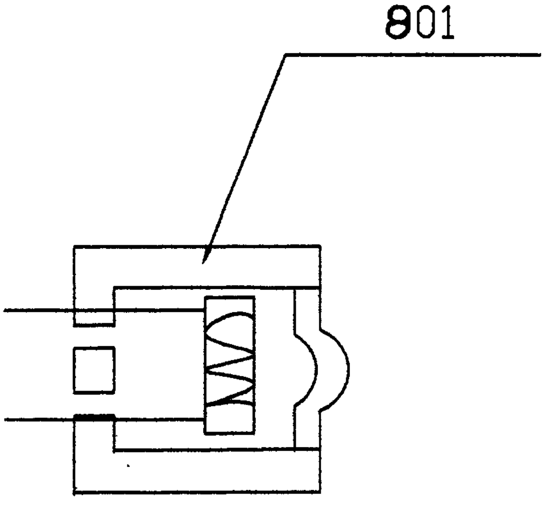

图10

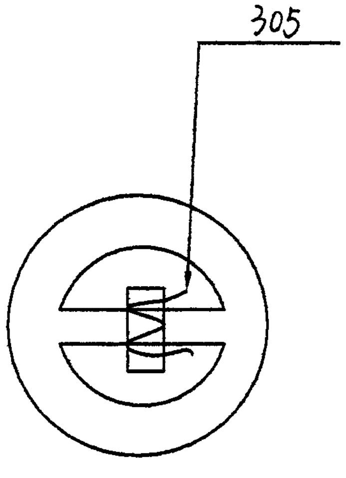

图11

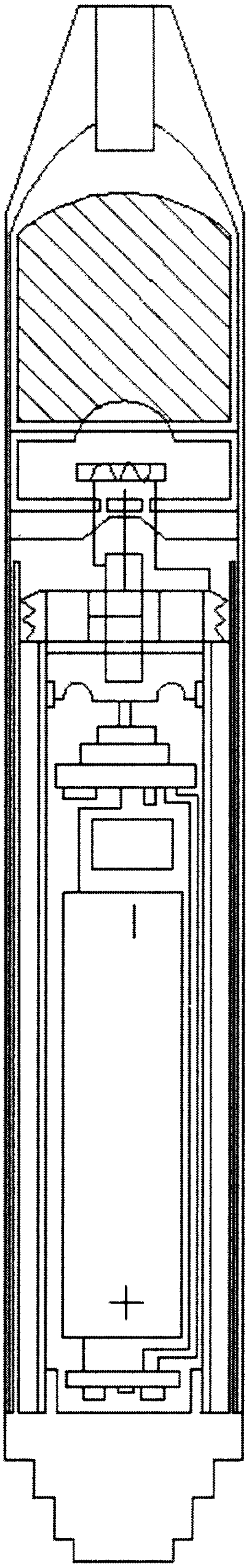

图 12

[19] 中华人民共和国国家知识产权局

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[12] 实用新型专利说明书

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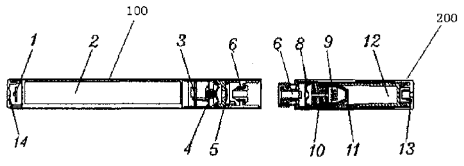
权利要求书 2 页 说明书 9 页 附图 4 页

[54] 实用新型名称

一种非可燃性喷雾电子香烟

[57] 摘要

本实用新型公开了一种非可燃性喷雾电子香烟，包括控制器与发生器，所述控制组件内依次设有指示灯盖、电源装置、集成线路板、微型气体传动开关和连接导体，所述发生器内依次设有连接导体、次级气压保压室、阻液片、次级贮液室、加热器、导液机构、贮液室和吸嘴，所述连接导体一侧上开有进气孔，所述控制器与发生器的连接导体中间开有通孔。 本实用新型的技术效果在于：吸烟无焦油、一氧化碳等有害物，大大降低致癌风险，使用者仍然有吸烟的感觉，无需点燃，无火灾危险，其吸出的烟雾其实是药液气化的水蒸气，无环境污染。



1、一种非可燃性喷雾电子香烟，其特征在于：包括控制器与发生器，所述控制组件内依次设有指示灯盖、电源装置、集成线路板、微型气体传动开关和连接导体，所述发生器内依次设有连接导体、次级气压保压室、阻液片、次级贮液室、加热器、导液机构、贮液室和吸嘴，所述连接导体一侧上开有进气孔，所述控制器与发生器的连接导体中间开有通孔。

2、如权利要求 1 所述的非可燃性喷雾电子香烟，其特征在于：所述指示灯盖侧边开有一对隐蔽的通气孔，指示灯盖下面设有发光 LED。

3、如权利要求 1 或 2 所述的非可燃性喷雾电子香烟，其特征在于：所述指示灯盖、电源装置、集成线路板、微型气体传动开关和连接导体外侧设有不锈钢壳体，所述连接导体、阻液片、次级贮液室、加热器、导液机构、贮液室和吸嘴外侧设有隔热层和不锈钢外壳。

4、如权利要求 1 所述的非可燃性喷雾电子香烟，其特征在于：所述微型气体传动开关内部设有弹性圆环，将微型气体传动开关开成两个独立的腔室。

5、如权利要求 4 所述的非可燃性喷雾电子香烟，其特征在于：所微型气体传动开关还包括定接触片、塑料底座和动接触片，所述动接触片通过塑料棒连接弹性圆环，弹性圆环固定于塑料底座内，定接触片固定于塑料底座外。

6、如权利要求 1 所述的非可燃性喷雾电子香烟，其特征在于：所述连接导体的右侧还设有一个次级开关气阀，以及由此形成的次级

气压保压室，侧边设有进气孔。

7、如权利要求 6 所述的非可燃性喷雾电子香烟，其特征在于：所述连接导体包括两个中空的柱形导体、内螺纹与外螺纹，所述中空的柱形导体连接加热器的引入导线的正极，所述内螺纹与外螺纹连接加热器的引入导线的负极。

8、如权利要求 1 所述的非可燃性喷雾电子香烟，其特征在于：所述加热器包括加热丝和其外面的隔热座，在隔热座底部和侧面分别开有喷射孔和溢流孔。

9、如权利要求 1 所述的非可燃性喷雾电子香烟，其特征在于：所述吸嘴外侧延长至阻液器底部，在吸嘴的内侧还开有阻液槽。

一种非可燃性喷雾电子香烟

技术领域

本实用新型涉一种非可燃性喷雾电子香烟。

背景技术

当今“吸烟有害健康”，已成为人所共知的常识，全世界仍然有10亿以上的烟民，美国环境保护署目前将空气中的烟草雾宣布为A级致癌物。据世界卫生组织等部门公布的数字，全球每年约有490万人死于与吸烟有关的疾病；但是由于种种原因，要吸烟者完全戒烟是一件极其困难的事。

烟碱是小分子生物碱，它能使人吸烟成瘾，在小剂量下对人体基本无害，而且在血液中的半衰期极短。烟草中的有害物质如：烟焦油，一氧化碳，苯并芘，多环芳烃，亚硝胺、偶氮杂质等都是强致癌物，对人类的生存和健康造成了巨大的危害，而二手烟对周围人群的危害则更大！而烟草对环境的污染亦不能忽视，意大利科学家的最新研究表明，吸烟冒出的烟雾造成的污染可能超过某些汽车发动机尾气造成的污染！

为了寻找即能满足吸烟对烟瘾的需求，而又将烟草的危害降到最低，最终戒烟。许多实用新型都是将小剂量的烟碱做成诸如：“戒烟贴”、“烟碱嗽口水”、“烟碱口香糖”等产品，这些产品虽然有其

一定的功效，没有烟焦油等其它有害物质的危害，但与吸烟都多年养成的习惯“抽吸”习惯格格不入，很难为烟民所接受。

发明内容

本实用新型的目的在于提供一种具有香烟代用品作用的环保型非可燃性喷雾电子香烟，避免了上述缺点，更接近真实的人性化香烟，没有环境污染。

本实用新型的目的是通过以下技术方案来实现的：一种非可燃性喷雾电子香烟，包括控制器与发生器，所述控制组件内依次设有指示灯盖、电源装置、集成线路板、微型气体传动开关和连接导体，所述发生器内依次设有连接导体、次级气压保压室、阻液片、次级贮液室、加热器、导液机构、贮液室和吸嘴，所述连接导体一侧上开有进气孔，所述控制器与发生器的连接导体中间开有通孔。

本实用新型的技术方案还包括：所述指示灯盖侧边开有一对隐蔽的通气孔，指示灯盖下面设有发光LED。

本实用新型的技术方案还包括：所述指示灯盖、电源装置、集成线路板、微型气体传动开关和连接导体外侧设有不锈钢壳体，所述连接导体、阻液片、次级贮液室、加热器、导液机构、贮液室和吸嘴外侧设有隔热层和不锈钢外壳。

本实用新型的技术方案还包括：所述微型气体传动开关内部设有弹性圆环，将微型气体传动开关开成两个独立的腔室。

本实用新型的技术方案还包括：所微型气体传动开关还包括定接触片、塑料底座和动接触片，所述动接触片通过塑料棒连接弹性圆环，

弹性圆环固定于塑料底座内，定接触片固定于塑料底座外。

本实用新型的技术方案还包括：所述连接导体的右侧还设有一个次级开关气阀，以及由此形成的次级气压保压室，侧边设有进气孔。

本实用新型的技术方案还包括：所述连接导体包括两个中空的柱形导体、内螺纹与外螺纹，所述中空的柱形导体连接加热器的引入导线的正极，所述内螺纹与外螺纹连接加热器的引入导线的负极。

本实用新型的技术方案还包括：所述加热器包括加热丝和其外面的隔热座，在隔热座底部和侧面分别开有喷射孔和溢流孔。

本实用新型的技术方案还包括：所述吸嘴外侧延长至阻液器底部，在吸嘴的内侧还开有阻液槽。

本实用新形的技术效果在于：吸烟无焦油、一氧化碳等有害物，大大降低致癌风险，使用者仍然有吸烟的感觉，无需点燃，无火灾危险，其吸出的烟雾其实是药液气化的水蒸气，无环境污染。

本实用新型的特征及优点将通过实施例结合附图进行详细说明。

附图说明

图 1 是本实用新型实施例的非可燃性喷雾电子香烟拆分结构示意图；

图 2 是本实用新型实施例的非可燃性喷雾电子香烟整体结构示意图；

图 3 是本实用新型实施例非的可燃性电子喷雾香烟中微型气体

传动开关结构示意图；

图 4 是本实用新型实施例非的可燃性电子喷雾香烟中导液机构与雾化室及与贮液芯的连接结构图；

图 5 是本实用新型实施例的非可燃性喷雾电子香烟中气压传动开关的结构示意图；

图 6 是本实用新型实施例的非可燃性喷雾电子香烟中加热器和导液机构结构示意图；

图 7 是本实用新型实施例的非可燃性喷雾电子香烟中集成线路板电路图。

具体实施方式

请参阅图 1，本实施例的非可燃性喷雾电子香烟包括控制器 100 与发生器 200。

如图 1 所示，在控制器 100 的一端设有一透明信号指示灯盖 14，并在指示灯盖 14 侧边开有一对隐蔽的通气孔，在另一端设有连接导体 6 用于和发生器 200 连成一个整体；在指示灯盖 14 下面有一个发光 LED；在指示灯盖 14 至连接导体 6 依次设有可充电锂电池 2、集成线路板 3、微型气体传动开关 4 、负压腔室 5，控制器 100 外面是不锈钢壳体。可充电锂电池 2 是内置的，控制器 100 的连接导体 6 连入充电器即可实现充电，而与发生器 200 连接后可组成一环保型非可燃性喷雾电子香烟。

发生器 200 的一侧也设有连接导体 6，另一侧设有烟嘴 13，从烟

嘴 13 一侧起依次设有贮液室 12、导液机构 11、加热器 9、次级贮液室 10、阻液片 8 和次级气压保压室 7；发生器 200 外面分别有隔热层和不锈钢外壳，而吸嘴 13 的延长部份将发生器 200 外包括在其中，在发生器 200 的连接导体 6 的一侧上也开有进气孔，在吸嘴 13 与贮液器 12 中间有气流通道，在吸嘴 13 的底部开有阻液槽。控制器 100 与发生器 200 之间通过边接导体 6 相连，中间开有通气孔，连接着负压腔 5 与次级气压保压室 7；在控制器与发生器连接的侧边开有进气孔；阻液片 8 防止液体倒流；次级贮液室 10 暂存药液，导液机构 11 与药液相接触，在导液机构 11 内部设有雾化工作室；药液芯外围四周开有雾气通道，中间装有药液。

如图 3 所示，微型气体传动开关 4 内部有一弹性圆环 401，弹性圆环 401 剖面呈 W 形，将微型气体传动开关开成两个独立的腔室，在所述弹性圆环 401 上连有一伸出软胶片，软胶片内装有一塑料棒 402 用于连接弹性圆环 401 与动接触片 406。弹性圆环 401 固定于塑料底座 405 内。集成线路板 3 上设有两片伸向弹性圆环 401 的定接触片 403 和 404，定接触片 403 和 404 固定于塑料底座 405 外。

如图 4 所示，在连接导体 6 的右侧还设有一个次级开关气阀 701，侧边设有进气孔 702，在使用者抽吸时，气流从进气孔 702 进入，次级开关气阀 701 被气流打开，在气流的作用下，在弹性圆环 401 的右侧与连接导体 6 之间形成一个负压腔室 5；在负压的作用下弹性圆环 401 向右移动，同时带动连接在塑料棒 402 上的动接触片 406 向右移动，从而与连接在集成线路板 3 上的定接触片 403 导通；而当使用者

吸力减小时，次级开关气阀 701 关闭，挡住进气孔 702，从而使负压腔室 5 维持一定时间，只有当使用者停止抽吸时，气流从连接导体 6 的中空通道 606 迅速进入负压腔室 5，负压立即消失，弹性圆环 401 在弹力作用下回复原位，塑料棒 402 左移，动接触片 406 与定接触片 403 断开，即可实现在小气流的作用下接通和断开开关，从而控制加热器 9 的实时加热。其中，弹性圆环 401 可用橡胶或硅胶制成。

连接导体 6 分别由内螺纹 603 与外螺纹 604 组成连接的外圈，用于连接加热器的引入导线的负极，由两个中空的柱形导体 601、603 连接加热器的引入导线的正极；在两个连接导体中间用绝缘材圈 605 隔开。控制器 100 与发生器 200 通过螺纹与中通的接触铜帽连接。

如图 5 所示，加热器 9 包括加热丝 901 和其外面的隔热座 902，在隔热座 902 底部和侧面分别开有喷射孔 904 和溢流孔 903，在加热器 9 右侧设有导液机构 11，导液机构 11 由支撑架 1101 与导液体 1102 组成，其支撑架 1101 起固定作用，导液体 1102 由多层泡沫镍网或其它金属多孔体制成，加热器 9 的左侧是次级贮液室 10、阻液片 8，加热丝 901 可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体或环状，隔热座 902 可用陶瓷等制成。次级贮液室 10 为多层泡沫镍网填充在隔热座 902 底部与周边构成，导液机构 11 的一端通过导液体 1101 与次级贮液室 10 相连，另一端与贮液室 12 接触，贮液室 12 是一一端开口的筒状物，中间置入药用棉纤，然后装入药原液，通过导液机构 11 的毛细作用，装存在贮液室 12 内的药液导入次级贮液室 10。在气流的作用下，将小液滴通过隔热座 902

中的喷射孔 904 吸入隔热座 902 的另一侧，在加热丝 901 的作用下，液体瞬间雾化，然后由开在贮液室 12 外侧的通孔经吸嘴 13 吸出。阻液器 8 可防止次级贮液室内 12 中的液体意外溢出。所述的液导液体 1102 还可用不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成。

请一并参阅图 6，所述吸嘴 13 外侧的烟嘴套 1301 延长至阻液器 8 底部，其材料可用聚丙烯 PP 等环保材料制成，可有效防止内部热量的传出。在吸嘴 13 的内侧还开有通气孔 1302，在吸嘴孔 1304 的内侧还开有阻液槽 1303 以防止液体吸入口中。

如图 7 所示，所述集成线路板 3 使用 IC 控制，用 3.7V 锂离子电池供电，VCC 接电池正极，GND 接电池负极，S1 为连接微型气体传动，属常开开关，IC1 为核心智能控制单元，主要负责接收并判别输入信号，同时对信号指示灯与加热器进行控制。当 S1（与前面所述微型气体传动开关相连）闭合时，IC1 接收到此信号，首先判断此时电源电压是否高于 3.3V，如果是，则输出控制信号给加热电路，使场效应管导通，发热丝接通电源发热，加热器 9 工作，把液态的烟碱液瞬间加热，同时输出显示信号使 LED 发出红色或橙色光，模拟香烟的火头，也可输出延时信号使 LED 灯渐亮或渐灭。使模拟烟头更加形像；如果电池电压低于 3.3V，则不对加热电路输出信号，此时加热室不产生任何动作，同时 LED 输出闪烁信号，使 LED 发出 1Hz 的闪烁并连续闪烁 20 秒钟，提示电池电量不足，需要充电。当整机无动作时，IC1 进入休眠状态，整机功耗＜5uA，使整机待机时间尽可能延长（理论待机时间 6 年半）；当使用都在一分钟内连续使用本

装置十五次时，IC1 将发出信号，切断加热电路输出，同时输出信号给 LED 指示灯，连续闪烁 10 秒；当 S1 连续接通 6 秒以上时，则自动切断加热电路，同时输出信号给 LED 等。此单片还可写入其它程序以实现更多的功能和为后序的更新改善提供便利。也可以在信号输出端接一 LCD 显示屏来显示更多的信息。

本实用新型用 IC 来控制其工作过程，保证电子烟工作可靠，吸烟方式更加形象。其吸出的“烟”其实是药液气化后的“水蒸气”，不含烟焦油，一氧化碳，苯并芘，多环芳烃，亚硝胺、偶氮杂质等都是强致癌物，“水蒸气”在空气中很快会液化，不污染环境。其加热部份是低电压低电流下瞬间加热，不燃烧，没有火灾隐患。其外壳用特种不锈钢制成，可有效屏蔽电磁波。

本实用新型的非可燃性喷雾电子香烟工作过程如下：控制器100与发生器200通过连接导体6连接后组成一环保型非可燃性喷雾电子香烟；当使用都抽吸时，气流经连接导体6侧的进气孔进入发生器200，经过次级气压保压室，阻液片8，加热器9，最后由吸嘴13吸出；而控制器100与发生器200的连接导体6中间开有通孔，在使用者抽吸时，控制器100内部的气流流向发生器200，从而带动控制器100的弹性圆环401右侧独立形腔部份低于正常大气压，而在控制器200的另一侧在指示灯盖侧也开有通气孔，使电池部份型腔与大气压相通，这样在控制器200一侧负气压的作用下，开关气嘴向连接导体6一侧拉伸，从而带动其上面的动接触片与静接触片导通，导通电流，此时指示灯IC控制下慢慢变亮，同时电流通过连接导体使加热器工作；在加热室由

于气流作用药液以微滴形式喷射进雾化室，药液通过加热器9的作用瞬间雾化，雾化后的大直径微滴在涡流的作用下附壁经溢流孔被导液机构11重吸收，小直径微滴悬浮在气流中形成水蒸气经雾汽通道和吸嘴吸出。

以上所述，仅为本实用新型的较佳实例而已，并非用于限制本实用新型的保护范围。任何熟悉本技术领域的技术人员在本实用新型揭露的技术范围内，可轻易想到的变化，都应涵盖在本实用新型的保护范围之内。

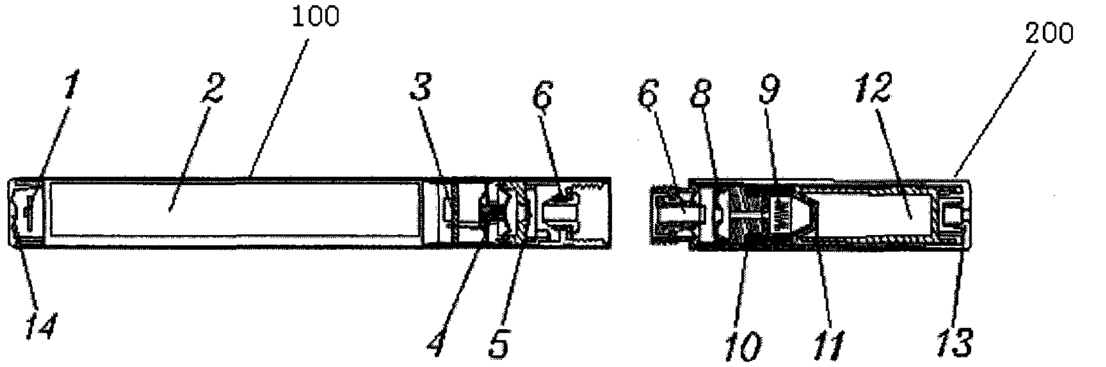


图 1

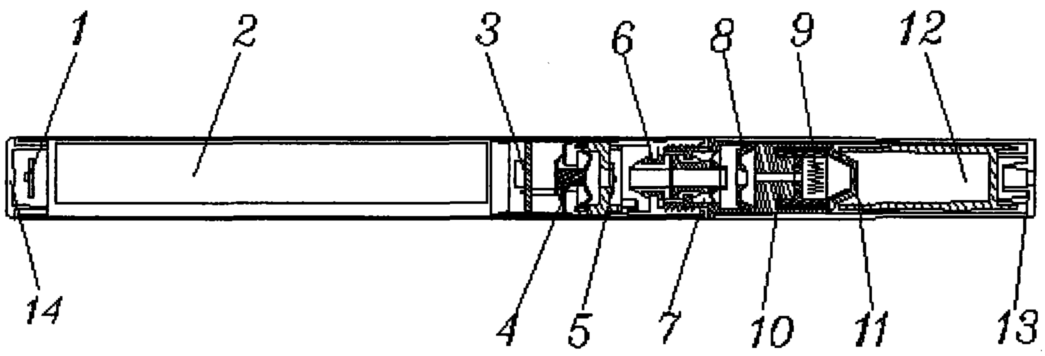


图 2

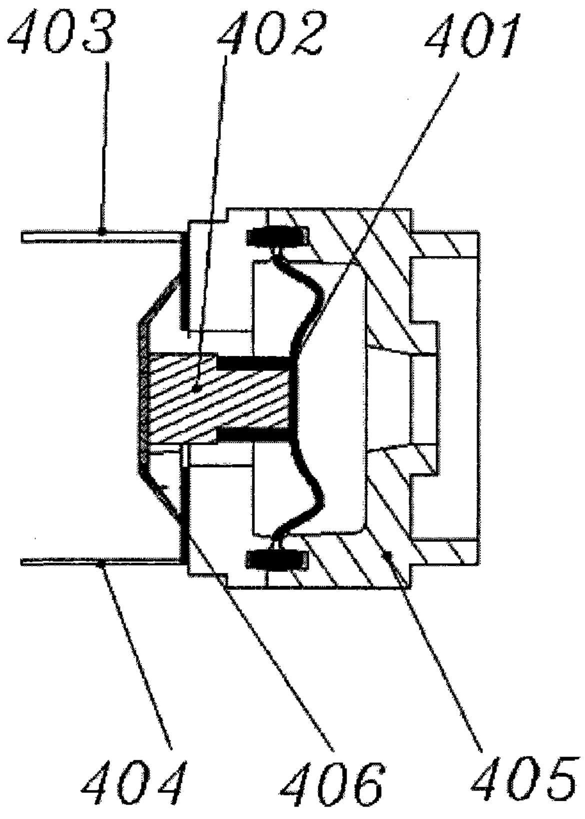


图 3

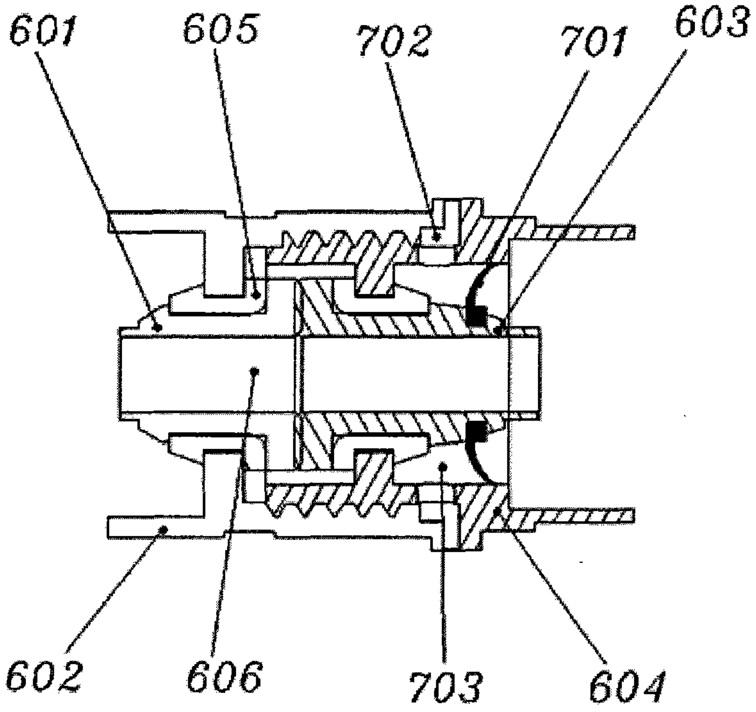

601
605
702
701
603
602
606
703
604

图 4

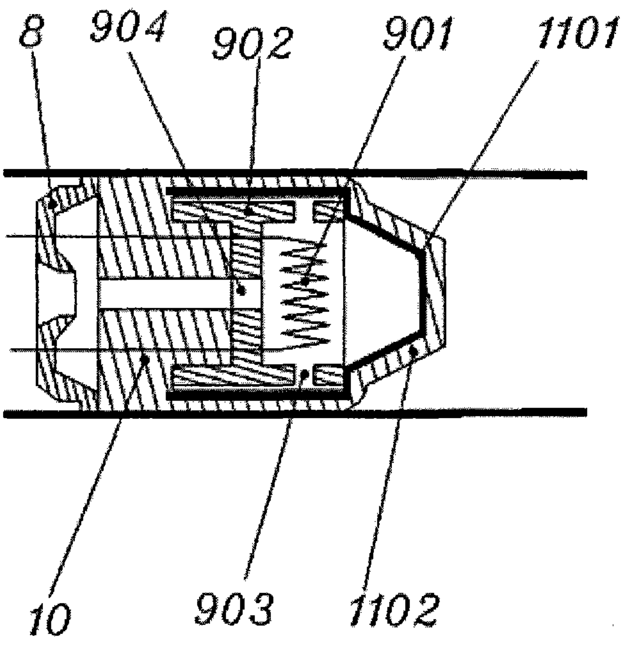

8
904
902
901
1101
10
903
1102

图 5

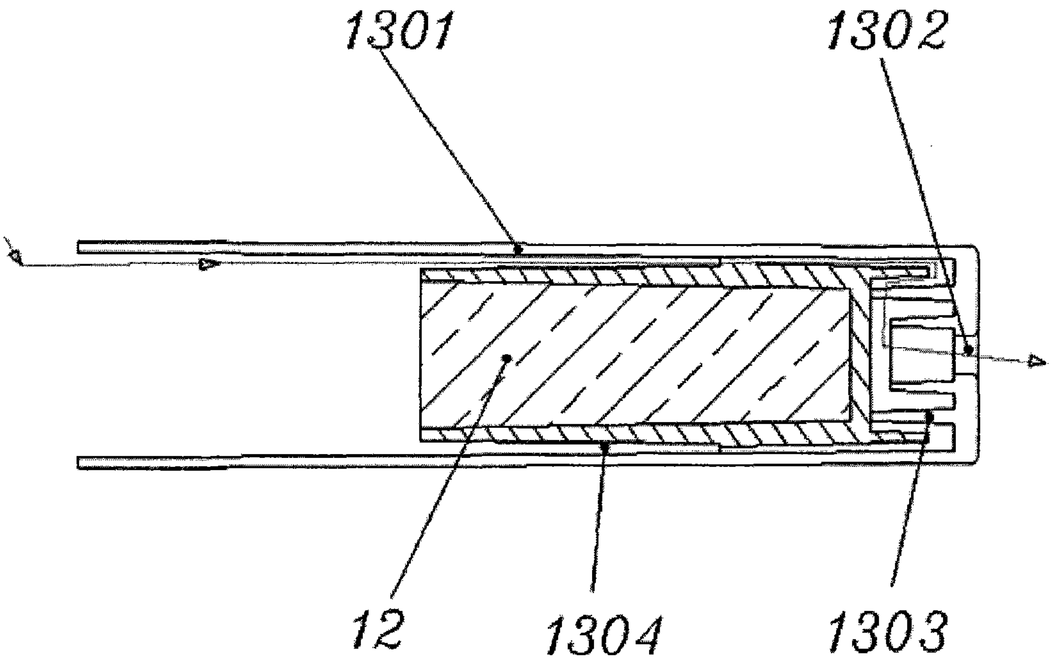

1301
1302
12
1304
1303

图 6

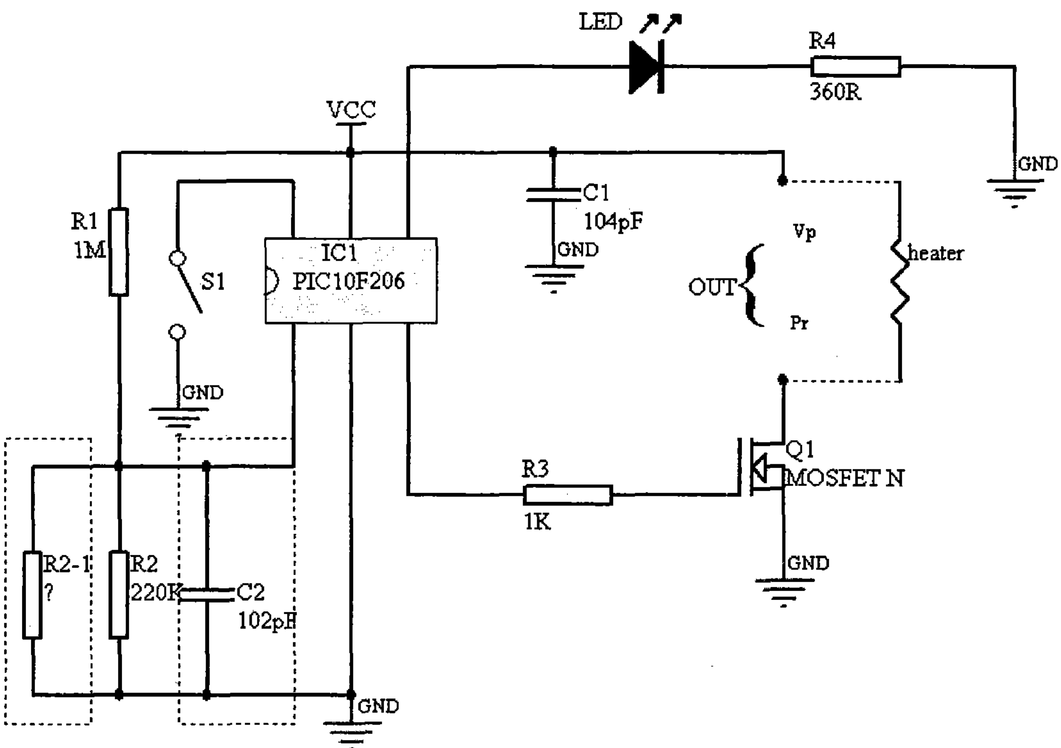

LED
R4
360R
VCC
GND
C1
104pF
GND
R1
1M
S1
IC1
PIC10F206
Vp
heater
OUT
Pr
GND
Q1
MOSFET N
R3
1K
GND
R2-1
?
R2
220K
C2
102pF
GND

图 7

Notice

DESCRIPTION CN201104488Y

10 Non-flammable spray electronic cigarette

[0001]

14 Technical field

[0002]

18 The utility model relates to a non-flammable spray electronic cigarette.

[0003]

22 Background technique

[0004]

26 Nowadays, "smoking is harmful to health" has become common knowledge. There are still more than 1 billion smokers in the world. The U.S. Environmental Protection Agency currently declares tobacco mist in the air as a Class A carcinogen.

29 According to figures released by the World Health Organization and other departments, about 4.9 million people die from smoking-related diseases each year; however, for various reasons, it is extremely difficult for smokers to quit smoking completely.

[0005]

35 Nicotine is a small molecular alkaloid, which can make people addicted to smoking, is basically harmless to the human body in small doses, and has an extremely short half-life in the blood.

37 Harmful substances in tobacco such as cigarette tar, carbon monoxide, benzopyrene, polycyclic aromatic

hydrocarbons, nitrosamines, azo impurities, etc. are all strong carcinogens, which have caused great harm to human survival and health, and second-hand smoke The harm to the surrounding people is even greater! The pollution of tobacco to the environment cannot be ignored. The latest research by Italian scientists shows that the pollution caused by smoking smoke may exceed the pollution caused by some car engine exhaust!

[0006]

45 In order to find that it can meet the needs of smoking for cigarette addiction, but also minimize the harm of tobacco, and finally quit smoking.

47 Many utility models make small doses of nicotine into products such as: "quit smoking patch", "nicotine mouthwash", "nicotine chewing gum" and other products. Although these products have certain effects, they do not have other harmful effects such as cigarette tar. The harm of substances, but it is incompatible with the habit of smoking, which has been cultivated for many years, and it is difficult to be accepted by smokers.

[0007]

54 Summary of the invention

[0008]

58 The purpose of the utility model is to provide an environmentally friendly non-flammable spray electronic cigarette with the function of a cigarette substitute, which avoids the above-mentioned shortcomings, is closer to a real humanized cigarette, and has no environmental pollution.

[0009]

64 The purpose of the utility model is achieved through the following technical solutions: a non-flammable spray electronic cigarette, including a controller and a generator, the control assembly is sequentially provided with an indicator cover, a power supply device, an integrated circuit board, and a micro A gas-driven switch and a connecting conductor. The generator is provided with a connecting conductor, a secondary air pressure holding chamber, a liquid barrier, a secondary liquid storage chamber, a heater, a liquid guiding mechanism, a liquid storage chamber and a suction nozzle in sequence. An air inlet is opened on one side of the connecting conductor, and a through hole is opened between the connecting conductor of the controller and the generator.

[0010]

75 The technical proposal of the utility model also includes: a pair of concealed ventilation holes are opened on the side of the indicator cover, and a light-emitting LED is arranged under the indicator cover.

[0011]

80 The technical scheme of the utility model also includes: the indicator light cover, the power supply device, the integrated circuit board, the miniature gas transmission switch and the connecting conductor are provided with a stainless steel shell outside, the connecting conductor, the liquid blocking sheet, and the secondary liquid storage chamber , The heater, the liquid guide mechanism, the liquid storage chamber and the outside of the suction nozzle are provided with a heat insulation layer and a stainless steel shell.

[0012]

88 The technical scheme of the utility model also includes: an elastic ring is arranged inside the micro gas transmission switch, and the micro gas transmission switch is opened into two independent chambers.

[0013]

93 The technical scheme of the utility model also includes: the miniature gas transmission switch also includes a fixed contact piece, a plastic base and a moving contact piece. The moving contact piece is connected to an elastic ring through a plastic rod, and the elastic ring is fixed in the plastic base. The contact piece is fixed outside the plastic base.

[0014]

100 The technical solution of the present invention also includes: a secondary switch air valve is also provided on the right side of the connecting conductor, and a secondary air pressure holding chamber formed thereby, and an air inlet hole is provided on the side.

[0015]

106 The technical solution of the present invention also includes: the connecting conductor includes two hollow cylindrical conductors, an internal thread and an external thread, the hollow cylindrical conductor is connected to the positive electrode of the heater's lead-in wire, and the internal thread is connected to the external thread. Thread the negative pole of the lead-in wire of the heater.

[0016]

113 The technical scheme of the present invention also includes: the heater includes a heating wire and a heat insulation seat outside of the heater, and injection holes and overflow holes are respectively opened on the bottom and side of the heat insulation seat.

[0017]

119 The technical scheme of the present invention also includes: the outer side of the suction nozzle is extended to the bottom of the liquid blocking device, and a liquid blocking groove is opened inside the suction nozzle.

[0018]

124 The technical effect of the new form of the utility model is that smoking has no harmful substances such as tar and carbon monoxide, which greatly reduces the risk of carcinogenesis. The user still has the feeling of smoking, does not need to be ignited, and there is no fire hazard. The smoke that it sucks is actually liquid liquid vaporized water. Steam, no environmental pollution.

[0019]

131 The features and advantages of the present invention will be described in detail through embodiments in conjunction with the drawings.

[0020]

136 Description of the drawings

[0021]

140 Fig. 1 is a schematic diagram of the disassembled structure of a non-flammable spray electronic cigarette according to an embodiment of the present utility model;

[0022]

145 2 is a schematic diagram of the overall structure of a non-flammable spray electronic cigarette according to an embodiment of the present invention;

[0023]

150 3 is a schematic diagram of the structure of a miniature gas-driven switch in a combustible electronic spray cigarette according to an embodiment of the present invention;

[0024]

155 4 is a structural diagram of the connection structure between the liquid guide mechanism and the atomization chamber and the liquid storage core in the combustible electronic spray cigarette according to the embodiment of the present invention;

[0025]

161 FIG. 5 is a schematic structural diagram of a pneumatic transmission switch in a non-flammable spray electronic cigarette according to an embodiment of the present invention;

[0026]

166 6 is a schematic diagram of the structure of the heater and the liquid guiding mechanism in the non-flammable spray electronic cigarette according to the embodiment of the present invention;

[0027]

171 Fig. 7 is a circuit diagram of an integrated circuit board in a non-flammable spray electronic cigarette according to an embodiment of the present invention.

[0028]

176 Detailed ways

[0029]

180 Please refer to FIG. 1, the non-flammable spray electronic cigarette of this embodiment includes a controller 100 and a generator 200.

[0030]

185 As shown in Figure 1, a transparent signal indicator cover 14 is provided at one end of the controller 100, and a pair of concealed vent holes are opened on the side of the indicator cover 14, and a connecting conductor 6 is provided at the other end for communication with the generator. 200 are connected into a whole; there is a light-emitting LED under the indicator cover 14; a rechargeable lithium battery 2, an integrated circuit board 3, a micro gas transmission switch 4, and a negative pressure chamber are arranged in sequence from the indicator cover 14 to the connecting conductor 6. 5. The outside of the controller 100 is a stainless steel shell.

191 The rechargeable lithium battery 2 is built-in. The connecting conductor 6 of the controller 100 can be connected to a charger to realize charging, and after being connected to the generator 200, an environmentally friendly non-flammable spray electronic cigarette can be formed.

[0031]

197 The generator 200 is also provided with a connecting conductor 6 on one side, and a cigarette holder 13 on the other side. From the cigarette holder 13 side, there are a liquid storage chamber 12, a liquid guiding mechanism 11, a heater 9, and a secondary liquid storage chamber 10 in sequence. , The liquid barrier 8 and the secondary air pressure holding chamber 7; the generator 200 has a heat insulation layer and a stainless steel shell respectively, and the extension of the suction nozzle 13 includes the generator 200 in it, and is connected to the generator 200 An air inlet hole is also opened on one side of the conductor 6, an air flow channel is provided between the suction nozzle 13 and the liquid reservoir 12, and a liquid blocking groove is opened at the bottom of the suction nozzle 13.

205 The controller 100 and the generator 200 are connected by a side conductor 6 with a vent hole in the middle.

which connects the negative pressure chamber 5 and the secondary pressure holding chamber 7; there is an inlet on the side where the controller and the generator are connected. Stoma; the liquid barrier 8 prevents the liquid from flowing back; the secondary liquid storage chamber 10 temporarily stores the liquid medicine, the liquid guiding mechanism 11 is in contact with the liquid medicine, and there is an atomizing studio inside the liquid guiding mechanism 11; around the periphery of the liquid medicine core There is a fog channel with a liquid medicine in the middle.

[0032]

As shown in FIG. 3, there is an elastic ring 401 inside the micro gas transmission switch 4, the cross section of the elastic ring 401 is W-shaped, the micro gas transmission switch is opened into two independent chambers, and the elastic ring 401 is connected There is an extended soft film, and a plastic rod 402 is installed in the soft film to connect the elastic ring 401 and the movable contact piece 406.

The elastic ring 401 is fixed in the plastic base 405.

The integrated circuit board 3 is provided with two fixed contact pieces 403 and 404 extending toward the elastic ring 401, and the fixed contact pieces 403 and 404 are fixed outside the plastic base 405.

[0033]

As shown in Figure 4, a secondary switch air valve 701 is also provided on the right side of the connecting conductor 6, and an air inlet 702 is provided on the side. When the user sucks, the airflow enters from the air inlet 702. The switch air valve 701 is opened by the air flow. Under the action of the air flow, a negative pressure chamber 5 is formed between the right side of the elastic ring 401 and the connecting conductor 6; the elastic ring 401 moves to the right under the action of the negative pressure. At the same time, the movable contact piece 406 connected to the plastic rod 402 is driven to move to the right, so as to be connected to the fixed contact piece 403 connected to the integrated circuit board 3; and when the user's suction is reduced, the secondary switch air valve 701 is closed, Block the air inlet 702 to maintain the negative pressure chamber 5 for a certain period of time. Only when the user stops sucking, the airflow quickly enters the negative pressure chamber 5 from the hollow channel 606 of the connecting conductor 6, and the negative pressure disappears immediately, and the elasticity is round. The ring 401 returns to its original position under the action of elastic force, the plastic rod 402 moves to the left, the movable contact piece 406 is disconnected from the fixed contact piece 403, and the switch can be turned on and off under the action of a small air flow, thereby controlling the heater 9 Real-time heating.

Among them, the elastic ring 401 can be made of rubber or silica gel.

[0034]

The connecting conductor 6 is respectively composed of an inner thread 603 and an outer thread 604 to form a connecting outer ring, which is used to connect the negative electrode of the heater's lead-in lead, and two hollow cylindrical conductors 601 and 603 are connected to the positive electrode of the heater's lead-in lead; The two connecting conductors are separated by an insulating material ring 605 between them.

The controller 100 and the generator 200 are connected with the contact copper cap of the center through a screw thread.

[0035]

252 As shown in Figure 5, the heater 9 includes a heating wire 901 and a heat-insulating seat 902 on the outside. The bottom and side of the heat-insulating seat 902 are respectively provided with injection holes 904 and overflow holes 903, and on the right side of the heater 9 there are The liquid guide mechanism 11, the liquid guide mechanism 11 is composed of a support frame 1101 and a liquid guide 1102. The support frame 1101 plays a fixed role. The liquid guide 1102 is made of multilayer nickel foam mesh or other metal porous bodies. The left side of the heater 9 is The secondary liquid storage chamber 10, the liquid barrier 8, the heating wire 901 can be made of platinum wire, nickel-chromium alloy or iron-chromium-aluminum alloy wire containing rare earth elements, or it can be made into a sheet or ring, and the heat insulation seat 902 It can be made of ceramics.

261 The secondary liquid storage chamber 10 is composed of multiple layers of foamed nickel mesh filled at the bottom and the periphery of the heat insulation seat 902. One end of the liquid guiding mechanism 11 is connected to the secondary liquid storage chamber 10 through the liquid guiding 1101, and the other end is in contact with the liquid storage chamber 12 , The liquid storage chamber 12 is a tube with an open end, and the medicinal cotton fiber is placed in the middle, and then the drug stock solution is filled. Through the capillary action of the liquid guiding mechanism 11, the liquid medicine stored in the liquid storage chamber 12 is introduced into the secondary Level storage chamber 10.

268 Under the action of the air flow, small droplets are sucked into the other side of the heat-insulating seat 902 through the spray holes 904 in the heat-insulating seat 902. Under the action of the heating wire 901, the liquid is instantly atomized and then opened in the liquid storage chamber. The through hole on the outside of 12 is sucked out through the suction nozzle 13.

272 The liquid baffle 8 can prevent the liquid in the secondary reservoir 12 from accidentally overflowing.

273 The liquid conducting liquid 1102 can also be made of stainless steel fiber felt, polymer foam and foam ceramics.

[0036]

278 Please also refer to FIG. 6, the cigarette holder cover 1301 on the outside of the mouthpiece 13 is extended to the bottom of the liquid baffle 8, and its material can be made of environmentally friendly materials such as polypropylene, which can effectively prevent internal heat from being transmitted.

281 A vent 1302 is also opened on the inner side of the suction nozzle 13, and a liquid blocking groove 1303 is also opened on the inner side of the suction nozzle hole 1304 to prevent liquid from being sucked into the mouth.

[0037]

286 As shown in Figure 7, the integrated circuit board 3 is controlled by IC, powered by a 3.7V lithium ion battery, VCC is connected to the positive electrode of the battery, GND is connected to the negative electrode of the battery, S1 is connected to a micro gas drive, which is a normally open switch, and IC1 is the core intelligence The control unit is mainly responsible for receiving and judging the input signal, and at the same time

controlling the signal indicator and heater.

291 When S1 (connected with the aforementioned micro gas transmission switch) is closed, IC1 receives this signal, and first judges whether the power supply voltage is higher than 3.3V at this time, and if it is, it outputs a control signal to the heating circuit to make the field effect tube conduction. The heating wire is connected to the power supply to generate heat, and the heater 9 works to instantly heat the liquid nicotine solution. At the same time, it outputs a display signal to make the LED emit red or orange light, which simulates the flame of a cigarette, and can also output a delay signal to make the LED light gradually Light up or fade away.

297 Make the analog cigarette butt more image; if the battery voltage is lower than 3.3V, no signal is output to the heating circuit, at this time the heating chamber does not produce any action, at the same time the LED outputs a flicker signal, so that the LED flashes at 1 Hz and flashes continuously for 20 seconds. It indicates that the battery is low and needs to be charged.

301 When the whole machine is inactive, IC1 enters the dormant state, and the power consumption of the whole machine is less than 5uA, so that the standby time of the whole machine is extended as much as possible (theoretical standby time is 6 and a half years); when used, the device is used continuously for fifteen times within one minute IC1 will send out a signal to cut off the output of the heating circuit, and at the same time output a signal to the LED indicator, flashing continuously for 10 seconds; when S1 is continuously turned on for more than 6 seconds, it will automatically cut off the heating circuit and output signals to LEDs.

307 This single chip can also be written into other programs to achieve more functions and provide convenience for subsequent updates and improvements.

309 You can also connect an LCD display to the signal output terminal to display more information.

[0038]

313 The utility model uses IC to control its working process to ensure the reliable operation of the electronic cigarette, and the smoking method is more vivid.

315 The "smoke" it sucks is actually the "water vapor" after the liquid medicine is vaporized. It does not contain smoke tar, carbon monoxide, benzopyrene, polycyclic aromatic hydrocarbons, nitrosamines, azo impurities, etc., which are all strong carcinogens. "Vapor" will quickly liquefy in the air and will not pollute the environment.

319 The heating part is instantaneously heated under low voltage and low current, no burning, no fire hazard.

320 The shell is made of special stainless steel, which can effectively shield electromagnetic waves.

[0039]

324 The working process of the non-flammable spray electronic cigarette of the present invention is as follows: the controller 100 and the generator 200 are connected through the connecting conductor 6 to form an environmentally friendly non-flammable spray electronic cigarette; when both are used for smoking, the airflow passes through the connecting conductor 6 The air inlet on the side enters the generator 200, passes through the secondary air pressure holding chamber, the liquid barrier 8, the heater 9, and finally sucked out by the suction nozzle 13; and the connecting conductor 6 of the controller 100 and the generator 200 is open. When the user inhales, the air flow inside the controller 100 flows to the generator 200, thereby driving the free-standing cavity on the right side of the elastic ring 401 of the controller 100 to be lower than the normal

atmospheric pressure, and the other part of the controller 200 There is also a vent hole on the indicator cover side to make part of the battery cavity communicate with atmospheric pressure. In this way, under the action of the negative air pressure on the side of the controller 200, the switch air nozzle is stretched to the side of the connecting conductor 6, thereby driving it. The upper moving contact piece and the static contact piece are connected to conduct current. At this time, the indicator light slowly lights up under the control of IC, and the current flows through the connecting conductor to make the heater work; in the heating chamber, the liquid medicine is in the form of droplets due to the airflow. Sprayed into the atomization chamber, the liquid medicine is instantly atomized by the action of the heater 9, and the atomized large-diameter droplets are re-absorbed by the liquid guiding mechanism **11** through the overflow hole under the action of the vortex, and the small-diameter droplets are suspended The water vapor formed in the airflow is sucked out through the mist channel and the suction nozzle.

[0040]

346 The above are only preferred examples of the present utility model, and are not used to limit the protection scope of the present utility model.

348 Any changes that can be easily conceived by those skilled in the art within the technical scope disclosed by the present utility model should be covered by the protection scope of the present utility model.

Emulation Aerosol Sucker

TECHNICAL FIELD

This utility model relates to an electronic suction apparatus, in particular, an emulation aerosol sucker that doesn't contain tar but nicotine.

BACKGROUND ART

Today when "smoking is harmful to your health" has become a common sense, there are one billion people smoking cigarettes, and this figure is still rising. On Mar. 1, 2003, the World Health Organization (WHO) issued the first international smoking ban-Framework Convention on **Tobacco** Control. According to WHO's data, smoking causes 4,900,000 deaths each year. Smoking causes serious respiratory system diseases and cancers, though it is a hard job to persuade the smokers to completely quit smoking.

Nicotine is the effective ingredient of cigarette, which produces a lot of tar mist as the cigarette burns. The tar mist accesses the pulmonary alveolus and is quickly absorbed into the blood. Nicotine thus acts on the receptor of the central nervous system, bringing the euphoria like stimulant drugs to the smokers, who feel light in the head and on wings as well.

Nicotine is a micromolecular alkaloid, which is basically harmless to human bodies with a small dosage. Plus, its half life period is extremely short in blood. Tar is the major harmful substance in tobacco. Tobacco tar comprises of several thousands of ingredients, dozens of which are carcinogenic substances. It has now been proved that second hand smoking is even more harmful to those who don't smoke.

To seek the cigarette substitutes that don't contain harmful tar but nicotine, many inventors have used the relatively pure nicotine to create such products as "Cigarette Patch", "Nicotine Gargle", "Aerosol Packed in the High Pressure Tank with Propellant", "Nicotine Chewing Gum", and "Nicotine Beverage". These products are not as harmful as tar, but are absorbed very slowly. As a result, its peak concentration can't be effectively established in blood, and the smokers can't be satisfied to the full. In addition, the smokers are deprived of the "smoking" habit. Therefore, the substituting products are not real cigarette substitutes or products helping to quit smoking.

CONTENTS OF THE UTILITY MODEL

The purpose of this utility model is to provide an emulation aerosol sucker that substitutes for cigarettes and helps the smokers to quit smoking.

The technical solution of this utility model is the further innovation of the utility model called "Aerosol Electronic Cigarette" for which the inventor filed with the State Intellectual Property Office of the People's Republic of China on Apr. 14, 2000, with the application number of 20040031182.0, and the international application number of PCT/CN2005/000337.

The purpose of this utility model is fulfilled with the following solution: this utility model includes a battery assembly, an atomizer assembly and a cigarette bottle assembly; an external thread electrode is located in one end of the battery assembly, and an internal thread electrode is located in one end of the atomizer assembly; the battery assembly and the atomizer assembly are connected through the thread electrodes, and the cigarette bottle assembly is inserted into the other end of the atomizer assembly, thus forming one cigarette type or cigar type body.

Therein, the battery assembly includes indicators, a lithium battery, a MOSFTET electric circuit board, a sensor, a silicon rubber corrugated membrane, a first thread electrode, a first negative pressure cavity, and a first shell. On one end of the first shell is the external thread electrode, while on the other end is the indicators. On one side of the first shell is an indicator cap, in which there is a fine hole. On the other side of the first shell, the lithium battery and the MOSFET electric circuit board are connected successively. The sensor is located on MOSFET electric circuit board. Between the first thread electrode and the sensor is the silicon rubber corrugated membrane, on which there is the first negative pressure cavity. The sensor is connected with the silicon rubber corrugated membrane through the reed switch fixed thereon. MCU is provided between the MOSFET electric circuit board and the sensor. On the surface of the first shell, a screen is provided. The MCU scans the sensor in the power-saving mode of pulse, and according to the signal parameters of the sensor, restricts the atomizing capacity with the integral function of frequency to single operation time. Also, the MCU accomplishes the following controls: the pulse width modulation and over discharging protection for the constant power output of the electric current; automatic cleaning function for thousands of times per operation; step lighting/dying down control of the indicators; display of the operation times and battery capacity; and automatic recovery after sensor malfunction shutdown, etc. The sensor may be switch sensor made of elastic alloy slice, Hall element of linear output, semiconductor force-sensitive chip, semiconductor matrix thermoelectric bridge chip, or capacitance and inductance sensor. The indicators are two red LEDs. The silicon rubber corrugated membrane may be made of fluorinated rubber, butyronitrile rubber, or elastic alloy film. The external thread electrode is a gold-coated stainless steel or brass part with a hole drilled in the center. The lithium battery may be either a rechargeable polymer lithium battery or a rechargeable lithium ion battery. The atomizer assembly includes the internal thread electrode, an air-liquid separator, an atomizer and the second shell. One end of the second shell is inserted into the cigarette bottle assembly for connection, while the other end of the second shell has the internal thread electrode, in which there is the second negative pressure cavity.

The air-liquid separator and the atomizer are connected with the internal thread electrode successively. On the second shell, there is an air intake channel. The internal thread electrode is a gold-coated stainless steel or brass part with a hole drilled in the center. The air-liquid separator is made of stainless steel or plastic with a hole drilled. The atomizer may be a capillary impregnation atomizer or a spray atomizer, inside which there is a heating body. The spray atomizer has a spray hole on it. The spray hole is made through molding and drilling foamed ceramics, micro-porous ceramics, foamed metal, stainless steel fiber felt, or chemical fiber. The heating body is made of a micro-porous ceramics holder on which electric heating materials, such as nickel-chromium alloy wire, iron-chromium alloy wire, or platinum wire, are wound. Alternatively, heating body may be a porous component made of electrically conductive ceramics or PTC ceramics, with a sintered electrode. The surface of the heating body is sintered into high-temperature glaze to fix the zeolite grains, which are made of natural zeolite, artificial non-organic micro-porous ceramics or aluminum oxide grains. The cigarette bottle assembly includes a cigarette liquid bottle, fiber and a suction nozzle. The fiber containing cigarette liquid is located on one end of the cigarette liquid bottle, and this end is inserted into the second shell and lies against the atomizer. The suction nozzle is located on the other end of the cigarette liquid bottle. Between the fiber and interior wall of the cigarette liquid bottle is an air suction channel. The cigarette liquid bottle and the suction nozzle are made of non-toxic plastic. The fiber is made of polypropylene fiber or nylon fiber. The cigarette liquid in the fiber for atomization contains 0.1-3.5% of nicotine, 0.05-5% of tobacco flavor, 0.1-3% of organic acid, 0.1-0.5% of stabilizer, and propanediol for the remaining. The said sucker and its connecting structure may be taken as a drug delivery device of pulmonary suction with routine medicines loaded.

This invention will bring the following benefits and active effects: For this utility model, smoking doesn't bring any cigarette tar, considerably reducing the carcinogenic risks. At the same time, the smokers can still enjoy the feel and excitement of smoking, and there is no fire hazard since there is no need for igniting. In addition, the apparatus and its connecting structure of this utility model may be loaded with conventional drugs for delivery to the lung.

DESCRIPTION OF DRAWINGS

FIG. 1 is the diagram of visual appearance of the cigarette type of this utility model.

FIG. 2A is the diagram of one structure of the battery assembly of this utility model.

FIG. 2B is the diagram of another structure of the battery assembly of this utility model.

FIG. 3 is the diagram of the atomizer assembly of this utility model.

FIG. 4 is the diagram of the cigarette bottle assembly of this utility model.

FIG. 5A is the diagram of one internal structure of this utility model.

FIG. 5B is the diagram of another internal structure of this utility model.

FIG. 6 is the diagram of the structure of the charger of this utility model.

FIG. 7 is the electric circuit diagram of MCU and MOSFET of this utility model.

FIG. 8 is the diagram of the structure of the capillary impregnation atomizer of this utility model.

FIG. 9 is the left view of FIG. 8.

FIG. 10 is the diagram of the structure of the spray atomizer of this utility model.

FIG. 11 is the left view of FIG. 10.

FIG. 12 is the diagram of the structure of the cigar type contour of this utility model.

SPECIFIC MODE FOR CARRYING OUT THE UTILITY MODEL

This utility model is further described as follows on the basis of the drawings.

Example 1

As shown in FIG. 1, the visual appearance of this utility model is similar to a cigarette inserted into the cigarette holder. The emulation aerosol sucker includes a battery assembly, an atomizer assembly and a cigarette bottle assembly. An external thread electrode 209 is located in one end of the battery assembly, and an internal thread electrode 302 is located in one end of the atomizer assembly. The battery assembly and atomizer assembly are connected through the thread electrodes into an emulation cigarette. The cigarette bottle assembly is inserted into the other end of atomizer assembly, to form one cigarette type emulation aerosol sucker.

As shown in FIG. 2A, the battery assembly includes indicators 202, a lithium battery 203, a MOSFTET electric circuit board 205, a sensor 207, a silicone rubber corrugated membrane 208, a first thread electrode 209, a first negative pressure cavity 210, and a first shell 211. On one end of the first shell 211 is the external thread electrode 209, while on the other end are the indicators 202. On one side of the shell 211, an indicator cap 201 is provided, in which there is a fine hole 501. On the other side of the shell 211, the lithium battery 203 and the MOSFET (Metallic Oxide Semiconductor Field Effect Tube) electric circuit board 205 are connected successively. The sensor 207 is located on the MOSFET electric circuit board 205. Between the first thread electrode 209 and the sensor 207 is the silicon rubber corrugated membrane 208, on which there is the first negative pressure cavity 210. The sensor 207 is connected with the silicon rubber corrugated membrane 208 through the reed switch 212 fixed thereon.

Therein, the sensor 207 may be switch sensor made of elastic alloy slice, Hall element of linear output, semiconductor force-sensitive chip, semiconductor matrix thermoelectric bridge chip, or capacitance and inductance sensor. The indicators 202 are two red LEDs. The lithium battery 203 may be either a rechargeable polymer lithium battery or a rechargeable lithium ion battery. The external thread electrode 209 is a gold-coated stainless steel or brass part with a hole drilled in the center. The silicon rubber corrugated membrane 208 may alternatively be made of fluorinated rubber, butyronitrile rubber, or elastic alloy film.

As shown in FIG. 3, the atomizer assembly includes an internal thread electrode 302, an air-liquid separator 303, an atomizer 307 and a second shell 306. One end of the second shell 306 is inserted into the cigarette bottle assembly for connection, while the other end has the internal thread electrode 302, in which there is a second negative pressure cavity 301. The air-liquid separator 303 and the atomizer 307 are connected with the internal thread electrode 302 successively. On the second shell 306, there is an air intake channel 502. The air-liquid separator 303 is made of stainless steel or plastic with a hole drilled. The internal thread electrode 302 is a gold-coated stainless steel or brass part with a hole drilled in the center.

The atomizer 307 may be a capillary impregnation atomizer as FIGS. 8 and 9 show, or a spray atomizer as FIGS. 10 and 11 show. For this embodiment, it is a spray atomizer.

As shown in FIG. 4, the cigarette bottle assembly includes a cigarette liquid bottle 401, fiber 402 and a suction nozzle 403. The fiber 402 containing cigarette liquid is located on one end of the cigarette liquid bottle 401, and this end is inserted into the second shell 306 and lies against the atomizer 307. The suction nozzle 403 is located on the other end of the cigarette liquid bottle 401. Between the fiber 402 and interior wall of the cigarette liquid bottle 401 is an air suction channel 503.

As shown in FIG. 5A, the standby state of this utility model has the fully charged battery assembly shown in FIG. 2A fastened onto the atomizer assembly shown in FIG. 3, which is then inserted into the cigarette bottle assembly shown in FIG. 4. When the user slightly sucks the suction nozzle 403 with mouth, the negative pressure is formed on the silicon rubber corrugated membrane 208 through the air suction channel 503 and the first and second negative pressure cavities 210, 301. The silicon rubber corrugated membrane 208, under the action of suction pressure difference, deforms to drive the reed switch 212 and the sensor 207, thereby starting the MOSFET electric circuit board 205. At this moment, the indicators 202 are lit gradually; the lithium battery 203 electrifies a heating body 305 inside the atomizer 307 through the MOSFET electric circuit board 205 as well as the internal and external thread electrodes 302, 209, so that the heating body 305 inside the atomizer 307 produces heat. The fiber 402 inside the cigarette liquid bottle 401 contains cigarette liquid, which soaks a micro-porous ceramics 801 inside the atomizer through the fiber 402. The air enters through the air intake hole 502, passes through the run-through hole on the air-liquid separator 303, and helps to form air-liquid mixture in a spray nozzle 304 of the atomizer 307. The air-liquid mixture sprays onto the heating body 305, gets vaporized, and is quickly absorbed into the airflow and condensed into aerosol, which passes through the air suction channel503 and is sucked out by suction nozzle 403 to form white mist type aerosol.

When suction stops, the reed switch 212 and the sensor 207 are reset; the atomizer 307 stops working; the indicators 202 gradually die down. When the operation times reaches the pre-set value, the atomizer 307 provides a work delay of 5-20 seconds per time, so as to remove the micro-dirt accumulated on the heating body 305.

Besides the micro-porous ceramics, the liquid supply material of the atomizer 307 may also be foamed ceramics, micro-porous glass, foamed metal, stainless steel fiber felt, terylene fiber, nylon fiber, nitrile fiber, aramid fiber or hard porous plastics. The heating body 305 may be a micro-porous ceramics holder on which electric heating materials, such as nickel-chromium alloy wire, iron-chromium alloy wire, or platinum wire, are wound. Alternatively, the heating body 305 may be a porous component made of electrically conductive ceramics or PTC (Positive Temperature Coefficient) thermosensitive ceramics, with a sintered electrode. The surface of the heating body 305 is sintered into high-temperature glaze to fix the zeolite grains, which are made of natural zeolite, artificial non-organic micro-porous ceramics or aluminum oxide grains. The cigarette liquid bottle 401 and the suction nozzle 403 in the cigarette bottle assembly are made of non-toxic plastic, and inside them, the fiber 402 made of polypropylene fiber or nylon fiber to absorb cigarette liquid is adhered. In the battery assembly, there is a fine hole 501 on the indicator cap 201 for balancing the pressure difference on both sides of the silicon rubber corrugated membrane 208.

The cigarette liquid for atomization contains 0.1-3.5% of nicotine, 0.05-5% of tobacco flavor, 0.1-3% of organic acid, 0.1-0.5% of stabilizer, and propanediol for the remaining.

The first and second shell 211, 306 of this utility model are made of stainless steel tube or copper alloy tube with baked-enamel coating of real cigarette color.

As shown in FIG. 12, this utility model may have the diameter of the battery assembly increased in proportion, so that it is consistent with the diameter of the atomizer assembly. Its shell may be decorated with the leaf veins and sub-gloss brown-yellow baked-enamel coating, to create a cigar type emulation aerosol sucker.

For recharging of the lithium battery 203 of this utility model, the thread electrode 601, as shown in Figure 6, that matches the external thread electrode 209 on the battery assembly may be used as the charging interface.

Example 2

As shown in FIG. 2B, the differences of this example from example 1 are as follows: MCU 206 is added between the MOSFET electric circuit board 205 and the sensor 207. On the surface of the first shell 211, there is a screen 204 for display of the battery level of the lithium battery 203 and the sucking times.

As shown in FIG. 5B, the standby state of this utility model has the fully charged battery assembly shown in FIG. 2A fastened onto the atomizer assembly shown in FIG. 3, which is then inserted into the cigarette bottle assembly shown in FIG. 4. When the user slightly sucks the suction nozzle 403 with mouth, the negative pressure is formed on the silicon rubber corrugated membrane 208 through the air suction channel 503 and the first and second negative pressure cavities 210, 301. The silicon rubber corrugated membrane 208, under the action of suction pressure difference, deforms to drive the reed switch 212 and the sensor 207, thereby starting the MCU 206 and the MOSFET electric circuit board 205. At this moment, the indicators 202 are lit gradually; the lithium battery 203 electrifies a heating body 305 inside the atomizer 307 through the MOSFET electric circuit board 205 as well as the internal and external thread electrodes 302, 209, so that the heating body 305 inside the atomizer 307 produces heat. The fiber 402 inside the cigarette liquid bottle 401 contains cigarette liquid, which soaks a micro-porous ceramics 801 inside the atomizer through the fiber 402. The air enters through the air intake hole 502, passes through the run-through hole on the air-liquid separator 303, and helps to form air-liquid mixture in a spray nozzle 304 of the atomizer 307. The air-liquid mixture sprays onto the heating body 305, gets vaporized, and is quickly absorbed into the airflow and condensed into aerosol, which passes through the air suction channel503 and is sucked out by suction nozzle 403 to form white mist type aerosol.

As shown in FIG. 7, when the action of suction actuate the sensor, the MCU 206 scans the sensor 207 in the power-saving mode of pulse, and according to the signal parameters of the sensor 207, restricts the atomizing capacity with the integral function of frequency to single operation time. Also, the MCU 206 accomplishes the following control functions: the pulse width modulation and over discharging protection for the constant power output of the power supply, automatic cleaning function for thousands of times per operation, step lighting/dying down control of the indicators, display of the operation times and battery capacity, automatic recovery after sensor malfunction shutdown, etc.

The apparatus and its connecting structure of this utility model may be taken as a drug delivery device of pulmonary suction with routine medicines loaded.

Claims

1. An emulation aerosol sucker, characterized in that it includes a battery assembly, an atomizer assembly and a cigarette bottle assembly, wherein the cigarette bottle assembly includes a cigarette liquid bottle and the atomizer assembly includes an atomizer, and wherein the cigarette bottle assembly is inserted into one end of the atomizer assembly, thus forming one cigarette type or cigar type body.

2. The emulation aerosol sucker of claim 1, characterized in that an external thread electrode is located in one end of the battery assembly and an internal thread electrode is located in one end of the atomizer assembly, and wherein the battery assembly and atomizer assembly are connected through the thread electrodes.

3. The emulation aerosol sucker of claim 1 or 2, characterized in that the battery assembly includes a lithium battery, a MOSFTET electric circuit board, a sensor, a first thread electrode, a first negative pressure cavity, and a first shell, wherein on one end of the first shell is the external thread electrode, and on the other side of the first shell, the lithium battery and the MOSFET electric circuit board are connected successively, and wherein the sensor is located on the MOSFET electric circuit board.

4. The emulation aerosol sucker of claim 3, characterized in that the said battery assembly further includes a silicon rubber corrugated membrane, wherein between the first thread electrode and the sensor, the silicon rubber corrugated membrane is installed, on which there is the first negative pressure cavity, and wherein the sensor is connected with the silicon rubber corrugated membrane through a reed switch fixed thereon.

5. The emulation aerosol sucker of claim 3, characterized in that the battery assembly further includes indicators, which are mounted on the other end of the first shell, wherein an indicator cap is provided on one side of the first shell and a fine hole is in the indicator cap, wherein MCU is provided between the MOSFET electric circuit board and the sensor, and wherein on the surface of the first shell, a screen is provided.

6. The emulation aerosol sucker of claim 5, characterized in that the MCU scans the sensor in a power-saving mode of pulse, and restricts the atomizing capacity with the integral function of frequency to single operation time according to the signal parameters of the sensor, wherein the MCU also accomplishes the following controls:

the pulse width modulation and over discharging protection for the constant power output of the electric current; automatic cleaning function for thousands of times per operation; step lighting/dying down control of the indicators; display of the operation times and battery capacity; and automatic recovery after sensor malfunction shutdown, and wherein the indicators are two red LEDs.

7. The emulation aerosol sucker of claim 3, characterized in that the sensor is a switch sensor made of elastic alloy slice, Hall element of linear output, semiconductor force-sensitive chip, semiconductor matrix thermoelectric bridge chip, or capacitance and inductance sensor.

8. The emulation aerosol sucker of claim 4, characterized in that the silicon rubber corrugated membrane is made of fluorinated rubber, butyronitrile rubber, or elastic alloy film.

9. The emulation aerosol sucker of claim 3, characterized in that the external thread electrode is a gold-coated stainless steel or brass part with a hole drilled in the center, and wherein the lithium battery is either a rechargeable polymer lithium battery or a rechargeable lithium ion battery.

10. The emulation aerosol sucker of claim 1 or 2, characterized in that the atomizer assembly includes the internal thread electrode, an atomizer and the second shell, wherein one end of the second shell is inserted into the cigarette bottle assembly for connection, while the other end of the second shell has the internal thread electrode, in which there is the second negative pressure cavity.

11. The emulation aerosol sucker of claim 3, characterized in that the atomizer assembly includes the internal thread electrode, an atomizer and the second shell, wherein one end of the second shell is inserted into the cigarette bottle assembly for connection, while the other end of the second shell has the internal thread electrode, in which there is the second negative pressure cavity.

12. The emulation aerosol sucker of claim 11, characterized in that the said atomizer assembly includes an air-liquid separator, wherein the air-liquid separator and the atomizer are connected with the internal thread electrode successively, and wherein on the second shell, there is an air intake channel.

13. The emulation aerosol sucker of claim 12, characterized in that the internal thread electrode is a gold-coated stainless steel or brass part with a hole drilled in the center, and wherein the air-liquid separator is made of stainless steel or plastic with a hole drilled.

14. The emulation aerosol sucker of claim 10, characterized in that the atomizer is a capillary impregnation atomizer or a spray atomizer, inside which there is a heating body, and wherein the spray atomizer has a spray hole on it.

15. The emulation aerosol sucker of claim 11, characterized in that the atomizer is a capillary impregnation atomizer or a spray atomizer, inside which there is a heating body, and wherein the spray atomizer has a spray hole on it.

16. The emulation aerosol sucker of claim 15, characterized in that the spray hole is made through molding and drilling foamed ceramics, micro-porous ceramics, foamed metal, stainless steel fiber felt, or chemical fiber.

17. The emulation aerosol sucker of claim 15, characterized in that the heating body is made of a micro-porous ceramics holder on which electric heating materials that are nickel-chromium alloy wire, iron-chromium alloy wire or platinum wire are wound, or the heating body is a porous component made of electrically conductive ceramics or PTC ceramics, with a sintered electrode, and wherein the surface of the heating body is sintered into high-temperature glaze to fix the zeolite grains, which are made of natural zeolite, artificial non-organic micro-porous ceramics or aluminum oxide grains.

18. The emulation aerosol sucker of claim 3, characterized in that the cigarette bottle assembly includes a cigarette liquid bottle, fiber and a suction nozzle, wherein the fiber containing cigarette liquid is located on one end of the cigarette liquid bottle, and this end is inserted into the second shell and lies against the atomizer, wherein the suction nozzle is located on the other end of the cigarette liquid bottle, and wherein between the fiber and interior wall of the cigarette liquid bottle is an air suction channel.

19. The emulation aerosol sucker of claim 11, characterized in that the cigarette bottle assembly includes a cigarette liquid bottle, fiber and a suction nozzle, wherein the fiber containing cigarette liquid is located on one end of the cigarette liquid bottle, and this end is inserted into the second shell and lies against the atomizer, wherein the

suction nozzle is located on the other end of the cigarette liquid bottle, and wherein between the fiber and interior wall of the cigarette liquid bottle is an air suction channel.

20. The emulation aerosol sucker of claim 18, characterized in that the said cigarette liquid bottle and the suction nozzle are made of non-toxic plastic, and wherein the said fiber is made of polypropylene fiber or nylon fiber.

Abstract

The utility model relates to an electronic suction apparatus, in particular to a emulation aerosol sucker which contains only nicotine without tar. The emulation aerosol sucker comprises a battery assembly, an atomizer assembly and a cigarette bottle assembly. An external thread electrode is located in one end of the battery assembly, and an internal thread electrode is located in one end of the atomizer assembly. The battery assembly and the atomizer assembly are connected through the thread electrodes. The cigarette bottle assembly is inserted into one end of the atomizer assembly, thus forming one cigarette type or cigar type body. The utility model contains no tar for smokers, greatly reduces carcinogenic risks, and leads users to have usual smoking feeling and excitement; the utility model does not need ignition and have fire hazard. The apparatus and the connection structure of the utility model can be taken as a drug delivery device of pulmonary suction medicines with routine medicines loaded.

VERIFICATION OF TRANSLATION

I, CHEN Lu

of Peksung Intellectual Property Ltd.
do hereby certify that I am familiar with the English and Chinese languages and that to the best of my knowledge and belief the following is a true translation into the English language of the specification of CN201067079Y(Application number: CN200620090805) published in Chinese.

Dated this 27th day of October, 2014.

Signature of translator:
CHEN Lu

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(54) Bezeichnung: **VORRICHTUNG ZUR ABGABE VON MEDIKAMENTEN**

Beschreibung

[0001] Diese Erfindung betrifft Vorrichtungen zur Abgabe vom Medikamenten und insbesondere aber nicht ausschließlich Zerstäuber und dosimetrische Inhalationshilfen.

[0002] Es sind zahlreiche verschiedene Typen von Zerstäubern zur direkten Abgabe von Medikamenten in die Lunge eines Patienten bekannt, gewöhnlich zur Behandlung von Erkrankungen der Atemwege. Zerstäuber geben das Medikament normalerweise in der Form von Tröpfchen oder eines trockenen Pulvers ab. In den meisten Zerstäubern erfolgt die Zerstäubung des Medikaments in einen Luftstrom kontinuierlich, unabhängig davon, ob der Patient ein- oder ausatmet. Die kontinuierliche Zerstäubung hat jedoch zur Folge, daß ein signifikanter Anteil des Medikaments während des Ausatmens verloren geht.

[0003] Die allgemein bekannten Zerstäuber sind entweder pneumatisch bestätigt, mit Hilfe einer Druckluftquelle, die an den Zerstäuber angeschlossen ist, der die Flüssigkeit zerstäubt, oder es sind Ultraschallzerstäuber, die die Flüssigkeit mit einem piezoelektrischen Kristall zerstäuben. In jüngerer Zeit ist ein siebartiger Zerstäuber entwickelt worden, bei dem das Medikament durch ein feines Sieb gedrückt wird, um Tröpfchen des Medikaments zu erzeugen. Ein weiterer Typ eines Zerstäubers oder Inhalationsgerätes ist von der Art, die einen piezoelektrischen Vibrator in Verbindung mit einer elektrostatischen Ladungsplatte verwendet, um ein Trockenpulver zu fluidisieren und als Aerosol in einem Luftstrom zu dispergieren. Ein solcher Zerstäuber wird in US 5 694 920 beschrieben.

[0004] Der optimale Durchmesser der Partikel oder Tröpfchen des Medikaments beträgt etwa 1–5 µm. Wenn die Partikel oder Tröpfchen größer sind als dieser Wert, werden sie mit hoher Wahrscheinlichkeit im Luftweg aufprallen, bevor sie die Lunge erreichen, und wenn sie kleiner sind als 1 µm, haben sie die Tendenz, beim Ausatmen wieder aus der Lunge ausgetragen zu werden, ohne daß sie sich in der Lunge absetzen.

[0005] Zerstäuber und Inhalationsgeräte dispergieren die kleinen Partikel des Medikaments in einen Luftstrom oder einen Strom eines anderen Gases, der zu einem Patienten führt. Soweit auf die Luft Bezug genommen wird, die als Träger für das darin mitgeführte Medikament dient, sollen andere Gase eingeschlossen sein, die als Träger für das Medikament geeignet sind.

[0006] Ein bekannter Zerstäuber analysiert die Druckänderungen innerhalb der Vorrichtung während der ersten drei Atemzüge, um eine mittlere Form des Atmungsmusters zu bestimmen. Ein zeitlich abgestimmter Zerstäubungsimpuls beginnt, wenn die nachfolgende Einatmungsphase einsetzt, so daß die Zerstäubung während der ersten 50% der Einatmungsphase stattfindet. Dies ist in Fig. 1 illustriert, wo das Atmungsmuster und der Impuls überlagert dargestellt ist. Dadurch wird der Verlust an Medikament während der Ausatmung auf etwa 3% reduziert. Fig. 1 zeigt die Atemzüge in einer Graphik, in der der Durchsatz gegen die Zeit aufgetragen ist. Wenn die Behandlung beginnt, atmet der Patient durch den Zerstäuber dreimal ein und aus, bevor die Behandlung einsetzt. Die ersten drei Atemzüge werden gemessen, so daß der zeitlich abgestimmte Zerstäubungsimpuls während 50% der mittleren Einatmungszeit auftritt. Die Dauer der Einatmungsphase ist mit T1, T2 und T3 angegeben. Diese Zeitspannen werden gemittelt und durch 2 dividiert, um die Impulslänge für den nächsten, vierten Atemzug zu bestimmen, bei dem die Behandlung beginnt. Für jeden nachfolgenden Atemzug wird die Dauer des Zerstäubungsimpulses bestimmt, indem die Dauer der Einatmungsphasen der vorherigen drei Atemzüge summiert und durch 3 dividiert wird, um einen Mittelwert zu erhalten, und indem dann durch 2 dividiert wird. Die an den Patienten abgegebene Dosis ist direkt proportional zur Dauer des Zerstäubungsimpulses, und somit wird die Zerstäubungsperiode summiert, und der Zerstäuber wird abgeschaltet oder zeigt an, daß der Patient aufhören sollte, sobald die an den Patienten verabreichte Dosis die für diese Behandlung vorgeschriebene Menge des Medikaments erreicht.

[0007] Es sind andere Zerstäuber bekannt, bei denen der zeitlich abgestimmte Zerstäubungsimpuls auf einen anderen Wert als 50% der Dauer der Einatmung festgelegt ist. Bei diesen anderen Zerstäubern muß jedoch die Impulslänge für jeden Patienten durch das medizinische Personal eingestellt werden. Viele der Zerstäuber sind deshalb nur für den Gebrauch in einer kontrollierten Umgebung, etwa in einem Krankenhaus geeignet. Die Einstellung der Impulslänge für jeden Patienten bedeutet, daß die meisten Zerstäuber nicht für den Heimgebrauch durch einen Patienten geeignet sind.

[0008] DE 36 36 669 beschreibt eine Vorrichtung zur Abgabe eines Aerosols in die Atemwege eines Patienten, die getrennte Einatmungs- und Ausatmungsleitungen aufweist. In der Einatmungsleitung ist ein Aerosolerzeuger angeordnet, der nur während der Ausatmungsphase des Patienten ein Aerosol erzeugt, so daß das Aerosol einen Bereich in der Einatmungsleitung füllt. Beim Einatmen des Patienten wird das Aerosol aus der

Eintatmungsleitung in die Lunge des Patienten eingesogen. Das Volumen des Aerosols ist jedoch festgelegt. Das Volumen des Aerosols ist festgelegt, damit es für das angenommene Atemvolumen angemessen ist, wenn ein Patient in einer bestimmten Weise atmet.

[0009] GB 2 077 444 beschreibt eine Vorrichtung, die geeignet ist für den Gebrauch bei der Bestimmung von wenigstens zwei Parametern eines menschlichen oder tierischen Atmungssystems. Die Vorrichtung umfaßt einen Drucksensor, einen Durchflußsensor, einen Volumensensor, eine Überwachungseinheit und eine Berechnungseinheit, wodurch während jedes Atmungszyklus die Überwachungseinheit wenigstens zwei Sätze von gemessenen Werten für den Druck und den Durchfluß und das Volumen an die Berechnungseinheit liefert und die Berechnungseinheit die gewünschten Parameter des Atmungssystems anhand der Sätze der gemessenen Werte berechnet. Das Volumen wird in herkömmlicher Weise berechnet, indem der Durchfluß über die Zeit integriert wird.

[0010] Es wird verwiesen auf unsere parallel anhängige internationale Patentveröffentlichung Nr. WO 97/48 431. Fig. 2 und Fig. 3 der vorliegenden Anmeldung zeigen den Zerstäuber, der in der oben genannten parallelen Patentanmeldung offenbart ist. In Fig. 2 ist ein Mundstück **1** gezeigt, durch das ein Patient in Richtung des Pfeiles **2** inhaliert. Unterhalb des Mundstücks **1** befindet sich ein entfernbarer Zerstäuberteil **3**, der seinerseits auf einem Sockel **4** ruht.

[0011] Der Sockel **4** ist in Fig. 3 genauer gezeigt. Gemäß Fig. 3 weist der Sockel **4** einen Einlaß **5** auf, durch den Luft unter Druck von einem Kompressor (nicht gezeigt) zugeführt wird. Die Druckluft wird über ein Rohr **6** zu einem Verteiler **7** geleitet, der die Strömung der Druckluft zu einem Luftauslaß **8** steuert, der Luft in den in Fig. 2 gezeigten Zerstäuberteil **3** lenkt. Der Sockel **4** enthält außerdem einen Drucksensor **9**, der über einen Port **10** den Druck im Inneren des Zerstäuberteils **3** erfaßt.

[0012] Wie wieder in Fig. 2 gezeigt ist, strömt Luft unter Druck durch den Luftauslaß **8** des Sockels **4** und wird durch eine rohrförmige Säule **11** zu einer Zerstäuberdüse **12** geleitet, aus der die Luft unter Druck austritt. Im Weg der aus der Düse **12** austretenden Druckluft ist ein Deflektor **13** angeordnet, so daß die Druckluft seitlich abgelenkt wird und unterhalb eines Schildes **14** durchströmt. Der Druchtritt der Druckluft durch das obere Ende der rohrförmigen Säule **11** bewirkt, daß das Medikament **15** zwischen der äußeren Oberfläche der rohrförmigen Säule **11** und der inneren Oberfläche einer die rohrförmige Säule **11** umgebenden Hülse **16** nach oben angesaugt wird. Das Medikament **15** wird in den Luftstrom zerstäubt und in dem Luftstrom unterhalb des Randes des Schildes **14** und nach oben durch das Mundstück **1** zu einem Patienten mitgenommen.

[0013] Der Drucksensor **9** im Sockel **4** überwacht das Atmungsmuster eines Patienten, und auf der Grundlage des Atmungsmusters wird der Verteiler **7** so gesteuert, daß er die Druckluft nur während der ersten 50% einer Inhalationsphase zum Zerstäuberteil **3** zuführt.

[0014] Während oben ein spezieller Typ eines Zerstäubers beschrieben wurde, ist die vorliegende Anmeldung für den Einsatz in einem beliebigen Typ eines Zerstäubers geeignet.

[0015] Die Erfindung bezieht sich auch auf andere Vorrichtungen zur Abgabe von Medikamenten, beispielsweise auf Dosimeter, bei denen eine Dosis eines Medikaments in Tröpfchen- oder Pulverform in eine Dosimeterkammer oder Haltekammer freigesetzt wird, aus der es der Patient inhaliert. Diese Vorrichtungen sind besonders geeignet für ältere Patienten oder Kinder, die Schwierigkeiten beim Gebrauch eines Multidosis- oder Trockenpulver-Inhalationsgerätes haben, z.B. weil es ihnen schwerfällt, die Freisetzung des Medikaments mit dem Beginn der Einatmungsphase zu koordinieren oder weil ihre Atmungsdurchsätze zu klein sind. Dosimeter werden z.B. in der internationalen Patentveröffentlichung Nr. WO 96/13294 beschrieben.

[0016] Gemäß einem ersten Aspekt der vorliegenden Erfindung umfaßt eine Abgabevorrichtung für Medikamente eine Abgabeeinrichtung zur Abgabe von mit Medikamenten beladener Luft sowie von Luft, die keinerlei Medikamente trägt, zur Einatmung durch einen Patienten, eine Überwachungseinrichtung zur Überwachung eines Atmungsmusters des Patienten und eine Steuereinrichtung zur Steuerung der Abgabeeinrichtung zur selektiven Abgabe der mit Medikamenten beladenen Luft und der Luft, die keinerlei Medikamente trägt, dadurch gekennzeichnet, daß die Steuereinrichtung dazu ausgebildet ist, die Abgabeeinrichtung so zu steuern, daß sie die mit Medikamenten beladene Luft in Impulsen abgibt, deren Länge und deren Verhältnis zur Einatmungsphase des Atmungsmusters durch die Steuereinrichtung in Abhängigkeit von dem durch die Überwachungseinrichtung überwachten Atmungsmuster variiert wird.

[0017] Ein Verfahren zur Bestimmung der Dauer eines Impulses, während dessen mit Medikamenten bela-

dene Luft während der Einatmung an einen Patienten abgegeben wird, umfaßt:
(i) Messung des Atemvolumens eines Patienten;
(ii) Messung der Dauer der Einatmungsphase eines Patienten;
(iii) Speichern eines Schätzwertes für das Volumen der oberen Luftwege eines Patienten und
(iv) Berechnen der Dauer des Impulses auf der Grundlage des gemessenen Atemvolumens des Patienten, der gemessenen Dauer der Einatmungsphase und des gespeicherten Schätzwertes für das Volumen der oberen Luftwege des Patienten.

[0018] In diesem Dokument bedeutet "obere Luftwege eines Patienten" den Mund und die Luftröhre und, sofern ein Zerstäuber verwendet wird, vorzugsweise einschließlich des Volumens der Zerstäuberkammer.

[0019] Die Bestimmung der Länge der Impulse ermöglicht es, den Anteil der Inhalationszeit, während der die Zerstäubung stattfindet, über 50% hinaus gegen 100% auszudehnen. Dies führt dazu, daß der Patient seine Behandlung in kürzerer Zeit erhält, da es weniger Atemzüge braucht, die erforderliche Dosis des Medikaments abzugeben. Allerdings ist es zwecklos, die Abgabe des Medikaments in die Luft fortzusetzen, die vom Patienten gegen Ende seiner Einatmungsphase eingeatmet wird (das Endvolumen), da sie in den oberen Luftwegen verbleiben wird. Das Medikament, das nicht über die oberen Luftwege hinaus kommt, geht verloren, wenn der Patient ausatmet.

[0020] Somit ermöglicht es die Erfindung, einen Impuls zu erzeugen, der länger ist als 50% aber endet, bevor das Endvolumen der Einatmung beginnt. Ein weiterer Vorteil dieser Erfindung besteht darin, daß der Patient die Behandlungsvorschriften wesentlich besser einhalten wird, wenn die Länge der Behandlung reduziert ist.

[0021] Zudem erlaubt die Erfindung die automatische Optimierung der Impulslänge, ohne daß sie durch das medizinische Personal eingestellt werden muß. Das bedeutet, daß die Impulslänge auf der Grundlage des Atmungsmusters des Patienten zu dem Zeitpunkt, an dem das Medikament verabreicht wird, automatisch an jeden Patienten angepaßt wird. Somit kann ein Zerstäuber oder eine andere Medikamentenabgabevorrichtung von dem Patienten außerhalb der kontrollierten Umgebung eines Krankenhauses benutzt werden und kann insbesondere auch zu Hause benutzt werden. Außerdem ist es möglich, daß das Gerät anzeigt, wenn eine bestimmte Dosis verabreicht worden ist, so daß der Patient nicht die Anzahl der Atemzüge zu zählen braucht, die er genommen hat.

[0022] Gemäß der bevorzugten Ausführungsform umfaßt die Einrichtung zur Messung des Atemvolumens eines Patienten eine Einrichtung zur Messung eines Spitzenwertes des Atemstroms des Patienten und eine Einrichtung zur Vorhersage des Atemvolumens, zur Berechnung des Atemvolumens auf der Grundlage des Spitzenwertes des Atemstroms, der von der Einrichtung zur Messung des Spitzenwertes des Atemstromes gemessen wird, und auf der Grundlage der vom Zeitgeber gemessenen Dauer der Einatmung.

[0023] Einige oder sämtliche Werte, die in den Berechnungen verwendet werden, sind Mittelwerte, die aus einer Anzahl früherer Messungen für jedes Atmungsmuster abgeleitet sind. Zum Beispiel wird der Patient mit der Einatmung durch das Gerät beginnen, und das Medikament wird nicht während der ersten drei Atemzüge verabreicht. Die ersten drei Atemzüge werden analysiert, indem die Dauer der Einatmungsphase und die Spitzenströme während der Einatmung aufgezeichnet werden, wie sie benötigt werden, um die Dauer eines Zerstäubungsimpulses zu bestimmen. Die Abgabe des Medikaments erfolgt beim vierten und den nachfolgenden Atemzügen, wobei jeweils die Werte in den Berechnungen aus einer Anzahl früherer Messungen der Einatmungsphase eines Patienten abgeleitet sind, in diesem Fall aus den vorherigen drei Einatmungsphasen.

[0024] Wenn das Gerät ein Zerstäuber ist, erfolgt die Zerstäubung vorzugsweise mit Hilfe eines Gasstroms unter Druck, der durch den Zerstäuber hindurchströmt und von einer Zufuhreinrichtung für Gas bereitgestellt wird. Bei diesem Gas handelt es sich normalerweise um Luft, und die Zufuhreinrichtung ist vorzugsweise ein Kompressor, der mit einem Akkumulator zusammenwirkt. Bei der Zerstäubung wird Gas aus dem Akkumulator dazu verwendet, das Medikament zu zerstäuben, und der Kompressor erzeugt Druckluft zum Füllen des Akkumulators.

[0025] Wenn ein Patient einatmet, kann der Akkumulator geleert werden, so daß die Zerstäubung unterbrochen wird. Deshalb enthält der Zerstäuber vorzugsweise eine Einrichtung zur Begrenzung der Dauer des Impulses, so daß der Akkumulator in einem Zustand gehalten wird, in dem er stets unter gewissem Druck steht. Außerdem kann der Akkumulator ein Ventil aufweisen, das, wenn der Akkumulator voll ist, Gas an die Atmosphäre abgibt und so verhindert, daß der Akkumulator gefährlich überfüllt wird. Häufig ist es besser, den Kompressor ständig in Betrieb zu halten und die überschüssige Luft an die Atmosphäre abzugeben als den Kompressor ein- und auszuschalten.

[0026] Ein Verfahren zur Vorhersage des Atemvolumens eines Patienten umfaßt:
(i) Messung des Spitzenstromes eines Patienten;
(ii) Messung der Dauer der Einatmungsphase des Patienten;
(iii) Berechnen des Atemvolumens auf der Grundlage des gemessenen Spitzenstromes und der gemessenen Dauer der Einatmungsphase des Patienten.

[0027] Die Messung des Atemvolumens des Patienten beinhaltete bisher die fortlaufende Überwachung des Atemstromes des Patienten, typischerweise alle 10 Millisekunden. Der Strömungsdurchsatz wird dann über die Dauer der Einatmung integriert, um das Einatemvolumen zu bestimmen. Gemäß der Erfindung kann jedoch das Atemvolumen eines Patienten wesentlich einfacher bestimmt werden. Diese Erfindung verringert das Ausmaß der erforderlichen Datenverarbeitung und vermindert damit die Gesamtkosten für den Zerstäuber. Der Sptizenstrom ist wesentlich einfacher zu messen und kann einfacher in einer Berechnung zur Bestimmung des Atemvolumens benutzt werden.

[0028] Ausführungsformen der vorliegenden Erfindung werden nachstehend als Beispiel und unter Bezugnahme auf die beigefügten Zeichnungen beschrieben, in denen zeigen:

[0029] Fig. 1 eine Graphik, die das Einatmungsmuster eines Patienten im Verlauf der Zeit angibt und zeigt, wann der Zerstäubungsimpuls in den ersten 50% der Einatmungsphase auftritt, wie es bei einem bekannten Zerstäuber der Fall ist;

[0030] Fig. 2 und Fig. 3 einen bekannten Zerstäuber, der Zerstäubungsimpulse während der ersten 50% der Einatmungsphase erzeugt;

[0031] Fig. 4 ein Flußdiagramm, das zeigt, wie der Zerstäubungsimpuls während der Einatmung bestimmt wird;

[0032] Fig. 5 eine Graphik, in der das vorhergesagte Atemvolumen gegen das gemessene Atemvolumen aufgetragen ist;

[0033] Fig. 6 ein Flußdiagramm, das die Begrenzung der Impulslänge in Abhängigkeit von der Zufuhr von Druckgas zeigt;

[0034] Fig. 7 den Zerstäuber zusammen mit einer Quelle für Druckgas;

[0035] Fig. 8 einen Luftakkumulator im Luft-Zufuhrsystem;

[0036] Fig. 9 ein Blockdiagramm, das zeigt, wie der Zerstäuber gesteuert wird; und

[0037] Fig. 10 eine Skizze eines Dosimeters gemäß der vorliegenden Erfindung.

[0038] Diese Erfindung bezieht sich u.a. auf Zerstäuber von der Art, die Zerstäubungsimpulse erzeugen, wie bei dem oben beschriebenen herkömmlichen Zerstäuber.

[0039] Die Erfindung ist jedoch nicht auf den oben beschriebenen speziellen Zerstäuber beschränkt, sondern kann auf andere Zerstäuber angewandt werden. Der Einfachheit halber wird die nachstehende Beschreibung der vorliegenden Erfindung auf die Komponenten der herkömmlichen Vorrichtung Bezug nehmen, wie sie in Fig. 2 und Fig. 3 gezeigt, ist, und weil viele dieser Komponenten, z.B. der Verteiler, in der vorliegenden Erfindung verwendet werden können. Der Zerstäuber kann ein Strahlzerstäuber, ein Ultraschallzerstäuber oder ein Druck-Siebzerstäuber sein.

[0040] Bei Strahlzerstäubern gibt es zwei Arten, nämlich Luftstrahlzerstäuber und Flüssigkeitsstrahlzerstäuber. Ein Beispiel eines Luftstrahlzerstäubers, der mit einer Druckluftquelle zur Zerstäubung einer Flüssigkeit arbeitet, wird in EP 0 627 266 beschrieben (Medic-Aid Limited). Ein Beispiel eines Flüssigkeitsstrahlzerstäubers, der eine Flüssigkeit durch eine oder mehrere Düsenauslässe preßt, um ein Spray aus feinen Tröpfchen zu erzeugen, wird in WO 94/07607 beschrieben (Boehringer Ingelheim International GmbH et al).

[0041] Ultraschallzerstäuber, die Flüssigkeit mit Hilfe von Ultraschallwellen zerstäuben, die gewöhnlich von einem oszillierenden piezoelektrischen Element erzeugt werden, haben viele Formen, einschließlich solcher, bei denen Flüssigkeit mit dem piezoelektrischen Element in direktem Kontakt steht, solcher, bei denen ein verstärkendes Zwischenglied, typischerweise ein eingeschlossenes Fluid, zwischen dem piezoelektrischen Element und der Flüssigkeit vorhanden ist, und solcher, bei denen das piezoelektrische Element ein Sieb in Schwingungen versetzt, von dem Aerosol erzeugt wird. Beispiele für Ultraschallzerstäuber werden beschrieben in US 4 533 082 (Maehara et al.) und US 5 261 601 (Ross et al.).

[0042] Die Zerstäuber, die in diesen Dokumenten beschrieben werden, haben ein Gehäuse, das ein Reservoir aufweist, das eine Menge der abzugebenden Flüssigkeit aufnimmt, und das Gehäuse hat eine perforierte Membran, die mit dem Reservoir in Berührung steht, und einen Ultraschall-Vibrator, der mit dem Gehäuse verbunden ist, um die perforierte Membran in Schwingungen zu versetzen.

[0043] Ein anderes Beispiel eines Ultraschallzerstäubers wird in WO 97/29851 beschrieben (Fluid Propulsion Technologies, Inc). Ein Beispiel eines Druck-Siebzerstäubers, der ein piezoelektrisches Element enthalten kann oder nicht, wird in WO 96/13292 beschrieben (Aradigm Corporation).

[0044] Die Ausdehung des Anteils der Inhalationsphase des Patienten, in der die Zerstäubung stattfindet, auf mehr als 50% führt dazu, daß die Patienten ihre Behandlung schneller erhalten, da weniger Atemzüge benötigt werden, um das geforderte Volumen des Medikaments abzugeben. Um jedoch die Vergeudung des Medikaments zu vermeiden, das im Endvolumen des Eintatmungsvolumens des Patienten zerstäubt wird, muß der Zerstäubungsimpuls beendet werden, bevor das Endvolumen erreicht wird. Das Endvolumen ist das Luftvolumen, das von einem Patienten am Ende des Einatmungsvolumens eingeatmet wird und in den oberen Luftwegen (dem Mund und der Luftröhre) verbleibt und nicht in die unteren Bereiche der Lunge eintritt. Das Medikament, das in dieses Endvolumen zerstäubt wird, geht verloren, wenn der Patient ausatmet, zusammen mit etwa in Luft zerstäubtem Medikament, das im Zerstäuber zurückgeblieben ist, da es nicht die Lungen erreicht.

[0045] Das Endvolumen ist das Volumen der oberen Luftwege des Patienten und ist proportional zur Größte des Patienten. Natürlich wird das Endvolumen als ein Prozentsatz des Einatmungsvolumens variieren, da sich das Atemvolumen signifikant ändert, je nach Art und Ausmaß der Atembeschwerden, unter denen der Patient leidet. Die optimale Dauer des Zerstäubungsimpulses wäre deshalb die Zeit vom Beginn der Einatmung bis zu dem Punkt während der Einatmungsphase, bei der das noch einzuatmende Volumen gleich dem Endvolumen ist. Die Zerstäubung würde dann beendet, und das verbleibende Endvolumen würde das zerstäubte Medikament aus der Vorrichtung und den oberen Luftwegen des Patienten entfernen und in die Lunge bringen. Somit wird der Prozentsatz der Einatmung, in der zerstäubtes Medikament abgegeben wird, maximiert, und dadurch wird die Behandlungszeit minimiert und dennoch eine Vergeudung des Medikaments vermieden. Die Länge des Zerstäubungsimpulses ist vom Einatemvolumen des Patienten abhängig. Der Zerstäuber muß deshalb das Atemvolumen des Patienten messen, vorzugsweise von Atemzug zu Atemzug, um, beispielsweise anhand der vorherigen drei Atemzüge, ein mittleres Einatemvolumen für den nächsten Atemzug zu berechnen. Somit wird der Zerstäubungsimpuls wie folgt berechnet:

$$\text{Impulsdauer} = \text{mittlere Einatmungszeit} \times \frac{(\text{mittleres Atemvolumen - Endvolumen})}{\text{mittleres Atemvolumen}}$$

[0046] In dem Zerstäuber ist ein Zeitgeber enthalten, der an den Drucksensor **9** (in Fig. 3 gezeigt) angeschlossen ist, um die Dauer der Einatmung zu messen. Weiterhin enthält der Zerstäuber eine Speichereinrichtung, in der ein Schätzwert für das Endvolumen eines speziellen Patienten gespeichert ist. Da diese Größe für einen speziellen Patienten eine Konstante ist, kann sie am Beginn eines Behandlungszyklus eingegeben werden, und sie wird abgeschätzt auf der Grundlage der Größe des Patienten. Der Zerstäuber enthält eine Einrichtung zur Messung des Atemvolumens eines Patienten. Gemäß einer Form der Erfindung wird der Atemstrom des Patienten fortlaufend überwacht, typischerweise alle 10 Millisekunden, und dieser Atemstrom wird über die Dauer der Einatmung integriert. Ein anderer, einfacherer Weg zur Messung des Atemvolumens eines Patienten wird später in dieser Beschreibung beschrieben werden.

[0047] Der Zerstäuber enthält auch eine Einrichtung zur Berechnung der Zeit des Zerstäubungsimpulses auf der Grundlage der Dauer der Einatmung, des Atemvolumens und des Endvolumens. Die Berechnungseinheit führt die oben skizzierte Berechnung aus.

[0048] In Anbetracht der Tatsache, daß sich der Zerstäuber an das Atmungsmuster eines Patienten anpaßt, wenn der Patient zu atmen beginnt, erfolgt keine Zerstäubung während der ersten drei Atemzüge. Diese ersten drei Atemzüge werden dazu verwendet, das Atmungsmuster des Patienten zu analysieren. Der Strömungsdurchsatz der ersten drei Atemzüge wird gemessen, und hieraus wird die Dauer der Einatmungsphase der ersten drei Atemzüge berechnet und ein Mittelwert gebildet. Die mittlere Dauer der Einatmungsphase wird dann in der Berechnung dazu benutzt, die Impulslänge des Zerstäubungsimpulses während des vierten Atemzuges zu bestimmen. Während der Patient weiterhin ein- und ausatmet, werden außerdem die vorherigen drei Atmungsmuster gemessen und zur Berechnung der nächsten Impulsdauer verwendet. Wenn sich das Atmungsmuster eines Patienten während der Behandlung verbessert, wird sich somit der Zerstäuber an diese Veränderung anpassen, um die während jedes Atemzuges verabreichte Dosis zu optimieren.

[0049] Die von dem Zerstäuber und dem Patienten ausgeführten Schritte werden nun unter Bezugnahme auf Fig. 4 beschrieben. Als erste Operation repräsentiert ein Block **30** den Beginn der Inhalation durch einen Patienten. Der Zeitgeber zeichnet die Zeit auf, zu der die Inhalation beginnt, wie in Block **31** gezeigt ist, und während der Inhalation wird eine Berechnung ausgeführt, um das Atemvolumen des Patienten vorherzusagen, wie in Block **33** gezeigt ist. Dieser Schritt wird weiter unten in dieser Beschreibung detaillierter beschrieben werden, es ist jedoch zu bemerken, daß die Berechnung Daten erfordert, die in die Berechnung einbezogen werden müssen, nämlich die Inhalationszeit und den Spitzenstrom als ein Mittelwert aus den letzten drei Atemzügen, wie in Block **32** gezeigt ist. Die Impulszeit wird dann durch die Berechnungseinrichtung berechnet, wie in Block **34** gezeigt ist, und die Impulszeit wird angepaßt, wie in Block **35** gezeigt ist, falls die Impulslänge den Akkumulator leeren würde, aus dem die Druckluft zum Zerstäuber zugeführt wird. Dieser Schritt, in Block **35** gezeigt, wird ebenfalls weiter unten in dieser Beschreibung näher erläutert werden. Der Zerstäubungsimpuls erfolgt während der Inhalation, und nachdem er beendet ist, wird eine Berechnung ausgeführt, um zu bestimmen, welche Dosis zerstäubt worden ist. Am Ende des Atemzuges werden, wie in Block **38** gezeigt ist, Einzelheiten des Spitzenstromes bei der Einatmung durch den Patienten und die Dauer der Einatmung aufgezeichnet, so daß Berechnungen zur Bestimmung der Impulslänge für die nachfolgenden Atemzüge gemacht werden können. Dies ist in Block **39** gezeigt.

[0050] Weiter oben wurde eine einfachere Vorhersage des Atemvolumens erwähnt. Es versteht sich, daß die Messung des Atemvolumens durch Integration des gemessenen Strömungsdurchsatzes über die Zeit der Einatmung eine beträchtliche Rechenleistung erfordert und verhältnismäßig teuer ist. Es wird ein einfacheres Verfahren zur Bestimmung des Atemvolumens vorgeschlagen, das wesentlich einfachere Berechnungen und wesentlich einfachere Messungen für die Verwendung in einer solchen Berechnung erfordert. Um die Messung auszuführen, enthält der Zerstäuber einen Spitzenstromdetektor zur Erfassung des Spitzenwertes des Strömungsdurchsatzes bei der Einatmung.

[0051] Das berechnete oder vorhergesagte Atemvolumen wird abgeleitet aus dem Spitzenstrom, der vom Spitzenstromdetektor gemessen wurde, und der Dauer der Einatmung, die vom Zeitgeber gemessen wurde. Die Berechnungseinheit für das Atemvolumen führt die folgende Berechnung aus:

$$\text{Vorhergesagtes Atemvolumen} = C \times \text{mittlerer Spitzenstrom} \times \frac{\text{Einatmungszeit}}{60}$$

C ist eine Konstante, und es zeigt sich, daß C = 0,7.

[0052] Fig. 5 ist eine Graphik, in der das vorhergesagte Atemvolumen gegen das gemessene Atemvolumen aufgetragen ist. Jeder Punkt in der Graphik repräsentiert einen Patienten, dessen Atemvolumen durch eine komplexe Berechnung des Atemvolumens gemessen wurde, durch Integration des Einatemstroms des Patienten über die Dauer der Einatmung, und das vorhergesagte Atemvolumen nach dem neuen, einfacheren Berechnungsverfahren. Man erkannt, daß die vorhergesagten Atemvolumen äußerst präzise sind und somit das vorhergesagte Atemvolumen in der Berechnung der Zeit des Zerstäubungsimpulses verwendet werden kann.

[0053] Die Verwendung eines Kompressors mit niedrigem Durchsatz in Verbindung mit einem Akkumulator zur Zufuhr von Druckluft zu dem Zerstäuber wird in unserer früheren Patentanmeldung beschrieben, die als WO 97/48431 veröffentlicht worden ist, auf die weiter oben Bezug genommen wurde. In der Vergangenheit wurde die Größe des Kompressors und des Akkumulators so gewählt, daß der maximale Impuls, der von der Vorrichtung abgegeben werden kann (gegenwärtig 50% der Einatmungszeit) für irgendeinen gegebenen Impuls oder für den mittleren Ausstoß des Kompressors nicht das Volumen des Akkumulators überschreitet. Da nun die Impulszeit variabel ist, ist es bevorzugt, die maximale Impulszeit zu berechnen, die vom Luft-Zufuhrsystem her verfügbar ist. Für Patienten, die einen etwas höheren Einatmungsbedarf haben, wird die Impulszeit für die Zerstäubung reduziert, so daß die Zufuhrkapazität des Luft-Zufuhrsystems nicht überschritten wird. Die

Berechnung wird Atemzug für Atemzug ausgeführt, unter der Annahme, daß der Akkumulator mit einem konstanten Durchsatz aus dem Kompressor gefüllt wird. Das Luftvolumen, das dem Akkumulator vom Ende des vorherigen Impulses bis zum Beginn des nächsten Impulses zugeführt wird, wird berechnet und dann zu dem Volumen addiert, das am Ende des vorherigen Impulses verblieben ist.

[0054] Fig. 6 ist ein Flußdiagramm, das die Berechnungen zeigt, die ausgeführt werden, um sicherzustellen, daß das Luftvolumen das Volumen des Akkumulators nicht überschreitet. Wenn berechnet wird, daß die Luft im Akkumulator oberhalb des Maximalvolumens des Akkumulators ist, wird das Volumen auf den Maximalwert gesetzt $V = V_{max}$). Der Grund ist, daß ein automatisches Entlüftungsventil vorhanden ist, das das im Akkumulator gespeicherte Luftvolumen begrenzt. Die maximale Impulszeit kann dann berechnet werden auf der Grundlage der Abflußrate der Luft aus dem Akkumulator, d.h., des Durchsatzes des Zerstäuberstrahls minus Durchsatz des Kompressors. Wenn diese das im Akkumulator verfügbare Volumen überschreitet, so wird die Impulszeit auf das aktuelle Akkumulatorvolumen begrenzt. Das Volumen des Akkumulators am Ende des Impulses wird dann berechnet, damit es am Beginn der nächsten Berechnung zu Beginn der nächsten Einatmungsphase des Patienten benutzt werden kann. Somit wird die maximale Impulszeit für einzelne Atemzüge berechnet, ohne daß die Kapazität des Luft-Zufuhrsystems überschritten wird. Der Kompressor hat einen konstanten Ausstoß-Durchsatz, typischerweise 1,5 Liter pro Minute, und der Zerstäuberstrahl hat einen Durchsatz von 6 Litern pro Minute während des Impulses. Der Akkumulator hat ein Volumen von annähernd 150 ml bei Normaldruck und -temperatur.

[0055] Fig. 7 zeigt den Zerstäuber **50**, der durch einen flexiblen Schlauch **52** mit der Luftzufuhr **51** verbunden ist.

[0056] In Fig. 8 ist der Akkumulator gezeigt, der ein Entlüftungsventil **63** zur Begrenzung der maximalen Ausdehnung des Akkumulators hat. Wenn jeder Impuls an den Zerstäuber abgegeben wird, wird der Durchmesser des Akkumulators reduziert, und das Entlüftungsventil **63** wird geschlossen.

[0057] Der Kompressor kann durch Netzspannung oder aus einer Batterie versorgt werden. Die Pumpe, insbesondere eine mit Netzspannung gespeiste Pumpe, arbeitet während des Gebrauchs kontinuierlich und bläht den Akkumulator auf. Wenn der Druck im Akkumulator ein gefordertes Niveau erreicht, wird ein Druckschalter in einem in der Hand gehaltenen Teil des Zerstäubers aktiviert, wie in einer oben erwähnten früheren Patentanmeldung beschrieben wird. Dadurch wird der Zerstäuber eingeschaltet. Wenn die Behandlung abgeschlossen ist, wird der Kompressor ausgeschaltet. Der Akkumulator kollabiert, und der Druckschalter in dem in der Hand gehaltenen Teil des Zerstäubers deaktiviert die Einheit.

[0058] Gemäß Fig. 8 versorgt die Pumpe den Akkumulator über einen Einlaß **64** mit Luft. Das Aufblähen der Membran **61** des Akkumulators wird durch eine Anordnung gesteuert, die einen Arm **62** aufweist, der mit einem Entlüftungsventil **63** verbunden ist. Wenn die Membran **61** des Akkumulators die maximal gewünschte Ausdehnung erreicht, berührt sie den Arm **62**, um das Entlüftungsventil **63** zu öffnen. Dieses gibt den Luftstrom aus dem Kompressor an die Atmosphäre ab und hält den Akkumulator auf einer festen Ausdehnung. Während des Gebrauchs wird Luft über einen Auslaß **65** aus dem Akkumulator abgelassen, und die Membran **61** schrumpft und verliert den Kontakt zu dem Ventilarm **62**, der das Ventil **63** schließt, so daß der Kompressor den Akkumulator wieder aufladen kann, bis der Ventilarm **62** wieder das Entlüftungsventil **63** betätigt.

[0059] Ist es auch vorteilhaft, den Akkumulator zur Atmosphäre zu entlüften, wenn der Kompressor ausgeschaltet wird, und dies wird dadurch erreicht, daß der Hauptschalter **66** mit einem Drehknopf **67** auf der Oberseite des Akkumulators montiert ist. Die Unterseite des Knopfes **67** weist einen Nocken **68** auf, der den Ventilarm **62** berührt, um das Ventil **63** zu öffnen und so den Druck aus dem Akkumulator abzulassen. Gleichzeitig wird der Kompressor ausgeschaltet. Wenn der Kompressor wieder eingeschaltet wird, löst sich der Nocken **68** vom Ventilarm **62**, so daß das Entlüftungsventil **63** geschlossen wird.

[0060] Fig. 9 illustriert eine vereinfachte Form der Art und Weise, in der all die Komponenten des Zerstäubers miteinander verbunden sind. Der Kompressor und Akkumulator **70** sind als vom in der Hand gehaltenen Teil des Zerstäubers **71** getrennt dargestellt, jedoch verbunden durch einen Schlauch **72**, der die Druckluft in den Zerstäuber **71** leitet. Im Kompressor- und Akkumulatorteil **70** ist die Pumpe gezeigt, die den Akkumulator mit Druckluft versorgt. Im Zerstäuberteil **71** wird der Zerstäuber durch das Vorhandensein von Druckluft im Schlauch **72** am Druckschalter **73** eingeschaltet. Der Zerstäuberteil **74** des Zerstäubers wird durch ein Ventil oder einen Verteiler **75** gesteuert, der die Druckluftimpulse steuert. Das Atmungsmuster eines Patienten wird von einem Sensor **76** detektiert, der Information über das Atmungsmuster an den Mikrocontroller **77** liefert, der seinerseits den Verteiler **75** steuert. Wenn eine Dosis des Medikaments abgegeben worden ist, so wird eine

Anzeigeeinrichtung wie etwa eine LED oder ein Summer **78** durch den Mikrocontroller aktiviert um anzuzeigen, daß die Behandlung des Patienten abgeschlossen ist.

[0061] Eine weitere Ausführungsform der Erfindung ist in Fig. 10 gezeigt, wobei es sich um ein Dosimeter **80** handelt, das eine Haltekammer **81** aufweist, die an einem Ende einen Auslaß **82** hat, der mit einem Mundstück **83** verbunden ist. Ein Drucksensor **84** ist zwischen dem Mundstück **83** und der Haltekammer **81** angeordnet. Dieser Sensor **84** mißt den Druck im Mundstück, woraus der Strömungsdurchsatz der vom Patienten ein- und ausgeatmeten Luft gemessen werden kann. Das Mundstück **83** hat auch ein Entlüftungsventil **85**, das es einem Patienten erlaubt, durch das Mundstück **83** auszuatmen, ohne die Haltekammer **81** zu füllen. Näheres über das Entlüftungsventil wird weiter unten beschrieben.

[0062] Innerhalb der Haltekammer ist ein Kolben **86** gezeigt, der sich in Längsrichtung bewegt, um das Volumen an Luft zu variieren, das in der Haltekammer **81** für einen Patienten beim Einatmen zur Verfügung steht. Der Kolben hat eine Zahnstange **87**, die durch das Ende der Haltekammer **81** herausragt, so daß die Zähne mit dem Finger eines Elektromagneten **88** in Eingriff kommen können. Ein Lufteinlaß **89** befindet sich am linken Ende der Haltekammer und erlaubt es, daß Luft in den Raum hinter dem Kolben eintreten oder daraus austreten kann, wenn sich der Kolben nach rechts oder links bewegt.

[0063] Im Gebrauch wird der Kolben **86** zurückgezogen, um die Haltekammer **81** mit Luft zu füllen. Die Luft in der Haltekammer **81** wird dann mit einem Medikament beladen, entweder in der Form von flüssigen Tröpfchen oder in der Form einer Wolke aus Pulver. Diese wird über einen Port **82** in die Haltekammer **81** abgegeben, und dies erfordert normalerweise das Entfernen des Mundstücks **83**. Ein Mundstück **83** kann dann wieder eingesetzt werden, und ein Patient atmet durch das Mundstück **83** ein und aus. Während der Einatmung atmet der Patient die mit Medikamenten beladene Luft aus der Haltekammer **81** ein, und während der Ausatmung wird die ausgeatmete Luft durch das Ventil **85** an die Atmosphäre abgegeben. Während der Ausatmung verriegelt der Elektromagnet **88** die Zahnstange **87** des Kolbens **86**, so daß dieser sich nicht bewegt und somit die Haltekammer nicht mit ausgeatmeter Luft gefüllt wird. Gemäß der Erfindung kann sich jedoch der Kolben **86** nur während eines Teils der Einatmungsphase frei bewegen, und er wird durch den Elektromagneten **88** in seiner Position verriegelt, während der Patient das Endvolumen einatmet. Nachdem der Kolben einmal verriegelt ist, ist das Ventil **85** so ausgebildet, daß der Druckabfall im Mundstück **83**, der durch das Verriegeln des Kolbens **86** verursacht wird, das Ventil **85** öffnet, so daß Umgebungsluft in das Mundstück eingesogen werden kann. Natürlich kann in dem Mundstück auch ein separates Ventil vorgesehen sein, um diese Funktion geeignet auszuführen.

[0064] Die Berechnung der Impulslänge, während der der Kolben **86** sich frei bewegen kann, um die Abgabe des Medikaments an den Patienten zu ermöglichen, wird auf die gleiche Weise bestimmt, wie oben in Bezug auf den Zerstäuber beschrieben wurde. Die Atmung des Patienten während der vorherigen drei Atemzüge wird von dem Sensor **84** so überwacht, daß die gleichen Berechnungen angestellt werden können, wie oben beschrieben wurde. Beim nachfolgenden Atemzug detektiert der Sensor den Beginn des Atemzuges, und nach der Dauer des Impulses wird der Kolben verriegelt.

[0065] Eine solche Anordnung verringert den Verlust des Medikaments, das im Endvolumen an Luft vorhanden ist, das normalerweise vom Patienten eingeatmet wird.

[0066] Diese Erfindung ist auch auf andere Typen von medizinischen Inhalationsgeräten anwendbar. Wie z.B. im Einleitungsteil dieser Beschreibung beschrieben wurde, wird in US 5 649 920 ein Inhalationsgerät für Trockenpulver beschrieben, das einen piezoelektrischen Vibrator und eine elektrostatische Ladungsplatte benutzt, um ein trockenes Pulver zu fluidisieren und in den Luftstrom des Patienten zu dispergieren. Die elektrostatische Ladungsplatte kann in Abhängigkeit vom Atmungsmuster des Patienten betätigt werden, so daß Impulse erzeugt werden, in denen das pulverförmige Medikament in den zum Patienten führenden Luftstrom abgegeben wird. Die Länge der Impulse kann genau auf die gleiche Weise wie bei den zuvor beschriebenen Ausführungsformen so bestimmt werden, daß das trockene Pulver nicht in das Endvolumen des zum Patienten führenden Luftstroms dispergiert wird.

Patentansprüche

1. Abgabevorrichtung für Medikamente, mit:
einer Abgabeeinrichtung zur Abgabe von mit Medikamenten beladener Luft, sowie von Luft, die keinerlei Medikamente trägt, zur Einatmung durch einen Patienten;
einer Überwachungseinrichtung (**9**, **76**) zur Überwachung eines Atmungsmusters des Patienten; und

einer Steuereinrichtung (**77**) zur Steuerung der Abgabeeinrichtung zur selektiven Abgabe der mit Medikamenten beladenen Luft und der Luft, die keinerlei Medikamente trägt,
dadurch gekennzeichnet, daß die Steuereinrichtung (**77**) dazu ausgebildet ist, die Abgabeeinrichtung so zu steuern, daß sie die mit Medikamenten beladene Luft in Impulsen abgibt, deren Länge und deren Verhältnis zur Einatmungsphase des Atmungsmusters durch die Steuereinrichtung (**77**) in Abhängigkeit von dem durch die Überwachungseinrichtung (**9**, **76**) überwachten Atmungsmuster variiert wird.

2. Vorrichtung nach Anspruch 1, bei der die Steuereinrichtung (**77**) dazu ausgebildet ist, zur Anpassung an Änderungen in dem überwachten Atmungsmuster die Länge des Impulses Atemzug für Atemzug zu steuern.

3. Vorrichtung nach Anspruch 1 oder 2, bei der die Vorrichtung ein Zerstäuber (**50**, **74**) ist, in dem die Einrichtung zur selektiven Abgabe der mit Medikamenten beladenen Luft eine Einrichtung zum Zerstäuben eines Medikaments ist und die Steuereinrichtung (**77**) die Zerstäubungseinrichtung so steuert, daß das Medikament impulsweise zerstäubt wird.

4. Zerstäuber (**50**, **74**) nach Anspruch 3, mit einer Einrichtung zur Bestimmung der Dauer des Zerstäubungsimpulses, enthaltend eine Einrichtung zur Messung des Atemvolumens eines Patienten, einen Zeitgeber zur Messung der Dauer der Einatmung, eine Einrichtung zur Speicherung eines Schätzwertes für das Volumen des oberen Luftweges eines Patienten und eine Einrichtung zur Berechnung der Dauer des Impulses auf der Grundlage des von der Einrichtung zur Messung des Atemvolumens gemessenen Atemvolumens, der vom Zeitgeber gemessenen Dauer der Einatmung des in der Speichereinrichtung gespeicherten Schätzwertes für das Volumen des oberen Luftweges des Patienten.

5. Zerstäuber (**50**, **74**) nach Anspruch 4, bei dem die Einrichtung zur Messung des Atemvolumens eines Patienten eine Einrichtung zur Messung eines Spitzenwertes des Atemstroms des Patienten und eine Atemvolumen-Vorhersageeinrichtung aufweist, zur Berechnung des Atemvolumens auf der Grundlage des Spitzenwertes des Atemstroms und der vom Zeitgeber gemessenen Dauer der Einatmung.

6. Zerstäuber nach Anspruch 4 oder 5, bei dem einige oder sämtliche der Werte, die in den Berechnungen verwendet werden, Mittelwerte sind, die aus einer Anzahl von früheren Messungen des Atmungsmusters des Patienten abgeleitet sind.

7. Zerstäuber nach einem der Ansprüche 3 bis 6, mit einer Quelle (**71**, **51**) für Druckgas zum Zerstäuben des Medikaments, welche Quelle (**70**, **51**) einen Akkumulator zum Sammeln des Gases unter Druck und eine Einrichtung (**73**) zur Begrenzung der Dauer des Impulses aufweist, um den Akkumulator in einem Zustand zu halten, in dem er stets unter gewissem Druck ist.

8. Zerstäuber nach Anspruch 7, bei dem der Akkumulator ein Ventil (**63**) aufweist, das, wenn der Akkumulator voll ist, Gas in die Atmosphäre abläßt.

9. Vorrichtung nach Anspruch 1 oder 2, bei der die Vorrichtung ein Dosimeter (**80**) ist, in dem die Abgabeeinrichtung zur selektiven Abgabe der mit Medikamenten beladenen Luft eine Haltekammer (**81**) zum Halten von mit Medikamenten beladener Luft ist.

10. Dosimeter (**80**) nach Anspruch 9, mit einer Einrichtung zur Bestimmung der Dauer des Zerstäubungsimpulses, enthaltend eine Einrichtung zur Messung des Atemvolumens eines Patienten, einen Zeitgeber zur Messung der Dauer der Einatmung, eine Einrichtung zur Speicherung eines Schätzwertes für das Volumen des oberen Luftweges eines Patienten und eine Einrichtung zur Berechnung der Dauer des Impulses auf der Grundlage des von der Einrichtung zur Messung des Atemvolumens gemessenen Atemvolumens, der vom Zeitgeber gemessenen Dauer der Einatmung des in der Speichereinrichtung gespeicherten Schätzwertes für das Volumen des oberen Luftweges des Patienten.

11. Dosimeter (**80**) nach Anspruch 10, bei dem die Einrichtung zur Messung des Atemvolumens eines Patienten eine Einrichtung zur Messung eines Spitzenwertes des Atemstroms des Patienten und eine Atemvolumen-Vorhersageeinrichtung aufweist, zur Berechnung des Atemvolumens auf der Grundlage des Spitzenwertes des Atemstroms und der vom Zeitgeber gemessenen Dauer der Einatmung.

12. Dosimeter (**80**) nach Anspruch 10 oder 11, bei dem einige oder sämtliche der Werte, die in den Berechnungen verwendet werden, Mittelwerte sind, die aus einer Anzahl von früheren Messungen des Atmungsmusters des Patienten abgeleitet sind.

13. Dosimeter (**80**) nach einem der Ansprüche 9 bis 12, mit einer Einrichtung (**86**) zur Verringerung des Volumens der mit Medikamenten beladenen Luft in der Haltekammer (**81**), um die Abgabe der mit Medikamenten beladenen Luft an einen Patienten zu ermöglichen.

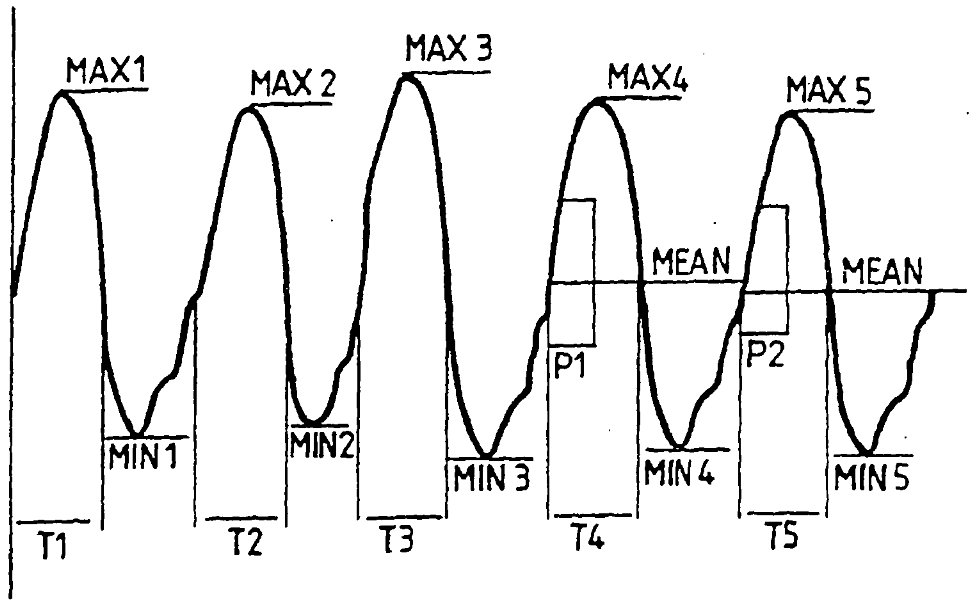
14. Dosimeter (**80**) nach Anspruch 13, bei dem die Einrichtung zur Verringerung des Volumens der mit Medikamenten beladenen Luft ein Kolben (**86**) ist, der in der Haltekammer (**81**) beweglich ist.

15. Dosimeter (**80**) nach Anspruch 13 oder 14, mit einer Einrichtung (**87**, **88**) zur Steuerung der Bewegung der Einrichtung (**86**) zur Verringerung des Volumens der Haltekammer (**81**) zur Abgabe der mit Medikamenten beladenen Luft in Impulsen.

16. Dosimeter (**80**) nach einem der Ansprüche 9 bis 15, mit einer Belüftungsöffnung (**85**), die das Einatmen von nicht mit Medikamenten beladener Luft außerhalb der Zeit erlaubt, in der ein Impuls vorhanden ist.

Es folgen 9 Blatt Zeichnungen

Anhängende Zeichnungen



Impulszeit $= 50\%\ \mathrm{sum}\ \frac{(T1 + T2 + T3)}{3}$,

Dosis = Sum (P1 + P2 + ...)

Fig.1.

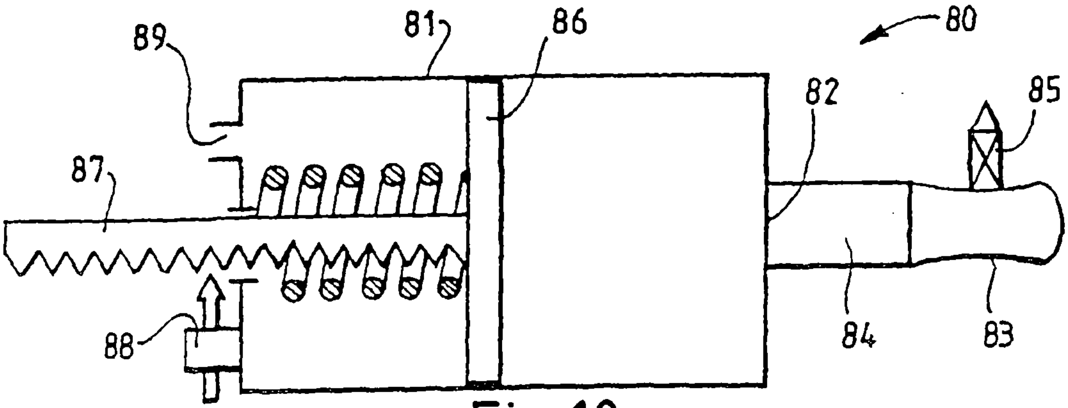


Fig.10.

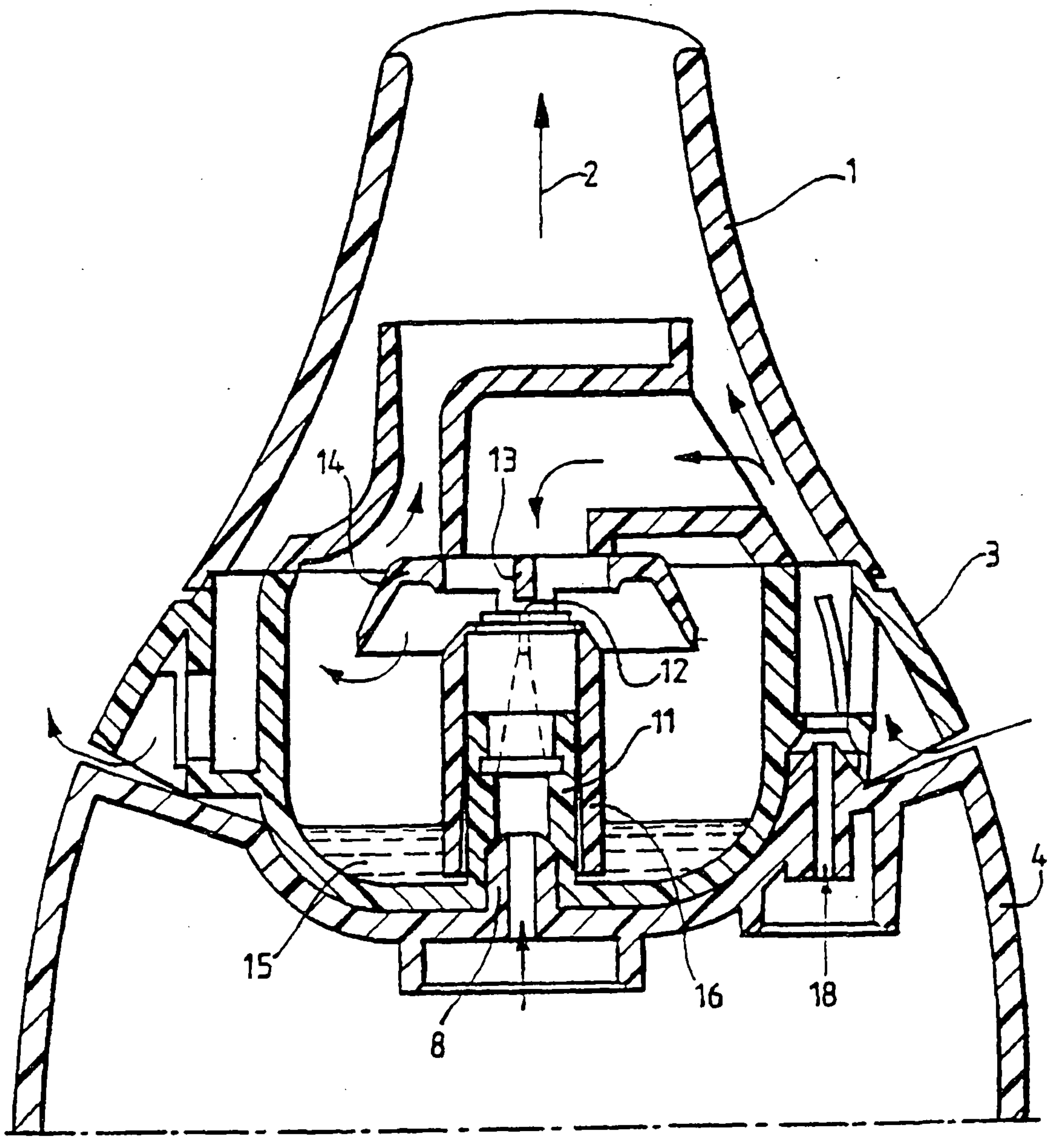


Fig.2.

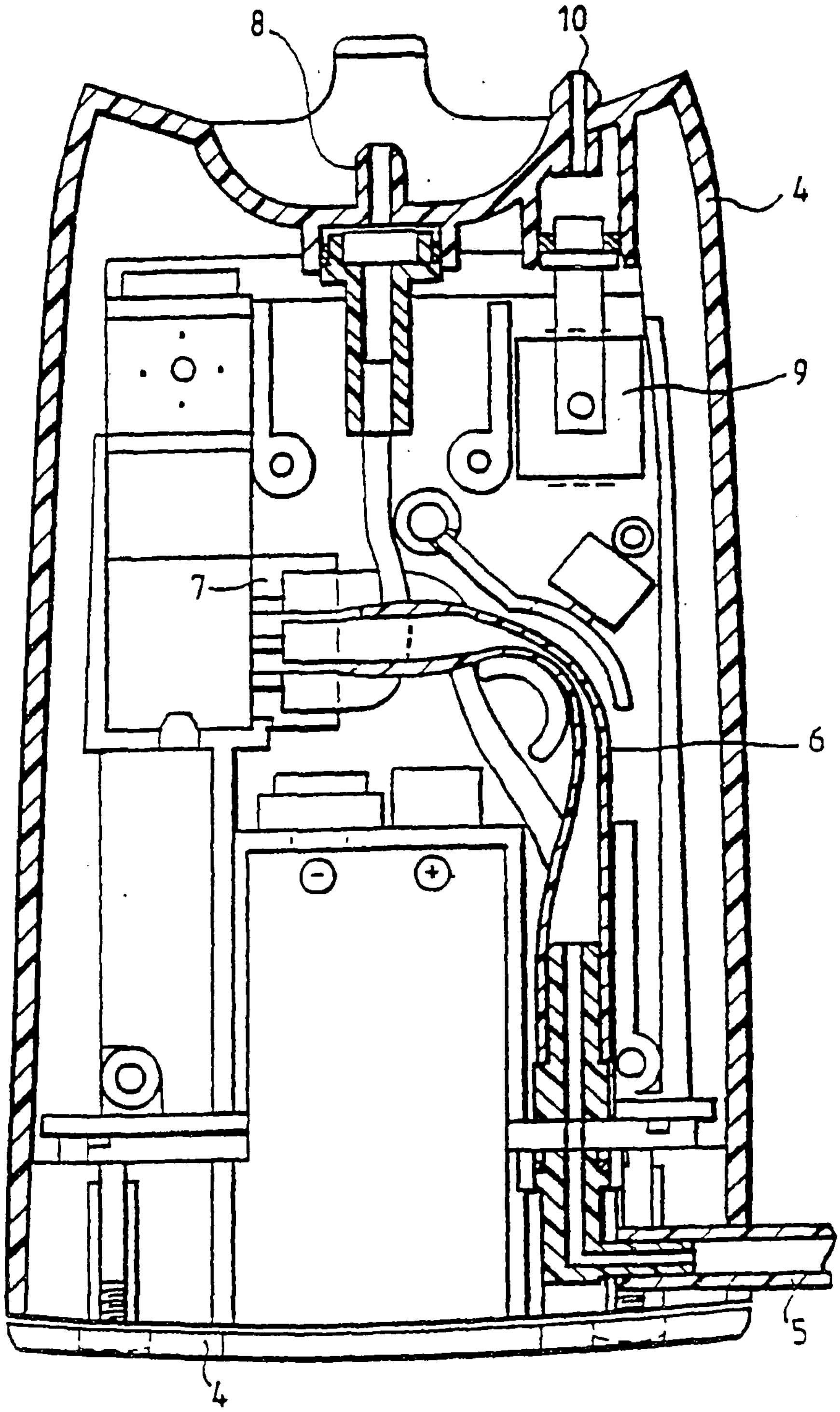


Fig.3.

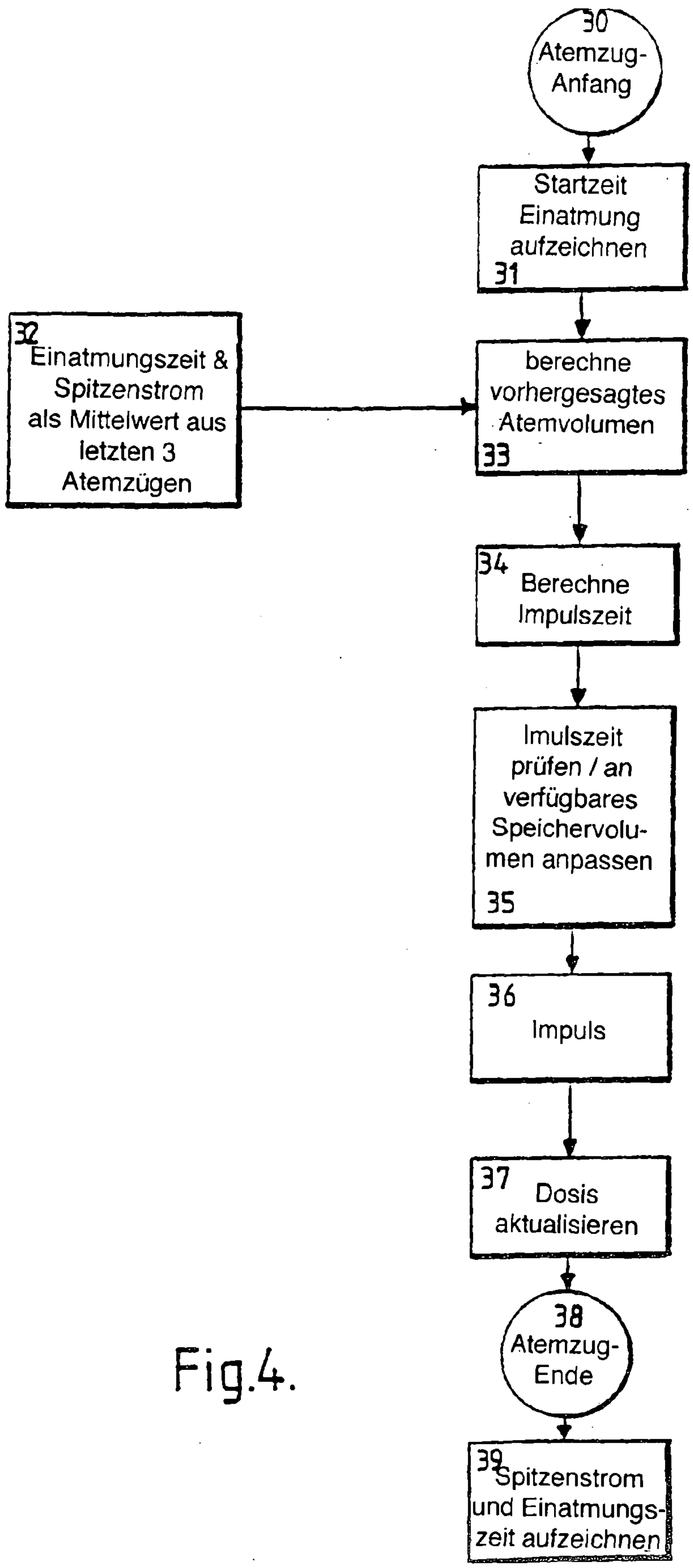

30
Atemzug-Anfang
Startzeit Einatmung aufzeichnen
31
32
Einatmungszeit & Spitzenstrom als Mittelwert aus letzten 3 Atemzügen
berechne vorhergesagtes Atemvolumen
33
34
Berechne Impulszeit
Imulszeit prüfen / an verfügbares Speichervolumen anpassen
35
36
Impuls
37
Dosis aktualisieren
38
Atemzug-Ende
39
Spitzenstrom und Einatmungszeit aufzeichnen

Fig.4.

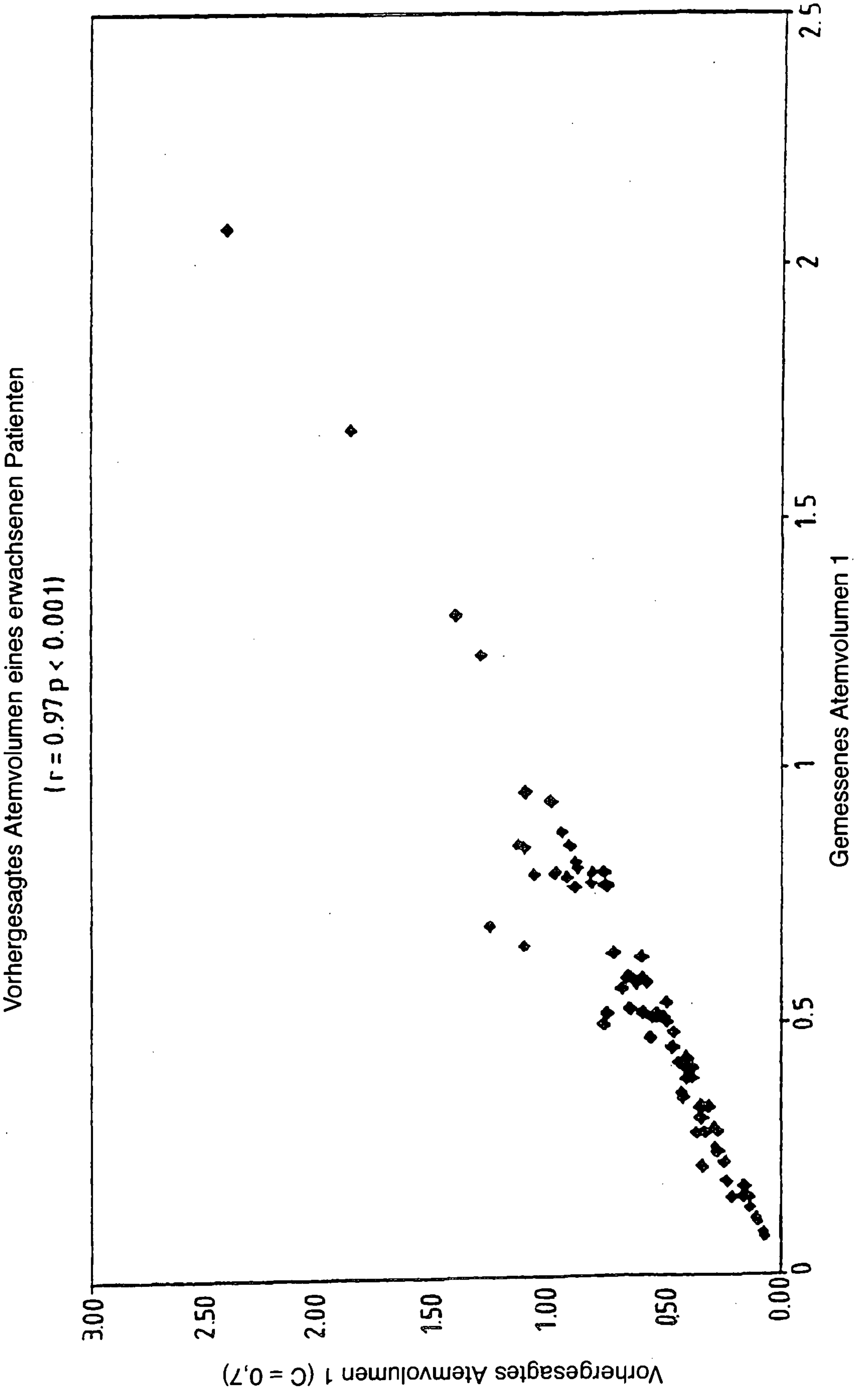

Vorhergesagtes Atemvolumen eines erwachsenen Patienten
(r = 0.97 p < 0.001)
Vorhergesagtes Atemvolumen 1 (C = 0,7)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Gemessenes Atemvolumen 1
0
0.5
1
1.5
2
2.5

Fig.5

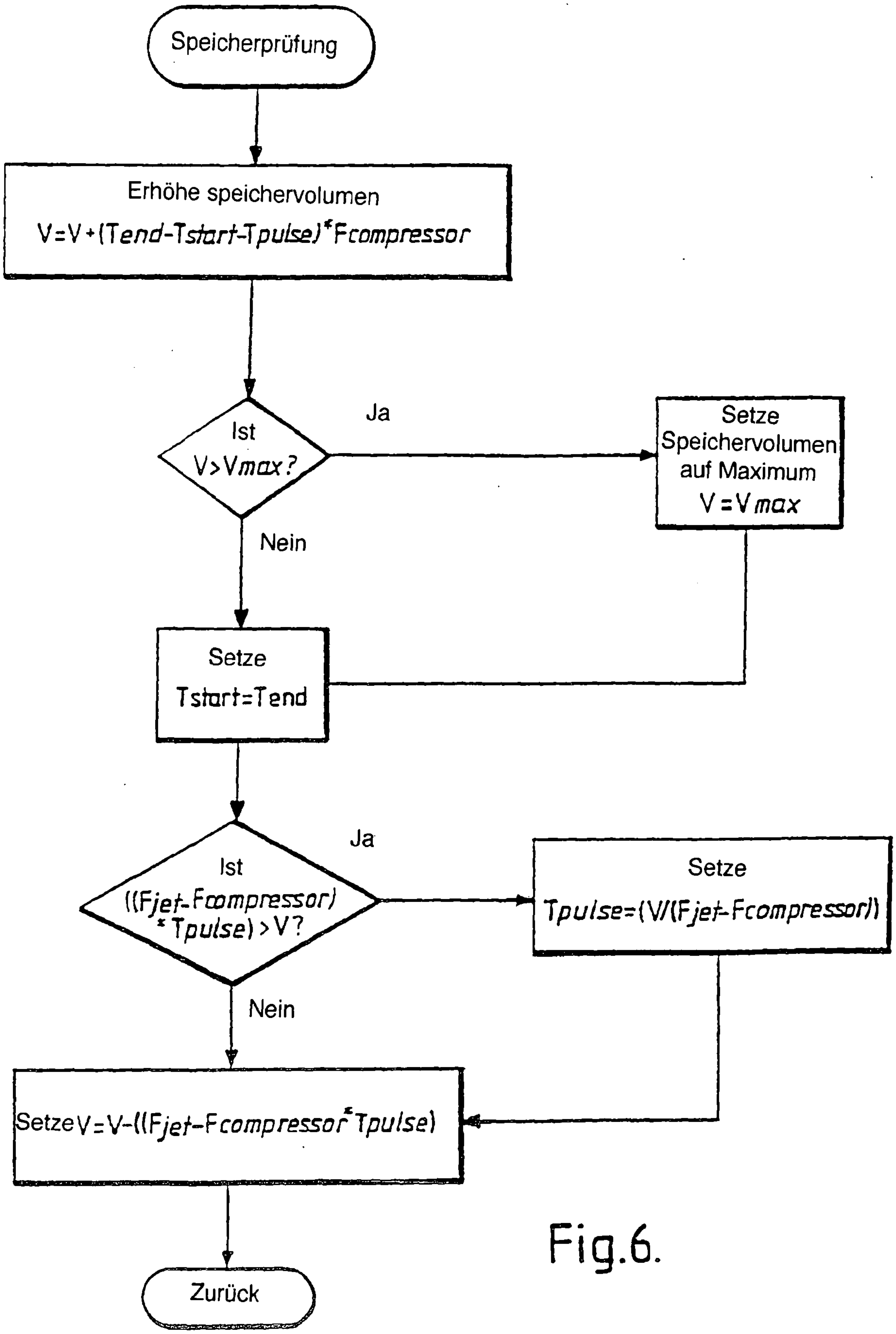

Speicherprüfung
Erhöhe speichervolumen
V=V+(Tend-Tstart-Tpulse)*Fcompressor
Ist
V>Vmax?
Ja
Setze
Speichervolumen
auf Maximum
V=Vmax
Nein
Setze
Tstart=Tend
Ist
((Fjet-Fcompressor)
*Tpulse)>V?
Ja
Setze
Tpulse=(V/(Fjet-Fcompressor))
Nein
SetzeV=V-((Fjet-Fcompressor*Tpulse)
Zurück

Fig.6.

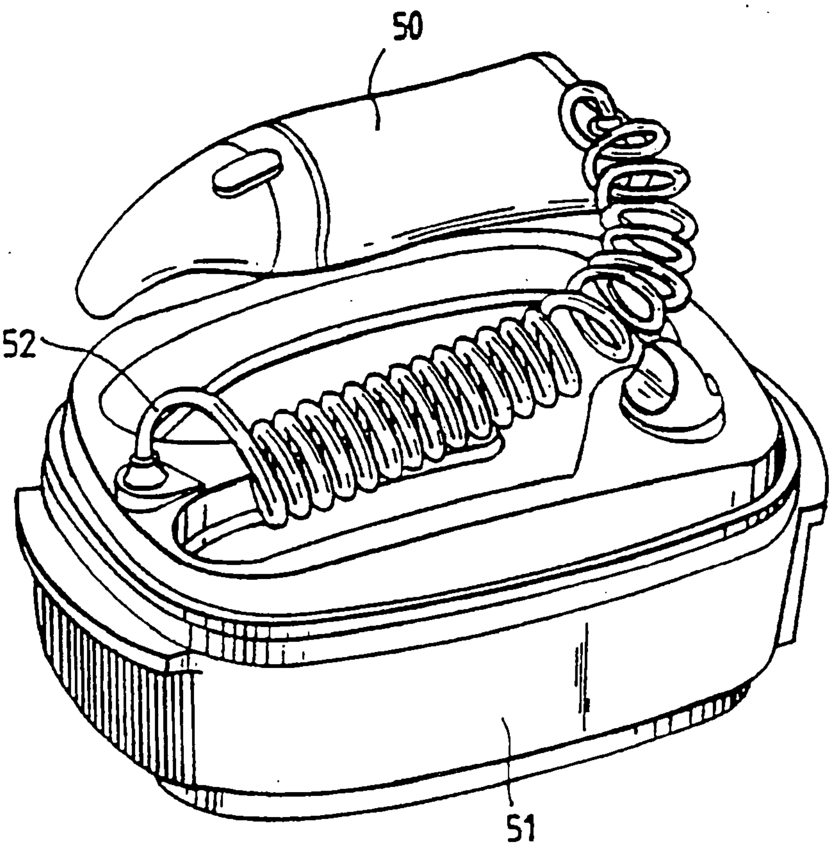


Fig.7.

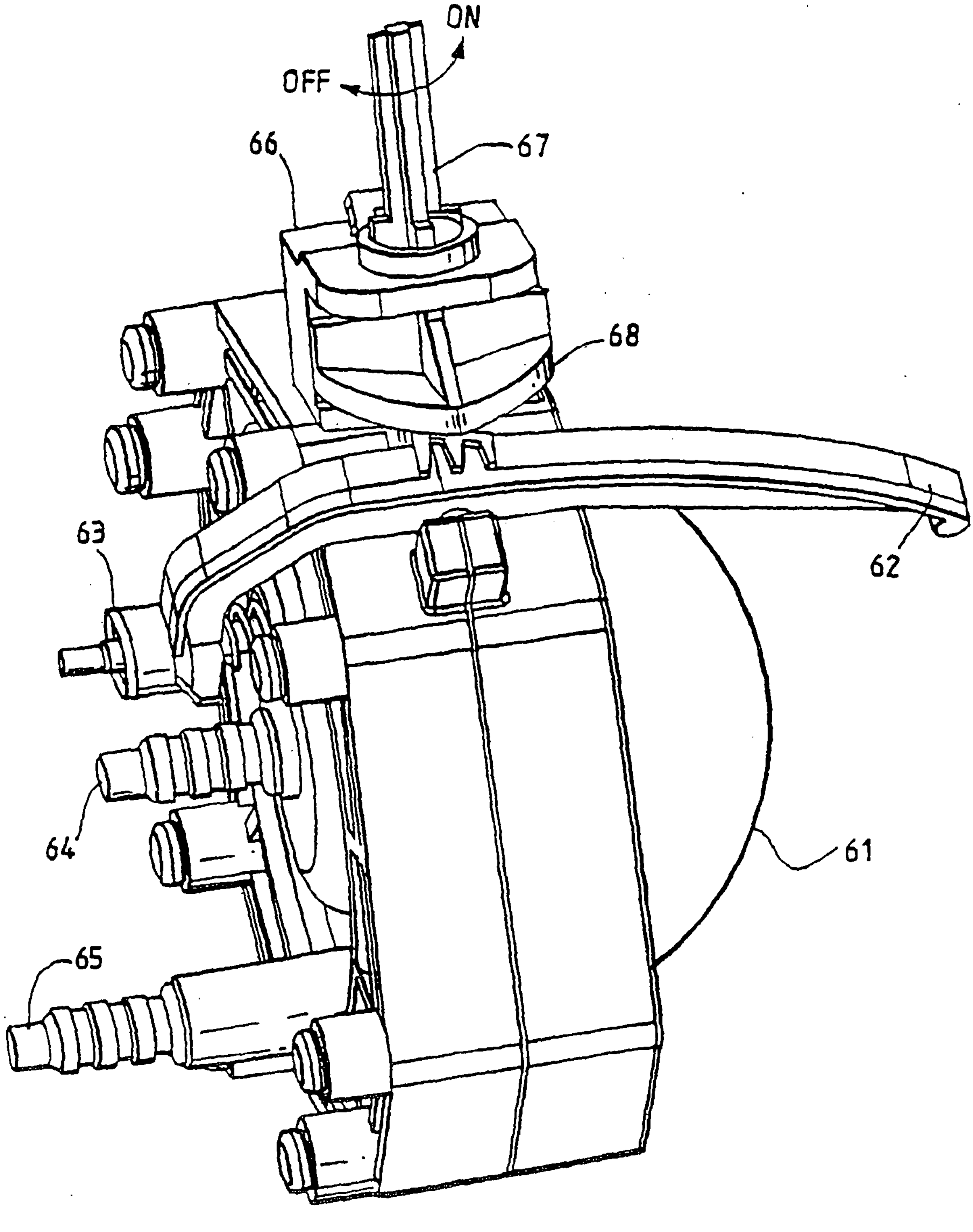


Fig.8.

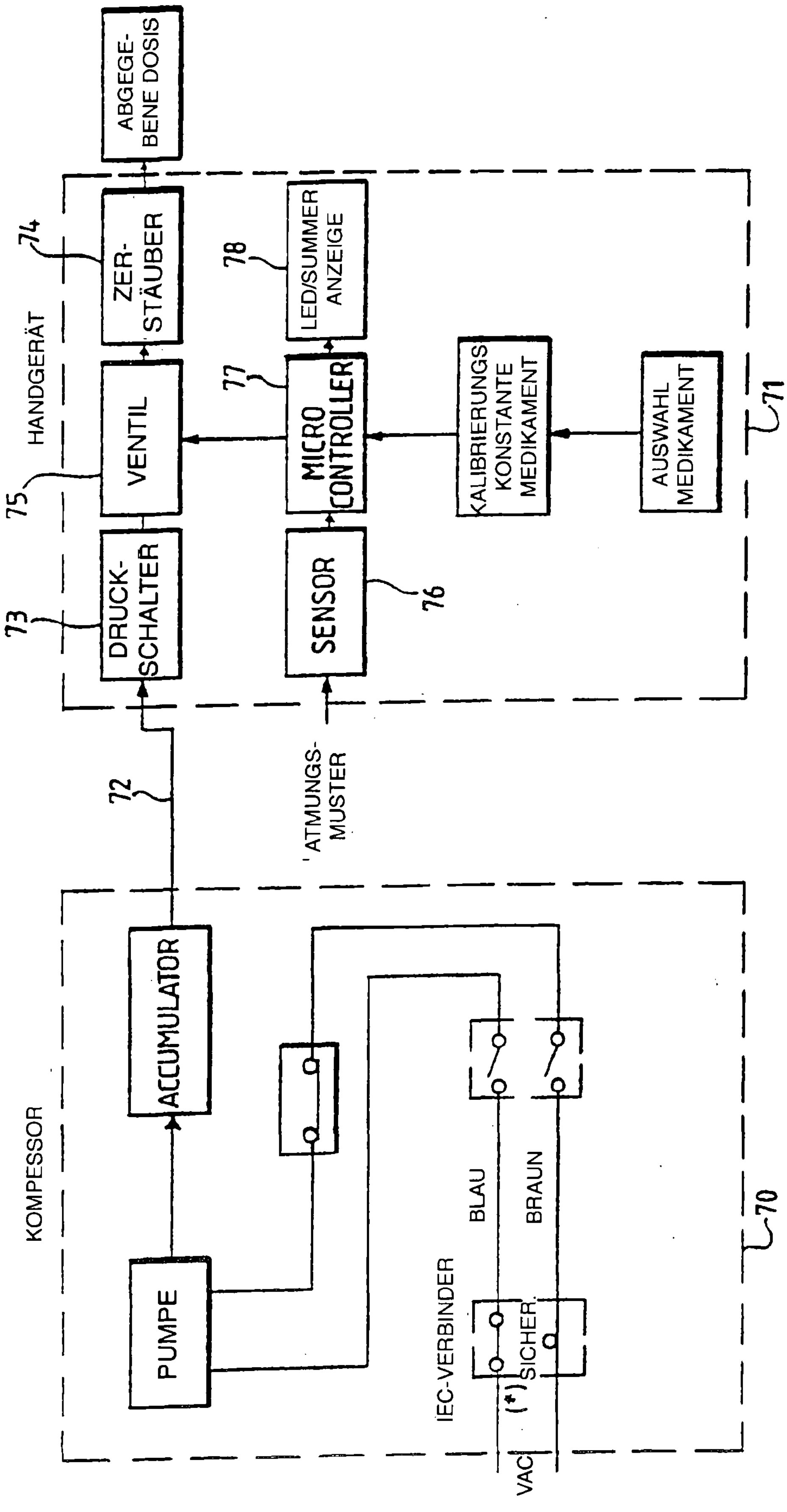

ABGEGE-
BENE DOSIS
HANDGERÄT
ZER-
STÄUBER
74
LED/SUMMER
ANZEIGE
78
VENTIL
75
MICRO
CONTROLLER
77
KALIBRIERUNGS
KONSTANTE
MEDIKAMENT
AUSWAHL
MEDIKAMENT
71
DRUCK-
SCHALTER
73
SENSOR
76
72
ATMUNGS-
MUSTER
KOMPESSOR
ACCUMULATOR
PUMPE
BLAU
BRAUN
IEC-VERBINDER
(*)
SICHER.
VAC
70

Fig.9.

Notice

DESCRIPTION DE69924862T2

[0001]

13 This invention relates to medicament delivery devices and more particularly, but not exclusively, to nebulizers and dosimetric inhalation aids.

[0002]

18 Many different types of nebulizers are known for delivering drugs directly into a patient's lungs, usually for the treatment of respiratory diseases.

20 Nebulizers usually deliver the drug in the form of droplets or a dry powder. In most nebulizers, the drug is continuously nebulized into a stream of air, regardless of whether the patient is inhaling or exhaling. The consequence of continuous nebulization, however, is that a significant proportion of the medicament is lost during exhalation.

[0003]

27 The well known nebulizers are either pneumatically operated, with the aid of a compressed air source connected to the nebulizer that nebulizes the liquid, or they are ultrasonic nebulizers that nebulize the liquid with a piezoelectric crystal.

30 More recently, a sieve-like nebulizer has been developed in which the drug is forced through a fine sieve to create droplets of the drug. Another type of nebulizer or inhalation device is of the type that uses a piezoelectric vibrator in conjunction with an electrostatic charge plate to fluidize a dry powder and disperse it as an aerosol in a stream of air. Such a nebulizer is described in US Pat. No. 5,694,920.

[0004]

The optimal diameter of the particles or droplets of the drug is about 1-5 μm. If the particles or droplets are larger than this value, there is a high probability that they will bounce in the airway before they reach the lungs, and if they are smaller than 1 μm they will have a tendency to be carried out of the lungs on exhalation, without them settling in the lungs.

[0005]

Nebulizers and inhalation devices disperse the small particles of drug into a stream of air or other gas that is delivered to a patient. As far as reference is made to the air which serves as a carrier for the medicament carried therein, other gases are intended to be included which are suitable as a carrier for the medicament.

[0006]

A known nebulizer analyzes the pressure changes within the device during the first three breaths to determine an average shape of the breathing pattern. A timed nebulization pulse begins when the subsequent inhalation phase begins, so that atomization occurs during the first 50% of the inhalation phase. This is illustrated in FIG. 1, where the breathing pattern and the pulse are shown superimposed. This reduces the loss of medication during exhalation to around 3%. Fig. 1 shows the breaths in a graph in which the throughput is plotted against time. When treatment begins, the patient will inhale and exhale three times through the nebulizer before treatment begins. The first three breaths are measured so that the timed nebulizer pulse occurs during 50% of the mean inhalation time. The duration of the inhalation phase is given as T1, T2 and T3. These times are averaged and divided by 2 to determine the pulse length for the next, fourth breath, at which treatment begins. For each subsequent breath, the duration of the nebulization pulse is determined by adding the duration of the inhalation phases of the previous three breaths and dividing by 3 to obtain an average value, and then dividing by 2. The dose delivered to the patient is directly proportional to the duration of the nebulization pulse and thus the nebulization period is summed and the nebulizer is turned off or indicates that the patient should stop as soon as the dose administered to the patient reaches the prescribed amount of the treatment Drug reached.

[0007]

Other nebulizers are known in which the timed nebulization pulse is set at a value other than 50% of the duration of inhalation. With these other nebulizers, however, the pulse length must be adjusted for each patient by the medical staff. Many of the nebulizers are therefore only suitable for use in a controlled environment, such as a hospital. Adjusting the pulse length for each patient means that most nebulizers are not suitable for home use by a patient.

[0008]

83 DE 36 36 669 describes a device for delivering an aerosol into the airways of a patient, which device has separate inhalation and exhalation lines.

85 An aerosol generator is arranged in the inhalation line, which generates an aerosol only during the exhalation phase of the patient, so that the aerosol fills an area in the inhalation line. When the patient inhales, the aerosol is drawn into the patient's lungs from the inhalation line. However, the volume of the aerosol is fixed. The volume of the aerosol is determined to be appropriate for the assumed tidal volume when a patient breathes in a particular way.

[0009]

93 GB 2 077 444 describes an apparatus suitable for use in determining at least two parameters of a human or animal respiratory system.

95 The device comprises a pressure sensor, a flow sensor, a volume sensor, a monitoring unit and a calculation unit, whereby during each breathing cycle the monitoring unit supplies at least two sets of measured values for the pressure and the flow rate and the volume to the calculation unit and the calculation unit supplies the desired parameters of the Respiratory system based on the sets of measured values. The volume is calculated in a conventional manner by integrating the flow over time.

[0010]

104 Reference is made to our co-pending International Patent Publication No. WO 97/48431.

105 Figures 2 and 3 of the present application show the nebulizer disclosed in the above-mentioned co-pending patent application. 2 shows a mouthpiece 1 through which a patient inhales in the direction of arrow 2. Below the mouthpiece 1 there is a removable atomizer part 3, which in turn rests on a base 4.

[0011]

112 The base 4 is shown in more detail in FIG. 3.

113 3, the base 4 has an inlet 5 through which air under pressure is supplied from a compressor (not shown). The compressed air is conducted via a pipe 6 to a distributor 7 which controls the flow of the compressed air to an air outlet 8 which directs air into the atomizer part 3 shown in FIG. The base 4 also contains a pressure sensor 9 which detects the pressure in the interior of the atomizer part 3 via a port 10.

[0012]

121 As shown again in Fig. 2, air under pressure flows through the air outlet 8 of the base 4 and is

passed through a tubular column 11 to an atomizing nozzle 12, from which the air exits under pressure.

124 A deflector 13 is arranged in the path of the compressed air emerging from the nozzle 12, so that the compressed air is deflected laterally and flows through below a shield 14. The passage of the compressed air through the upper end of the tubular column 11 causes the medicament 15 to be drawn up between the outer surface of the tubular column 11 and the inner surface of a sleeve 16 surrounding the tubular column 11. The medicament 15 is atomized into the air stream and carried along in the air stream below the edge of the shield 14 and up through the mouthpiece 1 to a patient.

[0013]

134 The pressure sensor 9 in the base 4 monitors the breathing pattern of a patient, and on the basis of the breathing pattern the distributor 7 is controlled so that it only supplies the compressed air to the nebulizer part 3 during the first 50% of an inhalation phase.

[0014]

140 While a particular type of nebulizer has been described above, the present application is suitable for use in any type of nebulizer.

[0015]

145 The invention also relates to other devices for dispensing medicaments, for example to dosimeters, in which a dose of medicament in droplet or powder form is released into a dosimeter chamber or holding chamber from which it is inhaled by the patient.

148 These devices are particularly suitable for elderly patients or children who have difficulty using a multi-dose or dry powder inhalation device, e.g.

150 B. because they find it difficult to coordinate the release of the drug with the beginning of the inhalation phase or because their respiratory flow rates are too small.

152 Dosimeters are z. As described in International Patent Publication No. WO 96/13294.

[0016]

156 According to a first aspect of the present invention, a dispensing device for medicaments comprises a dispenser for dispensing air laden with medicaments and air which does not carry any medicament for inhalation by a patient, a monitoring device for monitoring a breathing pattern of the patient and a control device for controlling the Dispensing device for the selective dispensing of the drug-laden air and the air that does not carry any drugs, characterized in that the control device is designed to control the dispensing device so that it dispenses the medicament-laden air in pulses, their length and their ratio for the inhalation phase of the breathing pattern is varied by the control device as a function of the breathing

pattern monitored by the monitoring device.

[0017]

168 One method of determining the duration of a pulse during which drug-laden air is delivered to a patient during inhalation comprises:

170 (i) measuring the tidal volume of a patient;

171 (ii) measuring the duration of a patient's inspiratory phase;

172 (iii) storing an estimate of the volume of a patient's upper airway; and

173 (iv) calculating the duration of the pulse based on the patient's measured tidal volume, the measured duration of the inspiratory phase, and the stored estimate of the patient's upper airway volume.

[0018]

179 In this document "upper airways of a patient" means the mouth and windpipe and, if a nebulizer is used, preferably including the volume of the nebulizer chamber.

[0019]

184 Determining the length of the pulses makes it possible to extend the portion of the inhalation time during which the nebulization takes place from over 50% to 100%. This results in the patient receiving his treatment in less time because it takes fewer breaths to deliver the required dose of medication. However, there is no point in continuing to deliver the drug into the air that the patient inhales towards the end of their inhalation phase (the final volume) because it will remain in the upper airways. The drug that does not get through the upper airways is lost when the patient exhales.

[0020]

194 Thus, the invention makes it possible to generate a pulse that is longer than 50% but ends before the end volume of inspiration begins.

196 Another advantage of this invention is that the patient will comply with treatment regimes much better if the length of the treatment is reduced.

[0021]

201 In addition, the invention allows the automatic optimization of the pulse length without it having to be adjusted by the medical staff.

203 This means that the pulse length is automatically adjusted for each patient based on the patient's breathing pattern at the time the drug is administered. Thus, a nebulizer or other drug delivery device can be used by the patient outside of the controlled environment of a hospital.

and, in particular, can also be used at home. It is also possible for the device to indicate when a certain dose has been administered so that the patient does not have to count the number of breaths he has taken.

[0022]

212 According to the preferred embodiment, the device for measuring the tidal volume of a patient comprises a device for measuring a peak value of the patient's respiratory flow and a device for predicting the tidal volume, for calculating the tidal volume on the basis of the peak value of the respiratory flow, which is provided by the device for measuring the Peak value of the respiratory flow is measured, and on the basis of the duration of the inhalation measured by the timer.

[0023]

221 Some or all of the values used in the calculations are mean values derived from a number of previous measurements for each breathing pattern.

223 For example, the patient will begin inhaling through the device and the drug will not be administered during the first three breaths.

225 The first three breaths are analyzed by recording the duration of the inhalation phase and the peak currents during inhalation, as needed to determine the duration of a nebulization pulse. The drug is released on the fourth and subsequent breaths, the values in the calculations being derived from a number of previous measurements of the patient's inhalation phase, in this case from the previous three inhalation phases.

[0024]

233 If the device is a nebulizer, the nebulization is preferably carried out with the aid of a gas flow under pressure which flows through the nebulizer and is provided by a supply device for gas.

235 This gas is normally air, and the supply device is preferably a compressor which cooperates with an accumulator. In nebulization, gas from the accumulator is used to nebulize the drug and the compressor generates compressed air to fill the accumulator.

[0025]

241 When a patient inhales, the accumulator can be emptied so that nebulization is interrupted.

242 The nebulizer therefore preferably contains a device for limiting the duration of the pulse, so that the accumulator is kept in a state in which it is always under a certain pressure. In addition, the accumulator can have a valve which, when the accumulator is full, releases gas to the atmosphere and thus prevents the accumulator from being dangerously overfilled. It is often better to keep the compressor running continuously and to release the excess air into the atmosphere than to switch the compressor on and off.

[0026]

251 A method for predicting a patient's tidal volume includes:
252 (i) measuring the peak current of a patient;
253 (ii) measuring the duration of the patient's inspiratory phase;
254 (iii) Calculating the tidal volume based on the measured peak flow and the measured duration of the patient's inhalation phase.

[0027]

259 The measurement of the patient's tidal volume previously included the continuous monitoring of the patient's respiratory flow, typically every 10 milliseconds.
261 The flow rate is then integrated over the duration of the inhalation in order to determine the inhalation volume.
263 According to the invention, however, the tidal volume of a patient can be determined much more easily.
265 This invention reduces the amount of data processing required, thereby reducing the overall cost of the nebulizer.
267 The peak current is much easier to measure and can be used more easily in a calculation to determine the tidal volume.

[0028]

272 Embodiments of the present invention are described below, by way of example and with reference to the accompanying drawings, in which:

[0029]

277 Fig. 1 is a graph plotting a patient's inhalation pattern over time and showing when the nebulization pulse occurs in the first 50% of the inhalation phase, as is the case with a prior art nebulizer;

[0030]

283 Figures 2 and 3 show a prior art nebulizer which generates nebulization pulses during the first 50% of the inhalation phase;

[0031]

288 Fig. 4 is a flow chart showing how the nebulization pulse is determined during inhalation;

[0032]

292 5 shows a graph in which the predicted tidal volume is plotted against the measured tidal volume;

[0033]

297 6 is a flow chart showing the limitation of the pulse length as a function of the supply of pressurized gas;

[0034]

302 7 shows the nebulizer together with a source of pressurized gas;

[0035]

306 8 shows an air accumulator in the air supply system;

[0036]

310 Fig. 9 is a block diagram showing how the nebulizer is controlled; and

[0037]

314 10 is a sketch of a dosimeter according to the present invention.

[0038]

318 This invention relates, inter alia, to atomizers of the type which produce atomizing pulses such as the conventional atomizer described above.

[0039]

323 However, the invention is not limited to the particular nebulizer described above, but can be applied to other nebulizers.

325 For the sake of simplicity, the following description of the present invention will refer to the components of the conventional apparatus as shown in Figs. 2 and 3, and because many of these components, e.g.

328 The manifold, can be used in the present invention.

329 The atomizer can be a jet atomizer, an ultrasonic atomizer or a pressure screen atomizer.

[0040]

333 Jet atomizers are of two types, namely air jet atomizers and liquid jet atomizers.

334 An example of an air jet atomizer that uses a source of compressed air to atomize a liquid is described in EP 0 627 266 (Medic-Aid Limited).

336 An example of a liquid jet atomizer which forces a liquid through one or more nozzle outlets to produce a spray of fine droplets is described in WO 94/07607 (Boehringer Ingelheim International GmbH et al).

[0041]

342 Ultrasonic nebulizers, which atomize liquid using ultrasonic waves commonly generated by an oscillating piezoelectric element, have many forms including those in which liquid is in direct contact with the piezoelectric element, those in which a reinforcing link, typically an enclosed one Fluid, between the piezoelectric element and the liquid, and those in which the piezoelectric element vibrates a sieve, is generated by the aerosol.

347 Examples of ultrasonic nebulizers are described in US 4,533,082 (Maehara et al.) And US 5,261,601 (Ross et al.).

[0042]

352 The nebulizers described in these documents have a housing which has a reservoir which holds a quantity of the liquid to be dispensed, and the housing has a perforated membrane which is in contact with the reservoir and an ultrasonic vibrator which is connected to the housing to vibrate the perforated membrane.

[0043]

359 Another example of an ultrasonic nebulizer is described in WO 97/29851 (Fluid Propulsion Technologies, Inc).

361 An example of a pressure screen atomizer which may or may not contain a piezoelectric element is described in WO 96/13292 (Aradigm Corporation).

[0044]

366 Extending the portion of the patient's inhalation phase during which nebulization takes place to more than 50% results in patients receiving their treatment more quickly because fewer breaths are required to deliver the required volume of drug.

369 However, in order to avoid wasting the medicament which is nebulized in the final volume of the patient's inspiratory volume, the nebulization pulse must be terminated before the final volume is reached.

372 The final volume is the volume of air that is inhaled by a patient at the end of the inspiratory volume and that remains in the upper airways (the mouth and windpipe) and does not enter

the lower areas of the lungs.
375 The drug that is nebulized into this final volume is lost when the patient exhales, along with any airborne drug that has been left in the nebulizer because it does not reach the lungs.

[0045]
380 The final volume is the volume of the patient's upper airway and is proportional to the patient's largest.
382 Of course, the final volume will vary as a percentage of the inspiratory volume since the tidal volume changes significantly depending on the nature and extent of the breathing difficulties the patient is experiencing.
385 The optimal duration of the nebulization pulse would therefore be the time from the beginning of inhalation to the point during the inhalation phase at which the volume still to be inhaled equals the final volume.
388 The nebulization would then stop and the remaining final volume would remove the nebulized medicament from the device and the patient's upper airways and bring it into the lungs. Thus, the percentage of inhalation in which atomized medication is delivered is maximized, thereby minimizing treatment time while still avoiding waste of the medication. The length of the nebulization pulse depends on the patient's inhalation volume. The nebulizer must therefore measure the patient's tidal volume, preferably from breath to breath, in order to calculate an average inhaled volume for the next breath, for example on the basis of the previous three breaths. Thus, the atomization pulse is calculated as follows:

[0046]
399 A timer is included in the nebulizer which is connected to the pressure sensor 9 (shown in Fig. 3) to measure the duration of inhalation.
401 The nebulizer also contains a memory device in which an estimate of the final volume of a particular patient is stored. Since this quantity is a constant for a particular patient, it can be entered at the beginning of a treatment cycle and it is estimated based on the patient's height. The nebulizer contains a device for measuring the tidal volume of a patient. According to one form of the invention, the patient's breath flow is continuously monitored, typically every 10 milliseconds, and this breath flow is integrated over the duration of the inhalation. Another, simpler way of measuring a patient's tidal volume will be described later in this specification.

[0047]
411 The nebulizer also includes means for calculating the time of the nebulization pulse based on duration of inhalation, tidal volume and final volume.
413 The calculation unit carries out the calculation outlined above.

[0048]

417 Given that the nebulizer adapts to a patient's breathing pattern when the patient begins to breathe, no nebulization occurs during the first three breaths.

419 These first three breaths are used to analyze the patient's breathing pattern. The flow rate of the first three breaths is measured, and from this the duration of the inhalation phase of the first three breaths is calculated and an average value is formed. The mean duration of the inhalation phase is then used in the calculation to determine the pulse length of the nebulization pulse during the fourth breath. As the patient continues to inhale and exhale, the previous three breathing patterns are also measured and used to calculate the next pulse duration. Thus, if a patient's breathing pattern improves during treatment, the nebulizer will adapt to this change in order to optimize the dose administered during each breath.

[0049]

430 The steps performed by the nebulizer and the patient will now be described with reference to FIG.

432 As a first operation, a block 30 represents the start of inhalation by a patient. The timer records the time the inhalation begins, as shown in block 31, and a calculation is made during the inhalation to predict the patient's tidal volume, as shown in block 33. This step will be described in more detail later in this specification, but it should be noted that the calculation requires data to be included in the calculation, namely the inhalation time and the peak flow as an average of the last three breaths, as in block 32 is shown. The pulse time is then calculated by the calculator as shown in block 34 and the pulse time is adjusted as shown in block 35 if the pulse length would empty the accumulator from which the compressed air is supplied to the atomizer. This step, shown in block 35, will also be explained in more detail further below in this description.

442 The nebulization pulse occurs during inhalation and after it is finished a calculation is made to determine what dose has been nebulized. At the end of the breath, as shown in block 38, details of the peak patient inhalation flow and duration of inhalation are recorded so that calculations can be made to determine the pulse length for subsequent breaths. This is shown in block 39.

[0050]

450 A simpler prediction of tidal volume was mentioned above.

451 It goes without saying that the measurement of the tidal volume by integrating the measured flow rate over the time of inhalation requires considerable computing power and is relatively expensive. A simpler method for determining the tidal volume is proposed, which requires considerably simpler calculations and considerably simpler measurements for use in such a calculation. In order to carry out the measurement, the nebulizer contains a peak flow detector for detecting the peak value of the flow rate during inhalation.

[0051]

460 The calculated or predicted tidal volume is derived from the peak flow measured by the peak flow detector and the duration of inhalation measured by the timer.

462 The calculation unit for the tidal volume carries out the following calculation: C is a constant, and it is found that C = 0.7.

[0052]

467 5 is a graph in which the predicted tidal volume is plotted against the measured tidal volume.

468 Each point in the graph represents a patient whose tidal volume was measured by a complex calculation of the tidal volume, by integrating the patient's inspiratory flow over the duration of the inhalation, and the predicted tidal volume using the new, simpler calculation method. It is recognized that the predicted tidal volumes are extremely precise and thus the predicted tidal volume can be used in calculating the time of the nebulization pulse.

[0053]

476 The use of a low flow compressor in conjunction with an accumulator to supply pressurized air to the nebulizer is described in our earlier patent application published as WO 97/48431, referenced above.

479 In the past, the size of the compressor and accumulator was chosen so that the maximum pulse that can be delivered by the device (currently 50% of the inspiratory time) for any given pulse or for the mean output of the compressor does not exceed the volume of the accumulator . Since the pulse time is now variable, it is preferred to calculate the maximum pulse time available from the air delivery system. For patients who have a somewhat higher inhalation requirement, the pulse time for the nebulization is reduced so that the supply capacity of the air supply system is not exceeded. The calculation is carried out breath by breath, assuming that the accumulator is being filled with a constant flow rate from the compressor. The volume of air supplied to the accumulator from the end of the previous pulse to the beginning of the next pulse is calculated and then added to the volume remaining at the end of the previous pulse.

[0054]

493 Figure 6 is a flow chart showing the calculations that are performed to ensure that the volume of air does not exceed the volume of the accumulator.

495 If it is calculated that the air in the accumulator is above the maximum volume of the accumulator, the volume is set to the maximum value (V = Vmax). The reason is that there is an automatic vent valve which limits the volume of air stored in the accumulator. The maximum pulse time can then be calculated based on the rate of discharge of air from the accumulator, i.e. the flow rate of the atomizing jet minus the flow rate of the compressor. If this

exceeds the volume available in the accumulator, the pulse time is limited to the current accumulator volume. The volume of the accumulator at the end of the pulse is then calculated so that it can be used at the beginning of the next calculation at the beginning of the patient's next inhalation phase. The maximum pulse time for individual breaths is thus calculated without the capacity of the air supply system being exceeded. The compressor has a constant output flow rate, typically 1.5 liters per minute, and the atomizing jet has a flow rate of 6 liters per minute during the pulse.

507 The accumulator has a volume of approximately 150 ml at normal pressure and temperature.

[0055]

511 FIG. 7 shows the atomizer 50 which is connected to the air supply 51 by a flexible hose 52.

[0056]

515 8 shows the accumulator which has a vent valve 63 for limiting the maximum expansion of the accumulator.

517 As each pulse is delivered to the nebulizer, the diameter of the accumulator is reduced and the vent valve 63 is closed.

[0057]

522 The compressor can be supplied by mains voltage or from a battery.

523 The pump, in particular a pump fed with mains voltage, works continuously during use and inflates the accumulator.

525 When the pressure in the accumulator reaches a required level, a pressure switch in a hand-held part of the atomizer is activated, as described in an earlier patent application mentioned above. This will turn on the atomizer. When the treatment is finished, the compressor will turn off. The accumulator collapses and the pressure switch in the hand-held part of the nebulizer deactivates the unit.

[0058]

533 According to FIG. 8, the pump supplies the accumulator with air via an inlet 64.

534 The inflation of the membrane 61 of the accumulator is controlled by an arrangement which has an arm 62 which is connected to a vent valve 63. When the membrane 61 of the accumulator reaches the maximum desired expansion, it contacts the arm 62 in order to open the vent valve 63. This releases the air flow from the compressor to the atmosphere and keeps the accumulator at a fixed expansion. During use, air is vented from the accumulator through an outlet 65 and the diaphragm 61 shrinks and loses contact with the valve arm 62 which closes the valve 63 so that the compressor can recharge the accumulator until the valve arm 62 again Vent valve 63 actuated.

[0059]

545 It is also advantageous to vent the accumulator to atmosphere when the compressor is switched off, and this is achieved in that the main switch 66 is mounted with a rotary knob 67 on the top of the accumulator.

548 The underside of button 67 has a cam 68 which contacts valve arm 62 to open valve 63 to relieve pressure from the accumulator. At the same time the compressor is switched off. When the compressor is turned on again, the cam 68 disengages from the valve arm 62 so that the vent valve 63 is closed.

[0060]

555 Figure 9 illustrates a simplified form of the manner in which all of the components of the atomizer are interconnected.

557 The compressor and accumulator 70 are shown as being separate from the hand-held portion of the nebulizer 71, but connected by a hose 72 which directs the compressed air into the nebulizer 71. In the compressor and accumulator part 70, the pump is shown, which supplies the accumulator with compressed air. In the atomizer part 71, the atomizer is switched on by the presence of compressed air in the hose 72 at the pressure switch 73. The nebulizer portion 74 of the nebulizer is controlled by a valve or manifold 75 which controls the pulses of compressed air. The breathing pattern of a patient is detected by a sensor 76, which supplies information about the breathing pattern to the microcontroller 77, which in turn controls the distributor 75. When a dose of medication has been delivered, an indicator such as an LED or buzzer 78 is activated by the microcontroller to indicate that treatment of the patient is complete.

[0061]

571 A further embodiment of the invention is shown in FIG. 10, which is a dosimeter 80 which has a holding chamber 81 which has an outlet 82 at one end which is connected to a mouthpiece 83.

573 A pressure sensor 84 is arranged between the mouthpiece 83 and the holding chamber 81. This sensor 84 measures the pressure in the mouthpiece, from which the flow rate of the air inhaled and exhaled by the patient can be measured. The mouthpiece 83 also has a vent valve 85 that allows a patient to exhale through the mouthpiece 83 without filling the holding chamber 81. More information about the vent valve is described below.

[0062]

581 A piston 86 is shown within the holding chamber which moves longitudinally to vary the volume of air that is available in the holding chamber 81 for a patient to inhale.

583 The piston has a rack 87 which protrudes through the end of the holding chamber 81 so that

the teeth of an electromagnet 88 can be engaged. An air inlet 89 is located at the left end of the holding chamber and allows air to enter or exit the space behind the piston as the piston moves right or left.

[0063]

590 In use, the piston 86 is withdrawn to fill the holding chamber 81 with air.

591 The air in the holding chamber 81 is then loaded with medicament, either in the form of liquid droplets or in the form of a cloud of powder. This is released into the holding chamber 81 via a port 82, and this normally requires the removal of the mouthpiece 83. A mouthpiece 83 can then be reinserted and a patient inhales and exhales through the mouthpiece 83. During inhalation, the patient inhales the drug-laden air from the holding chamber 81, and during exhalation, the exhaled air is exhausted through the valve 85 to the atmosphere. During exhalation, the electromagnet 88 locks the toothed rack 87 of the piston 86 so that it does not move and thus the holding chamber is not filled with exhaled air. In accordance with the invention, however, the piston 86 is free to move only during part of the inhalation phase and is locked in position by the electromagnet 88 while the patient is inhaling the final volume.

601 Once the piston is locked, the valve 85 is designed so that the pressure drop in the mouthpiece 83 caused by the locking of the piston 86 opens the valve 85 so that ambient air can be drawn into the mouthpiece. Of course, a separate valve can also be provided in the mouthpiece in order to carry out this function in a suitable manner.

[0064]

608 The calculation of the pulse length during which the plunger 86 is free to move to allow the drug to be delivered to the patient is determined in the same manner as described above with respect to the nebulizer.

611 The patient's breathing during the previous three breaths is monitored by sensor 84 so that the same calculations can be made as described above. During the next breath, the sensor detects the beginning of the breath, and after the duration of the pulse the piston is locked.

[0065]

617 Such an arrangement reduces the loss of medicament present in the final volume of air that is normally inhaled by the patient.

[0066]

622 This invention is also applicable to other types of medical inhalation devices.

623 Such as

624 For example, as described in the introductory section of this specification, US 5,649,920 describes a dry powder inhaler which uses a piezoelectric vibrator and an electrostatic charge

plate to fluidize a dry powder and disperse it into the patient's air stream. The electrostatic charge plate can be actuated as a function of the patient's breathing pattern, so that pulses are generated in which the powdered medicament is released into the air stream leading to the patient. The length of the pulses can be determined in exactly the same way as in the previously described embodiments so that the dry powder is not dispersed into the final volume of the air flow leading to the patient.

United States Patent [19]

Brooks et al.

[11] **Patent Number: 4,947,874**

[45] **Date of Patent: Aug. 14, 1990**

[54] **SMOKING ARTICLES UTILIZING ELECTRICAL ENERGY**

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[73] Assignee: **R. J. Reynolds Tobacco Company,** Winston-Salem, N.C.

[21] Appl. No.: **242,086**

[22] Filed: **Sep. 8, 1988**

[51] **Int. Cl.**[5] **A24D 1/00;** A24F 1/00; A24F 47/00; A61M 16/00

[52] **U.S. Cl.** **131/329;** 131/273; 131/194; 128/202.21; 128/203.26; 128/203.27; 128/204.21

[58] **Field of Search** 131/329, 194, 273; 128/202.21, 202.27, 203.12, 203.13, 203.15, 204.21, 203.17, 203.26, 203.27, 204.13, 204.23

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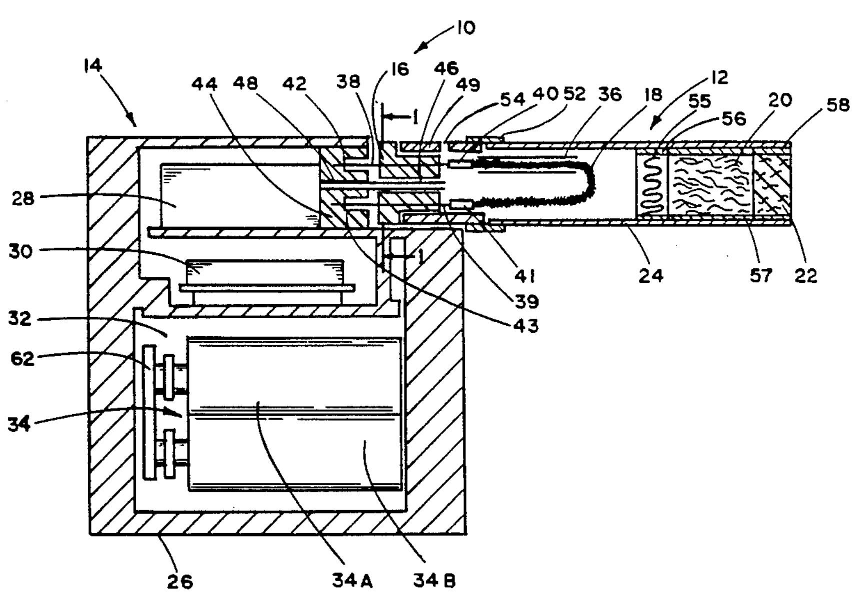
Primary Examiner—V. Millin

[57] **ABSTRACT**

Smoking articles employ an electrical resistance heating element and an electrical power source to provide a tobacco-flavored smoke or aerosol and other sensations of smoking. The smoking articles advantageously comprise a disposable portion and a reusable controller. The disposable portion, which may be a cigarette, normally includes (i) an air permeable resistance heating element having a surface area greater than 1 m^2/g, which usually carries an aerosol forming material, and (ii) a charge or roll of tobacco. The reusable controller normally includes a puff-actuated current actuation means, a time-based current regulating means to control the temperature of the heating element, and a battery power supply.

202 Claims, 8 Drawing Sheets



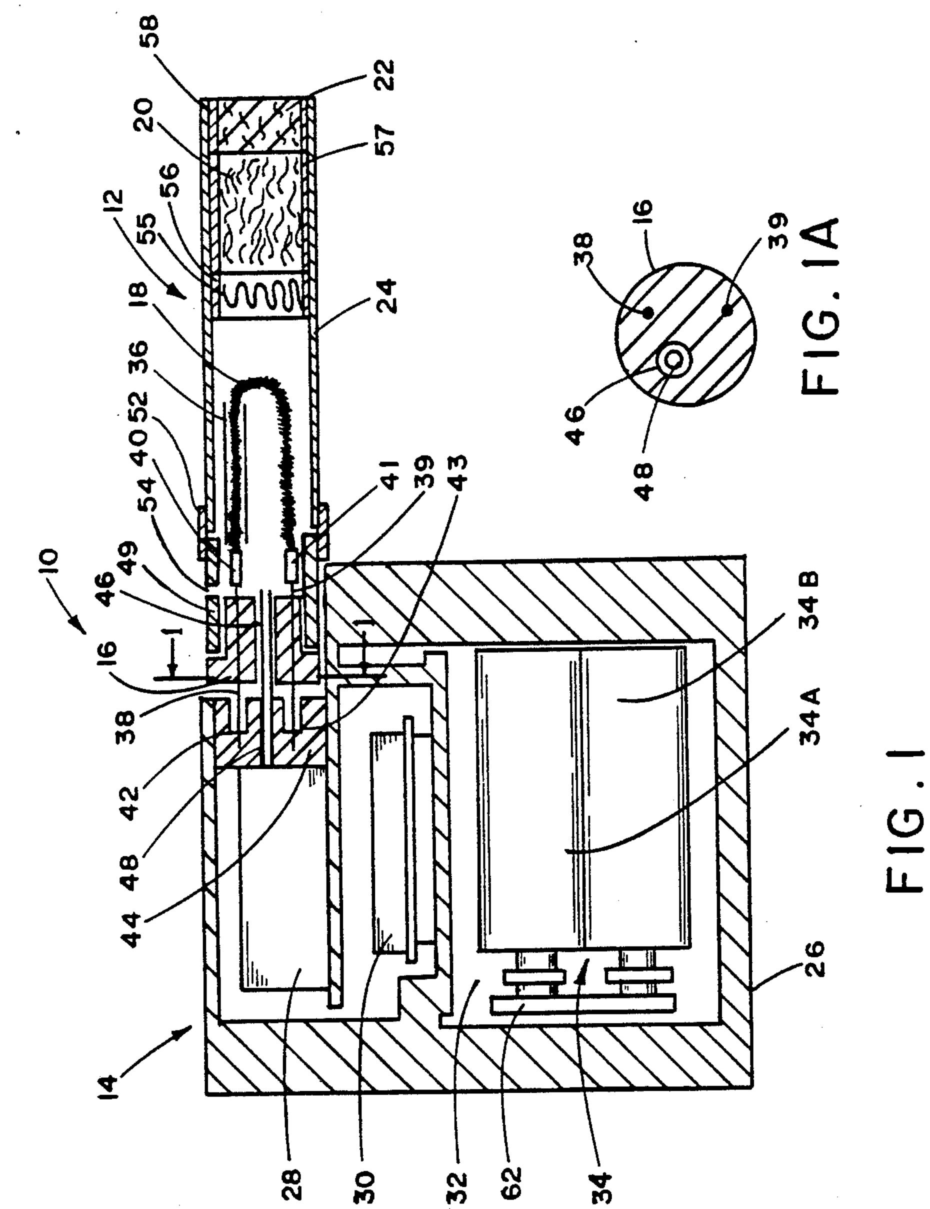


FIG. 1

FIG. 1A

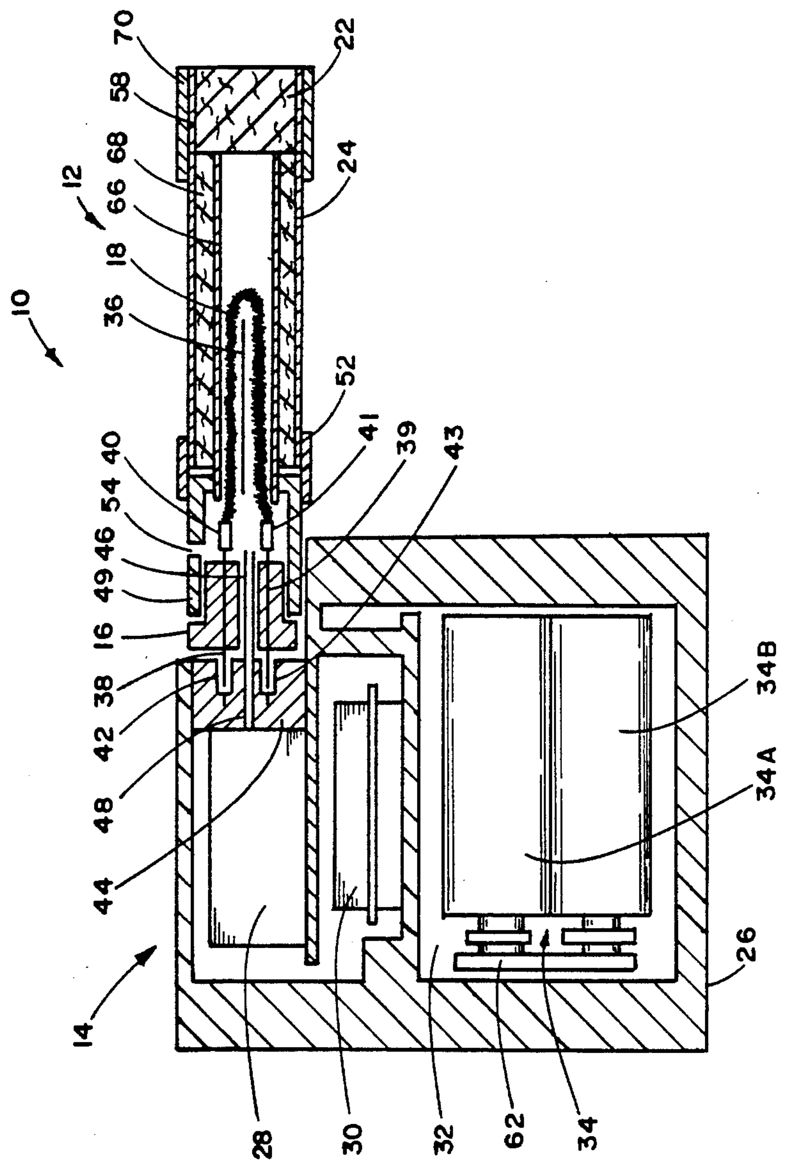


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FIG. 2

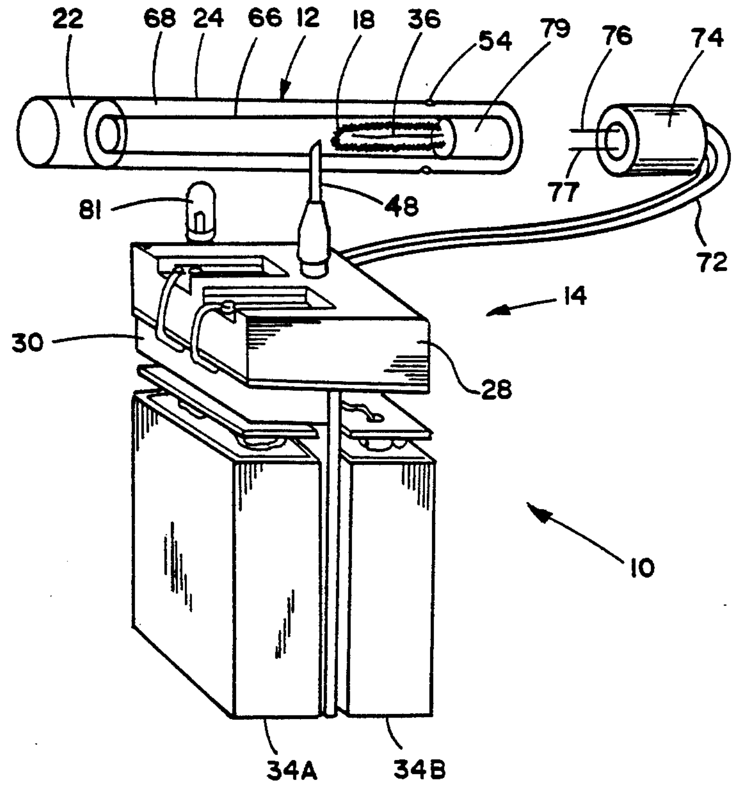

FIG. 3

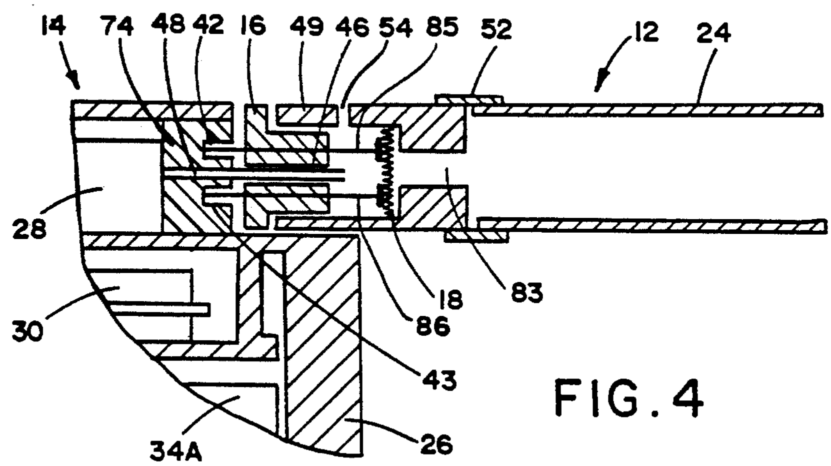

FIG. 4

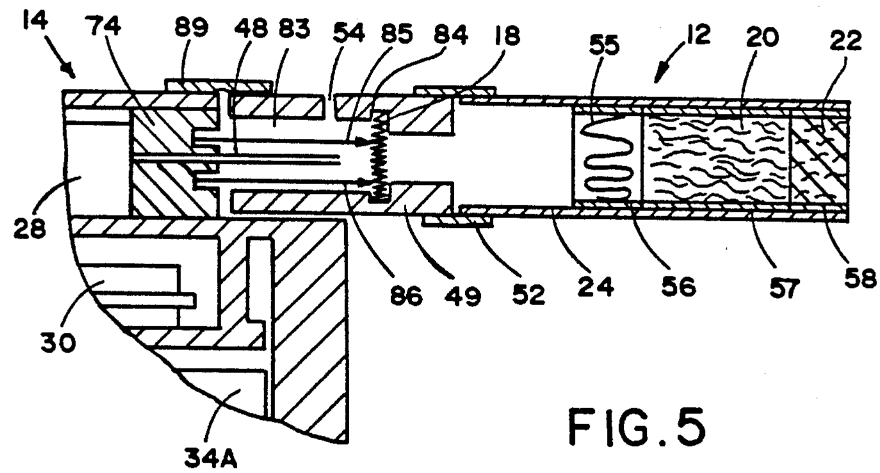

FIG. 5

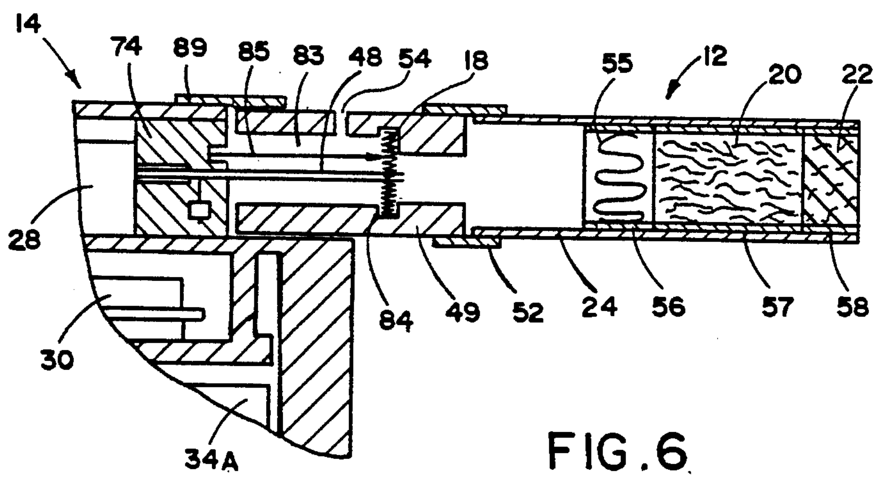

FIG. 6

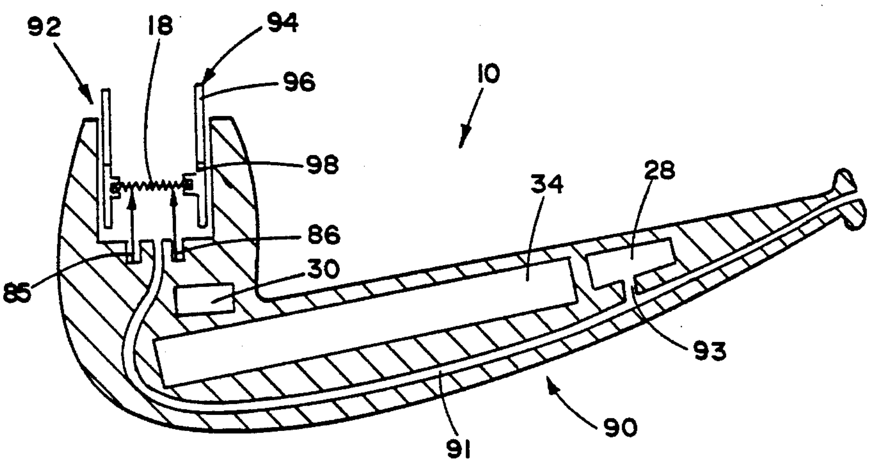
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FIG. 7

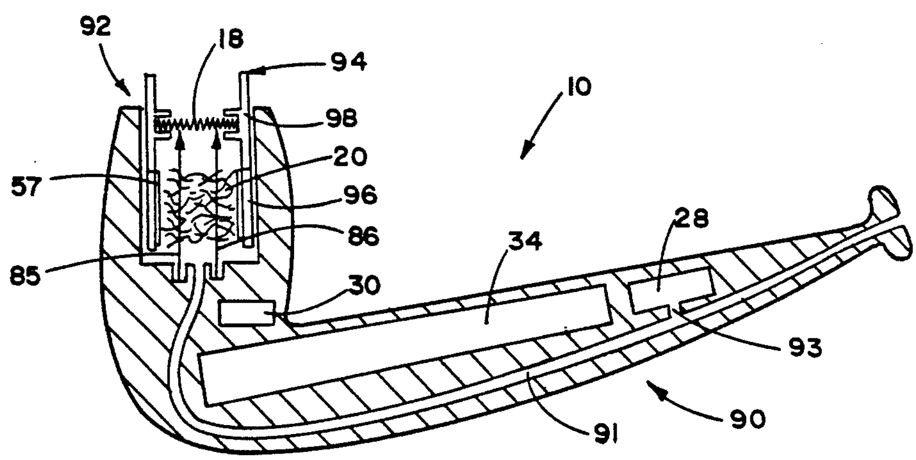
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FIG. 8

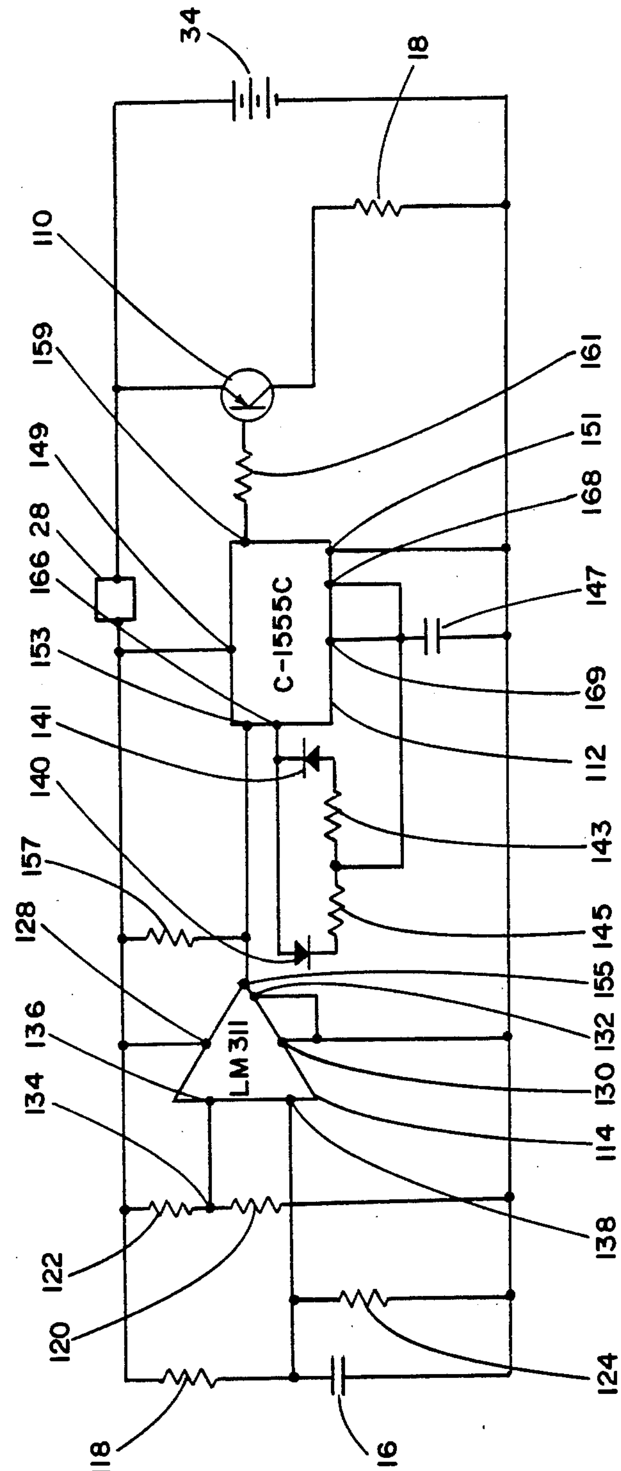
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FIG. 9

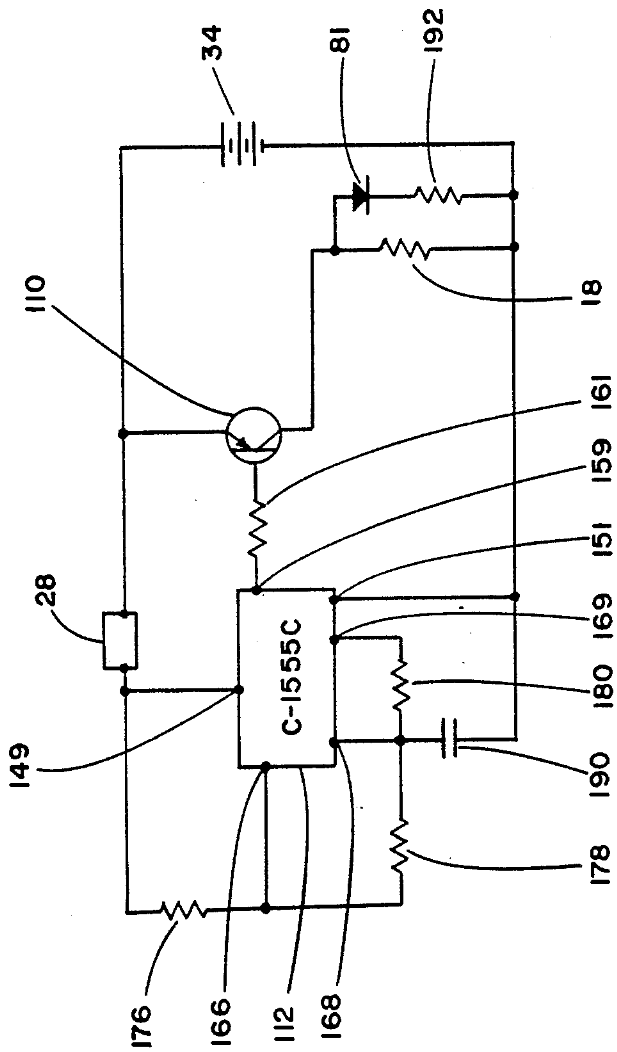
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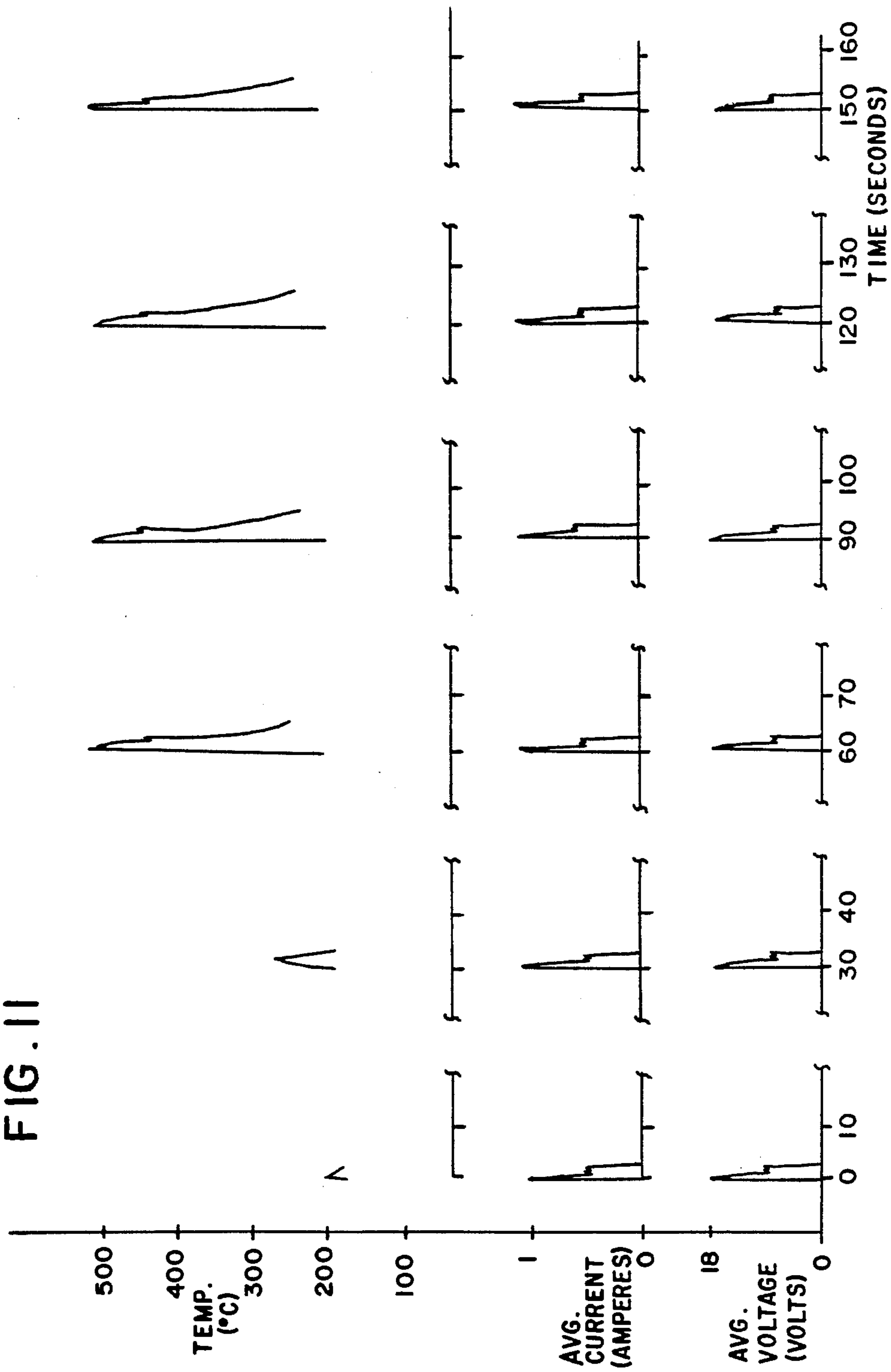
FIG. 10

FIG. 11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SMOKING ARTICLES UTILIZING ELECTRICAL ENERGY

BACKGROUND OF THE INVENTION

The present invention relates to cigarettes and other smoking articles such as cigars, pipes, and the like, which employ an electrical resistance heating element and an electrical power source to produce a tobacco-flavored smoke or aerosol.

Preferred smoking articles of the invention are capable of providing the user with the sensations of smoking (eg., smoking taste, feel, satisfaction, pleasure, and the like), by heating but not burning tobacco, without producing sidestream smoke or odor, and without producing carbon monoxide. As used herein, the term "smoking article" includes cigarettes, cigars, pipes, and the like, which use tobacco in various forms.

Many smoking articles have been proposed through the years as improvements upon, or alternatives to, smoking products which burn tobacco.

Many tobacco substitute smoking materials have been proposed, and a substantial listing of such materials can be found in U.S. Pat. No. 4,079,742 to Rainer et al. Tobacco substitute smoking materials having the tradenames Cytrel and NSM were introduced in Europe during the 1970's as partial tobacco replacements, but did not realize any long-term commercial success.

Numerous references have proposed smoking articles which generate flavored vapor and/or visible aerosol. Most of such articles have employed a combustible fuel source to provide an aerosol and/or to heat an aerosol. See, for example, the background art cited in U.S. Pat. No. 4,714,082 to Banerjee et al.

However, despite decades of interest and effort, no one had successfully developed a smoking article which provided the sensations associated with cigarette or pipe smoking, without delivering considerable quantities of incomplete combustion and pyrolysis products.

Recently, however, in European Patent Publication Nos. 174,645 and 212,234, and U.S. Pat. Nos. 4,708,151, 4,714,082, and 4,756,318, assigned to R. J. Reynolds Tobacco Co., there are described smoking articles which are capable of providing the sensations associated with cigarette and pipe smoking, by heating but not burning tobacco, and without delivering considerable quantities of incomplete combustion products. Such articles rely on the combustion of a fuel element for heat generation, resulting in the production of some combustion products.

Over the years, there have been proposed numerous smoking products, flavor generators and medicinal inhalers which utilize electrical energy to vaporize or heat a volatile material, or attempt to provide the sensations of cigarette or pipe smoking without burning tobacco.

U.S. Pat. No. 2,057,353 to Whittemore, Jr. proposed a vaporizing unit. In particular, a wick reportedly carried liquid medicament by capillary action to a point where the liquid was vaporized by an electrical resistance heating element.

U.S. Pat. No. 2,104,266 to McCormick proposed an article having a pipe bowl or cigarette holder which included a resistance coil (i) wound on an insulating and heat resisting material, and (ii) contained in an insulated chamber. Prior to use of the article, the pipe bowl was filled with tobacco or the holder was fit with a cigarette. Current then was passed through the resistance coil. Heat produced by the resistance coil was transmitted to the tobacco in the bowl or holder, resulting in the volatilization of various ingredients from the tobacco. A thermostatic switch was employed to maintain a predetermined temperature range to which the tobacco was heated.

U.S. Pat. No. 3,200,819 to Gilbert proposed a smokeless, non-tobacco cigarette having a flavor cartridge, such as a porous substrate impregnated with mentholated water. The article included a battery for powering a tube or bulb which was illuminated before assembly. The bulb was placed in a tubular liner, which was in turn located within a tube of plastic having the size, color and form of a cigarette. In use, the illuminated bulb reportedly heated the flavored air drawn through passages formed between the bulb and the tubular liner. As such, warm, moist, flavored air was delivered to the user.

French Patent Publication No. 2,128,256 to Ribot et al proposed an article for delivering denicotinized smoke. The proposed article included a sealed ampule which contained pressurized denicotinized smoke. An electric resistor was immersed in the smoke. In use, the terminals of the resistor were pushed into contact with a microbattery causing the resistor to generate heat and heat the smoke within the ampule. Draw by the user reportedly caused warm smoke to exit a valve near the mouthend of the article.

Japanese Patent Publication 8231/73 to Takeda proposed a cigar-shaped inhaler which included a battery powered Nichrome wire to heat air that, in turn, evaporated an essence from an essence container. The Nichrome wire was energized by either a manually-actuated or a draw actuated "on-off" switch.

West German Patent Application No. 2,653,133 to Kovacs proposed a smoking simulator having an internal battery which could accelerate or control the vaporization or emission of aromatic substances for delivery to the user. In supplemental West German Patent Application No. 2,704,218, Kovacs described the use of a vacuum or draw-actuated switch to switch "on" the battery operated heating coil.

A draw actuated, pressure transducer switch was described in U.S. Pat. No. 4,246,913 to Ogden et al, as part of a smoke aversion therapy article which delivered a small electrical shock to a smoker whenever the smoker drew on a cigarette.

U.S. Pat. No. 4,141,369 to Burruss proposed an article similar to the previously discussed McCormick articles. Burruss proposed a container which was electrically heated to a temperature sufficient to volatilize desired components from smoking material inserted therein. Heated air passing through the container during draw reportedly carried volatilized materials to the mouth of the user.

U.S. Pat. No. 4,303,083 to Burruss proposed a pipe having an electrical resistance heating element, a manually operated "on-off" power switch, and an opening above the resistance element for the addition of volatile compound. During use, the volatile compound was applied, using a squeeze tube or eye dropper, to a heated surface within the pipe, apparently on a puff-by-puff basis. The volatile compounds reportedly were vaporized, mixed with air drawn into the pipe, and inhaled by the user.

PCT Publication No. WO 86/02528 to Nilsson et al proposed an article similar to that described by McCormick. Nilsson et al proposed an article for releasing volatiles from a tobacco material which had been treated with an aqueous solution of sodium carbonate. The article resembled a cigarette holder and reportedly included a battery operated heating coil to heat an untipped cigarette inserted therein. A switch was activated to supply current to the heating coil. A temperature sensor reportedly disconnected and reconnected the battery in order to maintain the temperature generated by the device in a narrow temperature range. Air drawn through the device reportedly was subjected to elevated temperatures below the combustion temperature of tobacco and reportedly liberated tobacco flavors from the treated tobacco contained therein.

U.S Patent No. 4,735,217 to Gerth et al proposed a "cigarette-shaped" medicament dosing article having a pellet of vaporizable medicament and a Nichrome resistance heating element connected in series with a battery power source and a draw actuated switch. In their only working example, the Nichrome heating element allegedly achieved a temperature in the range of 190° F. to 220° F. (90° C. to 105° C.) within a two second puff, which apparently was sufficient to volatilize menthol from a menthol pellet. At Column **8**, lines 43-63, Gerth et al. went on to speculate that their article could be used to vaporize nicotine from a nicotine-containing pellet and that they believed it feasible to coat the heating element with a nicotine-containing compound in lieu of using a vaporizable pellet.

However, it is believed that it would not be possible to coat a Nichrome heating element, of the type described by Gerth et al, with enough vaporizable liquid material to deliver sufficient volatile material to the user, over the 6 to 10 puff life of a typical cigarette. It also is believed that the article of Gerth et al would not be able to provide enough electrical energy to (i) vaporize volatile material until near the end of a typical two second puff, or (ii) provide a high enough temperature (e.g., 150° C. to 350° C.) to vaporize many volatile materials within a two second puff, including many desirable aerosol forming substances and most volatile tobacco flavor components. In addition, even with only a single AA battery, the article described by Gerth et al. is more than 3 times the diameter and many times heavier than a typical cigarette and is provided with a relatively imprecise draw actuated control switch and with no means of regulating the current or heat during the puff.

Despite many years of interest and effort, none of the foregoing articles employing electrical energy has ever realized any significant commercial success, and it is believed that none has ever been widely marketed. Moreover, it is believed that none of the foregoing electrical energy articles is capable of providing the user with the sensations of cigarette or pipe smoking.

Thus, it would be desirable to provide a smoking article which can provide the sensations of cigarette or pipe smoking, which does not burn tobacco or other material, and which does not produce combustion products.

SUMMARY OF THE INVENTION

The present invention relates to cigarettes and other smoking articles which employ an electrical resistance heating element and an electrical power source to provide a tobacco-flavored smoke or aerosol and other sensations of smoking, without burning tobacco or other substances, without producing any combustion or pyrolysis products including carbon monoxide or any sidestream smoke or odor. Preferred articles can produce aerosol almost immediately upon commencement of a puff, as well as provide the controlled production of aerosol throughout the puff and over the 6 to 10 puff life of a typical cigarette.

In one aspect of the invention, the smoking article includes a cigarette or a disposable portion (eg., a cartridge) which utilizes an air permeable high surface area electrical resistance heating element that normally carries aerosol forming and/or tobacco flavor substances prior to use. This resistance heating element typically is a porous material having a surface area greater than 1 m^2/g, as determined using the Brunaver, Emmett and Teller (BET) method described in *J. Am. Chem. Soc.*, Vol. 60, p. 309 (1968); and *Adsorption Surface Area and Porosity*, Gregg et al, Academic Press, N.Y. (1967). Preferably, the heating element is a fibrous carbon material, most preferably having a surface area greater than about 1,000 m^2g. (In contrast, the surface area of the Nichrome metal resistance element of Gerth et al is believed to be about 0.01 m^2g.) Preferably, such porous heating elements are impregnated with liquid aerosol forming substances, such as glycerin, and with tobacco extracts. Such heating elements are particularly advantageous in that they are capable of holding and efficiently releasing relatively large quantities of liquid aerosol forming substances and tobacco flavor materials. For example, such heating elements can carry enough aerosol forming substances to provide aerosol for 6 to 10 puffs, or more.

The cigarette or disposable portion includes tobacco, such as a roll or charge of cut filler. Other forms of tobacco also can be used.

Another aspect of the invention relates to a reusable controller which can be used with the cigarettes or disposable portions of the invention, as well as with other resistance heating aerosol producing articles. This reusable controller normally includes a current actuation means, a separate current regulating means to control the temperature of the heating element, and a battery power supply. Alternatively, the electrical power supply can be provided separately from the current actuation and current regulating means; e.g., as a separate battery pack or as normal household current stepped down by an appropriate transformer. The reusable controller can be in the form of a pipe, a reusable cigarette holder, or a hand-held unit or other portable form into which the disposable portion can be inserted. The use of such a reusable article with the cigarette and disposable portions of the invention is particularly advantageous in that it permits the use of (i) relatively large power sources, capable of generating 10 to 40 watts of power or more, and (ii) accurate and sophisticated current actuation and current regulating means that normally would be too costly to incorporate into a single use, disposable article.

Preferably, the current actuation means is puff actuated, so that current flows through the resistance heating element to produce aerosol only during draw by the user.

The current regulating means normally functions only during periods of current actuation, and preferably is time based. That is, the current regulating means preferably is based on controlling the time period during which current passes through the resistance element during draw. This, in turn, controls the temperature experienced by the resistance element and by the aerosol forming substances. The current regulating means normally includes an electrical control circuit which maximizes initial heating of the heating element, until a desired temperature range for volatilization of the aerosol former and the tobacco flavor substances is reached, usually between about 150° C. and about 350° C. Thereafter, the control circuit, by regulating, restricting or interrupting current flow through the resistance element, normally maintains the heating element within the desired temperature range during the balance of the puff and/or ensures that the heating element does not overheat during puffing.

Preferably, the time-based current regulating means includes a means for permitting uninterrupted current flow through the heating element for an initial period after current actuation, thus permitting rapid heating of the resistance element. The current regulating means preferably includes a timer means for subsequently regulating or interrupting current flow through the heating element, such as by repeated off-on switching, to control the average current flow through the heating element during the balance of the puff. This, in turn, controls the temperature range experienced by the heating element. More preferably, the current regulating means also includes a means to prevent the heating element from overheating during rapid puffing.

Depending upon factors such as the wattage generated by the power source and the resistivity of the heating element, preferred current regulating means of the invention are capable of producing almost immediate aerosol generation upon puffing, preferably within about 0.5 second, more preferably within about 0.1 second. Such preferred regulating means also ensure that sufficient aerosol forming and tobacco flavor substances remain for later puffs, and that such substances are not degraded by exposure to excessive temperatures.

To use the smoking articles of the invention, the user simply inserts the cigarette or disposable portion into the controller, to electrically connect the heating element to a circuit including the current actuation and current regulating means and to the battery. When the user draws on the mouthend of the article, the preferred current actuation and current regulating means permit unrestricted or uninterrupted flow current through the resistance heating element to generate heat rapidly. This heating volatilizes the aerosol forming and/or tobacco flavor substances, which in turn form an aerosol and pass through the article and into the mouth of the user. At the same time, the current regulating means (i) regulates current flow through the heating element to control heating of the resistance element and the temperature experienced thereby, and (ii) prevents overheating and degradation of the aerosol former. When the user stops drawing on the article, the current actuation means prevents further current flow through the heating element and disables the current regulating means. This process continues, puff after puff, until the user decides to stop drawing on the article. At that point, the cigarette or disposable portion can be removed and discarded, and a new one inserted in its place.

Another important aspect of the invention relates to the various configurations of the cigarette or disposable portions described herein. For example, in certain preferred embodiments, the disposable portion advantageously is provided with an electrical connection means at one end thereof. This electrical connection means includes means for connecting the resistance element to the battery or other external power source, and preferably includes an air passageway used in conjunction with the preferred puff actuated current actuation means. In other preferred embodiments, the disposable portion is adapted for connection to the external power source via connectors located on the reusable controller. In certain preferred embodiments, the resistance heating element is located centrally in the disposable portion and/or does not occupy a significant portion of the cross-sectional area of the disposable portion. In other preferred embodiments, the resistance heating element is located adjacent an end of the disposable portion, and/or at least substantially fills the cross-sectional area of the disposable portion or the air passageway therethrough.

In another aspect of the invention, the current actuation means, the current regulating means, and/or the electrical power source may be incorporated into the portion of the smoking article containing the electrical resistance heating element, so that the reusable controller may be reduced in size or even eliminated.

Yet another aspect of the invention relates to a current control circuit for resistance heating aerosol producing articles which includes the current regulating means described herein.

Preferred smoking articles of the invention are capable of delivering an average of at least 0.5 mg, more preferably at least 0.8 mg, of aerosol per puff, measured as wet total particulate matter (WTPM), under standard FTC smoking conditions of 2 second, 35 ml puffs, taken once every 60 seconds. Preferred smoking articles of the invention can deliver such aerosol, preferably in visible form, for a plurality of puffs, preferably at least about 6 puffs, more preferably at least about 10 puffs, under such conditions.

Smoking articles of the invention also are capable of providing an aerosol which is chemically simple. A chemically simple aerosol consists essentially of air, the aerosol former, tobacco volatiles, and desired flavorants. This aerosol preferably has no significant mutagenic activity according to the Ames test; Ames et al, *Mut. Res.*, 31:347–364 (1975); Nagao et al, *Mut. Res.*, 42:335 (1977).

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 heat from the resistance heating element upon aerosol forming substances and/or tobacco flavor substances located on the resistance element or elsewhere in the article.

The articles of the present invention are described in greater detail in the accompanying drawings and in the detailed description of the invention which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal, partial sectional view of a smoking article of this invention;

FIG. 1A is a sectional view of a portion of the embodiment shown in FIG. 1 taken along lines 1—1;

FIG. 2 is a longitudinal, partial sectional view of a smoking article of this invention;

FIG. 3 is a perspective of a smoking article of this invention including an exposed inner view of the reusable portion thereof;

FIGS. 4, 5, and 6 are longitudinal, partial sectional views of preferred smoking articles of this invention showing the disposable portions and cut-away views of the controllers;

FIGS. 7 and 8 are longitudinal sectional views of additional smoking articles of the invention;

FIGS. 9 and 10 are representative schematic diagrams of time-based control circuits and related wiring for preferred controllers of the invention; and

FIG. 11 depicts the temperature, average current and average voltage profiles experienced by a resistance heating element during heating controlled by the preferred current regulating means of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, smoking article 10 includes a cigarette 12 and a reusable, hand-held controller 14. The cigarette 12 includes electrical connection plug 16, resistance heating element 18 carrying an aerosol forming substance, a roll of tobacco 20, mouth end filter 22, and a resilient overwrap 24. The preferred controller 14 includes a case 26, a puff actuated current actuation mechanism 28 having the form of a pressure sensitive switch, a time-based current control circuit 30, and a chamber 32 into which battery power supply 34 (shown as batteries 34A and 34B) is inserted.

The resistance heating element 18 employed in cigarette 12 preferably is a fibrous material having a high surface area and an adsorbant, porous, wettable character, in order to carry a suitable amount of aerosol forming substance for effective aerosol formation. Suitable heating elements preferably have surface areas above about 50 m^2g, more preferably above about 250 m^2g, and most preferably above about 1,000 m^2g.

Preferred heating elements normally have low mass, low density, and moderate resistivity, and are thermally stable at the temperatures experienced during use. Such heating elements heat and cool rapidly, and thus provide for the efficient use of energy. Rapid heating of the element also provides almost immediate volatilization of the aerosol forming substance. Rapid cooling prevents substantial volatilization (and hence waste) of the aerosol forming substance during periods when aerosol formation is not desired. Such heating elements also permit relatively precise control of the temperature range experienced by the aerosol forming substance, especially when the preferred time based current control means of the invention is employed.

Preferred resistance heating elements include carbon filament yarns available from American Kynol, Inc., New York, N.Y., as Catalog Nos. CFY-0204-1, CFY-0204-2, and CFY-0204-3. Such yarns typically have surface areas of about 1,500 m^2g and resistivities of about 10 to about 30 milliohm-cm. See, Kirk-Othmer: *Encycl. Chem. Tech.*, Vol. 16, 3rd Ed., pp. 135–136 (1981). Representative lengths of such yarns range from about 15 mm to about 50 mm. Other preferred heating elements include carbon felts and activated carbon felts available from American Kynol, Inc., as Catalog Nos. CN-157(HC), CN-210(HC), ACN-211-10, ACN-210-10, and ACN-157-10. Such felts typically have surface areas of about 1,500 m^2g and resistivities of about 5 to about 30 milliohm-cm. Such felts can be used in the form of circular discs having diameters of about 4 to 8 mm, as described in greater detail hereinafter with reference to FIGS. 4–6. Other suitable heating elements include porous metal wires or films; carbon yarns, cloths, fibers, discs or strips; graphite cylinders, fabrics or paints; microporous high temperature polymers having moderate resistivities; porous substrates in intimate contact with resistance heating components; and the like.

Preferably, the heating element 18 is impregnated with or otherwise carries the aerosol forming substance in order that the aerosol forming substance is in a heat exchange relationship with the electrical heating element. The aerosol forming substance can be, for example, a polyhydric alcohol, such as glycerin, propylene glycol, or a mixture thereof; water; a tobacco material such as a tobacco aroma oil, a tobacco essence, a spray dried tobacco extract, a freeze dried tobacco extract, tobacco dust, or the like, in order to provide tobacco flavor; or a combination thereof. Other suitable aerosol forming substances are well known in the art. See, for example, U.S. Pat. Nos. 4,714,092 and 4,756,318. While the loading of the aerosol forming substance can vary from substance to substance and from heating element to heating element, the amount of liquid aerosol forming substance used typically will be greater than about 15 mg and preferably ranges from about 25 mg to about 50 mg.

A heat resistant, electrically insulative strip, tube or spacer 36, preferably is provided in order to maintain the heating element in place and to prevent the heating element from contacting itself. The insulative spacer 36 can be a heat resistant plastic material (such as a polyimide), a cellulosic sheet treated with fire retardant, an aluminum foil having a surface coating of aluminum oxide, an insulative ceramic material, or the like.

The electrical connection plug 16 preferably is manufactured from a resilient, electrically insulative material such as a thermoplastic material. The plug 16 includes two electrical connector pins or prongs 38, 39 connected to the ends of heating element 18 via connectors 40, 41. The pins 38, 39 engage with electrical terminals 42, 43 located in electrical connection receptacle 44 of the controller 14. Plug 16 also includes a passageway 46 through which tube 48 from pressure sensing switch 28 extends. As shown in FIG. 1A, pins 38, 39 and passageway 46 are offset with respect to the longitudinal axis of plug 16.

A portion of the length of the electrical connection plug 16 preferably is circumscribed by a collar 49 having the form of a thermoplastic tube, which preferably is friction fit around a portion of the length of the plug. The collar 49 in turn is secured to the remaining portion of the cigarette via overwrap 24 using tipping paper 52 or other appropriate means such as adhesive, a friction fit, or the like. Preferably, the collar 49 includes one or more peripheral air inlet openings 54 which provide a flow of ambient air through the cigarette during draw. Alternatively, the air inlet can be positioned through the extreme inlet end of the cigarette or elsewhere through the periphery of the cigarette, such that drawn ambient air passing through the cigarette to the mouth of the user passes the resistance element.

The cigarette can include a plug spacer member 55 positioned between the heating element 18 and the roll or charge of tobacco 20. The plug spacer member 55 conveniently permits passage of aerosol therethrough, while preventing tobacco filler from contacting the heating element. The plug spacer member can be a cylindrical plug of pleated tobacco paper (eg., pleated tobacco paper of the type commercially available from Kimberly-Clark Corp. as P144-185-GAPF Reconstituted Tobacco Sheet). Preferably, the spacer member is overwrapped with a paper overwrap 56.

The tobacco charge **20** can be tobacco filler such as strands or shreds of tobacco laminae, reconstituted tobacco, volume expanded tobacco, processed tobacco stems, or blends thereof. Extruded tobacco materials and other forms of tobacco, such as tobacco extracts, tobacco dust, or the like, also can be employed. Preferably, the tobacco charge **20** is overwrapped with a paper overwrap **57**.

Tobacco extracts; tobacco flavor modifiers such as levulinic acid; and other flavoring agents such as menthol, vanillin, chocolate, licorice, and the like; can be carried by the heating element, placed between the heating element and the spacer member, applied to the spacer member, blended with the tobacco charge, or applied to the mouthend filter.

The mouthend filter **22** preferably is a low efficiency filter made from a melt blown thermoplastic such as polypropylene. For example, the filter can be manufactured by pleating a web of nonwoven polypropylene available from Kimberly-Clark Corp. as experimental melt blown, macrofiber polypropylene PP-100-F. Alternatively, the mouthend filter **22** can be manufactured from cellulose acetate tow, or the like. Preferably, the filter material is overwrapped with a paper plug wrap **58**.

To maximize aerosol and flavor delivery which otherwise would be diluted by radial (i.e., outside) air infiltration through the overwrap **24**, one or more layers of non-porous cigarette paper can be used to envelop the cigarette. Examples of suitable non-porous cigarette papers are commercially available from Kimberly-Clark Corp. as KC-63-5, P878-5, P878-16-2 and 780-63-5. If desired, the overwrap can be a resilient paperboard material, foil-lined paperboard, or the like; and the paperboard can be circumscribed by a cigarette paper wrap.

The reusable controller **14** includes a case **26** or outer housing which provides a convenient and aesthetic holder for the user. The outer housing **26** can have a variety of shapes and can be manufactured from plastic, metal, or the like. Controller **14** includes an insulative receptacle **44** which includes plug-in connectors **42, 43** for engagement with prongs **38, 39** of plug **16**. Receptacle **44** also includes tube **48** which is inserted into passageway **46** of plug **16** to be in airflow communication with the internal region of the cigarette. The other end of tube **48** is in airflow communication with pressure sensing switch **28**, so that changes in air pressure which occur within the cigarette during draw can be sensed by the switch.

Controller **14** also preferably includes a control circuit **30**, which is connected to a puff actuated, differential pressure sensitive switch **28** by electrically conductive wires (not shown), as well as to batteries **34A** and **34B** via battery terminal **62**. The control circuit **30** preferably is time based. That is, the preferred current control circuit preferably is based on controlling the time period during draw during which current passes through the resistance element. This time based control, in turn, controls the temperature experienced by the resistance element and by the aerosol forming substances. Preferred pressure sensitive switches and control circuits, and their connection power source **34** and resistance element **18**, are described in greater detail hereinafter with reference to FIGS. **9** and **10**.

While the heat needed to volatilize the aerosol forming substance during a puff varies for each particular substance, sufficient heat usually is necessary, during a puff, to heat the aerosol forming substance to a temperature above about 120° C. in order to volatilize an appropriate amount of the aerosol forming substance. More typically, a temperature above about 150° C., often above about 200° C., and sometimes as high as about 300° C. to about 350° C., is necessary to volatilize adequate amounts of the aerosol forming substance during a puff. However, it is desirable to avoid heating the aerosol forming substance to temperatures substantially in excess of about 550° C. in order to avoid degradation and/or excessive, premature volatilization of the aerosol forming substance.

For a particular resistance heating element and a particular aerosol forming substance, a sufficient current is required, during each puff, to generate the heat necessary to volatilize enough aerosol forming substance to provide an adequate amount of delivered aerosol. For the preferred aerosol forming substances and the preferred carbon heating elements described herein, an 18 volt battery usually generates sufficient power (i.e., about 18 watts) to heat the aerosol forming substance to a suitable temperature to volatilize the aerosol forming material almost immediately after current actuation, i.e., within about 0.5 second, preferably within about 0.1 second. The 18 volt battery can be provided using two fully charged 9 volt manganese dioxide-zinc transistor batteries (as shown in FIG. **1**) or three 6 volt lead acid batteries. Also useful is a silver-zinc alkaline battery using potassium hydroxide as an electrolyte and having about 12 to about 15 single cells connected in series, wherein the surface area of each positive electrode is about 3.25 cm^2. Other batteries can include nickel-zinc or nickel-cadmium batteries.

In use, the user inserts the plug **16** of the cigarette **12** into the receptacle **44** of the controller **14**. Such action provides electrical connection of the resistance heating element **18** with the switch **28**, the control circuit **30** and the batteries **34A** and **34B**. Such action also provides for airflow communication between the switch **28** and the inner portion of the cigarette. When the user puffs on the mouthend of the cigarette, ambient air enters the cigarette through air inlet **54**. The pressure actuated switch **28** responds to a sensed change in air pressure within the cigarette during draw and permits current flow through the heating element **18**. As a result, the heating element experiences an increase in temperature which in turn heats and volatilizes the aerosol forming substance. The volatilized aerosol forming substance mixes with the drawn air and forms an aerosol. The volatilized aerosol forming substance (in aerosol or vapor form) passes through the tobacco roll **20** where it elutes tobacco flavor from the tobacco, and exits the mouthend filter **22** into the mouth of the user. During the puff, the preferred current control circuit (described in detail hereinafter) regulates the flow of current to control the temperature experienced by the heating element and the amount of aerosol forming substance which is volatilized.

When the user stops drawing on the cigarette, the pressure actuated switch **28** again responds to the sensed change in air pressure within the cigarette, and further current flow through the heating element ceases. As a result, the temperature of the heating element and the aerosol former quickly drop below the volatilization temperature of the aerosol former, and aerosol formation ceases. This process continues, puff after puff, normally for at least about **6** puffs, until aerosol delivery drops below the level desired by the user.

Then, the user can remove the cigarette 12 from the control pack 14, and dispose of the cigarette. The user then can select a new cigarette, insert the new cigarette into the reusable controller, and repeat the smoking process.

The embodiment illustrated in FIG. 2 is generally similar to the embodiment of FIG. 1, except that the heating element 18 is positioned within a heat resistant, insulative tube 66. The insulative tube 66 preferably is manufactured from a high temperature plastic such as a polyimide, a ceramic, a heat resistant cellulosic, an extruded tobacco material, an aluminum tube having a surface coating of aluminum oxide, or the like. Preferably, a plasticized cellulose acetate tube 68 circumscribes the insulative tube 66, and is itself circumscribed by paper overwrap 24. This embodiment also includes tipping overwrap 70 circumscribing the mouthend of the cigarette in order to attach filter element 22 to the remaining portion of the cigarette.

Referring to FIG. 3, the illustrated embodiment is generally similar to the embodiment of FIG. 2, except that the controller or power pack 14 includes a flexible, cord-like connector 72 which terminates in a plug 74 having prongs 76, 77 for electrical connection into a receptacle 79 at one end of cigarette 12. A needle-like tube 48 extends from switch 28 and extends through resilient overwrap 24 in order that changes in air pressure within the cigarette during draw can be sensed by the switch. If desired, the tube 48 can be incorporated into the cord-like connector 72 and extend into the cigarette through the receptacle 79. With such a design, it is possible for the user to place the control pack in a shirt pocket or on a table, and hold the cigarette in a normal fashion, without holding the added weight of the control pack in his/her hands. A light emitting diode 81 is positioned near the differential switch 28. The diode 81 is electrically connected to the electrical circuitry (as described hereinafter) such that it emits light during draw. As such, the user has a visual means for identifying periods when current passes through the resistance heating element 18.

Referring to FIG. 4, the illustrated embodiment is generally similar to the embodiment of FIG. 2, except that the heating element 18 is a circular disc or pad, preferably formed from an American Kynol carbon felt. The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar 49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18. Electrical connection pins 85, 86 from plug 74 contact the heating element and help hold it in place against collar 49. In this embodiment, the collar 49 can be a thermoplastic material, a thermally stable plastic material, a ceramic, or the like.

The embodiment illustrated in FIG. 5 is generally similar to the embodiment of FIG. 1. In this embodiment, the heating element 18 is a circular disc or pad of carbon felt disposed across an air passageway 83 extending through tubular collar 49. The pad is held in place by shoulder 84 on the collar 49. In addition, the cigarette does not have an electrical connect plug. Instead, electrical connection pins 85, 86 for the heating element extend from a plug 74 located on the controller 14. The cigarette 12 is held in place relative to the controller 14 via a clip 89 extending from the controller, or other suitable connection means.

The embodiment illustrated in FIG. 6 is generally similar to the embodiment of FIG. 5, except that the pressure sensing tube 48 also is used as one of the connecting pins (e.g., in lieu of connection pin 86 of FIG. 5).

Referring to FIG. 7, smoking article 10 has the form of a pipe. The pipe includes a stem 90 having an air passageway 91 and a bowl 92 into which a disposable smoking cartridge 94 is inserted. The bowl and stem can be manufactured from briarwood, or the like. The pipe 10 includes power source 34, such as one or more batteries, pressure sensing switch 28, pressure sensing passageway 93, current control circuit 30, and electrical pins 85, 86 extending from the bottom of the bowl. Preferred pressure sensing current control circuits and their connection to power source 34 and heating element 18 are described in greater detail hereinafter with reference to FIGS. 9 and 10.

The cartridge 94 includes an outer tubular housing 96 connected to a collar 98 which in turn supports resistance element 18 and the aerosol forming and tobacco flavor substances at one end of the cartridge. The resistance element 18 can be a carbon fiber felt pad which extends perpendicularly to the longitudinal axis of the cartridge so that drawn air passes through the resistance element. The disposable cartridge 94 is positioned within the bowl 90, with the resistance heating element 18 positioned near the bottom of the bowl so that the electrical connection pins 85, 86 extending from the bowl contact the resistance element.

Referring to FIG. 8, the illustrated embodiment is generally similar to the embodiment of FIG. 7. In this embodiment, the resistance element 18 is positioned towards the air inlet end of the cartridge (i.e., remote from the bottom of the bowl) rather than near the air outlet end of the cartridge. Also, a charge of tobacco 20 is positioned within the cartridge 94 between the resistance element and the air outlet end of the cartridge. In this case, the electrical connection pins 85, 86 extend from the bottom of the bowl through the tobacco charge 20 to contact the resistance element 18.

The foregoing embodiments preferably incorporate the preferred circuit shown schematically in FIG. 9. In particular, the circuit of FIG. 9 includes a power source 34, the electrical resistance heating element 18, a current actuation mechanism 28, and a preferred current regulating circuit or means for controlling the passage of current through the resistance element during periods of current actuation.

The circuit includes a puff actuated control switch 28, or some other suitable current actuation/deactuation mechanism, such as a manually actuated on-off switch, a temperature actuated on-off switch, or a lip pressure actuated switch. The preferred puff actuated switch 28 enables current to pass through the heating element 18 only during draw on the article. A typical puff actuated switch includes a means for sensing the difference in air pressure in a region within the previously described cigarette or disposable cartridge and an "on-off" switch responsive thereto.

A preferred puff actuated switch 28 is a pressure differential switch such as Model No. MPL-502-V, range A, from Micro Pneumatic Logic, Inc., Ft. Lauderdale, Fla. Another suitable puff actuated mechanism is a sensitive pressure transducer (eg., equipped with an amplifier or gain stage) which is in turn coupled with a comparator for detecting a predetermined threshold pressure. Yet another suitable puff actuated mechanism is a vane which is deflected by airflow, the motion of which vane is detected by a movement sensing means. Yet another suitable actuation mechanism is a piezoelectric switch. Also useful is a suitably connected Honeywell Microswitch Microbridge Airflow Sensor, Part No. AWM 2100V from Microswitch Division of Honeywell, Inc., Freeport, Ill. Other suitable differential switches, analog pressure sensors, flow rate sensors, or the like, will be apparent to the skilled artisan.

The current regulating circuit preferably is time based. Normally, such a circuit includes a means for permitting uninterrupted current flow through the heating element for an initial time period during draw, and a timer means for subsequently regulating current flow until draw is completed. Preferably, the subsequent regulation involves the rapid on-off switching of current flow (eg., on the order of about every 1 to 50 milliseconds) to maintain the heating element within the desired temperature range. Alternatively, the subsequent regulation involves the modulation of current flow through the heating element to maintain the heating element within a desired temperature range.

One preferred time-based current regulating circuit preferably includes a transistor **110**, a timer **112**, a comparator **114**, and a capacitor **116**. Suitable transistors, timers, comparators and capacitors are commercially available and will be apparent to the skilled artisan. Exemplary timers are those available from NEC Electronics as C-1555C and from General Electric Intersil, Inc. as ICM7555, as well as various other sizes and configurations of so-called "555 Timers". An exemplary comparator is available from National Semiconductor as LM311.

In the preferred circuit of FIG. **9**, the means for determining the length of the initial time period of uninterrupted current flow includes resistors **118**, **120**, **122** and **124**; capacitor **116**; and comparator **114**. The comparator **114** is powered by connection to entrance pin **128** and to ground pins **130**, **132**. Resistors **122** and **120** constitute a voltage divider which provides a predetermined reference or threshold voltage at the voltage divider tap **134** (i.e., the common point between resistors **122** and **120**). The voltage divider tap **134** is connected to the negative entrance pin **136** of comparator **114**. Capacitor **116** is connected in parallel with resistor **124**. The parallel combination of capacitor **116** and resistor **124** is connected in series with resistor **118** at one end and to the ground reference point of the power source **34** at the other end. The other end of resistor **118** is connected to power source **34** via switch **28**. The common node point between the resistor **118** and the parallel combination of capacitor **116** and resistor **124** is connected to the positive entrance pin **138** of comparator **114**.

Resistors **118** and **124** and the capacitance of capacitor **116** are chosen so that the charge rate of capacitor **116** approximates the heating and cooling rate of the resistance heating element **18**. The ratio of the resistance of resistor **124** to the sum of the resistances of resistors **118** and **124** sets the maximum voltage to which capacitor **116** can charge. Preferably, the resistances of voltage divider resistors **120** and **122** provide a voltage which is slightly below the maximum capacitor voltage set by resistors **118** and **124**.

The timer means for regulating (or interrupting) current flow after the initial time period includes timer **112**, diodes **140**, **141**, resistors **143**, **145**, and capacitor **147**. This timer means generates a periodic digital wave having a preset on-off duty cycle, which is used to rapidly switch the current "on" and "off" at transistor **110** after the passage of the initial time period, to control the temperature range experienced by the resistance heating element.

Timer **112** is powered by connection through entrance pin **149** and ground pin **151**. The reset pin **153** of timer **112** is connected to output pin **155** of comparator **114**. As a result, the comparator **114** disables the timer during the initial period of uninterrupted current flow. A resistor **157** provides a so-called "pull-up" function for the reset pin **153** of timer **112**.

Timer **112** also is connected to diodes **140**, **141** at discharge pin **166**. Diodes **140**, **141** are in turn connected to resistors **145** and **143**, respectively. In addition, timer **112** is connected to resistors **143** and **145**, and capacitor **147** through trigger pin **168** and threshold pin **169**. Capacitor **147** is provided to set the overall time period of the duty cycle. Preferably capacitor **147** is one which charges and discharges at a rapid rate in order that a relatively rapid duty cycle (e.g., in the order of 1 to 50 milliseconds) is provided.

Resistor **145** determines the charge rate of capacitor **147**, and thus the "off" period of the duty cycle, while resistor **143** determines the discharge rate of the capacitor and thus the "on" period of the duty cycle. Diode **140** acts to allow current flow from the timer **112** through resistor **145** and to capacitor **147** during periods when the capacitor is charging, and prevents current passage through resistor **145** when the capacitor is discharging. Diode **141** acts to allow current flow from the capacitor **147** through resistor **143** and to the timer during periods when the capacitor is discharging, and prevents current passage through resistor **143** when the capacitor is charging. Thus, the relative on-off duty cycle of the wave form can be varied by selection of the resistances of resistors **143** and **145**.

The output pin **159** of timer **112** is connected to resistor **161**. The resistor **161** is in turn connected to the base of transistor **110** in order to limit "on" current through the base-emitter (BE) junction of the transistor. The transistor **110** acts to control the relatively large current which passes through the resistance element **18** from the power source **34** by switching "on" and "off" in response to current flow from the timer.

When draw commences, the puff actuated switch **28** closes to allow current flow through the circuit. The normally "off" transistor switches "on" in response to current flow through the timer **112**. This allows current to flow through the resistance heating element **18**.

Simultaneously, capacitor **116** begins to charge. When capacitor **116** is charged to the predetermined threshold voltage determined by resistors **120** and **122**, which typically occurs in about 1 second, comparator **114** activates timer **112** through reset pin **153**. This terminates the uninterrupted current flow to the transistor **110** by switching the transistor "off." At the same time, the timing means begins generating the periodic digital wave form having a preset on-off duty cycle at output pin **159**. Such action of the timing means in turn causes the transistor to switch "on" and "off" rapidly, thus rapidly enabling and disabling current flow through the heating element **18**. This rapid switching acts to control the average current flow through the heating element, thus controlling the temperature range experienced by the heating element during the balance of a puff.

As described above, the capacitance of capacitor **147** determines the overall time period of the preset duty cycle, while the relative "on" and "off" periods of the duty cycle are determined by the relative resistances of resistors **143** and **145**. By varying these resistances, it is possible to closely control the temperature range experienced by the heating element **18**, so as to provide a relatively steady state temperature range, or a controlled decrease or increase in the temperature range during the latter portion of a puff.

When draw ceases, puff actuated switch **28** opens to prevent further current flow through the circuit. As a result, the transistor **110** switches to its normally "off" position, thus preventing further current flow through the heating element **18**. As a result, the heating element begins to cool, and volatilization of the aerosol forming substance ceases. At the same time, capacitor **116** begins to discharge, preferably at about the same rate at which the heating element cools.

When a subsequent draw commences, the puff actuated switch again closes, thus allowing current to flow through the circuit. If the subsequent draw is taken before the capacitor **116** has discharged completely (i.e., before the heating element has cooled completely), the capacitor **116** preferably recharges to the predetermined threshold voltage at about the same rate at which the heating element heats. This activates timer **112** and terminates the period of uninterrupted current flow at about the same time that the heating element **18** reaches the preferred temperature range. As such, the heating element is prevented from overheating during periods of rapid puffing by the user.

Controllers and smoking articles of the invention also can incorporate the alternate time-based circuit shown schematically in FIG. **10**. In particular, the circuit of FIG. **10** includes a power source **34**, the electrical resistance heating element **18**, a current actuation mechanism **28**, and a current regulating circuit or means for controlling the passage of current through the resistance element during current actuation.

The preferred current actuation mechanism **28** is a puff actuated control switch of the type described previously.

The current regulating circuit shown in FIG. **10** is time based. This circuit includes timer **112**, resistors **161**, **176**, **178** and **180**, capacitor **190**, and transistor **110**.

Exemplary timers have been described previously. The timer **112** is powered by connection through entrance pin **149** and ground pin **151**. The output pin **159** of the timer **112** is connected to the base of transistor **110** through resistor **161**. The timer **112** is connected to resistor **180** through threshold pin **169**; to the node point between resistors **180** and **178** through trigger pin **168**; and to the node point between resistors **178** and **176** through discharge pin **166**. The node point between resistors **180** and **178** is in turn connected to capacitor **190** which is connected to ground reference point of the power source **34**.

The sum of the resistances of resistors **178** and **176** determines the period of uninterrupted current flow through resistance element **18**, while the resistance of resistor **176** determines the period during which current flow is prevented from passing through the resistance element. Resistor **180** limits the voltage discharge rate of capacitor **190** so as to limit the initial heating time of the resistance element during a subsequent puff taken a short time after the preceeding puff.

If desired, light emitting diode **81** and resistor **192** can be employed. The light emitting diode **81** is connected in series with resistor **192**. The series combination of diode **81** and resistor **192** is connected in parallel with the resistance element **18**. The light emitting diode thus illuminates during draw, and the user then can have a visual means for identifying periods when current passes through the resistance element for heat generation. Such light emitting diodes also can be employed in the preferred circuit illustrated in FIG. **9**.

When draw commences, the puff actuated switch **28** closes to allow current flow through the circuit of FIG. **10**. The normally "off" transistor switches "on" in response to current flow through the timer **112**, and in turn allows current to flow through the resistance heating element **18**.

Simultaneously, capacitor **190** begins to charge. When capacitor **190** is charged to the predetermined voltage determined by resistors **178** and **176**, timer **112** acts to switch the transistor **110** and current flow through heating element **18** "off." However, after a further period of time determined by resistor **176**, the timer **112** again is turned "on." This process repeats itself until draw ceases. As such, the temperature experienced by the resistance element can be controlled so as to not overheat during a relatively long draw period. For example, a duty cycle can consist of an "on" period of uninterrupted current flow immediately upon draw for about 1.5 to about 2 seconds, followed by an "off" period of about 0.5 to about 1 second.

When draw ceases, puff actuated switch **28** opens to prevent further current flow through the circuit. As a result, the transistor **110** returns to its normally "off" position, thus preventing further current flow through the resistance element **18**. The resistance element cools, and volatilization of the aerosol forming substance ceases. At the same time, capacitor **190** discharges.

Current regulating means which modulate current flow through the heating element can be employed in place of the previously described on-off time-based circuits. In addition, on-off and current modulating means can be connected to temperature sensors or other sensing means, rather than to a time-based circuit, in order to control the passage of current through the resistance heating element. Such sensors can be temperature sensors such as infrared sensors, piezoelectric films or the like, or thermostats such as bimetallic strips. Such temperature sensors can sense either the temperature of the heating element directly or the temperature of the air passing the heating element. Alternatively, the temperature sensors can sense the temperature of a second or "model" resistance heating element having a heating and cooling character related to that of the aerosol carrying heating element. Another type of sensor which can be employed is a dynamic resistance sensor which senses the change in resistance of the heating element during the heating period.

The following examples are provided in order to further illustrate the invention but should not be construed as limiting the scope thereof. Unless otherwise noted, all parts and percentages are by weight, and all sizes are approximate.

EXAMPLE 1

A smoking article substantially as shown in FIG. **2** was prepared as follows:

A. Preparation of the Disposable Portion

End plug **16** was formed from a Delrin plastic cylinder to have a 2 mm long section of 8 mm diameter and a 3 mm long section of 7 mm diameter. The plug was provided with a passageway **46** of sufficient size to receive an **18** gauge needle **48** and two smaller passageways to receive electrical connector pins **38**, **39**.

The electric resistance heating element 18 was formed from a 35 mm length of carbon filament yarn obtained from American Kynol, Inc., under Catalogue No. CFY-0204-1. This heating element had a resistance of 20.6 ohms and a reported surface area of about 1,500 m^2g. The heating element was impregnated, dropwise, with 35 mg of a liquid aerosol forming substance comprising a mixture of 31 parts propylene glycol, 62 parts glycerin and 7 parts of a tobacco extract.

Two 15 mm long crimp connectors **40, 41**, including pins **38, 39**, were obtained from Black Box Corp., Pittsburgh, Pa. under Catalog No. GH-FA810. Crimp connectors **40, 41** were attached to each end of the heating element **18**. Pin **38** of the first connector **40** was inserted through one of the smaller passageways in the plug **16**. The heating element then was folded over a 20 mm long, 5 mm wide strip of Kapton polyimide film **36**, to keep the heating element from contacting itself, and pin **39** of the second connector **41** was then inserted through the second small passageway of the plug **16**.

A 9 mm long Delrin tube **49** was fabricated from an 8 mm diameter cylinder. One section, 6 mm long, had a 7 mm inner diameter (I.D.), and a second section, 3 mm long, had a 4 mm I.D. A single air inlet hole **54** was made about 4 mm from the 4 mm I.D. end of the tube using a No. 64 drill bit. The 7 mm I.D. end of the tube **49** was then friction fit over the 7 mm end of plug **16**.

A 39 mm long, 4 mm outer diameter Kapton polyimide tube **66** was slipped over the resistance element **18** and inserted about 4 mm into the 4 mm I.D. end of the Delrin tube **49**. A 36 mm length of a 8 mm O.D. plasticized cellulose acetate tube **68**, SCS-1 from American Filtrona Corp., was slipped over the polyimide tube. This tube **68** was then overwrapped with a layer of Kimberly-Clark P-850-192-2 paper **24**.

A 10 mm long, low efficiency cellulose acetate filter **22** (8 denier per filament, 40,000 total denier) was fastened to the open end of the wrapped tubes with a layer of tipping paper **70**. The overall length of the disposable portion **12** was about 55 mm.

B. Assembly of the Controller

A polystyrene housing for the controller was formed to provide chambers for a pressure sensitive switch, a current control circuit, and a battery power supply.

The pressure sensitive switch was the switch portion of a Model No. MPL-502-V, range A, differential switch obtained from Micro Pneumatic Logic, Inc. A 20 mm long 18 gauge steel needle **48** was inserted into the appropriate opening in the switch. A polymethylmethacrylate receptacle **44** having a length of 26 mm, a height of 12 mm and a width of 9 mm was formed with a hole for the gauge needle and fitted with two Black Box Model No GH-FA820 plug-in connectors **42, 43**. The receptacle was slipped over the needle and inserted into an appropriately sized opening in the case.

The control circuit employed is schematically illustrated in FIG. **9**. It was designed to provide uninterrupted current flow through the heating element for 1 second after the commencement of a puff. During the balance of the puff, the control circuit was designed to alternately switch off for 5 milliseconds and then on for 5 milliseconds (a 50 percent duty cycle), until the pressure actuated control switch opened. Comparator **114** was a Model LM 311 obtained from National Semiconductor. As shown in FIG. **9**, connections were made at entrance pin **128**, ground pins **130** and **132**, negative entrance pin **136**, positive entrance pin **138**, and output pin **155**. Timer **112** was a Model C-1555C obtained from NEC Electronics. Connections to timer **112** were made at trigger pin **168**, threshold pin **169**, output pin **159**, discharge pin **166**, entrance pin **149** and ground pin **151**. Transistor **110** was a Model MJE 2955 from Motorola Semiconductor Products. Diodes **140** and **141** were Type IN914 diodes from Fairchild Semiconductor Corp. Capacitor **116** had a capacitance of 2.2 uF. Capacitor **147** had a capacitance of 0.1 uF. The resistances of the resistors **118, 120, 122** and **124** were 1,000,000 ohm; 180,000 ohm; 1,000,000 phm; and 820,000 ohm, respectively. The resistances of resistors **157, 143, 145** and **161** were 120,000 ohm; 39,000 ohm; 100,000 ohm; and 1,000 ohm, respectively.

The control circuit was connected to the switch, the receptacle for the plug on the disposable portion, and the battery terminals, as schematically illustrated in FIG. **9**. The battery supply consisted of two 9 volt alkaline transistor batteries connected in series.

C. Use

The end plug **16** was placed against receptacle **44** to electrically connect the disposable portion to the controller and insert the needle into the disposable portion. The filter end of the disposable portion was then inserted into a standard smoking machine and was smoked under FTC conditions of 2 second, 35 ml puffs, taken every 60 seconds. The smoking article produced visible aerosol on all puffs for 10 consecutive puffs. Four similar disposable portions also were smoked, and the five samples yielded an average of 13 mg of wet total particulate matter (WTPM), and no detectable carbon monoxide.

EXAMPLE 2

Kynol Catalogue No. CFY-0204-2 carbon fiber yarn having a length of about 32 mm had a resistance of 18 ohms was used to prepare a heat generating electrical resistance element. The yarn had 18 ul of glycerin applied thereto. Each end of the yarn was electrically connected to an 18 volt/1 ampere limited power source. The arrangement was equipped with the control circuit described in Example 1.

The assembly was actuated such that the resistance element generated heat for a 2 second interval once every 30 seconds. During each puff, the timing mechanism began to control current flow 1 second after current flow through the resistance element was commenced. The duty cycle provided by the timing mechanism was 10 milliseconds. Maximum current was allowed to flow through the resistance element over one half the duty cycle, and no current was allowed to flow through the resistance element over the other half of the duty cycle. As such, the average current experienced during the timer cycle period was about one half of the maximum current.

Voltage and current levels were measured over time, and the temperature of the resistance element was monitored over time using a Wahl Model HSM-672 IR Spy focused onto the resistance element. Values of the measured and monitored data were recorded, and are presented in FIG. **11**.

As shown in FIG. **11**, the maximum temperature reached on the first puff was about 200° C., on the second puff about 350° C., and thereafter about 500° C. Moreover, on each puff, the heating element rapidly achieved the maximum temperature and thereafter maintained that temperature during the balance of the puff, after which the element cooled to ambient temperature over about a 5 second period.

EXAMPLE 3

A smoking article substantially as shown in FIGS. 1 and 1A was prepared as follows:

A. Preparation of the Cigarette

End plug 16 was formed from a Delrin cylinder to have a 2 mm long section of 8 mm diameter and a 3 mm long section of 7 mm diameter. As shown in FIG. 1A, the plug was provided with a passageway 46 of sufficient size to receive an 18 gauge needle 48 and two smaller passageways to receive electrical connector pins 38, 39.

The electric resistance heating element 18 was formed from a 46 mm length of carbon filament yarn obtained from American Kynol, Inc., under Catalogue No. CFY-0204-2. This heating element had a resistance of 20 ohms and a reported surface area of about 1,500 m^2g. The heating element was impregnated with 47 mg glycerin. Two 15 mm long crimp connectors 40, 41 including pins 38, 39, were obtained from Black Box Corp., Pittsburgh, Pa. under Catalog No. GH-FA810. Crimp connector 40 was attached to one end of the heating element and pin 38 was inserted through one of the smaller passageways in the plug. The second end of the heating element is passed through a Kapton polyimide tube having an outer diameter of 4 mm and a length of 20 mm, to keep the heating element from contacting itself. The second end of the heating element was fit with a second crimp connector 41, and the second pin 39 was then inserted through the second small passageway.

A 9 mm long Delrin tube 49 was fabricated from an 8 mm diameter cylinder. One section, 6 mm long, had a 7 mm I.D., and a second section, 3 mm long, had a 4 mm I.D. A single air inlet hole 54 was made about 4 mm from the 4 mm I.D. end of the tube using a No. 64 drill bit. The 7 mm I.D. end of the tube 49 was then friction fit over the 7 mm end of plug 16.

A 10 mm long tobacco rod was formed from Burley tobacco cut filler wrapped in paper, and was friction fit into one end of a resilient paperboard tube 24 having an outer diameter of 8 mm and a length of 75 mm. Immediately behind the tobacco rod 20 was positioned a 3 mm length of a moderate efficiency cellulose acetate filter 22. The other end of the tube 24 was slipped over the heating element and abutted against the 4 mm I.D. end of the tube 49, and adhesive tape 52 was used to hold the tubes in place. The heating element 18 was positioned so as to not contact the paperboard tube, and to extend 25 mm into the tube and 5 mm from the nearest end of the tobacco charge (i.e., so as to be physically separate and spaced apart from the tobacco charge).

C. Use

The end plug 16 was placed against receptacle 44 to electrically connect the cigarette to the controller and insert the needle into the cigarette. The filter end of the cigarette was then inserted into a standard smoking machine and was smoked under conditions of 2 second, 50 ml puffs, taken every 30 seconds. The cigarette produced visible aerosol on all puffs for 10 consecutive puffs, yielded 12 mg of wet total particulate matter (WTPM), and delivered no detectable carbon monoxide. The cigarette exhibited a draw resistance of 88 mm H_2O pressure drop as determined using a Model No. FTS-300 pressure drop tester from Filtrona Corp.

A similar cigarette was prepared and smoked, and yielded tobacco flavor and visible aerosol.

EXAMPLE 4

A smoking article substantially as shown in FIG. 3 was prepared as follows:

A. Preparation of the Disposable Portion

Ceramic receptacle 79 was formed from a 7 mm long, 4 mm diameter section of a ceramic cylinder having two longitudinal, 1.5 mm diameter passageways.

The electric resistance heating element 18 was formed from a length of carbon filament yarn obtained from American Kynol, Inc., under Catalogue No. CFY-0204-2 sufficient to provide a measured resistance of 18 ohms when incorporated into the disposable portion. This element was impregnated with 38 mg of a liquid aerosol forming substance comprising a mixture of polyhydric alcohols and a tobacco extract. The polyhydric alcohol mixture consisted primarily of glycerin, and included some propylene glycol and triethylene glycol. The ends of the heating element were inserted through the passageways of the receptacle 79 form a loop, and the ends of the element were folded back over the receptacle. A strip of polyimide film 36 was positioned within the loop to prevent the heating element from contacting itself.

Over the resistance element loop and the receptacle 79 was friction fit a Kapton tube of 4 mm O.D. and a length of 80 mm. The length of the polyimide tube then was enveloped to a diameter of about 8 mm with insulative glass fibers 68 obtained from Owens Corning, Toledo, Ohio, as Glass No. 6437. The glass fibers 68 were enveloped by a non-porous cigarette paper wrap 24, available as P-850-192-2 paper from Kimberly-Clark Corp. The diameter of the resulting rod was 8 mm.

At the end of the rod remote from the ceramic receptacle was positioned a low efficiency cellulose acetate tow (8 denier per filament, 40,000 total denier) filter element 22 having a length of about 10 mm and a diameter of about 8 mm. The rod and filter element were held together using tipping paper.

About 1 mm behind the insulative receptacle 79 were pierced several openings 54 through the paper wrap 24 and the polyimide tube 66 to provide air inlet openings for aerosol formation. The perforations were of about 0.8 mm diameter, which was sufficient to provide the disposable portion with a draw resistance of about 100 mm H_2O pressure drop as determined using a Model No. FTS-300 pressure drop tester from Filtrona Corp.

B. Assembly of the Controller

The controller included a pressure sensitive switch 28, a current control circuit 30, a battery power supply 34A, 34B and a flexible, electric cord 72 which terminated in a cylindrical plug 74.

The cord 72 was a 50 mm length of insulated copper wire. The plug 74 included a ceramic cylinder, having a length of 10 mm and a diameter of 4 mm with two small passageways extending longitudinally therethrough; and a heat resistant bushing made from Zydar from Dartco Mfg., Inc., Augusta, Ga. which fits over the cylinder. The cylindrical plug had a diameter of about 8 mm. Copper pins 76, 77 connected to cord 72 were inserted through the passageways in the ceramic cylinder to extend 10 mm beyond the face of the plug.

The pressure sensitive switch **28** was a Model No. MPL-502-V, range A, differential switch obtained from Micro Pneumatic Logic, Inc. A 12 mm long, 18 gauge steel needle was inserted into the appropriate opening in the switch.

The control circuit employed is schematically illustrated in FIG. **10**. It was designed to provide uninterrupted current flow through the heating element for 2 seconds after the commencement of a puff. During the balance of the puff, the control circuit was designed to alternately switch off for 1 second and then on for 2 seconds, until the pressure actuated control switch opened. Timer **112** was a Model C-1555C obtained from NEC Electronics. Connections to timer **112** were made at trigger pin **168**, threshold pin **169**, output pin **159**, discharge pin **166**, entrance pin **149** and ground pin **151**. Transistor **110** was a Model MJE 2955 from Motorola Semiconductor Products. Capacitor **190** had a capacitance of 22 uF. The resistances of the resistors **176**, **178** and **180** were 20,000 ohm; 120,000 ohm; and 68,000 ohm, respectively. Resistors **161** and **192** each had resistances of 1,000 ohm.

The control circuit was connected to the switch, the cord **72**, and the battery terminals, as schematically illustrated in FIG. **10**. The battery supply consisted of two 9 volt alkaline transistor batteries connected in series.

C. Use

The pins **76**, **77** of plug **74** were inserted into receptacle **79** to contact the heating element **18** and hence electrically connect the disposable portion to the controller by contacting each end of the resistance element **18**. The needle **48** was pierced through the outer wrap **24** and the polyimide tube **66** of the disposable portion. For testing purposes, the filter element **22** was removed from the disposable portion. The smoking article was smoked as described in Example 1. Visible aerosol was provided on all puffs for 12 consecutive puffs and, during each puff period, the indicator light illuminated.

EXAMPLE 5

Five additional disposable portions similar to the disposable portions of Example 4 were prepared and smoked under FTC smoking conditions with the controller described in Example 4. The smoking articles yielded visible aerosol on all puffs for 10 puffs, an average of 13 mg WTPM and no detectable carbon monoxide.

EXAMPLE 6

A smoking article substantially as shown in FIG. **4** was prepared as follows:

A. Preparation of the Disposable Portion

Electrically insulative plug **16** was formed from a Delrin cylinder to have a 2 mm long section of 8 mm diameter and a 3 mm long section of 7 mm diameter. The plug was provided with a passageway **46** of sufficient size to receive an 18 gauge needle and two smaller passageways to receive electrical connector pins **38**, **39**.

The pins **38**, **39** were gold plated copper pins which extended through the passageways in the plug, beyond the 8 mm O.D. end of the plug, and 3 mm beyond the 7 mm O.D. end. The pins had a flattened bead of silver solder applied at the ends which extended beyond the 7 mm O.D. end.

An insulative collar **49** was formed from a Delrin cylinder having a length of 9 mm and a diameter of 8 mm to a tubular form having a 3 mm segment of 4.5 mm I.D. and a 6 mm segment of 6 mm I.D. A single air inlet **54** was made about 4 mm from the 6 mm I.D. end of the collar.

The electric resistance heating element **18** was formed from a 6 mm diameter circular disc of carbon filament felt obtained from American Kynol as Kynol Activated Carbon Felt ACN-211-10. The resistance element weighed about 8 mg had a reported resistivity of 20 to 30 ohms-cm. The felt had about 39.5 mg of a liquid aerosol forming substance applied thereto in a dropwise manner. The aerosol forming substance was 9 parts glycerin and 1 part of a viscous tobacco essence. The essence was obtained by aqueously extracting Burley tobacco; spray drying the aqueous extract; extracting the spray dried extract with ethanol; and concentrating the resulting tobacco components which were extracted by the ethanol.

The resistance element **18** was inserted into the 6 mm I.D. end of the collar **49** to abut against the 4.5 mm I.D. portion of the collar.

The 6 mm I.D. end of the collar **48** then was fit over the narrow end of plug **16** such that the flattened silver solder ends of pins **38** and **39** each contacted the resistance element **18**.

A resilient paperboard tube having an 8 mm O.D. and a length of 75 mm was abutted against the end of collar **49** opposite plug **16**, and the two tubes were held in place using adhesive tape **52**.

B. Use

The plug **16** was placed against receptacle **88** of the controller described in Example **1** to electrically connect the disposable portion to the controller and insert the needle **48** into the disposable portion. The smoking article was smoked as described in Example 1. The smoking article yielded visible aerosol on all puffs for 10 measured puffs, yielded 8.1 mg WTPM, and delivered no detectable carbon monoxide.

A similar disposable portion prepared and smoked in a similar fashion and yielded tobacco flavor and visible aerosol on each puff.

What is claimed is:

1. A cigarette for use with a source of electrical power comprising:

(a) an electrical resistance heating element having a surface area greater than 1 m^2/g;

(b) aerosol forming substance carried by the heating element prior to use; and

(c) tobacco.

2. The cigarette of claim **1**, wherein the heating element has a surface area greater than 50 m^2/g.

3. The cigarette of claim **1**, wherein the heating element has a surface area greater than 250 m^2g.

4. The cigarette of claim **1**, wherein the heating element has a surface area greater than 1,000 m^2g.

5. The cigarette of claim **1**, **2**, **3**, or **4**, wherein the heating element comprises a porous material and the aerosol forming substance comprises a liquid impregnated within the heating element.

6. The cigarette of claim **1**, **2**, **3** or **4**, wherein the heating element is a fibrous material.

7. The cigarette of claim **1**, **2**, **3** or **4**, wherein the heating element comprises a fibrous material and the aerosol forming substance comprises a liquid impregnated within the fibrous material.

8. The cigarette of claim 1, 2, 3 or 4, wherein the heating element comprises carbon fibers.

9. The cigarette of claim 1, 2, 3 or 4, wherein the heating element comprises carbon fibers and the aerosol forming substance comprises a liquid impregnating the carbon fibers.

10. The cigarette of claim 1, wherein the cigarette includes an air passageway at least partially therethrough, and the heating element comprises an air permeable heating element positioned in the passageway.

11. The cigarette of claim 10, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway.

12. The cigarette of claim 10, wherein the heating element is disposed substantially across the passageway.

13. The cigarette of claim 10, wherein the heating element comprises a pad positioned across the air passageway.

14. The cigarette of claim 10, 11, 12 or 13, wherein the heating element has a surface area greater than 50 m^2g.

15. The cigarette of claim 10, 11, 12 or 13, wherein the heating element has a surface area greater than 1,000 m^2g.

16. The cigarette of claim 7, 8 or 9, wherein the heating element comprises carbon fibers.

17. The cigarette of claim 1, 3, 10, 11, 12 or 13, wherein the heating element is adapted for connection to an external source of electrical power.

18. The cigarette of claim 17, wherein the heating element is positioned adjacent one end of the cigarette.

19. The cigarette of claim 1, 10, 11, 12 or 13, including means for connecting the heating element to an external source of electrical power.

20. The cigarette of claim 19, wherein the means for connecting the heating element to the external source of electrical power includes an air passageway.

21. The cigarette of claim 19, including an air outlet for delivering aerosol to the user, and wherein the air outlet and the means for connecting the heating element to the external source of electrical power are at opposite ends of the cigarette.

22. The cigarette of claim 1, 3, 10 or 13, including an air outlet for delivering aerosol to the user and a charge of tobacco located between the heating element and the air outlet.

23. The cigarette of claim 1, 2, 3, 4 or 10, wherein the aerosol forming substance includes at least one polyhydric alcohol.

24. The cigarette of claim 1, 2, 3, 4 or 10, wherein the aerosol forming substance includes a tobacco extract.

25. The cigarette of claim 1, 2, 3, 4 or 10, wherein the aerosol forming substance includes a tobacco extract and at least one polyhydric alcohol.

26. A disposable portion of a smoking article for use with a source of electrical power comprising:

(a) an electrical resistance heating element having a surface area greater than 1 m^2g; and

(b) aerosol forming substance carried by the heating element prior to use.

27. The disposable article of claim 26, wherein the heating element has a surface area greater than 50 m^2g.

28. The disposable article of claim 26, wherein the heating element has a surface area greater than 50 m^2g.

29. The disposable article of claim 26, wherein the heating element has a surface area greater than 1,000 m^2g.

30. The disposable article of claim 26, 27, 28 or 29, wherein the heating element comprises a porous material and the aerosol forming substance comprises a liquid impregnated within the heating element.

31. The disposable article of claim 26, 27, 28 or 29, wherein the heating element is a fibrous material.

32. The disposable article of claim 26, 27, 28 or 29, wherein the heating element comprises a fibrous material and the aerosol forming substance comprises a liquid impregnated within the fibrous material.

33. The disposable article of claim 26, 27, 28 or 29, wherein the heating element comprises carbon fibers.

34. The disposable article of claim 26, 27, 28 or 29, wherein the heating element comprises carbon fibers and the aerosol forming substance comprises a liquid impregnating the carbon fibers.

35. The disposable article of claim 26, wherein the disposable article includes an air passageway at least partially therethrough, and the electrical resistance element comprises an air permeable heating element positioned in the passageway.

36. The disposable article of claim 35, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway.

37. The disposable article of claim 35, wherein the heating element is disposed substantially across the passageway.

38. The disposable article of claim 35, wherein the heating element comprises a pad positioned across the air passageway.

39. The disposable article of claim 35, 36, 37 or 38, wherein the heating element has a surface area greater than 50 m^2g.

40. The disposable article of claim 35, 36, 37 or 38, wherein the heating element has a surface area greater than 1,000 m^2g.

41. The disposable article of claim 35, 36, 37 or 38, wherein the heating element comprises carbon fibers.

42. The disposable article of claim 26, 35, 36, 37 or 38, wherein the heating element is positioned adjacent one end of the article.

43. The disposable article of claim 42, wherein the heating element is adapted for connection to an external source of electrical power.

44. The disposable article of claim 26, 35, 36, 37 or 38, including means for connecting the heating element to an external source of electrical power.

45. The disposable article of claim 44, wherein the means for connecting the heating element to the external source of electrical power includes an air passageway.

46. The disposable article of claim 44, including an air outlet for delivering aerosol to the user, and wherein the air outlet and the means for connecting the heating element to the external source of electrical power are at opposite ends of the disposable article.

47. The disposable article of claim 44, including an air outlet for delivering aerosol to the user and wherein the air outlet and the means for connecting the heating element to the external source of electrical power are at the same end of the disposable article.

48. The disposable article of claim 26, 27, 35 or 37, including an air outlet for delivering aerosol to the user and a charge of tobacco located between the heating element and the air outlet.

49. The disposable article of claim 26, 27, 28, 29 or 35, wherein the aerosol forming substance includes a tobacco extract.

50. The disposable article of claim 26, 27, 28, 29 or 35, wherein the aerosol forming substance includes a tobacco extract and at least one polyhydric alcohol.

51. The disposable article of claim 35, 36, 37 or 38, wherein the aerosol forming substance is a liquid impregnated within the electrical resistance element.

52. The disposable article of claim 26, 35 or 38, in the form of a cartridge.

53. A disposable portion of a smoking article for use with a source of electrical power comprising:

(a) an air passageway at least partially through the disposable portion;

(b) an air permeable electrical heating element located in the air passageway; and

(c) an aerosol forming substance.

54. The disposable article of claim 53, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway.

55. The disposable article of claim 53, wherein the heating element substantially fills the cross sectional area of the air passageway.

56. The disposable article of claim 53, wherein the heating element comprises a pad positioned across the air passageway.

57. The disposable article of claim 53, 54, 55 or 56, wherein the aerosol forming substance is carried by the heating element prior to use.

58. The disposable article of claim 53, 54, 55 or 56, wherein the heating element comprises a fibrous mass.

59. The disposable article of claim 58, wherein the aerosol forming substance is a liquid carried by the fibrous mass.

60. The disposable article of claim 53, 54, 55 or 56, wherein the heating element comprises carbon fibers.

61. The disposable article of claim 60, wherein the aerosol forming substance is a liquid carried by the carbon fibers.

62. The disposable article of claim 53, 54, 55 or 56, wherein the heating element is adjacent one end of the article.

63. The disposable article of claim 62, wherein the heating element is adapted for connection to an external source of electrical power.

64. The disposable article of claim 62, including an air outlet for delivering aerosol to the user and wherein the heating element is adjacent the end remote from the air outlet.

65. The disposable article of claim 53, 54, 55 or 56, including an air outlet for delivering aerosol to the user and wherein the heating element is adjacent the air outlet.

66. The disposable article of claim 53, 54, 55 or 56, including a charge of tobacco.

67. The disposable article of claim 66, including an air outlet for delivering aerosol to the user and wherein the charge of tobacco is located between the heating element and the air outlet.

68. The disposable article of claim 53, 54, 55 or 56, wherein the aerosol forming substance comprises a tobacco extract.

69. The disposable article of claim 26, 35, 53 or 56, wherein the article includes sufficient aerosol forming substance to deliver at least 0.5 mg of wet total particulate matter on each puff, for at least 6 puffs, when the article is smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

70. The disposable article of claim 26, 35, 53 or 56, wherein the article includes sufficient aerosol forming substance to deliver at least 0.8 mg of wet total particulate matter on each puff, for at least 6 puffs, when the article is smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

71. The disposable article of claim 26, 35, 53 or 56, wherein the aerosol forming substance comprises a liquid, and wherein the article includes sufficient aerosol forming substance to deliver at least 0.5 mg of wet total particulate matter on each puff, for at least 6 puffs, when the article is smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

72. The cigarette of claim 1 or 10, wherein the cigarette includes sufficient aerosol forming substance to deliver at least 0.5 mg of wet total particulate matter on each puff, for at least 6 puffs, when the cigarette is smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

73. The cigarette of claim 1 or 10, wherein the cigarette includes sufficient aerosol forming substance to deliver at least 0.8 mg of wet total particulate matter on each puff, for at least 6 puffs, when the cigarette is smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

74. The cigarette of claim 1 or 10, wherein the aerosol forming substance comprises a liquid, and wherein the cigarette includes sufficient aerosol forming substance to deliver at least 0.5 mg of wet total particulate matter on each puff, for at least 6 puffs, when the cigarette is smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

75. A smoking article for use with a source of electrical power comprising:

(a) an electrical resistance heating element having a surface area greater than 1 m^2g;

(b) aerosol forming substance carried by the heating element prior to use; and

(c) puff actuated control means for permitting current flow through the heating element during draw by the user.

76. The smoking article of claim 75, further including means for regulating current flow through the heating element during draw.

77. The smoking article of claim 75 or 76, further comprising a source of electrical power.

78. The smoking article of claim 75 or 76, wherein the heating element comprises a porous material and the aerosol forming substance comprises a liquid impregnated within the heating element.

79. The smoking article of claim 75 or 76, wherein the heating element is a fibrous material.

80. The smoking article of claim 75 or 76, wherein the heating element comprises a fibrous material and the aerosol forming substance comprises a liquid impregnated within the heating element.

81. The smoking article of claim 75 or 76, wherein the heating element comprises carbon fibers.

82. The smoking article of claim 75 or 76, wherein the heating element comprises carbon fibers and the aerosol forming substance comprises a liquid impregnating the carbon fibers.

83. The smoking article of claim 75 or 76, wherein the heating element has a surface area greater than 50 m^2g.

84. The smoking article of claim 75 or 76, wherein the heating element has a surface area greater than 1,000 m^2g.

85. The smoking article of claim 75 or 76, including an air outlet for delivering aerosol to the user and a

charge of tobacco located between the heating element and the air outlet.

86. The smoking article of claim 75 or 76, wherein the aerosol forming substance includes a tobacco extract.

87. The smoking article of claim 75 or 76, wherein the aerosol forming substance includes a tobacco extract and at least one polyhydric alcohol.

88. The smoking article of claim 75 or 76, wherein the heating element carries sufficient aerosol forming substance to deliver at least 0.5 mg of wet total particulate matter on each puff, for at least 6 puffs, when smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

89. The smoking article of claim 76, wherein the means for regulating current flow during draw comprises a timer.

90. The smoking article of claim 89, wherein the means for regulating current flow during draw further comprises a timer responsive switching means for enabling and disabling current flow to the resistance element during draw.

91. The smoking article of claim 76, 89 or 90, wherein the means for regulating current flow during draw includes capacitor and means for charging and discharging the capacitor at a rate which approximates a rate at which the resistance element heats and cools.

92. The smoking article of claim 76, wherein the means for regulating current flow during draw comprises (i) means for permitting uninterrupted current flow through the resistance element for an initial time period during draw, and (ii) means for subsequently regulating current flow until draw is completed.

93. The smoking article of claim 92, wherein the means for subsequently regulating current flow comprises means for switching the current flow alternately off and on.

94. The smoking article of claim 93, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle.

95. The smoking article of claim 94, wherein the means for generating the preset switching cycle includes a timer.

96. The smoking article of claim 95, wherein the timer generates a periodic digital wave form.

97. The smoking article of claim 76, wherein the means for regulating current flow comprises (i) timer means, activated by the puff control means, for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling current flow to the heating element in response to the pulse train from the timer means.

98. The smoking article of claim 76, wherein the means for regulating current flow during draw includes means for controlling the average current flow through the heating element during a portion of the draw.

99. The smoking article of claim 76, wherein the means for regulating current flow during draw includes (i) means for enabling uninterrupted passage of current through the heating element for a predetermined initial time period, and (ii) means for controlling the average current which passes through the heating element upon passage of the predetermined initial time.

100. The smoking article of claim 99, wherein the average current control means comprises (i) timer means for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling the current through the electrical heating element in response to the pulse train from the timer means, and wherein the enabling means for the initial time period comprises means for disabling the timer means during the initial time period and enabling the timer means upon passage of the initial time period.

101. The smoking article of claim 100, wherein the enabling means for the initial time period further comprises (i) comparator means for comparing a first voltage at a first input to a threshold voltage at a threshold input and generating an output signal when the first voltage is equal to the threshold voltage, the output signal enabling the timer means; (ii) means for generating the threshold voltage at the threshold input; and (iii) means for generating the threshold voltage at the first input upon passage of the initial time period.

102. The smoking article of claim 76, further comprising means for limiting the temperature of the heating element when a puff occurs before the heating element has cooled after a prior puff.

103. The smoking article of claim 76, wherein the puff actuated control means comprises means for sensing changes in air pressure within the article.

104. A smoking article for use with a source of electrical power comprising:

(a) an electrical resistance heating element;
(b) aerosol forming substance;
(c) switch means for actuating and deactuating current flow through the heating element; and
(d) time based means for (i) permitting unrestricted current flow through the heating element for an initial predetermined time period upon current actuation, and (ii) for subsequently regulating current flow until current deactuation.

105. The smoking article of claim 104, wherein the aerosol forming substance is carried by the heating element prior to use.

106. The smoking article of claim 105, wherein the heating element has a surface area greater than 1 m^2g.

107. The smoking article of claim 104, 105 or 106, further comprising a source of electrical power.

108. The smoking article of claim 104, 105 or 106, wherein the heating element comprises a porous material and the aerosol forming substance comprises a liquid impregnated within the heating element.

109. The smoking article of claim 104, 105 or 106, wherein the heating element is a fibrous material.

110. The smoking article of claim 104, 105 or 106, wherein the heating element comprises a fibrous material and the aerosol forming substance comprises a liquid impregnated within the heating element.

111. The smoking article of claim 104, 105 or 106, wherein the heating element comprises carbon fibers.

112. The smoking article of claim 104, 105 or 106, wherein the heating element comprises carbon fibers and the aerosol forming substance comprises a liquid impregnating the carbon fibers.

113. The smoking article of claim 104, 105 or 106, wherein the heating element has a surface area greater than 50 m^2/g.

114. The smoking article of claim 104, 105 or 106, wherein the heating element has a surface area greater than 1,000 m^2g.

115. The smoking article of claim 104, 105 or 106, including an air outlet for delivering aerosol to the user and a charge of tobacco located between the heating element and the air outlet.

116. The smoking article of claim **104**, **105** or **106**, wherein the aerosol forming substance includes a tobacco extract.

117. The smoking article of claim **104**, **105** or **106**, wherein the aerosol forming substance includes a tobacco extract and at least one polyhydric alcohol.

118. The smoking article of claim **104**, **105** or **106**, wherein the heating element carries sufficient aerosol forming substance to deliver at least 0.5 mg of wet total particulate matter on each puff, for at least 6 puffs, when smoked under standard FTC smoking conditions of 2 second, 35 ml puffs, taken every 60 seconds.

119. The smoking article of claim **104**, **105** or **106**, wherein the means for subsequently regulating current flow until current deactivation includes means for controlling the average current flow through the heating element.

120. The smoking article of claim **104**, **105** or **106**, wherein the means for permitting current flow for the initial time period and for subsequently regulating current flow until current deactivation includes means for controlling the temperature range to which the heating element is heated during draw.

121. The smoking article of claim **104**, **105** or **106**, wherein the means for subsequently regulating current flow until current deactivation comprises a timer.

122. The smoking article of claim **104**, **105** or **106**, wherein the means for subsequently regulating current flow until current deactivation further comprises a timer responsive switching means for enabling and disabling current flow to the heating element.

123. The smoking article of claim **104**, **105** or **106**, wherein the means for permitting current flow for the initial time period comprises a comparator means.

124. The smoking article of claim **104**, **105** or **106**, wherein the means for permitting current flow for the initial time period includes a capacitor and means for charging and discharging the capacitor at a rate which approximates a rater at which the heating element heats and cools.

125. The smoking article of claim **104**, **105** and **106**, wherein the means for subsequently regulating current flow comprises means for switching the current flow alternately off and on.

126. The smoking article of claim **104**, wherein the means for subsequently regulating current flow comprises a timer means for generating a periodic digital wave form having a preset duty cycle.

127. The smoking article of claim **104**, wherein the means for subsequently regulating current flow until current deactivation comprises (i) timer means for generating a pulse train having a predetermined duty cycle, and (ii) time responsive switching means for enabling and disabling the current through the electrical heating element in response to the pulse train from the timer means, and wherein the means for permitting current flow for the initial time period comprises means for disabling the timer means during the initial time period and enabling the timer means upon passage of the initial time period.

128. The smoking article of claim **127**, wherein the means for permitting current flow for the initial time period further comprises (i) comparator means for comparing a first voltage at a first input to a threshold voltage at a threshold input and generating an output signal when the first voltage is equal to the threshold voltage, the output signal enabling the timer means; (ii) means for generating the threshold voltage at the threshold input; and (iii) means for generating the threshold voltage at the first input upon passage of the initial time period.

129. The smoking delivery article of claim **127** or **128**, wherein the means for permitting current flow for the initial time period includes a capacitor and means for charging and discharging the capacitor at a rate which approximates the rate at which the heating element heats and cools.

130. The smoking article of claim **104**, wherein the means for permitting current flow for the initial time period and for subsequently regulating current flow comprises (i) timer means, activated by the current actuation and deactuation means, for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling current flow to the heating element in response to the pulse train from the timer means.

131. A smoking delivery article for use with a source of electrical power comprising:

((a) an air passageway at least partially through the article;

((b) an air permeable electrical resistance heating element located in the air passageway;

((c) an aerosol forming substance;

(d) puff actuated control means for permitting current flow through the heating element during draw by the user; and

(e) a mouth end.

132. The smoking article of claim **131**, wherein the aerosol forming substance is carried by the heating element.

133. The smoking article of claim **131**, further comprising means for regulating current flow through the heating element during draw.

134. The smoking article of claim **133**, wherein the aerosol forming substance is carried by the heating element.

135. The smoking article of claim **131**, **132**, **133** or **134**, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway.

136. The smoking article of claim **131**, **132**, **133** or **134**, wherein the heating element substantially fills the cross sectional area of the air passageway.

137. The smoking article of claim **131**, **132**, **133** or **134**, wherein the heating element comprises a pad positioned across the air passageway.

138. The smoking article of claim **131**, **132**, **133** or **134**, wherein the aerosol forming substance is carried by the heating element prior to use.

139. The smoking article of claim **132** or **134**, wherein the heating element comprises a fibrous mass.

140. The smoking article of claim **132** or **134**, wherein the heating element comprises a fibrous mass and the aerosol forming substance is a liquid carried by the fibrous mass.

141. The smoking article of claim **132** or **134**, wherein the heating element comprises carbon fibers.

142. The smoking article of claim **132** or **134**, wherein the heating element comprises carbon fibers and the aerosol forming substance is a liquid carried by the carbon fibers.

143. The smoking article of claim **131**, **132**, **133** or **134**, wherein the heating element is adjacent one end of the article.

144. The smoking article of claim 133, wherein the means for regulating current flow during draw comprises a timer.

145. The smoking article of claim 134, wherein the means for regulating current flow during draw comprises a timer.

146. The smoking article of claim 144, wherein the means for regulating current flow during draw further comprises a timer responsive switching means for enabling and disabling current flow to the heating element during draw.

147. The smoking article of claim 145, wherein the means for regulating current flow during draw further comprises a timer responsive switching means for enabling and disabling current flow to the heating element during draw.

148. The smoking article of claim 133, 134, 144 or 145, wherein the means for regulating current flow during draw includes a capacitor and means for charging and discharging the capacitor at a rate which approximates a rate at which the heating element heats and cools.

149. The smoking article of claim 133, wherein the means for regulating current flow during draw comprises (i) means for permitting uninterrupted current flow through the heating element for an initial time period during draw, and (ii) means for subsequently regulating current flow until draw is completed.

150. The smoking article of claim 149, wherein the means for subsequently regulating current flow comprises means for switching the current flow alternately off and on.

151. The smoking article of claim 150, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle.

152. The smoking article of claim 151, wherein the means for generating the preset switching cycle includes a timer.

153. The smoking article of claim 152, wherein the timer generates a periodic digital wave form.

154. The smoking article of claim 133, wherein the means for regulating current flow comprises (i) timer means, activated by the puff control means, for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling current flow to the heating element in response to the pulse train from the timer means.

155. The smoking article of claim 133, wherein the means for regulating current flow during draw includes means for controlling the average current flow through the heating element during a portion of the draw.

156. The smoking article of claim 133, wherein the means for regulating current flow during draw includes (i) means for enabling unrestricted passage of current through the resistance element for a predetermined initial time period, and (ii) means for controlling the average current which passes through the resistance element upon passage of the predetermined initial time.

157. The smoking article of claim 156, wherein the average current control means comprises (i) timer means for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling the current through the electrical resistance element in response to the pulse train from the timer means, and wherein the enabling means for the initial time period comprises means for disabling the timer means during the initial time period and enabling the timer means upon passage of the initial time period.

158. The smoking article of claim 157, wherein the enabling means for the initial time period further comprises (i) comparator means for comparing a first voltage at a first input to a threshold voltage at a threshold input and generating an output signal when the first voltage is equal to the threshold voltage, the output signal enabling the timer means; (ii) means for generating the threshold voltage at the threshold input; and (iii) means for generating the threshold voltage at the first input upon passage of the initial time period.

159. The smoking article of claim 132, further comprising means for limiting the temperature of the heating element when a puff occurs before the heating element has cooled after a prior puff.

160. The smoking article of claim 132, wherein the puff actuated control means comprises means for sensing changes in air pressure within the article.

161. A controller for use with a disposable article having an aerosol forming substance and an electrical heating element, the controller comprising:

(a) means for electrically connecting the controller to the electrical heating element;
(b) means for electrically connecting the controller to an electrical power source;
(c) puff actuated control means for permitting current flow through the heating element during draw by the user; and
(d) means for regulating current flow through the heating element during draw.

162. The controller of claim 161, wherein the means for regulating current flow during draw comprises a timer.

163. The controller of claim 162, wherein the means for regulating current flow during draw further comprises a timer responsive switching means for enabling and disabling current flow to the heating element during draw.

164. The controller of claim 161, 162 or 163, wherein the means for regulating current flow during draw includes a capacitor and means for charging and discharging the capacitor at approximately the rate at which the heating element heats and cools.

165. The controller of claim 161, wherein the means for regulating current flow during draw comprises (i) means for permitting uninterrupted current flow through the heating element for an initial time period during draw, and (ii) means for subsequently regulating current flow until draw is completed.

166. The controller of claim 165, wherein the means for subsequently regulating current flow comprises means for switching the current flow alternately off and on.

167. The controller of claim 165, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle.

168. The controller of claim 167, wherein the means for generating the preset switching cycle includes a timer.

169. The controller of claim 168, wherein the timer generates a periodic digital wave form.

170. The controller of claim 161 or 165, wherein the means for regulating current flow comprises (i) timer means, activated by the puff control means, for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and

disabling current flow to the heating element in response to the pulse train from the timer means.

171. The controller of claim **161**, wherein the means for regulating current flow during draw includes means for controlling the average current flow through the heating element during a portion of the draw.

172. The controller of claim **161**, wherein the means for regulating current flow during draw includes (i) means for enabling the uninterrupted passage of current through the heating element for an initial time period, and (ii) means for controlling the average current which passes through the heating element upon passage of the initial time.

173. The controller of claim **172**, wherein the average current control means comprises (i) timer means for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling the current through the electrical heating element in response to the pulse train from the timer means, and wherein the enabling means for the initial time period comprises means for disabling the timer means during the initial time period and enabling the timer means upon passage of the initial time period.

174. The controller of claim **173**, wherein the enabling means for the initial time period further comprises (i) comparator means for comparing a first voltage at a first input to a threshold voltage at a threshold input and generating an output signal when the first voltage is equal to the threshold voltage, the output signal enabling the timer means; (ii) means for generating the threshold voltage at the threshold input; and (iii) means for generating the threshold voltage at the first input upon passage of the initial time period.

175. The controller of claim **161**, **165** or **173**, further comprising means for limiting the temperature of the heating element when a puff occurs before the heating element has cooled after a prior puff.

176. The controller of claim **161**, **165** or **173**, wherein the puff actuated control means comprises means for sensing changes in air pressure within the disposable article.

177. The controller of claim **161**, **165** or **172**, wherein the puff actuated control means includes an air pressure differential switch.

178. The controller of claim **161**, wherein the means for electrically connecting the controller to a power source includes means for connection to a battery.

179. The controller of claim **178**, further comprising a chamber for receiving at least one battery.

180. A controller for use with a disposable article having an aerosol forming substance and an electrical heating element for thermally generating an aerosol from the aerosol forming substance, the controller comprising:

((a) means for electrically connecting the controller to the electrical resistance heating element;

((b) means for electrically connecting the controller to an electrical power source;

((c) current actuation and deactuation means; and

(d) time based means for (i) permitting unrestricted current flow through the heating element for an initial predetermined time period upon current actuation, and (ii) for subsequently regulating current flow until current deactuation.

181. The controller of claim **180**, wherein the current actuation and deactuation means is a puff actuated control means for permitting current flow through the heating element during draw by the user.

182. The controller of claim **180**, wherein the means for subsequently regulating current flow until current deactivation includes means for controlling the average current flow through the heating element.

183. The controller of claim **180**, wherein the means for permitting current flow for the initial time period and for subsequently regulating current flow until current deactivation includes means for controlling the temperature range to which the heating element is heated during draw.

184. The controller of claim **180**, **182** or **183**, wherein the means for subsequently regulating current flow until current deactivation comprises a timer.

185. The controller of claim **180**, **182** or **183**, wherein the means for subsequently regulating current flow until current deactivation further comprises a timer responsive switching means for enabling and disabling current flow to the heating element.

186. The controller of claim **180**, **182** or **183**, wherein the means for permitting current flow for the initial time period comprises a comparator means.

187. The controller of claim **180**, **182** or **183**, wherein the means for permitting current flow for the initial time period includes a capacitor and means for charging and discharging the capacitor at a rate which approximates a rate at which the heating element heats and cools.

188. The controller of claim **180** or **181**, wherein the means for subsequently regulating current flow comprises means for switching the current flow alternately off and on.

189. The controller of claim **188**, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle.

190. The controller of claim **188**, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle, and the means for generating the preset switching cycle includes a timer means.

191. The controller of claim **188**, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle, and means for generating the preset switching cycle includes timer means generates a periodic digital wave form having a preset duty cycle.

192. The controller of claim **180**, wherein the means for subsequently regulating current flow until current deactivation comprises (i) timer means for generating a pulse train having a predetermined duty cycle, and (ii) time responsive switching means for enabling and disabling the current through the electrical heating element in response to the pulse train from the timer means, and wherein the means for permitting current flow for the initial time period comprises means for disabling the timer means during the initial time period and enabling the timer means upon passage of the initial time period.

193. The controller of claim **192**, wherein the means for permitting current flow for the initial time period further comprises (i) comparator means for comparing a first voltage at a first input to a threshold voltage at a threshold input and generating an output signal when the first voltage is equal to the threshold voltage, the output signal enabling the timer means; (ii) means for generating the threshold voltage at the threshold input; and (iii) means for generating the threshold voltage at the first input upon passage of the initial time period.

194. The controller of claim **192** or **193**, wherein the means for permitting current flow for the initial time period includes a capacitor and means for charging and discharging the capacitor at a rate which approximates a rate at which the heating element heats and cools.

195. The controller of claim **180** or **181**, wherein the means for permitting current flow for the initial time period and for subsequently regulating current flow comprises (i) timer means, activated by the current actuation and deactuation means, for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling current flow to the heating element in response to the pulse train from the timer means.

196. The controller of claim **180**, wherein the means for electrically connecting the controller to a power source includes means for connection to a battery, and wherein the controller further comprises a chamber for receiving at least one battery.

197. A current control circuit for an article having an aerosol forming substance and a heat generating electrical resistance element for thermally generating an aerosol from the aerosol forming substance, the circuit comprising (i) means for permitting current flow through the resistance element for an initial time period, and (ii) means for subsequently regulating current flow through the resistance element.

198. The circuit of claim **197**, wherein the means for subsequently regulating current flow comprises means for switching the current flow alternately off and on.

199. The circuit of claim **198**, wherein the means for switching the current flow off and on includes means for generating a preset switching cycle.

200. The circuit of claim **199**, wherein the means for generating the preset switching cycle includes a timer.

201. The circuit of claim **200**, wherein the timer generates a periodic digital wave form having a preset duty cycle.

202. The circuit of claim **198**, wherein the means for regulating current flow comprises (i) timer means for generating a pulse train having a predetermined duty cycle, and (ii) timer responsive switching means for enabling and disabling current flow to the resistance element in response to the pulse train from the timer means.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,947,874

DATED : August 14, 1990

INVENTOR(S) : Johnny Lee Brooks, Donald Leroy Roberts, Jerry Scott Simmons and Carl Christopher Morrison

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

On the Cover Sheet under Inventors, the name "Carl C. Morrison of Winston-Salem, NC" should be added.

Signed and Sealed this

Eleventh Day of February, 1992

Attest:

HARRY F. MANBECK, JR.

Attesting Officer *Commissioner of Patents and Trademarks*

[redacted]

United States Patent [19]

Loeppert et al.

[11] **Patent Number: 5,870,482**

[45] **Date of Patent: Feb. 9, 1999**

[54] **MINIATURE SILICON CONDENSER MICROPHONE**

[75] Inventors: **Peter V. Loeppert**, Hoffman Estates; **David E. Schafer**, Glen Ellyn, both of Ill.

[73] Assignee: **Knowles Electronics, Inc.**, Itasca, Ill.

[21] Appl. No.: **805,983**

[22] Filed: **Feb. 25, 1997**

[51] **Int. Cl.**[6] **H04R 25/00**

[52] **U.S. Cl.** **381/174**; 381/191

[58] **Field of Search** .... 381/170, 174, 381/191, 113, 116, 173; 29/25.41, 594; 367/181; 73/517 R, 862.59; 437/209

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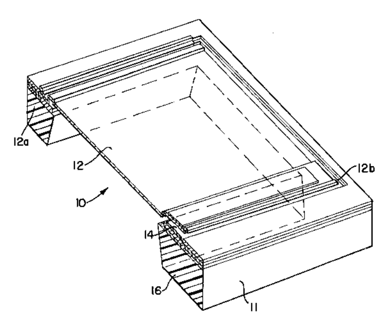
Primary Examiner—Huyen Le

[57] **ABSTRACT**

Multiple embodiments of a solid state condenser transducer, and methods of manufacture, are disclosed. The transducer comprises a semi-conductor substrate forming a frame and having an opening, a thin-film cantilever structure forming a diaphragm extending over a portion of the opening, the structure having a proximal portion and a distal portion. The proximal portion is attached to the frame, and the distal portion extends over a portion of the frame. A variable gap capacitor having a movable plate and a fixed plate is provided, wherein the movable plate is disposed on the distal portion of the structure and the fixed plate is disposed on the frame adjacent the movable plate.

28 Claims, 13 Drawing Sheets



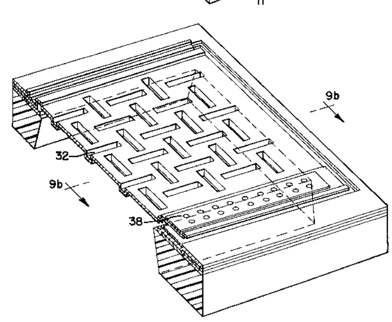


FIG. 1

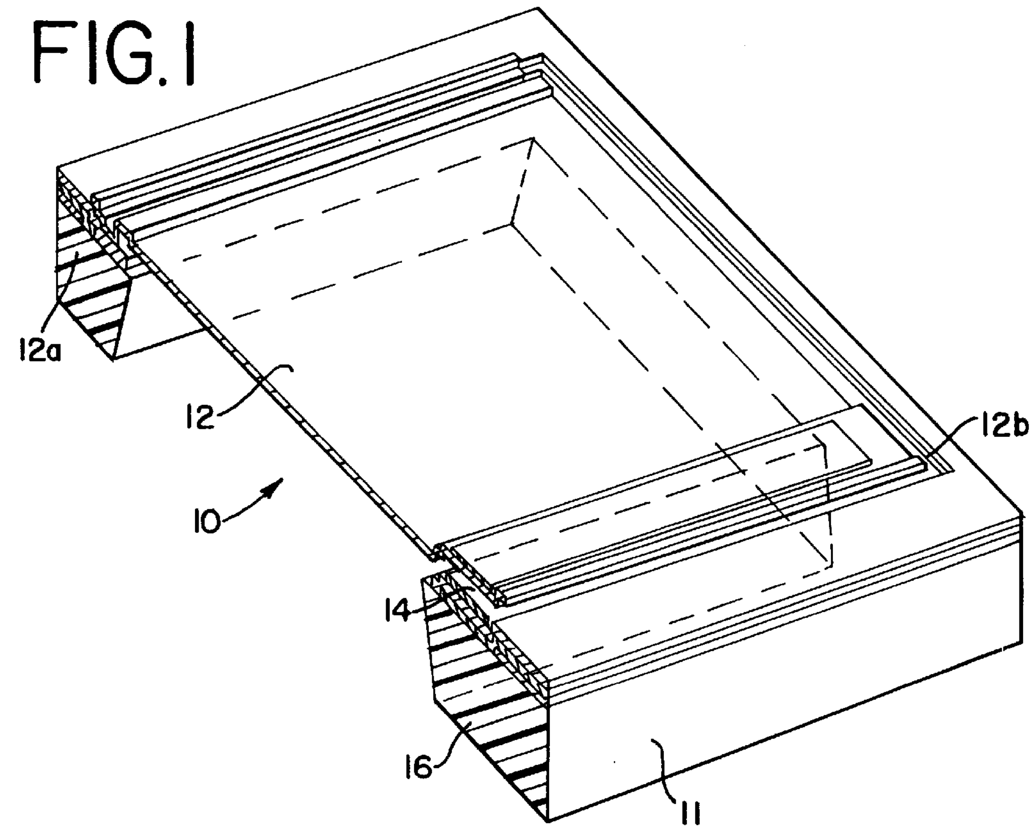
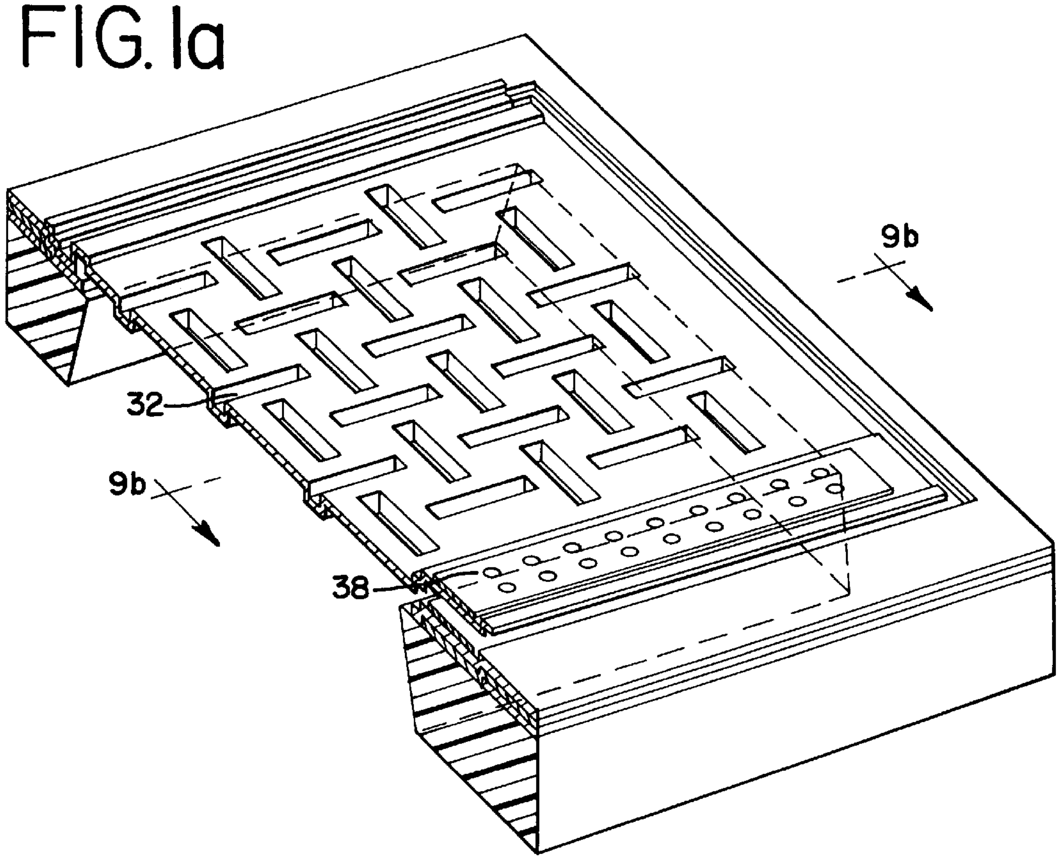


FIG. 1a



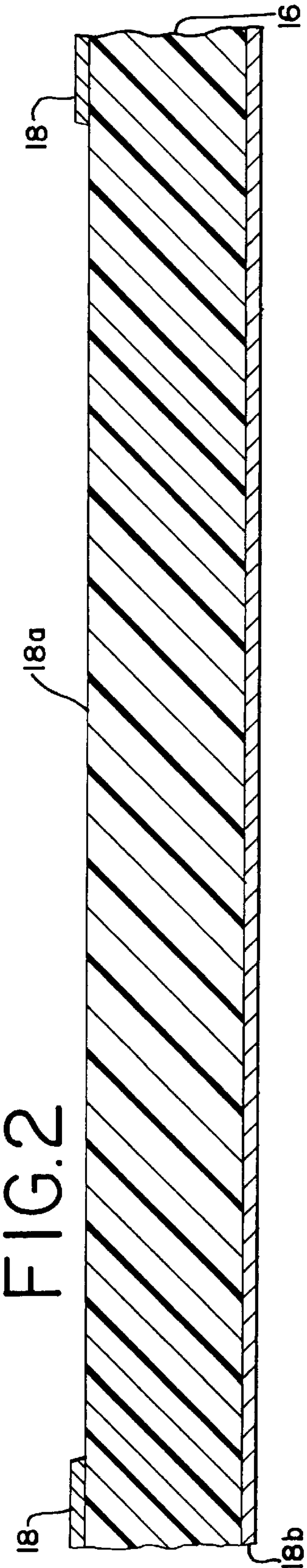


FIG. 2

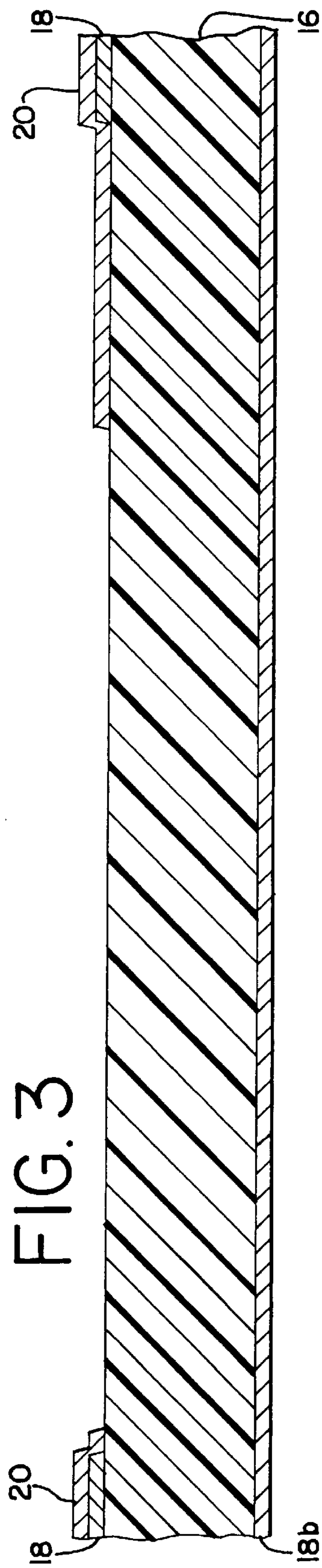


FIG. 3

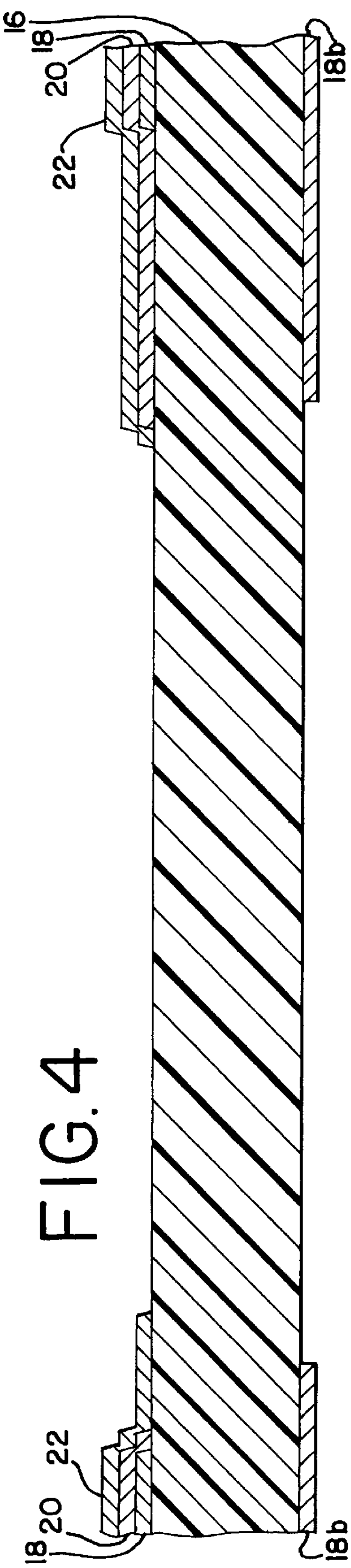


FIG. 4

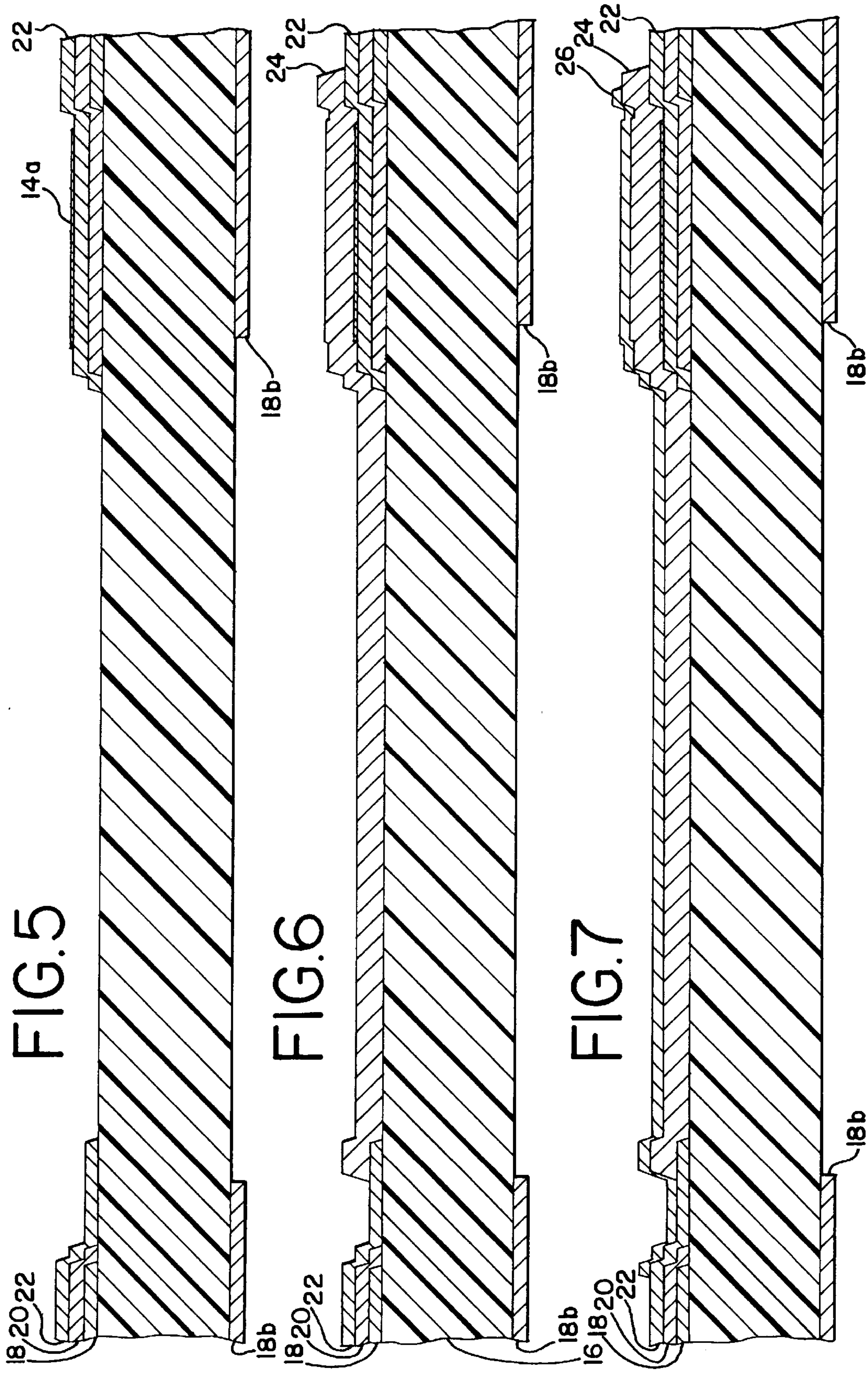


FIG.5

FIG.6

FIG.7

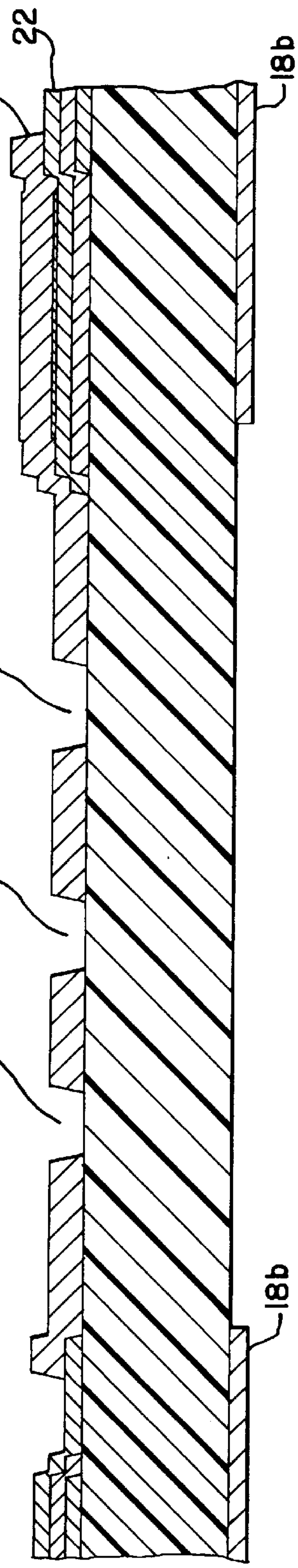


FIG.6a

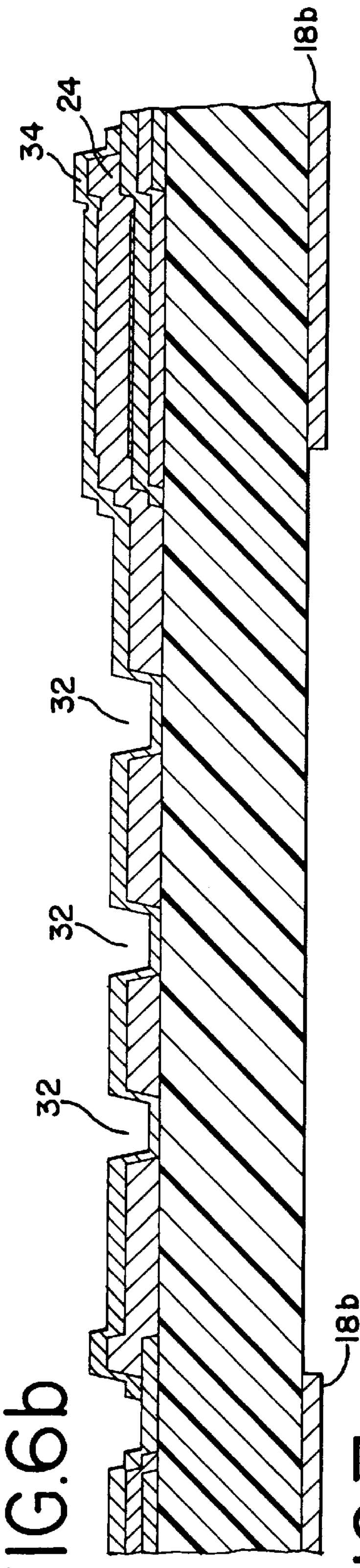


FIG.6b

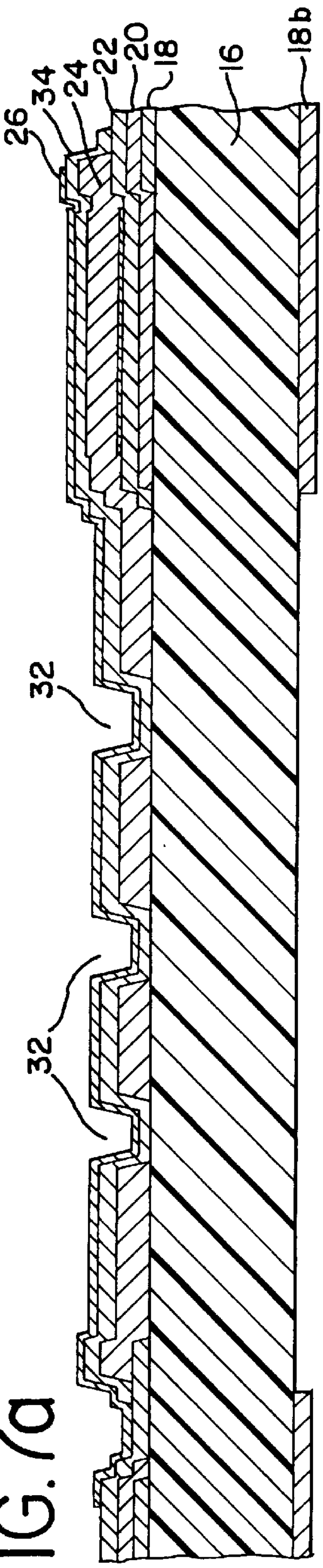
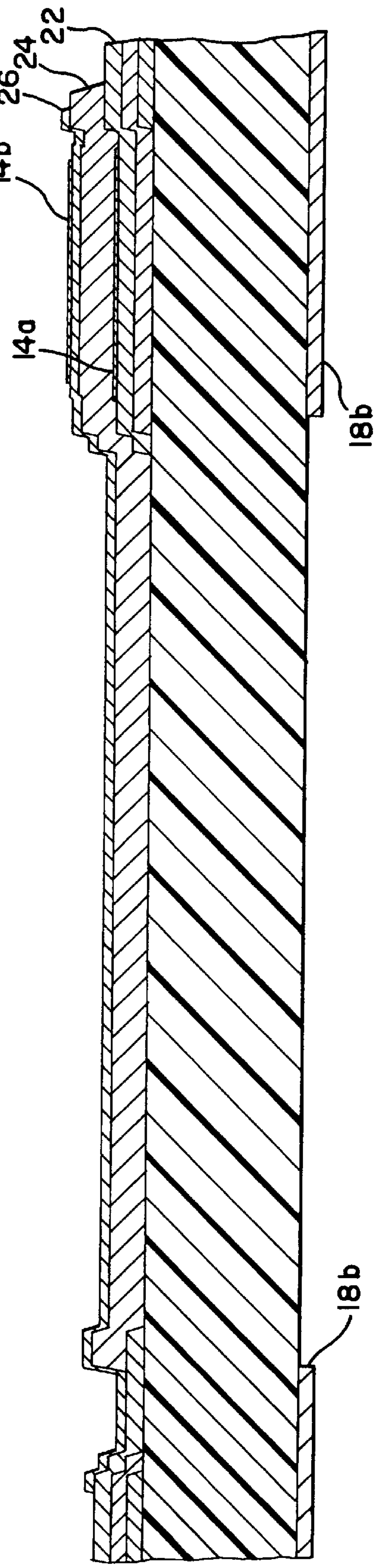
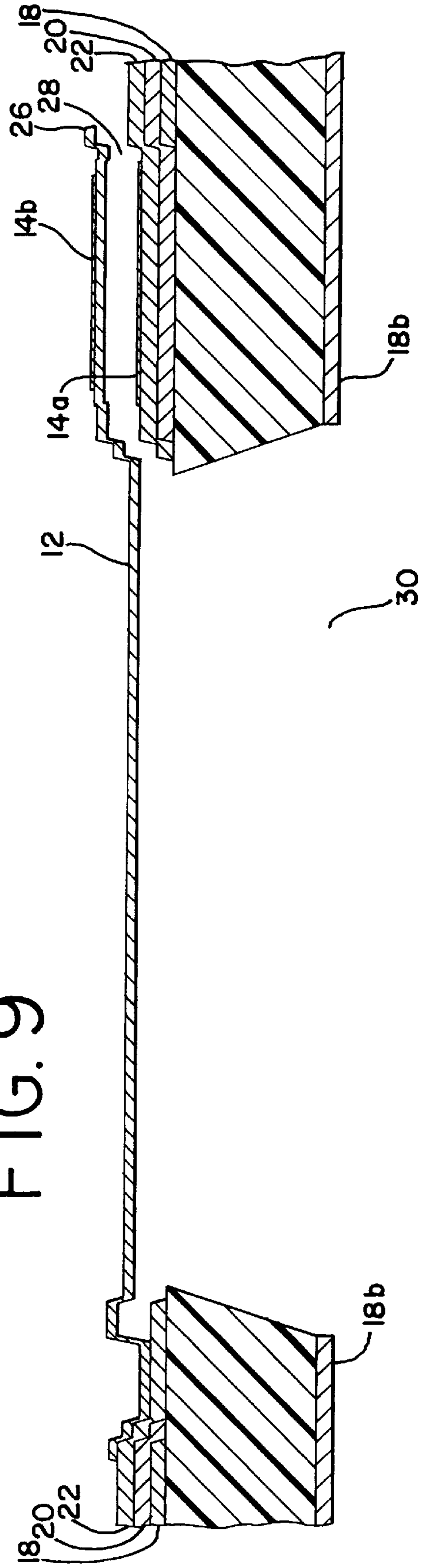


FIG.7a



22
24
26
14b
14a
18b
18b

FIG. 8



18
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18b
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22

FIG. 9

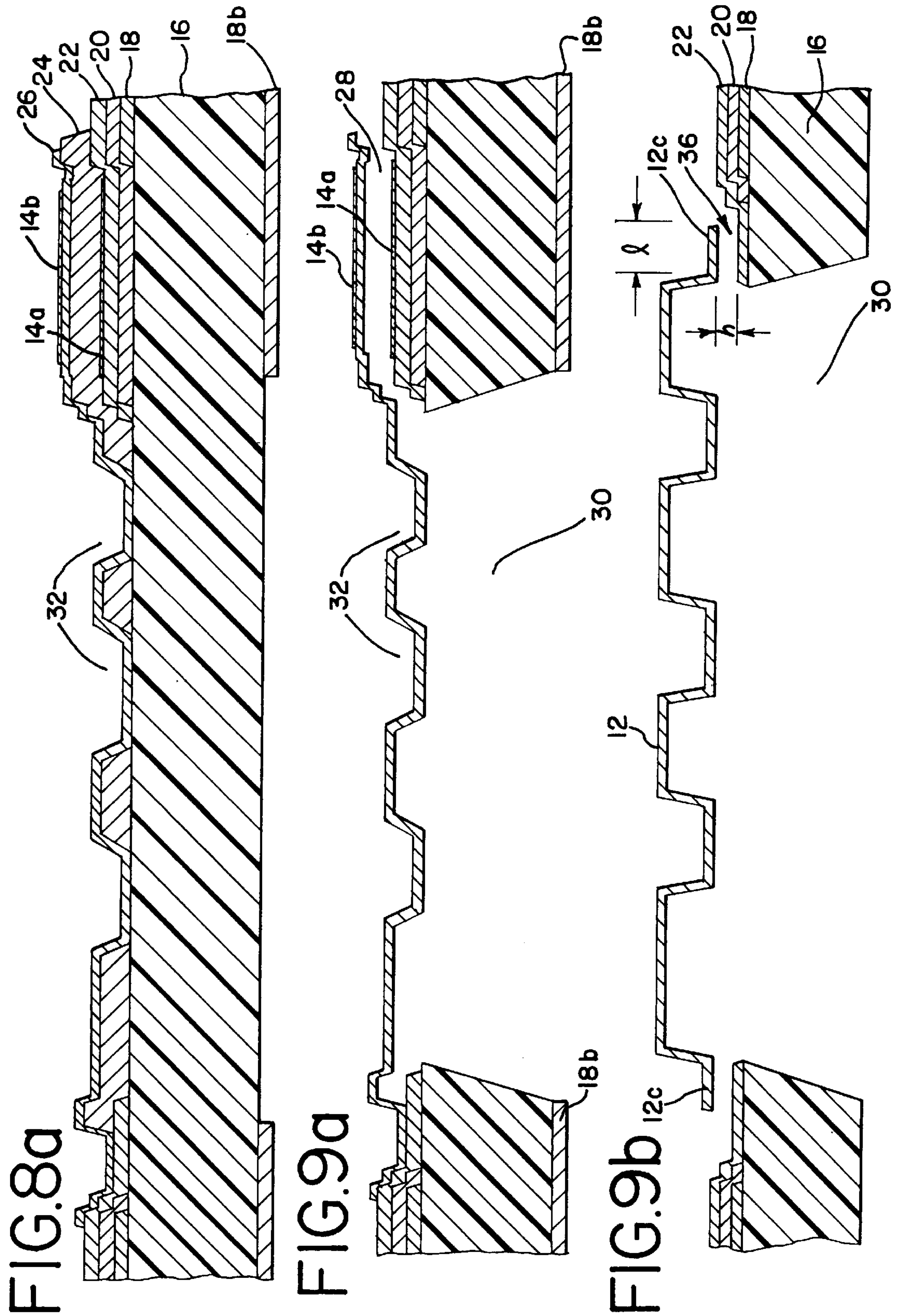


FIG.8a

FIG.9a

FIG.9b

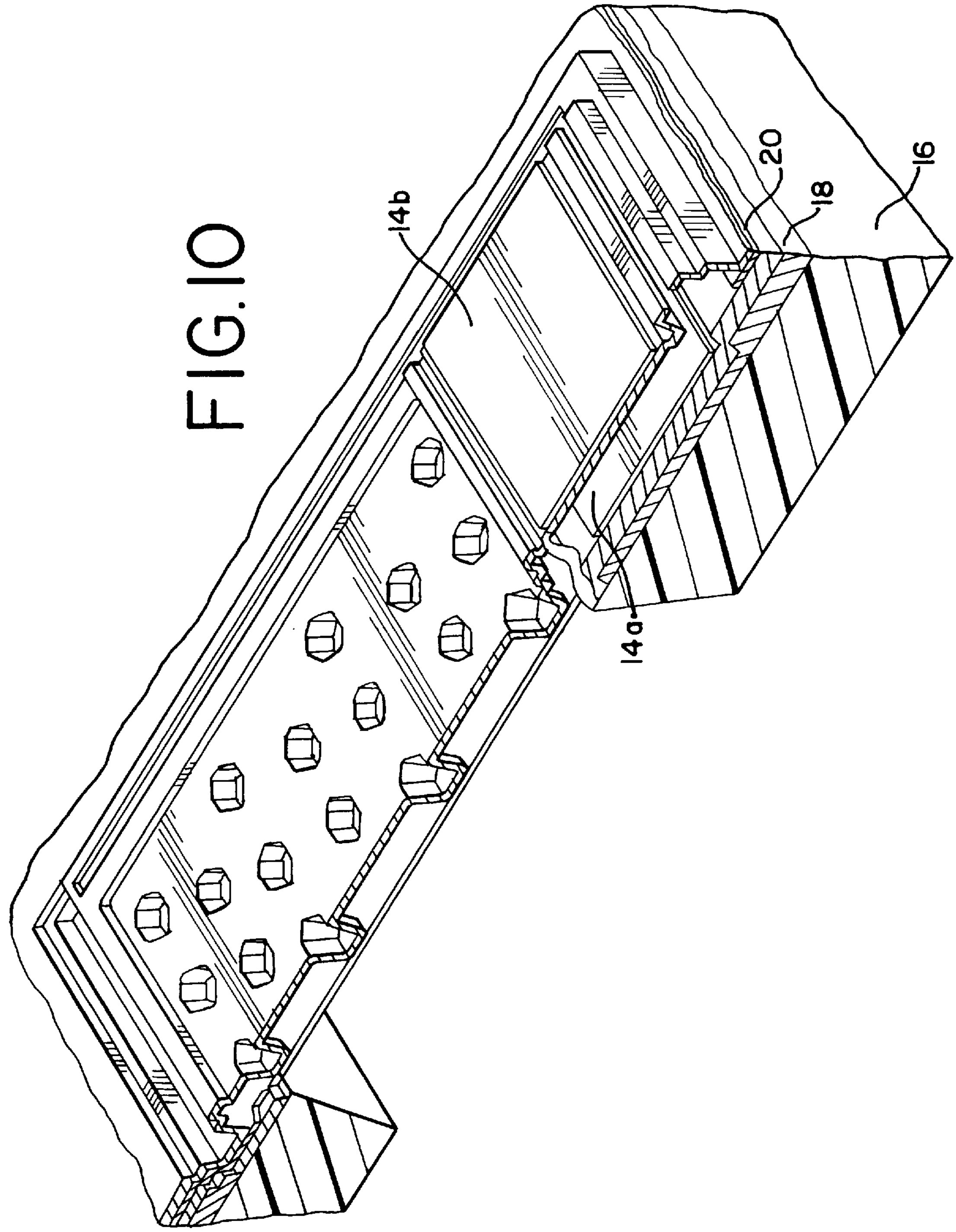


FIG.10

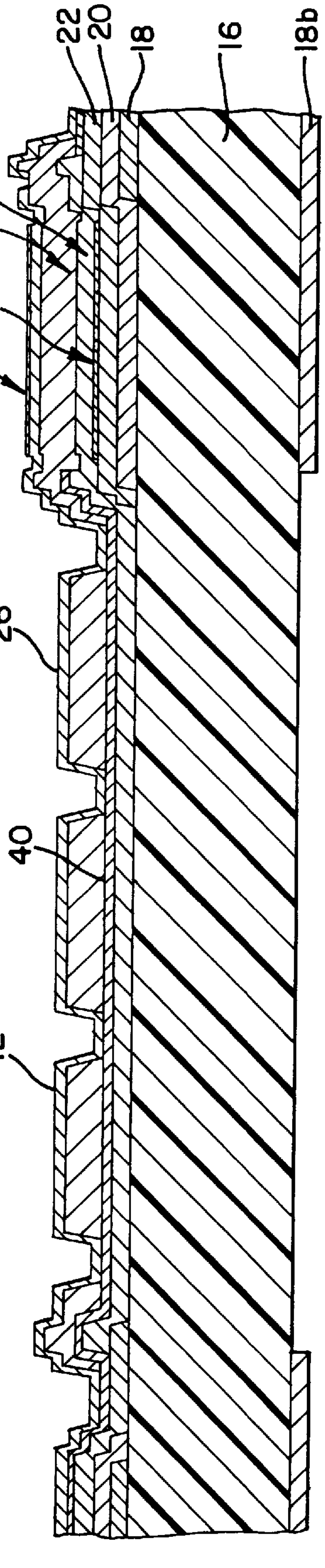


FIG.11

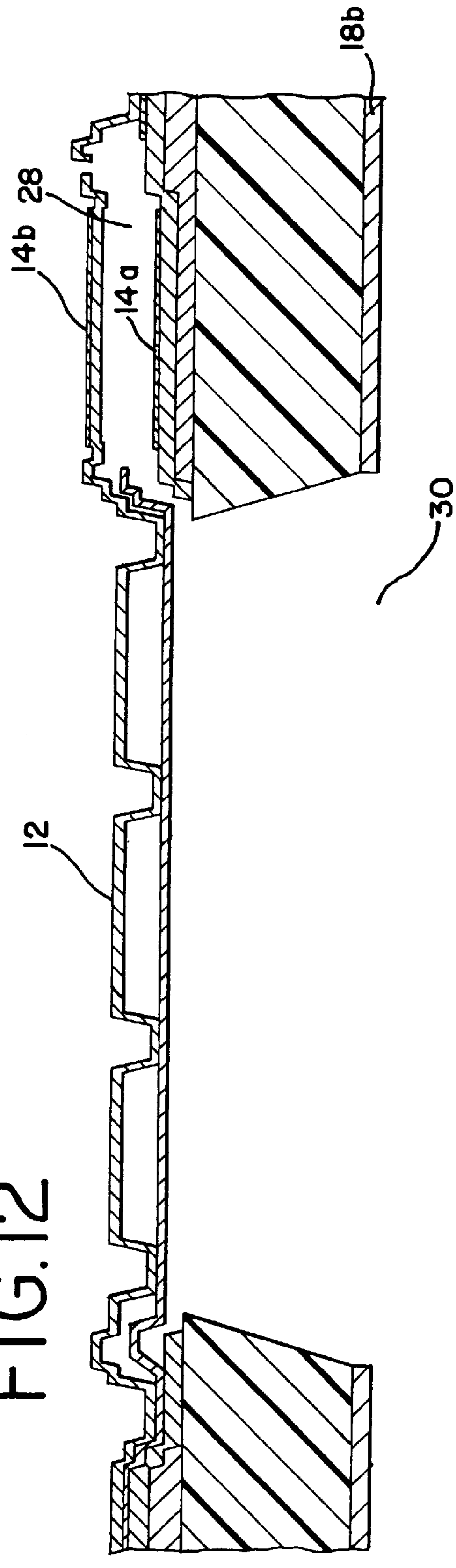


FIG.12

FIG. 13

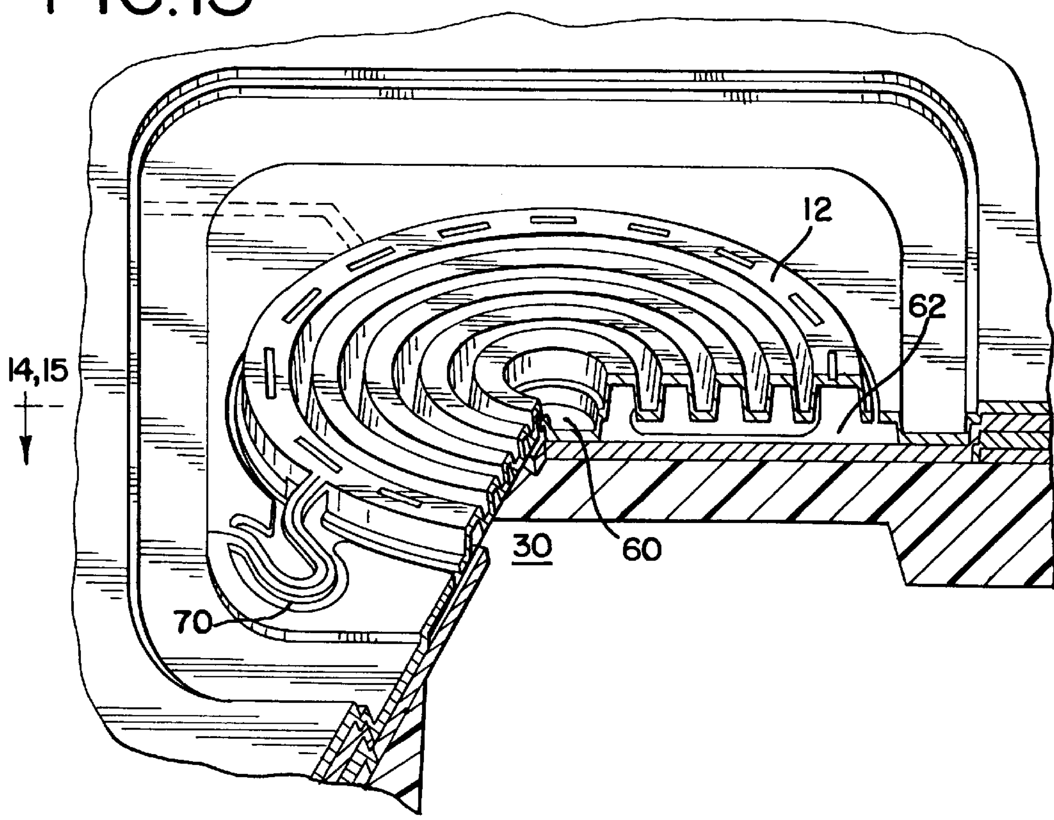


FIG. 13d

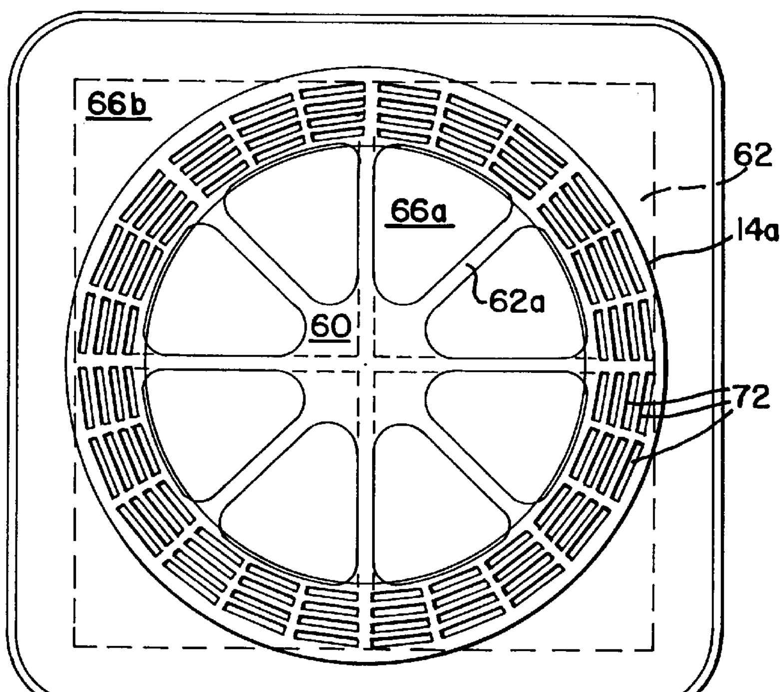


FIG. 13a

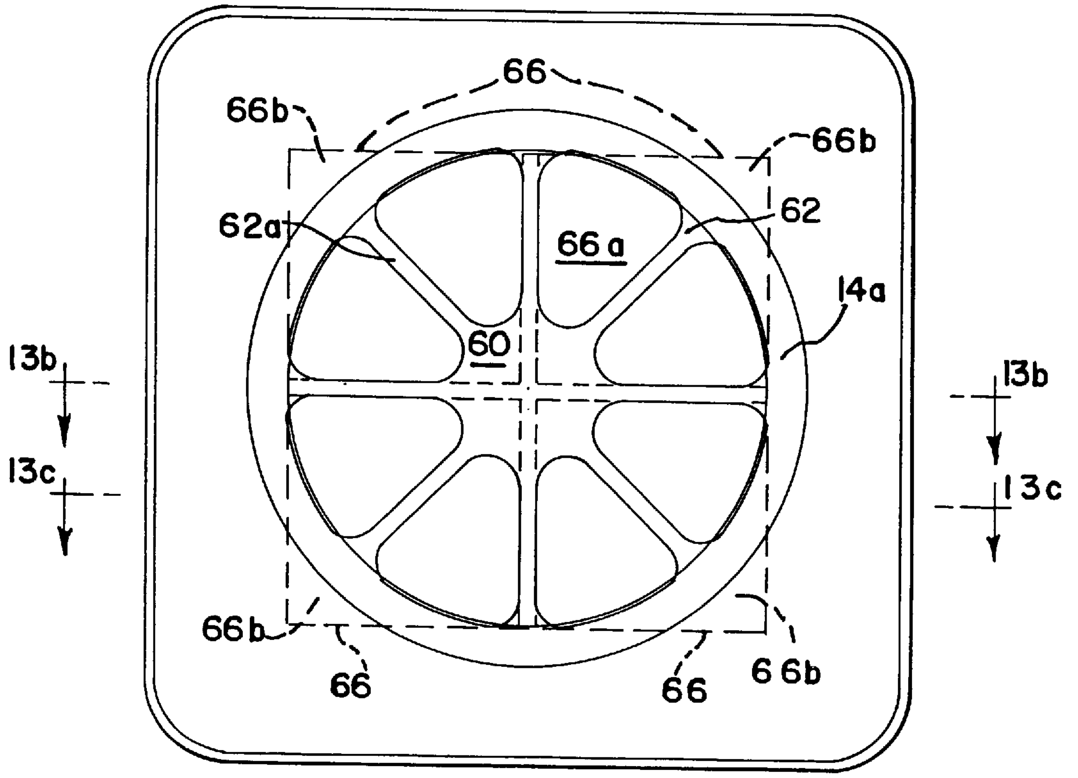


FIG. 13b

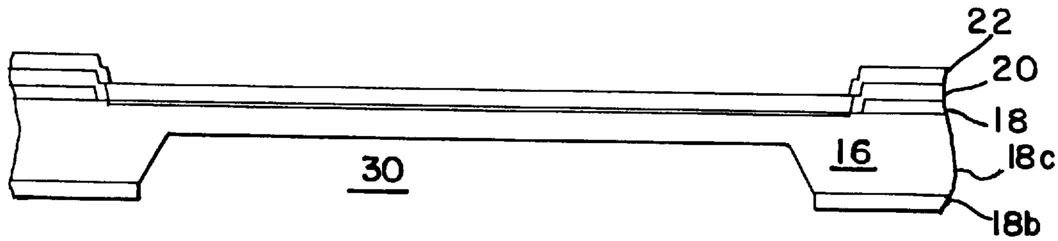
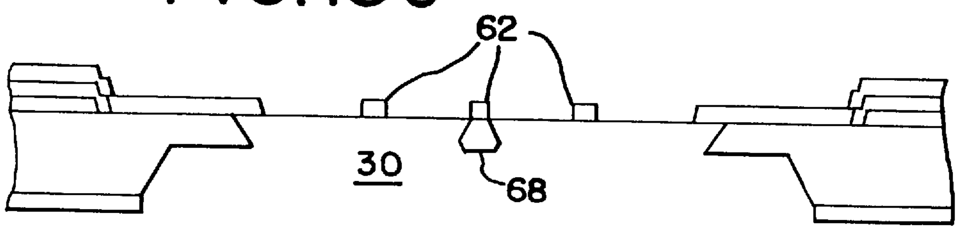


FIG. 13c



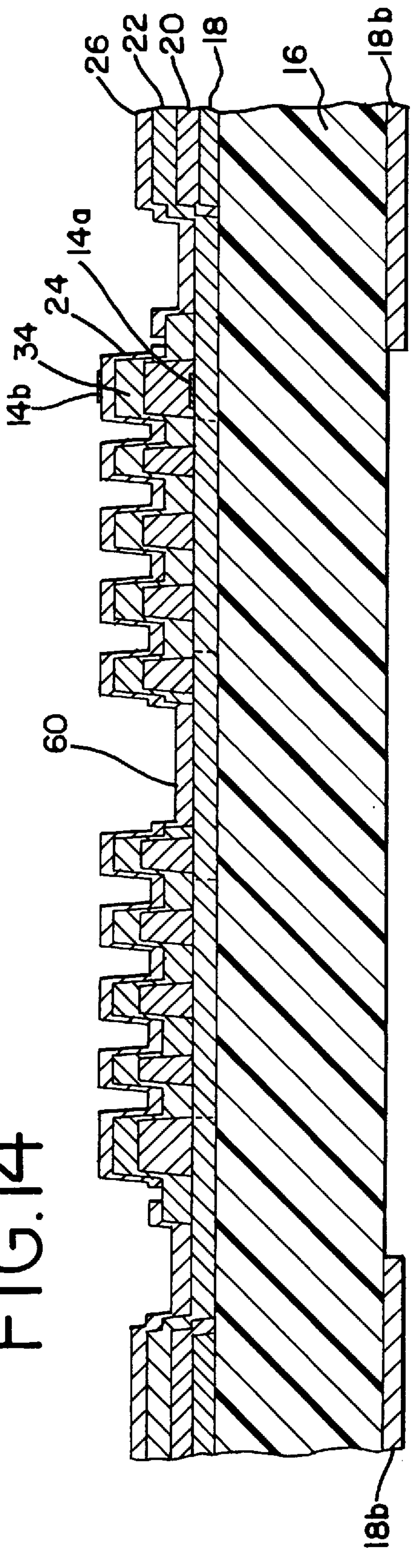


FIG. 14

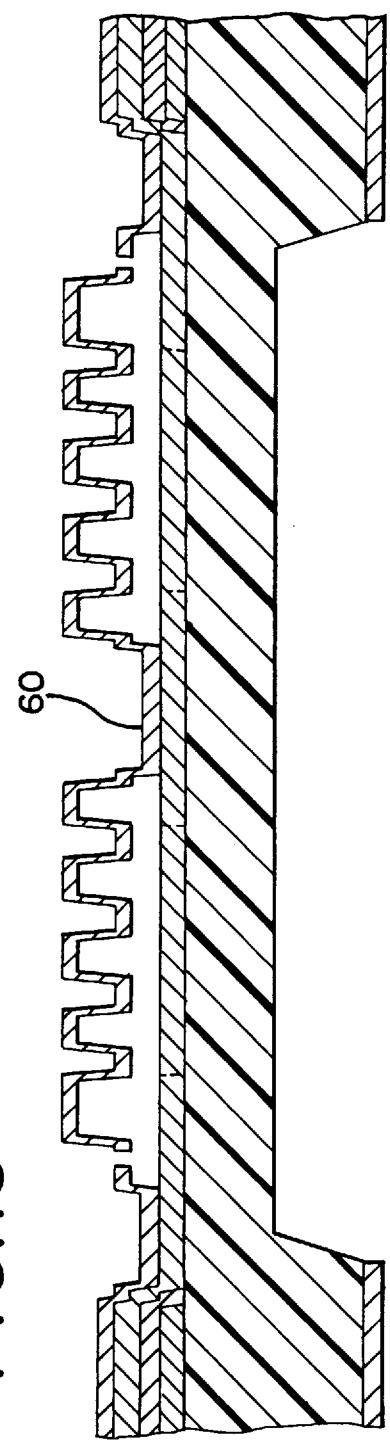


FIG. 15

FIG. 16a

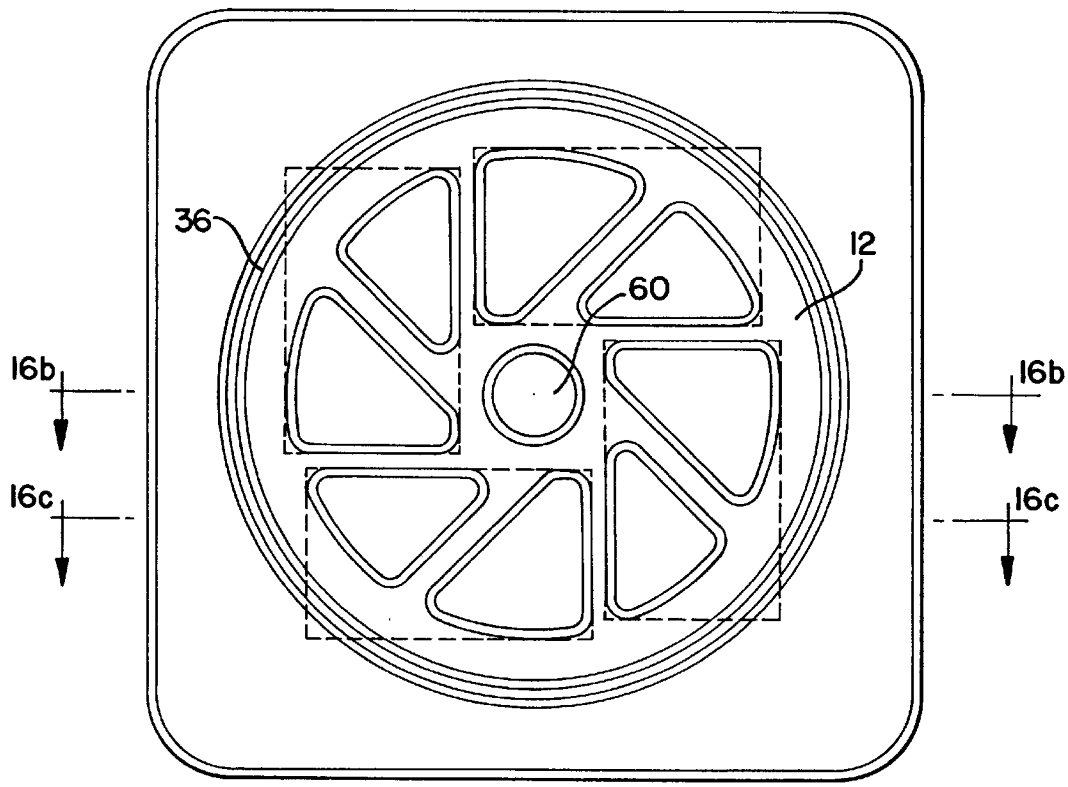


FIG. 16b

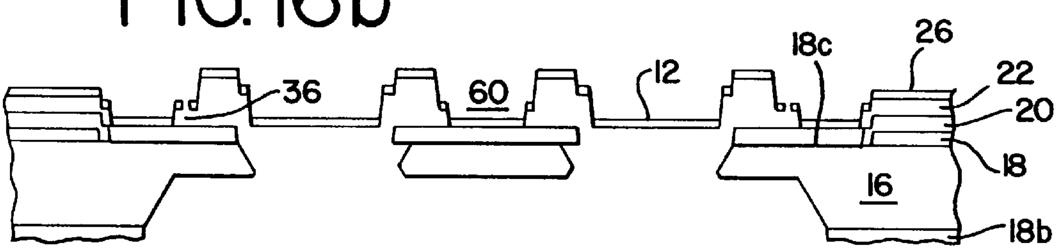


FIG. 16c

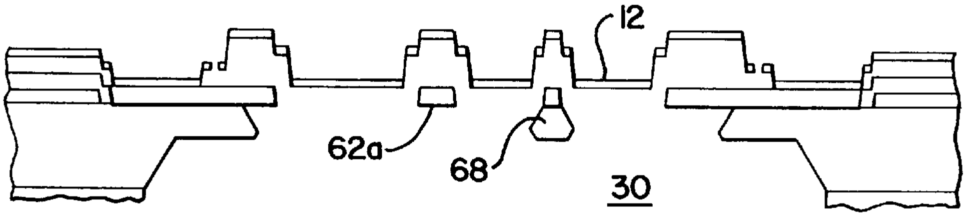


FIG. 16

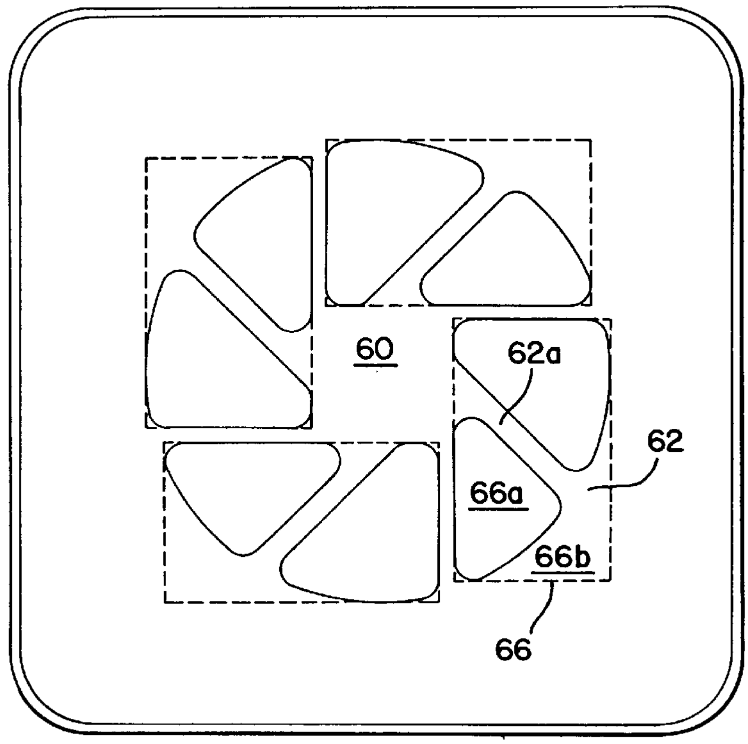


FIG. 17a

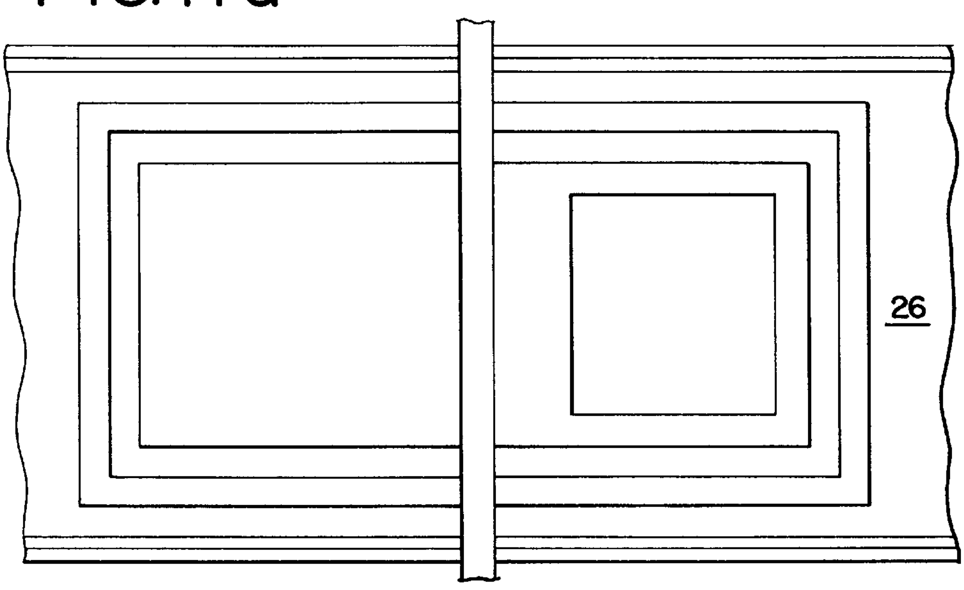
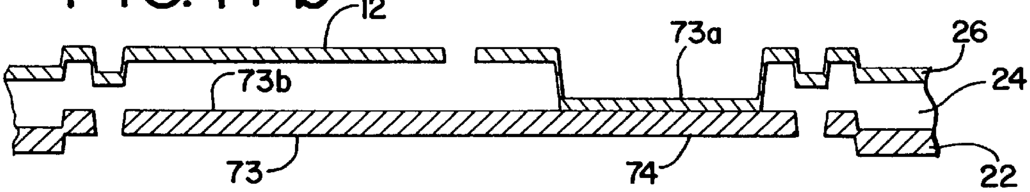


FIG. 17b



MINIATURE SILICON CONDENSER MICROPHONE

DESCRIPTION

1. Technical Field

The present invention is directed toward a miniature silicon condenser microphone which can be integrated with CMOS circuitry.

2. Background Prior Art

Miniature silicon condenser microphones which can be integrated with CMOS circuitry require a number of trade-offs to achieve high sensitivity and low noise in the smallest volume. Typically a condenser microphone consists of four elements; a fixed, perforated backplate, a highly compliant, moveable diaphragm (which together form the two plates of a variable air-gap capacitor), a voltage bias source, and a buffer amplifier.

The diaphragm must be highly compliant and precisely positioned relative to the backplate, while the backplate must remain stationary and present a minimum of resistance to the flow of air through it. Achieving all of these characteristics in microphones below 1 mm in size using integrated circuit materials has been challenging in three respects. First, silicon-based miniature condenser microphones to date have used a diaphragm held by a surrounding frame, with maximum deflection occurring at the diaphragm center. In this configuration, unrelieved stress in the diaphragm material detracts from either diaphragm compliance (if the stress is tensile which stiffens the diaphragm) or positioning accuracy (if the stress is compressive which buckles the diaphragm). Typical stress levels in integrated circuit thin films, if not relieved in the finished diaphragm, are many times greater than the levels at which the diaphragm becomes unusable due to over-stiffening or buckling.

A second problematic aspect of sub-mm-sized diaphragms is that the compliance tends to decrease very rapidly with decreasing size for a given diaphragm material and thickness. If the units of diaphragm compliance are taken as linear deflection per unit pressure, the compliance scales as the fourth power of the diaphragm size. In a specific example, cutting the diaphragm diameter in half is expected to cut the diaphragm compliance to one-sixteenth of its former value if the diaphragm material, thickness and configuration are kept the same.

The third challenge in miniaturization of microphones below 1 mm in size is that of maintaining a low mechanical damping of the diaphragm displacement. As the structure is made smaller, the air gap must be made smaller (scaling as the inverse of the square of the device size) to keep the capacitor value in a range which can drive the input of the buffer amplifier effectively. Unfortunately as the air gap is reduced, the damping effects due to viscous flow of the air trapped between diaphragm and backplate increase rapidly, varying as the inverse of the third power of the air gap size. The net result is that mechanical damping tends to increase extremely rapidly as the inverse of the sixth power of the device size. This damping affects the frequency response and in accordance with well established theory, generates pressure fluctuations in the microphone structure which contributes noise to the microphone output.

Various approaches have been developed to avoid the problem of excessive stress in miniature condenser microphone diaphragms. The approaches can be categorized by whether they focus on diaphragm material or diaphragm construction. On the material side, *Bergquist and Rudolf,*

Transducers 91, *Proceedings of the International Conference on Solid-State Sensors and Actuators* (IEEE, New York, 1991) pp. 266–269 discloses single crystal silicon as the diaphragm material to minimize differential stresses from developing with respect to the diaphragm support, which is also made of single crystal silicon.

Bernstein, U.S. Pat. No. 5,146,435, discloses an all-silicon structure consisting of a single crystal silicon diaphragm supported at its periphery by patterned silicon springs.

On the diaphragm construction side, Loeppert, U.S. Pat. No. 5,490,220 discloses a free-plate diaphragm configuration wherein the diaphragm is disconnected from its frame and captured only by a set of lateral restraints. According to Loeppert, material stress is released completely in the finished diaphragm regardless of material mismatches between the diaphragm and its frame.

PCT International Publication WO 95/34917 discloses a piezoelectric cantilever pressure transducer. Alternatively, the transducer may be magnetostrictive, piezoresistive or thermal.

However, none of the above-described approaches solves the inherent film stress issues while maintaining good performance in a manufacturing process.

The present invention is provided to solve this and other problems.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an alternative diaphragm and backplate construction in which the form of the diaphragm is based on a cantilever and in which alternate configurations for venting the backplate, appropriate for sub-mm-size microphones are used. Such microphones are useful for ultrasonic, as well as audio, transduction of sound.

In the cantilever format, diaphragm material stress is relieved in the final diaphragm structure to almost the same degree as in the free-plate construction, but without the need for the capturing restraints associated with the free-plate. In addition, the compliance of a cantilever structure is over one hundred times greater than that of an edge-clamped diaphragm of the same material, span and thickness, which eases the design of smaller scale devices in spite of the aforementioned difficulties with compliance in diaphragms below 1 mm in size.

This diaphragm, as well as the backplate and integrated CMOS circuitry for backplate voltage bias and buffer amplifier can be fabricated on a single silicon wafer. Several embodiments are given below. The method for venting of the capacitor air gap to minimize mechanical damping depends on the context of the particular embodiment and is thus given in context in each case. The net result is an approach which offers advantages in microphone size and sensitivity which are readily apparent to those skilled in the art.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view of a first embodiment of a silicon condenser microphone made in accordance with the present invention;

FIG. **1***a* is a perspective view of a second embodiment of a silicon condenser microphone made in accordance with the present invention;

FIGS. **2–9** are sectional views illustrating sequential steps in the manufacture of the microphone of FIG. **1**;

FIGS. **6***a,* **6***b,* **7***a,* **8***a,* **9***a* and **9***b* are sectional views illustrating sequential steps in the manufacture of the microphone of FIG. **1***a;*

FIG. **10** is a perspective view of a third embodiment of a silicon condenser microphone made in accordance with the present invention;

FIGS. **11–12** are sectional views illustrating sequential steps in the manufacture of the microphone of FIG. **10**;

FIG. **13** is a perspective view of a fourth embodiment of a silicon condenser microphone made in accordance with the present invention;

FIG. **13***a* is a plan view of the microphone without a diaphragm of FIG. **13**;

FIGS. **13***b* and **13***c* are sectional views of the microphone of FIG. **13***a;*

FIG. **13***d* ia a plan view of the microphone of FIG. **13***a,* including the diaphragm;

FIGS. **14–15** are sectional views illustrating sequential steps in the manufacture of the microphone of FIG. **13**;

FIG. **16** is a plan view of the web structure of a modification of the fourth embodiment of the invention;

FIG. **16***a* is a plan view of a modification of the fourth embodiment of the invention;

FIGS. **16***b* and **16***c* are sectional views of the microphone of FIG. **16***a;*

FIG. **17***a* is a plan view of an overpressure stop structure for use with the microphone of the fourth embodiment; and

FIG. **17***b* is a sectional view of the overpressure stop structure of FIG. **17***a.*

DETAILED DESCRIPTION

While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail, preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspects of the invention to the embodiments illustrated.

A cantilever design for a silicon condenser microphone **10** is shown in FIG. **1**. The microphone **10** includes a diaphragm **12** anchored to a support structure or frame **11** at a proximal or fixed edge **12***a* and which is free on the other three edges, including a distal edge **12***b*. In this way the stiffness of the diaphragm **12** is determined by the thickness and material properties of the diaphragm **12** and not by stresses induced in the diaphragm **12** by processing. A capacitor **14** is disposed adjacent the distal edge **12***b* of the diaphragm away from the fixed edge **12***a,* where maximum deflection of the diaphragm **12** due to sound pressure occurs.

Referring to FIG. **2**, in accordance with the invention, the microphone **10** is manufactured on a substrate **16**, preferably a double side polished silicon wafer, during CMOS processing of other components (not shown) on the substrate **16**. During CMOS processing, an active area **18***a* surrounded by field oxide **18** is formed by a standard LOCOS process where the diaphragm **12** will ultimately be located. As is well known, the LOCOS process also results in a nitride layer **18***b* on the back side of the substrate **16**. The nitride layer **18***b* is left on the back side of the substrate **16** upon completion of the LOCOS process.

Referring to FIG. **3**, a low temperature oxide layer **20** is deposited over the entire surface of the wafer **16**. In the CMOS process, the oxide layer **20** is usually left on virtually the entire wafer surface as a dielectric between poly silicon gates and aluminum interconnect (not shown). The aluminum interconnect is used to connect circuits formed elsewhere on the wafer **16**. A portion of the oxide layer **20** is then removed to expose the bare silicon substrate **16**.

Similarly, in the CMOS process, a silicon nitride passivation layer **22** is usually left on virtually the entire surface of the wafer **16** to protect the low temperature oxide **20** and the layer of aluminum interconnect. As shown in FIG. **4**, the silicon nitride passivation layer **22** is patterned in such a way as to provide the usual protection in CMOS circuit areas elsewhere on the wafer **16**, but once again is locally removed to expose the bare silicon substrate **16** in the area where the diaphragm **12** will be. The silicon nitride passivation layer **22** thus forms a barrier to protect the CMOS area from an anisotropic etchant, preferably potassium hydroxide (KOH), in the final micro-machining step, discussed below. The back layer of nitride **18***b* is also patterned to form an etch mask for the final micromachining step, discussed below.

The capacitor **14** includes a fixed plate **14***a,* or backplate, and a movable plate **14***b*. Referring to FIG. **5**, a metal layer, preferably chrome in the range of 0.1–0.2 microns thick, is deposited and patterned to form the fixed plate **14***a.*

Referring to FIG. **6**, a sacrificial layer **24**, preferably aluminum, approximately **4** microns thick, is deposited and patterned. This sacrificial layer **24** will eventually be removed to form the gap between the fixed plate **14***a* and movable plate **14***b* of the capacitor **14**.

Referring to FIG. **7**, a silicon nitride diaphragm layer **26**, typically 1 micron thick, is deposited and patterned.

Referring to FIG. **8**, a metal layer, preferably chrome approximately 0.02 micron thick, is deposited and patterned on the silicon nitride diaphragm layer **26** to form the movable plate **14***b*. A thickness of 0.02 microns was utilized as a balance between stress and conductance considerations. A thinner layer would result in less conductance, but would also result in less stress.

Although not specifically shown, a layer of titanium tungsten alloy followed by a layer of gold can be deposited and patterned to protect aluminum bond pads elsewhere on the wafer **16**.

The final micromachining step is illustrated in FIG. **9**. In this step, the entire wafer is etched with an anisotropic etchant, preferably potassium hydroxide (KOH). This step forms both a capacitor gap **28** between the movable and fixed elements of the microphone **10** as well as forms a hole **30** below the diaphragm **12**.

The performance of the cantilevered microphone **10** illustrated in FIG. **1** tends to deviate from the optimum in two respects. First, because of the aforementioned compliance properties of cantilevers versus edge-clamped diaphragms, this cantilever structure as shown in FIG. **1** is actually so compliant that it overloads at the highest sound pressures encountered in certain microphone applications. Second, the cantilevered diaphragm of FIG. **1** fabricated from integrated circuit thin film materials as described above tend to curl due to three sources of unrelieved stress: (1) stress gradients through the thickness of the thin film remaining from deposition; (2) differential stresses caused by the addition of thin chrome or other metallization to the surface of the diaphragm; and (3) unrelieved film stresses at the fixed edge **12***a,* where the diaphragm **12** is anchored.

Two types of constructions described below have been developed to match the diaphragm compliance to the desired pressure range as well as to counteract any curling tendency of the diaphragm **12**.

A structure has a "bending moment", which relates its shape to its stiffness. A thicker film would increase the bending moment, but would also increase the diaphragm mass undesirably and would also simply increase the forces and moments which drive the curling tendency. Both types of constructions, described below, work by increasing the bending moment of the diaphragm without changing the thickness of the film.

The first construction for increasing the bending moment is to corrugate a diaphragm built from a single film layer. An initial approach might consist of running corrugations from the root of the cantilever to the tip. The film, however, has an equal tendency to curl across the cantilever as along it, so that a structure having only straight longitudinal corrugations could still curl in the transverse direction. Thus a more sophisticated corrugation pattern must be used which raises the bending moment about all possible cross sections of the diaphragm. One such corrugation pattern is shown in FIG. **1***a*. Many other patterns are possible. As disclosed in FIG. **1***a*, no matter what section is taken, it will cross several corrugations.

The manufacture of the diaphragm of FIG. **1***a* is similar to that of the diaphragm of FIG. **1**, but for the steps illustrated in FIGS. **6***a*, **6***b*, **7***a*, **8***a*, **9***a* and **9***b*.

Referring to FIG. **6***a*, the sacrificial layer **24** has been additionally patterned to form corrugations **32**.

As illustrated in FIG. **6***b*, a second sacrificial layer **34**, in the range of 1–2 microns, is deposited and patterned upon the first sacrificial layer **24**. This second sacrificial layer **34** permits one to separately control the dimension of the capacitor gap **28** and the height of the corrugations **32**.

Referring to FIG. **7***a*, the silicon nitride diaphragm layer **26**, typically 1 micron thick, is deposited and patterned. This step is similar to that illustrated in FIG. **7**, but for the presence of the corrugations **32**.

Referring to FIG. **8***a*, the metal layer, preferably chrome approximately 0.01 micron thick, is deposited and patterned on the silicon nitride diaphragm layer **26** to form the movable plate **14***b*. This step is similar to that illustrated in FIG. **8**, but for the presence of the corrugations **32**.

Although not specifically shown, as with the first embodiment, a layer of titanium tungsten alloy followed by a layer of gold can be deposited and patterned to protect aluminum bond pads elsewhere on the wafer **16**.

The final micromachining step is illustrated in FIG. **9***a*. In this step, the entire wafer **16** is etched with an anisotropic etchant, preferably potassium hydroxide (KOH). This step forms both the capacitor gap **28** between the movable and fixed elements of the microphone **10** as well as forms the hole **30** below the diaphragm **12**. This step is similar to that illustrated in FIG. **9**, but for the presence of the corrugations **32**.

If deeper corrugations are required, the silicon is trench etched before deposition and patterning of the sacrificial layers in order to increase the total corrugation amplitude.

The low frequency rolloff point of a microphone is determined by the inverse of the product of the back volume compliance, in acoustic farads, and the acoustic resistance of the pressure equalization path, in acoustic ohms. The equalization path in this device is around the edges of the cantilever diaphragm and continuing through the hole in the silicon substrate. For the very small microphones which are sought here, with back volumes on the order of 2 to 3 cubic mm, the acoustic resistance of this path must be quite high, on the order of 1 million acoustic ohms, to maintain flat response down below 100 Hz.

FIG. **9***b* is a section of FIG. **1***a*, taken along the line **9***b*—**9***b* thereof. As illustrated in FIG. **9***b*, the high acoustic resistance is obtained by forming an overlap **12***c* of the diaphragm **12** extending past the edge of the hole **30**. This overlap **12***c* defines an equalization path **36** which has a length "l" on the order of 5 to 10 microns, and has a gap height "h" between the diaphragm **12** and the wafer **16** of 1 to 2 microns.

The various vertical dimensions needed for the capacitor gap **28**, the corrugations **32** and the pressure equalization path **36** can all be realized using the two independently patterned sacrificial layers. As an example, and referring to FIG. **6***b*, a first sacrificial layer **24** of 3 micron thickness can be patterned to create the height differences needed for diaphragm corrugations while the second sacrificial layer **34** of 1 micron thickness is used to set up the height "h" of the equalization path **36**. The second (1 micron) sacrificial layer **34** is also left covering the entire corrugation relief pattern so that the height of the corrugations **32** is unchanged, but together the sacrificial layers **24**, **34**, create a 4 micron capacitor gap **28**. If complete independent control of these three dimensions (corrugation height, capacitor gap, equalization path height) is desired, then a third sacrificial layer (not shown) is required.

For all condenser microphones, there is a combination of sound level and bias voltage which will result in a irreversible collapse of the diaphragm onto its backplate. The position of a diaphragm in a zero bias voltage/zero sound pressure condition will be referred to as the unloaded position of the diaphragm. While in typical applications, the bias voltage can be controlled, it is often difficult to control the maximum sound pressure. If movement of the diaphragm from its unloaded position is limited, and the proper bias voltage is maintained, then this irreversible collapse can be prevented.

In microphones of the present invention, the small height "h" of the pressure equalization path **36** (see FIG. **9***b*) also serves, under high sound pressures, to limit diaphragm deflection to about 1 micron, so that the electrostatic forces at the capacitor **14** can not take over and cause irreversible collapse of the diaphragm **12**.

The great majority of the area under the diaphragm **12** in the previously described structures is directly over the hole **30** in the substrate **16**. This means that air displaced by movement of the diaphragm **12** can move freely without appreciable resistance. However, in the area of the capacitor **14**, the air is trapped in the 3 to 4 micron capacitor gap **28** between diaphragm and backplate and forced to flow laterally until the air reaches an opening. Due to the viscosity of air and the small dimension of this flow path through the capacitor gap, considerable damping of the diaphragm response can occur. This damping can both affect the high frequency response and add noise to the microphone output. The common method to overcome this is to perforate the backplate, but since in this case the backplate is formed on solid silicon, the damping problem is solved by introducing perforations, or holes, **38** extending through the diaphragm **12**, including the movable plate **14***b*, as shown in FIG. **1***a*. The use of holes has provided satisfactory response out to 50 kHz.

A second structure for increasing the bending moment is to build the diaphragm **12** using a sandwich of two quilted films separated by a thin 2–3 micron sacrificial spacer. The two films are periodically attached together, as shown in FIG. **10**, to form a quilted structure. The bending moment is now increased to virtually the same degree across all sections, except for a slight deviation for those cross sections which cut through the rows of attachment points. This deviation can be minimized by keeping the ratio of attachment size to attachment spacing small.

The method of manufacture of this diaphragm is similar to that disclosed above with respect to the embodiment of FIG. 1*a*, but is more particularly illustrated in FIGS. **11** and **12**.

According to this method, after deposition and patterning of the first sacrificial layer **24**, having a thickness of 1 micron, a first silicon nitride diaphragm layer **40**, having a thickness of 0.5 micron is deposited and patterned. Thereupon a second sacrificial layer **34** (corresponding to the layer **34** of the embodiment of FIG. **1***a*, and having a thickness of 3 microns) is deposited and patterned. Subsequently, a second silicon nitride layer **26**, having a thickness of 0.5 micron, is deposited and patterned. The layer **26** alone will serve to support the moving plate **14***b* of the capacitor **14**.

An alternate and preferred diaphragm structure is illustrated in FIG. **13**. This structure comprises a circular diaphragm which is anchored in the center. The advantage of this form is that it eliminates the two free side edges of the linear cantilever where lateral curling is most difficult to suppress. The only free edge left is the circular periphery. For a given diaphragm size and diaphragm material and thickness, the compliance of this structure, if the structure is kept flat to within a dimension equal to the corrugation amplitude, is intermediate between that of the edge-supported diaphragm and the linear cantilever, being five times the former and approximately one-twentieth of the latter. The curling tendencies of this structure are also intermediate. The compliance of this structure can also be adjusted to the desired value by incorporating corrugations of the appropriate amplitude. These corrugations can be radial, circular (preferred) or tangential to an inner radius like a pinwheel. Circular corrugations are preferred because they can be put in without being interrupted by the anchor area.

The process of constructing the embodiment of FIG. **13** is similar to that of forming the embodiment of FIG. **1***a*, but for the step of forming the anchor **60**. FIGS. **14** and **15** illustrate cross-sections of this embodiment.

The anchor **60** for the center-supported circular diaphragm **12** falls at the center of the substrate hole **30**. Thus some means of diaphragm support other than the surrounding substrate surface must be provided to connect the anchor to the surrounding substrate.

The preferred method is to pattern a deposited combination of a LOCOS nitride film **18***c* on the front side of the wafer **16** (which in the linear cantilever design had been removed) and the passivation nitride **22** in such a way as to form a tensioned, perforated thin film structure, or web, **62** across the substrate hole **30**, and to attach the diaphragm **12** to the web **62** at the anchor **60**. As described above in connection with the cantilever design of FIG. **1**, an active area is formed during CMOS processing where the diaphragm and substrate hole will be. However, in this case the LPCVD silicon nitride layer **18***c,* which is typically used to define the active areas in a LOCOS process by blocking the growth of field oxide, is left in place over the area where the diaphragm **12** and the substrate hole **30** will be. In a conventional LOCOS process, this nitride layer is stripped away entirely after it masks the field oxidation step. The silicon nitride typically is highly tensile, which is of use in tensioning the final structure. Within the active area, the CMOS low temperature oxide **20** is removed as before to expose silicon nitride **18***c*. Silicon nitride passivation **22** is deposited on the wafer **16** and patterned by etching. In the etch step however, the etch time is extended so that the underlying LOCOS nitride **18***c* is etched as well, acquiring the same pattern as the silicon nitride passivation **22**, thus forming the web **62**, as shown in FIG. **13***a*. When the wafer **16** is etched in KOH at the end of the process, the bulk silicon etch acting on the front of the wafer **16** ultimately forms 4 pockets **66**. The pockets **66** begin at the 8 openings **66***a* in the web **62** and then expand laterally until a limiting rectangular boundary **66***b* is reached. As expected for an anisotropic etchant, this boundary is the largest rectangle which circumscribes the original etch openings and which is aligned with the (111) crystal planes of the substrate **16**. In the present case, the extent of this lateral etch undercuts the web **62** so that a large area of the web **62** becomes free-standing. There are, however, 4 thin silicon ribs **68**, one between each of the pockets **66***b,* which ribs **68** extend between the anchor **60** and the substrate **16**. The rigidity of this structure is then derived both from the ribs **68** as well as from the tension in the films **18***c,* **22** from which the structure is made. The patterning of the films **18***c,* **22** is done in such a way as to include a sufficient total area of web **62** attached on the surrounding substrate to provide stiff support but also so as to include a sufficient number of openings to minimize the resistance of displaced air flow into the hole **30**. If the silicon nitride passivation layer **22** is available in a tensile state as deposited, the preferred embodiment is to leave out the LOCOS nitride **18***c* and use the silicon nitride passivation layer **22** alone, thus making the process flow more like that of a conventional CMOS process. The hole **30** is formed by the simultaneous pocket etching from the front of the wafer **16** and the back side etching through the openings in the LOCOS nitride **18***b*.

In this center supported circular diaphragm design, the compliance in the capacitive region is a result of the sum of the compliances of the diaphragm **12** and the backplate web **62**.

In order to achieve greater compliance, the ribs **68** can be eliminated by extending the etch time of the final micromachining. In fact, all of the compliance can be obtained from the backplate web **62**, and the diaphragm **12** can be very stiff.

An advantage of the silicon center support for a circular diaphragm is that it is a very flat and stable foundation for the diaphragm. The center silicon support is also more isolated from package generated stresses than the tensioned thin film support structure. Also since the support is made of bulk silicon, its reaction to unrelieved film stresses at the diaphragm attachment are negligible compared to the tensioned thin film support structure.

The preferred method of substrate etching (anisotropic etch) creates a square hole. The periphery of the round diaphragm must either overlap substantial areas of the surrounding substrate surface or leave the corners of the substrate hole uncovered, depending on the relative sizes chosen for diaphragm and substrate hole. In the former case, a substantial area of air is trapped between diaphragm and substrate, requiring diaphragm perforations, in the manner described above, to avoid viscous damping due to flow of displaced air. In the latter case, large leakage areas are created at the corners of the substrate hole, which can be eliminated if the tensioned film used in connection with the aforementioned diaphragm support methods (preferably silicon nitride passivation) is extended to fill in the corners of the hole. A region of narrow-gap overlap between diaphragm and substrate is thus re-established as required to control leakage through the barometric relief path. Free edges of the added tensioned film in the hole corners tend to curl somewhat, which detracts from control of the narrow gap in the barometric relief path; in the preferred design a few additional strips **62***a* of the tensioned film are included which flatten the free edges of the corner film areas by pulling them toward the center of the device. The capacitor is incorporated into the device near the edge of the diaphragm because the maximum amplitude of pressure-driven motion occurs there. The diaphragm electrode is established by metallizing the capacitor area of the diaphragm. The construction of the backplate depends on the size chosen for the diaphragm. For a large diaphragm which overlaps the solid substrate surfaces surrounding the substrate hole, the backplate electrode is established by metallizing the surface of the passivation-coated substrate.

For a smaller diaphragm, as shown in FIG. **13***d,* for which areas of tensioned film must already fill the corners of the substrate hole as described above, the backplate is established by simply extending these areas of tensioned film further, forming a free-standing backplate film structure which underlies the metallized peripheral area of the diaphragm. These additional tensioned film areas are then also metallized to form the backplate electrode **14***a*. The stress of the backplate metallization may be chosen to enhance the net tension of the film structure; in any case the net stress of the metallized backplate film must be tensile. Once again the air trapped between diaphragm and backplate must be properly vented to avoid viscous damping. In this case the preferred approach is to perforate the backplate film rather than the diaphragm since the backplate structure has less of a tendency to curl when perforated. The backplate perforations **72** may be shaped as either holes or slots. Typical parameters of hole perforation are a hole diameter of 5 micrometers and a hole spacing of 10 micrometers. Typical parameters of slot perforation are 14 micrometer slot, 24 micrometer spacing. In the case of slot venting the remaining backplate material takes on a web-like character; the intersection angles and widths of the linear elements of such a backplate structure must be chosen such that tensioning forces are balanced in the structure as it was first patterned and tensioning forces do not become redistributed when the backplate structure is released.

The electrical connection to the metallized diaphragm **14***a* can be routed through the center post or preferably on a thin nitride leader **70** to attach to the edge of the diaphragm. As shown in FIG. **13**, this results in a minimum of additional parasitic capacitance.

A problem which arises when a given diaphragm corrugation design and a backplate perforation pattern are combined is that some low areas of the corrugation pattern fall over backplate film material. This generates regions in which the air gap is on the order of one micrometer rather than the 4 micrometer dimension found elsewhere. Since, as stated above, viscous damping effects scale as the inverse of the cube of the air gap, mechanical damping accumulates over fifty times more rapidly per unit area in these locations than in the rest of the structure.

Two methods for avoiding this are included here. The first is to perforate the diaphragm at such locations, discussed above. If these locations are not too numerous the corrugation of the diaphragm is not upset enough to alter the compliance or the curl suppression of the diaphragm significantly.

The second method for avoiding this damping contribution is to avoid corrugation/backplate crossings altogether. FIGS. **16**, **16***a*. **16***b* and **16***c* show such a design. This approach uses a generally radial arrangement of corrugations and a matching radial arrangement of strips **62***a* of the web **62**. All of the web strips **62***a* fall underneath high areas of the diaphragm corrugation pattern except for the equalization path **36** at the periphery, where the height "h" of the equalization path **36** is reduced, and near the central diaphragm anchor area where there is very little diaphragm deflection. This design also illustrates the third corrugation scheme, mentioned above, which represents a mixture of the radial and the circular methods. As shown in FIG. **16***a,* the corrugations are placed tangential to an inner radius, which makes them mostly radial in character at the edge of the diaphragm but converging to a circular corrugation near the center. When this placement of diaphragm corrugations is matched with strips of tensioned film a web is formed which constitutes the backplate structure and masks the silicon hole etch to form the silicon ribs and an enlarged central diaphragm support area described above. The silicon ribs under the web provide stiffness to the structure. The converged diaphragm corrugations anchor to this central support area.

The rectangular and circular cantilevers both have a natural motion stop in one direction should the structure experience over-pressure (specifically, the narrow-gap barometric relief path and small intentional crossings of corrugation troughs and backplate film). To provide stops in the other direction, islands **73** of passivation nitride **22** are created using CMOS metal **74** as a sacrificial layer. One end **73***a* is attached to the edge of the diaphragm while the other end **73***b* is trapped under an overhang of diaphragm nitride outside of the working area. FIG. **17** shows this pressure stop structure.

Repeatability of the gap is a concern in silicon microphones. One mode of operation is to provide a high enough bias voltage to cause the diaphragm to come in contact with the backplate at the outer edge. This establishes a very repeatable gap and there is still enough compliance to provide good sensitivity.

It will be understood that the invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present examples and embodiments, therefore, are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein.

We claim:

1. A solid state condensor microphone comprising:

a semi-conductor substrate forming a support structure and having an opening;

a thin-film cantilever structure forming a diaphragm responsive to fluid-transmitted acoustic pressure extending over a portion of the opening, the structure having a proximal end and a distal end, wherein the proximal end is attached to the support structure, and the distal end is detached from and extends over a portion of the support structure; and

a variable gap capacitor having a movable plate and a fixed plate, wherein the movable plate is disposed on the distal end of the structure and the fixed plate is disposed on the support structure adjacent the movable plate, wherein said condenser microphone produces an output proportional to the position of the movable plate relative to the fixed plate.

2. The transducer of claim **1** wherein said semi-conductor substrate is silicon.

3. The transducer of claim **1** wherein said proximal end of said cantilever structure is along an edge of said opening.

4. The transducer of claim **3** wherein said cantilever structure is generally in the form of a rectangle.

5. The transducer of claim **1** wherein said cantilever structure is formed of multiple layers of thin-films.

6. The transducer of claim **5** wherein said multiple layers of thin-films are quilted.

7. The transducer of claim **1** wherein said diaphragm includes means defining a pressure equalization path extending over a portion of said support structure for restricting airflow between opposing sides of the diaphragm.

8. The transducer of claim **1** including means for limiting travel of said diaphragm away from said support structure.

9. The transducer of claim **8** wherein said travel limiting means comprises means extending over said distal end of said diaphragm.

10. The transducer of claim **1** wherein said diaphragm distal end includes a vent.

11. The transducer of claim **10** wherein said vent comprises a plurality of holes extending through said distal portion.

12. A solid state condenser microphone comprising:

a silicon substrate forming a support structure and having an opening;

a multi-layer thin-film cantilever structure forming a diaphragm responsive to fluid-transmitted acoustic pressure extending over a portion of the opening, the structure having a proximal end and a distal end, wherein the proximal end is attached to the support structure, and the distal end is detached from and extends over a portion of the support structure; and

a variable gap capacitor having a movable plate and a fixed plate, wherein the movable plate is disposed on the distal end of the structure and the fixed plate is disposed on the support structure adjacent the movable plate, wherein said condenser microphone produces an output proportional to the position of the movable plate relative to the fixed plate.

13. The transducer of claim **12** wherein said proximal end of said cantilever structure is along an edge of said opening.

14. The transducer of claim **13** wherein said cantilever structure is generally in the form of a rectangle.

15. The transducer of claim **12** wherein said cantilever structure is corrugated.

16. The transducer of claim **12** wherein said diaphragm includes means defining a pressure equalization path extending over a portion of said support structure for restricting airflow between opposing sides of the diaphragm.

17. The transducer of claim **12** including means for limiting travel of said diaphragm away from said support structure.

18. The transducer of claim **17** wherein said travel limiting means comprises means extending over said distal end of said diaphragm.

19. The transducer of claim **12** wherein said diaphragm distal end includes a vent.

20. The transducer of claim **12** wherein said vent comprises a plurality of holes extending through said distal end.

21. A solid state condenser microphone comprising:

a silicon substrate support structure including a frame defining an opening and a thin-film web attached to said frame and extending across said opening;

a thin-film cantilever forming a diaphragm responsive to fluid-transmitted acoustic pressure having a central portion and a peripheral end, wherein the central portion is attached to the web, and the peripheral end is detached from and extends over a portion of the support structure; and

a variable gap capacitor having a movable plate and a fixed plate, wherein the movable plate is disposed on the peripheral end of the structure and the fixed plate is disposed on the support structure adjacent the movable plate wherein said condenser microphone produces an output proportional to the position of the movable plate relative to the fixed plate.

22. The transducer of claim **21** wherein said central portion of said cantilever structure is disposed in the center of said opening.

23. The transducer of claim **21** wherein said cantilever structure is generally in the form of a circle.

24. The transducer of claim **21** wherein said cantilever structure includes corrugations.

25. The transducer of claim **24** wherein said corrugations form concentric circles.

26. The transducer of claim **21** wherein said cantilever structure is quilted.

27. The transducer of claim **24** wherein said corrugations form generally radial lines.

28. The transducer of claim **24** wherein said corrugations form generally tangential lines.

* * * * *

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United States Patent [19]

Voges

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[45] **Date of Patent: *Apr. 20, 1999**

[54] **DISPENSER**

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[73] Assignee: **Ponwell Enterprises Limited**, Wanchai, The Hong Kong Special Administrative Region of the People's Republic of China

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

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[52] **U.S. Cl.** **128/203.12**; 128/200.14; 128/200.16; 128/203.21; 239/102.2

[58] **Field of Search** 128/203.12, 200.14, 128/200.16, 200.18, 200.21, 200.23, 200.22, 203.21, 203.26; 239/102.2, 4, 406

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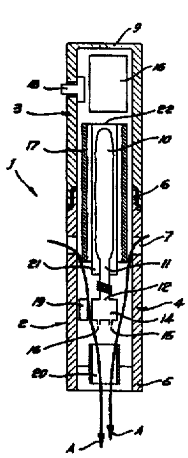
Assistant Examiner—V. Srivastava
Attorney, Agent, or Firm—Wilson Sonsini Goodrich and Rosati

[57] **ABSTRACT**

A dispenser (FIG. **1**, **1**) comprises a reservoir (**10**) of a physiologically active substance and a droplet ejection device (**14**), for example a bubble jet or pizeoelectric device, which is controlled to issue a predetermined number of discrete droplets of the substance from ejection orifices (**15**) upon actuation. Device (**14**) may be actuated by a pressure transducer (**19**) responsive to inhalation and issue the droplets into an airstream (A) which enters at slot (**7**) and is then inhaled via mouthpiece (**5**). In other embodiments (FIG. **5**) the dispenser is finger actuated and directed by hand for topical application. The number and/or frequency of droplets issued is programmatically controlled by a control circuit (**16**) whereby average and total dose of the substance are predetermined.

42 Claims, 3 Drawing Sheets



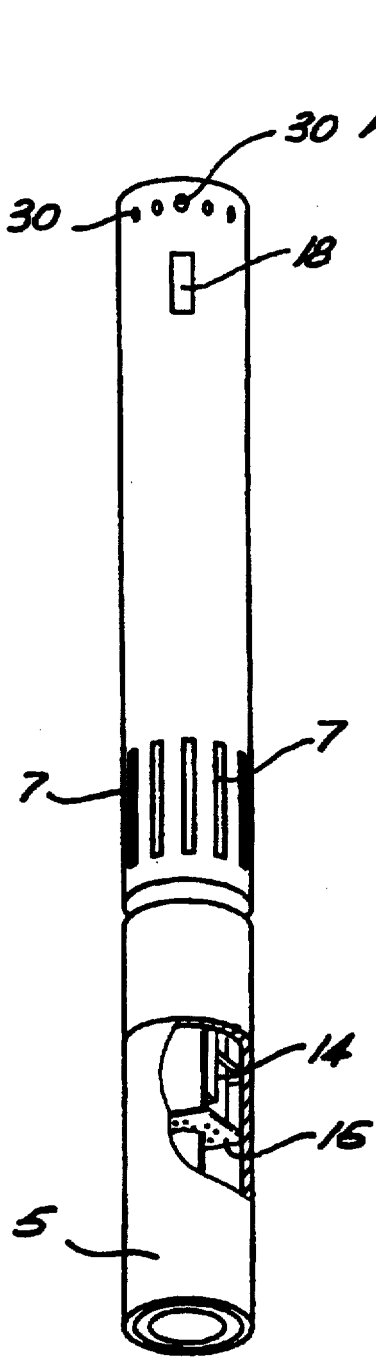

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FIG. 1

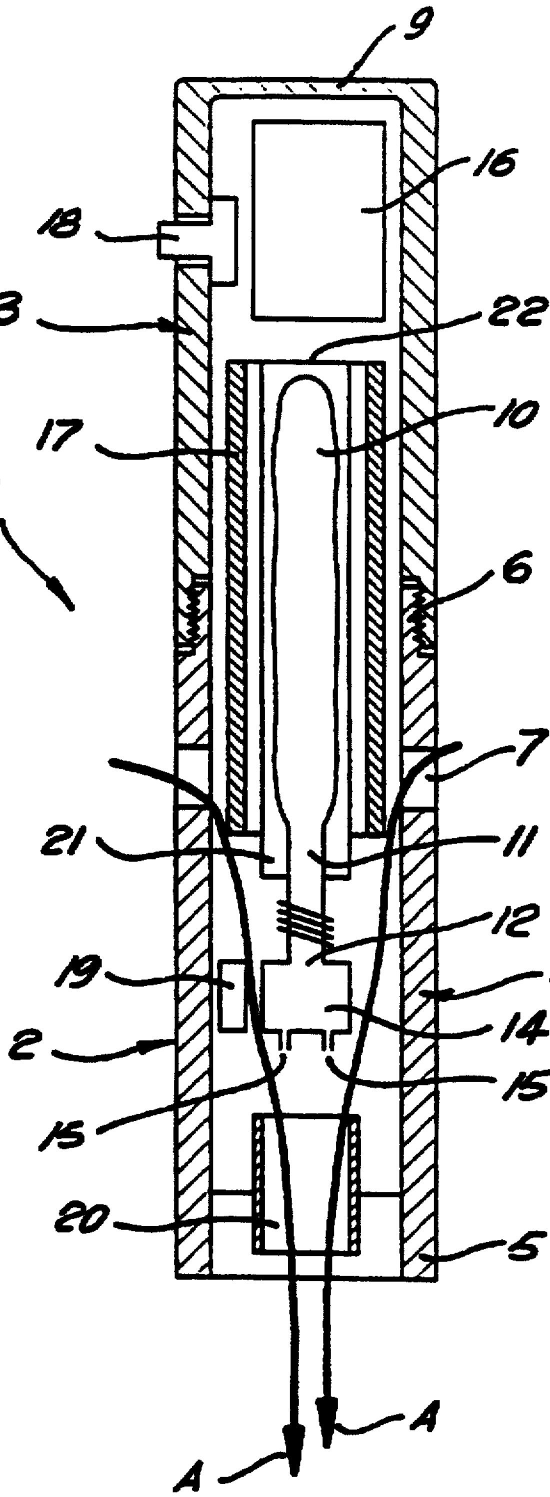
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FIG. 2

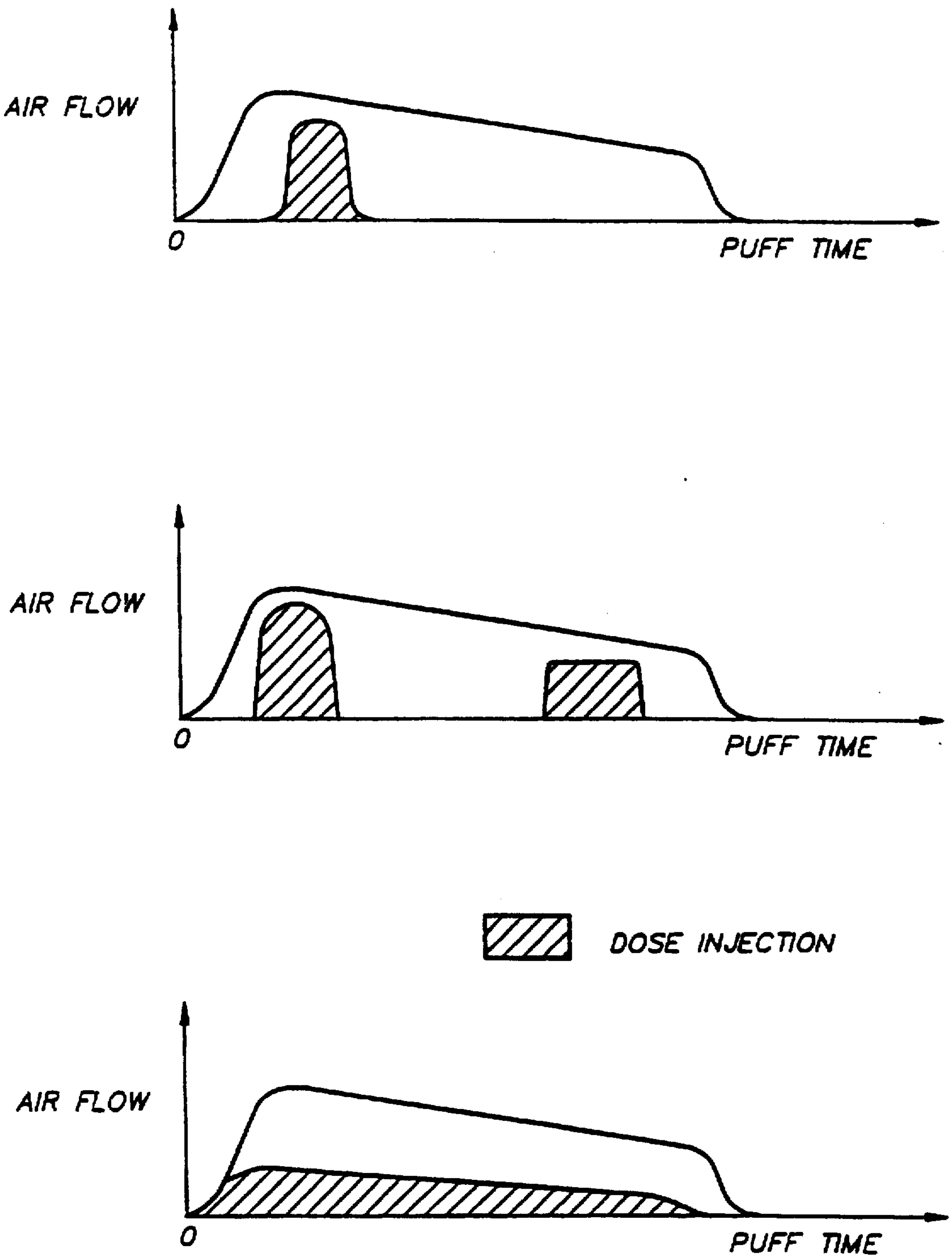
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FIG. 3

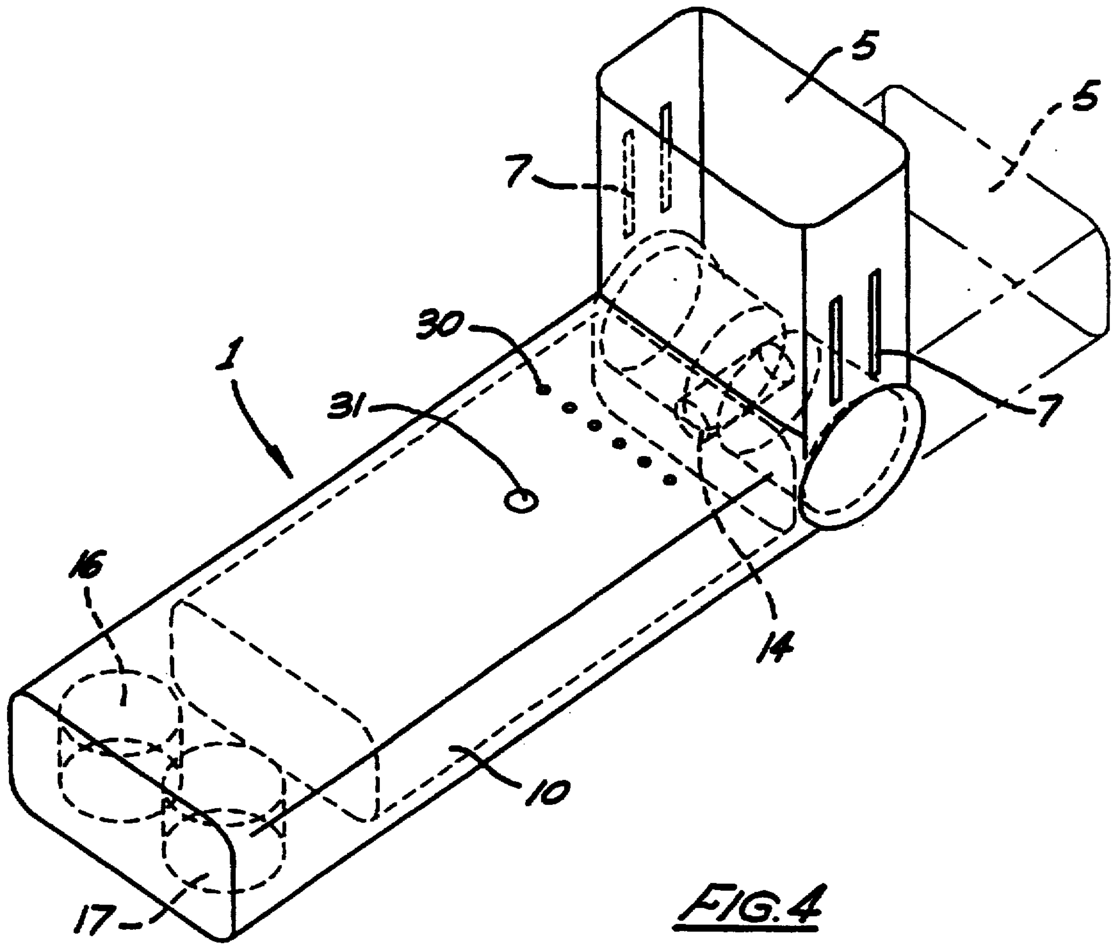

FIG. 4

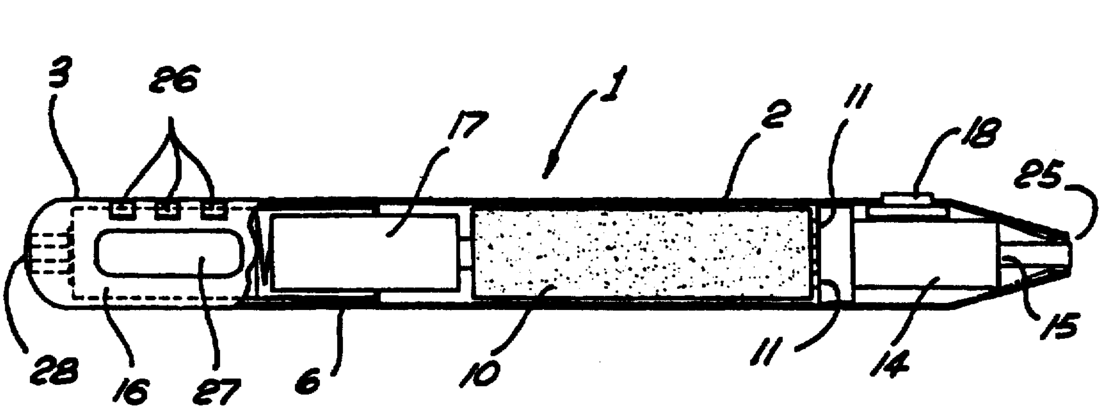

FIG. 5

DISPENSER

FIELD OF THE INVENTION

This invention relates to a hand held dispensing device. The device is of particular suitability for the self-administration of physiologically active substances by inhalation and will be herein described with primary emphasis on that use but may be used for other purposes.

BACKGROUND OF THE INVENTION

There are currently three main methods for drug delivery via the respiratory tract, namely metered dose inhalers, dry powder inhalers, and nebulisers.

Metered dose inhalers ("MDI") are widely used in the management of asthma. The MDI comprises a drug packaged with a propellant in a pressurised aerosol container can having a valve which releases a volumetric metered dose of aerosol upon actuation. These devices are portable, small, and convenient to carry but deliver a dose which varies in quantity, delivery speed, and droplet size distribution as the vapour pressure of the propellant varies. The propellant pressure varies with temperature and decreases progressively as the content becomes depleted so that the range in dose variation may be substantial. Incomplete evaporation of the propellant may cause "sticking" and localised concentration of drug droplets at an impact area, and this in turn can cause undesirable side effects. For example bronchosteroids can cause local immuno-suppression and local fungal infection while local concentration of bronchodilator can lead to swallowing, with unwanted systemic affects. In addition, the use of an MDI requires a degree of synchronisation between manual valve actuation and inhalation which many users find difficult.

Dry powder inhalers ("DPI") devices rely upon a burst of inspired air to fluidise and draw a dose of an active powder into the bronchial tract. While this avoids the synchronisation problem of the MDI, DPI's are sensitive to humidity and may provoke asthma attacks in some individuals sensitive to inhaled powder. Moreover, because the force of inspiration varies from person to person, the dose administered varies.

Nebulisers generate an aerosol by atomising a liquid in a carrier gas stream and require a continuous gas compressor or bulky supply of compressed gas. In general, the droplet size of the aerosol is a function of carrier gas pressure and velocity and hence cannot be easily varied independently of concentration of the active substance in the gas stream. Inhalation reduces the pressure at the nebulizer nozzle and thus dosage and particle size are also influenced by the duration and strength of each breath. Most nebulisers operate continuously during inhalation and exhalation but special control systems can be employed to meter the aerosolised gas flow from the nebuliser to a holding chamber from which the user may draw a charge.

In general the precision of dose delivery of each of these devices is less accurate than desirable and restricts their use to drugs which have broad dosage tolerance. In each case delivery of the active agent to the intended application site is overly dependent on user technique and is variable from dose to dose and person to person. Not only is an improved delivery system required to optimise current nasal and pulmonary therapies utilising locally acting drugs but there has long been recognised a potential for the administration of many additional local and systemic drugs if a more satisfactory means of delivery were available. Medical advances suggest that pulmonary delivery of drugs such as

peptides, proteins and analgesics might be of considerable advantage compared with conventional oral or injection delivery means. For example it has been suggested that insulin for diabetics may be delivered via the pulmonary route if a suitable means of delivery were available. The deposition of drug particles on lung tissue is a function of size, shape and density of particles or droplets. For many drugs, control of one or more of these factors along with precise dose or dose rate control would be desirable. However, at the present time no means of drug delivery is available which adequately meets such requirements.

Many attempts have been made to provide a cigarette substitute which provides nicotine by inhalation but which avoids the need for combustion of tobacco. Provision of a cigarette substitute involves complexities additional to those involved in the administration of a therapeutic agent. Although it is relatively easy to administer nicotine (for example in tablet form, via transdermal patches and the like), such forms do not satisfy habitual smokers because they do not satisfy important complex physiological and psychological affinities acquired by habitual smokers of combustible cigarettes.

In an attempt to provide an acceptable alternative, many cigarette substitutes have been proposed which provide nicotine on inhalation without combustion of tobacco. Conceptually, such devices are less harmful to the inhaler than smoking, avoid the hazards of passive smoking among bystanders and avoid the fire hazard and environmental problems associated with cigarette smoking. However, despite these major advantages, no device so far proposed has met with consumer acceptance.

Early cigarette substitutes employed a porous carrier impregnated with a liquid nicotine containing composition through which an air stream could be drawn to volatilize nicotine. This approach yielded insufficient nicotine per puff, suffered from a tendency for the carrier to dry out and delivered a variable amount of nicotine per puff, depending on factors such as air temperature, humidity, lung capacity of the user and amount of liquid composition remaining in the carrier.

Subsequent devices delivered nicotine from a pressurised aerosol container from which nicotine can be released by mechanical valve actuator. In one such device the valve is microprocessor controlled to limit the frequency and duration of actuation. However, the dose delivered varies with the vapour pressure of aerosol remaining in the container as well as with duration of valve actuation. The disposable pressure container, aerosol valve, and CFC propellant add considerably to active substance cost. These devices share the disadvantages of MDI devices previously discussed.

In yet other devices a nicotine containing substance is heated to vapourise an amount of nicotine which is then available for inhalation. The amount of nicotine delivered by such devices is difficult to control and is temperature dependant. In one such device a plurality of nicotine-containing pellets may be heated sequentially so that each liberates a predetermined dose. However, in that case, the dose is fixed during pellet manufacture, particle size of the aerosol is uncontrolled, and temperature of the inhaled air cannot be varied independently of dose.

Factors such as the quantity of nicotine per puff, the temperature of the puff, the draw, the presence and size distribution of flavour particles in the puff and like factors are of considerable importance in satisfying habitual smokers. The various alternatives proposed to date have simply proved unacceptable to most smokers.

To date no device has provided a satisfactory means of adjusting both the quantity of nicotine delivered in each puff in response to user demand and/or maintaining adequate precision and accuracy in the dose quantum metered out. Further the devices have failed adequately to mimic the sensations obtained during smoking.

Because the requirements for a cigarette substitute are particularly difficult to satisfy, the present invention is herein described primarily with reference to nicotine delivery, but it will be understood that the invention is more generally applicable and addresses the general need for a device which can precisely dispense doses and preferably which can dispense doses of a variety of drugs or other substances and which are adjustable from one individual to another or at different times.

Preferred embodiments of devices of the kind under consideration may be used as a less harmful form of administration of nicotine than smoking or may be used to reduce or eliminate nicotine dependence among those wishing to give up smoking.

It is, without limitation, an object of the present invention to provide a method and means for administration or self-administration of an active substance which avoids at least some of the above discussed disadvantages of prior art. It is an object of preferred embodiments of the invention to provide a method and means for dispensing the active substance for administration via inhalation.

It is an object of other preferred embodiments of the invention to provide a cigarette substitute.

DISCLOSURE OF THE INVENTION

According to one aspect the invention consists in a method for administering a substance to a human or animal subject by inhalation, said method comprising the steps of:

(i) ejecting a predetermined number of discrete droplets of the substance from at least one droplet ejection device in response to an actuation signal, and

(ii) entraining the droplets in an inhalation airstream.

According to a second aspect the invention consists in a method for topical application of a substance to a human or animal subject comprising the steps of:

(1) ejecting a predetermined number of discrete droplets of the substance from at least one droplet ejection device in response to an actuation signal, and

(2) directing the droplets at a selected area or region of the subject.

According to a third aspect the invention consists in an apparatus for administering a substance to a human or animal subject, said apparatus comprising:

a droplet ejection device containing a substance to be administered, means responsive to an actuation signal to eject a predetermined number of discrete droplets of the substance, and

means for directing the ejected droplets at, or into, the subject.

The substance to be administered may be a therapeutic or other physiologically active agent and may be a liquid, a solution or a suspension for example a colloidal solid in a liquid carrier or an emulsion.

In preferred embodiments of the invention, the droplet ejection device ("DED") device is a piezoelectric device of the kind used in ink jet printing or is a thermal "bubble jet" device of the kind used in ink jet printing.

These devices are sometimes referred to as "droplet on demand" devices. By way of example piezoelectric devices are broadly described in "Ink-Jet Printing" [M. Doring Philips Tech Rev 40, 192–198, 1982 No. 7], while thermal devices are broadly described in "Thermal Ink-Jet Print Cartridge Designers Guide" (2nd Edition Hewlett Packard), both incorporated herein by reference.

Briefly, a typical thermal device consists of a liquid-containing chamber provided with an array of twelve coaxially divided nozzles and has twelve thin film resistors, a resistor being located directly behind each nozzle. Each nozzle supplies a droplet of liquid from the chamber if and when the corresponding resistor is energized by a short electrical pulse. The resistors thus function as ejection means. Within a few microseconds liquid in contact with the resistor is vapourised and forms a bubble. The vapour bubble grows rapidly and imparts momentum to liquid above the bubble. Some of this liquid is ejected as a droplet from the adjacent nozzle at a velocity typically exceeding 10 meters/second. The ejected volume of liquid is automatically replaced in the chamber from a reservoir by capillary action or by atmospheric pressure acting on collapsible reservoir bladder, a piston or the like. Devices of this kind when used for printing eject a typical drop of about 50 micron diameter at velocities in excess of 10 meters/second and are capable of drop ejection frequencies of up to several thousand droplets per second. The piezoelectric device generates a droplet by means of a pressure wave in the fluid produced by applying a voltage pulse to a piezoelectric ceramic which in this device acts as the ejection means. As with the thermal device, the droplet is ejected through a fine aperture. The fluid is ejected in the form of a fine droplet whose velocity depends on the energy contained in the voltage pulse. In conventional ink jet applications, ejection velocities in excess of 2 meters/second with droplet diameters of around 150 microns and droplet ejection rates of in excess of 6,000 droplets per second can be achieved.

Although conventional "droplet on demand" or "droplet ejection" devices such as used in ink jet printers may be employed in embodiments of the invention, the droplet ejection devices for use in the invention preferably differ from those used for printing. With printheads the ejection orifices are typically arranged as a rectangular matrix of, for example, 2×6 or 4×6 orifices the droplets being expelled in parallel direction from various combinations of orifice to form characters on a paper moving past the printhead at a distance of from 0.7 mm to 1.0 mm from the orifice. Droplet size is chosen to provide optimum print quality and high dot resolution. For use in the present invention there may be a smaller or greater number of orifices than used for printing and there is no need for the orifices to be arranged in a rectangular matrix with parallel orifice axes. The droplet ejection orifices may, for example, be arranged in a circle and/or may be directed at a converging or diverging angle to the axis of each other. Also for use in the present invention it is often preferred to eject much smaller droplets than are useful for printing. Additionally, the droplet ejection orifices may differ in diameter one from another so that the particle size of the active agent sprayed from the device may be controlled programmatically by selecting which orifices are used for droplet ejection and particle size may be varied from one time interval to another. Because the size of droplet ejected from the device in response to a predetermined signal is predetermined for a given liquid and device, and because the number and frequency of droplets ejected can be controlled with great precision, it is possible to closely control the total volume of liquid (dose) delivered in a given time interval. For example the device might deliver 1,000 droplets of 50 micron diameter in a second. This volume can in principle be increased or decreased in increments of one droplet.

In preferred embodiments of devices according to the invention the DED is provided with orifices of an aperture size selected to eject a droplet of less than 10 microns diameter and, more preferably, of from 1 to 5 microns diameter. Droplets may be emitted from the DED from a selected orifice in succession or from a plurality of orifices simultaneously.

In preferred embodiments the droplet delivery device or devices may be manually actuated or may actuate in response to an inhalation detector signal or other signal. The apparatus is provided with control means programmed to eject a predetermined number of droplets. The number may be varied in response to stored data and/or other input signals and programme logic may control such factors as the number of droplets ejected in a predetermined time interval, frequency of droplet ejection, the total number of droplets of active substance issued within a time period, or the like. The control means may be programmed to provide many other desirable functions as hereinafter described.

The means for directing the ejected droplets at or into the subject may for example be a simple mouth piece provided with an air inlet, a nasal shroud, face mask or other spray directing means. The active agent is typically in solution and is emitted from the DED as a fine spray which may be combined with air and/or may be heated prior to inhalation.

BRIEF DESCRIPTION OF DRAWINGS

Various embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a schematic part sectional perspective view of one embodiment of a dispenser (cigarette substitute) according to the invention; and

FIG. 2 is a schematic section in an axial plane of the dispenser of FIG. 1; and

FIGS. 3A, 3B and 3C are graphs showing the dispensation of an active ingredient (hatched) as a function of inhalation time in use of the embodiment of FIG. 1, and

FIG. 4 is a schematic perspective view of a second embodiment of the invention, and

FIG. 5 is a schematic diagram of a third embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to FIGS. 1 and 2 there is shown a first embodiment of the invention consisting of a nicotine dispenser comprising a cigarette-shaped hollow tubular body 1 comprising connected body parts 2, 3. Body part 2 has a sidewall 4, a mouthpiece 5 at or adjacent one end and a threaded other end 6. A plurality of axially extending slots 7 penetrate side wall 4. Body part 3 is screw threaded at one end for connection with threaded end 6 of body part 2. Body part 3 is closed or constricted at the end 9 remote from mouthpiece 5.

Nicotine in a suitable solvent (for example water) is provided in a container 10 which is adapted by means of a spiggot shaped outlet and coupling 11, for fluid connection to an inlet port 12 of a droplet ejection device 14. In the present example, device 14 is of the kind used in a bubble jet printer and is provided with one or more droplet ejection orifices 15. Device 14 is controlled by control means 16, for example a microelectronic circuit or microprocessor means. Device 14 and control means 16 as well as other electrically-powered parts are energised by means of a hollow cylindrical battery 17 via an on-off switch 18 extending through side wall 14 and operable by the user. When a user inhales at mouthpiece 5, a stream of air "A" is drawn into body 1 via slots 7, through body part 2, and mouthpiece 5 into the user's lungs. Slots 7 may be provided with a damper or the like (not illustrated) to control airflow or the device may be provided with a porus plug to control airflow ("draw") on inhalation at mouthpiece 5. A pressure sensor 19 detects a change in pressure in the device due to inhalation or suction at mouthpiece 5 and issues an actuation signal via cables (not illustrated) to control means 16. Control means 16 responds to the actuation signal by issuing an output signal or signals via cables (not illustrated) to device 14 according to preprogrammed parameters or algorithms as hereinafter described. The output or "dose" signal is, or includes, a set of "eject" signals for example a train of voltage pulses. Device 14 responds to the output signal or signals by issuing a plurality of droplets of nicotine solution from orifices 15 of device 14. The liquid containing nicotine issues from device 14 as a fine spray of droplets which are entrained in the inhalation airflow from slots 7 towards mouthpiece 5. The spray typically comprises fine droplets which tend to vaporise in the airflow. Optionally, heating means 20 are provided. In that case the combination of air with nicotine droplets may be brought into thermally conductive contact with heating means 20 prior to leaving mouthpiece 5. This not only produces a sensation on inhalation similar to that obtained by smoking a combustible cigarette, but also serves to enhance the vaporisation of active substance droplets in the gas stream reducing droplet size.

In the embodiment illustrated in FIGS. 1, 2 the active substance container 10 is a collapsible bladder which is housed within a protective hollow cylindrical cartridge 21 having an air vent 22. However other forms of container (for example a cylinder fitted with a piston) could be used. Cartridge 21 is optional and serves to shield bladder 10. Container 10 is disposable or replaceable and may be adapted for fluid communication with inlet 12 of device 14 by means of a threaded, bayonet, or other suitably sealing connection.

Optionally, battery 17 may be of annular form and adapted to sleeve cartridge 21 to save space. Heating means 20 may be infrared heating plates or elements, resistance elements or the like.

Control means 16 desirably comprises a programmable logic circuit for example a microprocessor together with associated Read Only Memory (ROM), Read and Write Memory (RAM), clocks, power supply and the like and is programmed to control the quantity of nicotine delivered by the DED upon inhalation, subject to predetermined criteria.

In normal operation of the device a drop of pressure at mouthpiece 5 is detected by pressure sensor 19 which issues a signal indicative of inhalation ("actuation" signal) to control means 16 (via cables not illustrated). Control means 16 responds by issuing a "dose" signal to device 14 resulting in a spray of droplets from the device.

The dose signal typically comprises a predetermined set of drop "eject" signals which causes one or more orifices 15 of device 14 to eject a predetermined number of droplets. The dose signal may, for example, be a train of pulses (each pulse being a droplet eject signal) directed serially to one resistance heater of a thermal bubble jet device, or may be a sequence of pulses directed in parallel to a number of such resistance heaters. Since the volume of a droplet issued from a selected orifice 15 is predetermined for a given liquid and orifice, and the number of droplets ejected is controlled by the dose signal, the total volume of nicotine-containing liquid ejected in response to the actuation signal is precisely determined.

Control means **16** controls the pulse spacing, pulse width, and pulse frequency of the "dose" signal as well as the number of pulses or droplet "eject" signals and therefore determines the time interval during which droplets enter the inhalation air stream i.e. the dose rate. The number of droplets issued and/or the droplet issue frequency may be altered by changing data stored in a control memory. Control means **16** may also be programmed to address specific resistance heaters so as to emit droplets from selected orifices which may differ one from another for example in respect of diameter or orientation.

Control means **16** may also be programmed to provide a time delay between receipt of an actuation signal indicative of inhalation from pressure sensor **19** and the issuance of a "dose signal". The time delay may be varied by changing data stored in a control memory. By controlling the time delay between the leading edge of an actuation signal and issue of the dose signal, and by controlling the frequency of droplet "eject" pulses in the dose signal, the active substance can, for example, be injected into an inhaled air stream as a spike near the start (FIG. 3A) or start and end (FIG. 3B) of an inhalation "puff", or can be spread over the puff duration (FIG. 3C), or may be confined to the leading or trailing portion of a puff. This enables the change in concentration of nicotine during a puff of a cigarette to be more closely mimicked.

The control means can also be programmed to prevent a dose signal from issue until a predetermined "non repeat" time has elapsed after a preceding dose signal has been issued, notwithstanding receipt of a inhalation signal. This provides a minimum delay between successive doses.

The control means may also be provided with means for counting and storing the total number of dose signals issued within a predetermined time interval and if the total exceeds a predetermined limit (for example 30 doses in a 30 minute period) then the control circuit prevents further dose issue until a further period (e.g. 1 hour) has elapsed. This limits the maximum dose issued within an extended period.

In preferred embodiments of the invention the control means enters a minimum energy drain mode to conserve battery power if for example more than 5 minutes have elapsed since an inhalation was detected.

The apparatus of FIG. **1** may optionally be provided with means for signalling the doses remaining in the device for example by means of a plurality of LEDs **30** which progressively extinguish. Each LED may for example correspond to a dose equivalent to smoking one cigarette and the apparatus might initially store a dose corresponding to one (or several) packets of cigarettes. Other indicator means e.g. an LCD display could be used.

In summary the control means allows programmable control of factors such as:

(1) Predetermined number of droplets of nicotine issued in a single dose (dose volume).

(2) Frequency of drop issue within a dose (dose rate).

(3) Synchronization of the dose relative to commencement of inhalation.

(4) Injection of dose as a function of time from commencement of inhalation. (Pulse spacing and frequency).

(5) Control of maximum frequency of issue of successive doses or non repeat time (e.g. successive doses available at not less than 60 second intervals).

(6) Control of maximum number of doses available in a given period i.e. maximum dose rate (e.g. no more than 20 doses available per hour).

(7) Programmed variation of dose from one actuation to another (e.g. successive reduction in dose to reduce drug dependence).

(8) Programmed variation from time to time (e.g. dose to decrease from day to day).

(9) Control of nozzles from which the droplets issue (and hence spray pattern).

(10) Discrimination for adequacy of inhalation (No dose unless accompanied by sufficient inhalation air).

It will be apparent from the above that the device can be programmed in other ways and to perform other functions by the addition of other sensors—for example temperature or humidity sensors.

In addition the control means may be provided with means by which control parameters may be altered or by which the device may be reprogrammed, for example by interfacing with a keyboard or an external computer.

As will be appreciated, the microprocessor may be pre-programmed or may be user-programmable to control the operation of various DED nozzles, the heater, the airflow or the like in various other combinations, sequences, or as functions of time, temperature, or the like.

Tubular body **1** may be made of any suitable material e.g. plastics, ceramics, precious metals or the like. Mouthpiece **5** may be integral or may be soft-tip, for example of rubber or plastics cardboard, or paper and may be independently disposable. The battery may be replaceable or rechargeable. The dispenser as a whole may be provided as a disposable item or may be reusable. In the latter case, the product container and DED device will normally be replaceable or may be provided as a combined unit. In that case, the body portion will be separable e.g. via screw-threaded or bayonet coupling into sections to facilitate installation and removal of the product cartridge and/or battery. The product to be dispensed may be for example an aqueous solution of nicotine and may contain additional substances such as glycols, flavours or essences, for example menthol. The active substance may be in the form of a gel, melt, solution or suspension.

If desired, more than one DED **14** may be incorporated whereby to produce droplet streams of different droplet size and in this case, one stream may be fully vapourised by heating plates **20** while a second stream may be directed so that the user receives the sensation of a wet vapour in combination with a dry vapour as occurs when smoking conventional cigarettes.

It is not essential that the spray of active ingredient be combined with air prior to heating and if preferred the spray and/or the air may be separately heated and subsequently combined or the active ingredient may be preheated e.g. by heating means in thermal communication with storage container **10**. By selective programming of the controller the smoking instrument can be adjusted to simulate "light" or "ultralight" cigarette nicotine levels or can be selectively adjustable therebetween. In other embodiments the air intake may be adjusted to vary the air to active substance ratio thus further to facilitate simulation of the sensation of smoking different kinds of cigarettes. The invention is of particular application for assisting those wishing to withdraw from cigarette smoking being programmable to progressively reduce the dose of nicotine obtainable. Devices according to the invention may either be pre-programmed, may be provided with simple means enabling the user to adjust dose within predetermined limits of safety or may be adapted to be programmed by a user e.g. by connection via an interface to a computer.

Although use of a battery is preferred other energization means for example photo cells, may be employed.

It will be understood that the apparatus described may be provided in a different form, for example with a mouthpiece which is flexible whereby the body may be held in a different orientation from the mouthpiece. Similarly the battery need not be annular and may be of any suitable shape.

With reference to FIG. **4**, there is shown another embodiment of the invention intended to dispense a bronchodilator. Parts in FIG. **4** which correspond in function to parts in FIG. **1** are identified with the same numerals. If the substance to be dispensed is heat sensitive it is preferred to use a piezoelectric DED. Disposable cartridge **10** of the embodiment of FIG. **4** contains for example, salbutamol. The embodiment of FIG. **4** differs from that of FIG. **1** in that the body is of rectangular cross-section and in that of the shape and arrangement of components differs.

A further difference is that in the embodiment of FIG. **4** the mouthpiece portion **5** is moveable hingedly between a storage position "A" in which it is in alignment with the body (shown in ghost outline in FIG. **4**) and an active position "B" in which it is inclined at an angle to the body portion.

The mouthpiece may swivel about a swivel pin **40** and the swivel motion may itself actuate an on/off switch to energize the electronic control systems **16**.

If desired the apparatus may be provided with manual actuation (e.g. a push-button switch, not illustrated) instead of a pressure-sensitive switch, to control the operation and initiate a "actuation" signal.

In cigarette substitute apparatus according to FIG. **1**, droplet sizes of the order of 1–10 micron diameter or more are acceptable. For pulmonary administration of drugs a small droplet size is preferred. For this purpose droplet size distribution is normally described as mass median aerodynamic diameter (MMAD), with a standard deviation to indicate the degree of poly dispersity. Particles with MMAD>5 micron tend to impact on the delivery system and do not readily follow respiratory passages.

For practical purposes droplets of below 10 micron diameter and more preferably of below 5 micron diameter are therefore preferred. If necessary, droplet size can be reduced after ejection from the DED device by directing droplets at each other or at a suitable target designed to further fragment the droplets, or by injecting the droplets into an inhaled stream in a suitable manner. Optionally heating devices can be employed to vapourise the liquid and reduce droplet size.

Suitable drugs for delivery by the apparatus described include, by way of example only, analgesics, peptides and proteins. Other suitable agents include

(i) β_2-bronchodilators—salbutamol, terbutaline sulphate, fenoterol hydrobromide, pirbuterol, reproterol hydrochloride, rimiterol hydrobromide, salmeterol (used extensively for treatment of acute asthma attacks and in prophylactic asthma therapy).

(ii) Antimuscarinic bronchodilators—Ipratropium bromide, oxitropium bromide (used in management of chronic bronchitis).

(iii) Corticosteroids—beclomethasone dipropionate, budesonide: used in prophylactic asthma therapy.

(iv) Sodium chromoglycate, nedocromil sodium (used in prophylactic asthma therapy) Antibiotic Therapy:

(v) Pentamidine isethionate—(antibiotic for the prophylaxis and treatment of pneumonia due to Pneumocystis carinii, a common secondary infection in HIV/AIDS patients).

Local Action

(vi) Range of proprietary 'Over the Counter' nasal decongestant sprays for common cold symptoms,

(vii) Corticosteroids—beclomethasone dipropionate, betamethasone sodium phosphate, budesonide, fluticasone propionate (used in prophylaxis and treatment of allergic rhinitis).

(viii) Sodium chromoglycate (used in prophylaxis of allergic rhinitis).

(ix) Anti-infective agents—e.g. dexamethasone, fusafungine, chlorhexadine hydrochloride (used in treatment of infection due to nasal staphylococci).

Systemic Action

(x) Nasal administration of peptides related to antidiuretic hormone—desmopressin, lypressin (used in management of diabetes insipidus).

Apparatus for use in dispensing certain drugs may comprise programmed control means which issues a predetermined dose into each of a plurality of successive inhalations and in that case may be provided with a "dose complete" signal for example via LED **31** to indicate to a user when a full dose has been dispensed. The dose can be varied according to the composition being dispensed and the prescription for each user.

With reference to FIG. **5**, there is shown a further embodiment of the invention which is adapted to dispense an active substance such as an anaesthetic, antiseptic or a liquid medication by topical application rather than by inhalation.

In surgery or medical treatment it is sometimes necessary to apply an anaesthetic, antiseptic or other fluid over a local area by means of an aerosol sprayed from a pressurised container. However it is difficult to control the amount and location of spray application. Moreover the use of CFC propellant as used in the aerosol is environmentally undesirable.

Parts of FIG. **5** corresponding in function to parts in the embodiment of FIG. **1** are identified by the same numerals.

With reference to FIG. **5** there is shown a dispenser comprising a pen shaped hollow tubular body **1** assembled from hollow body parts **2**, **3**. Body part **2** has a nozzle opening **25** at one end while body part **3** is closed at the dispenser end remote from nozzle opening **4**. Body parts **2**, **3** are separably connected at **6**, for example by interengaging thread formations. A cartridge **10** is situated within body **1** and contains a liquid. Cartridge **10** is in fluid communication with one or more droplet ejector devices **14** via one or more conduits **11**. In the present example DED **14** is a piezoelectric crystal or thermal resistor bubble jet device such as used in an ink jet print head. Device **14** can be energized from a battery **17** via an on off control switch **18** adapted for finger operation while the device is hand held. For example the device may be held between thumb and middle finger and may carry a push button switch **18** which is operable by the first finger. In the embodiment of FIG. **5** when control **18** is actuated, device **14** delivers liquid from cartridge **10** as a spray directed outwardly from the dispenser via nozzle **25**. The duration of the spray is determined by whether the switch **8** is "on" or "off".

In a more highly preferred embodiment of the invention the volume sprayed per unit time is also be controlled. For example, the dispenser **1** is provided with one or more switches **26** (for example touch pad switches) which condition control means **16** (for example a microprocessor circuit) which in turn controls a number of bubble jet orifices **15** of device **14** through which spray droplets are emitted and/or which controls the repetition rate of device **14** and thus the number of droplets delivered in a unit of time. Thus the spray rate may be selectively light or heavy depending on the number of orifices emitting droplets and depending on the repetition rate of droplet emission.

If the device **14** is provided with a plurality of emitting orifices which are directed at preselected angles to the axis of the body, droplets of liquid may be directed in the axial direction or selectively at predetermined angles to the axial direction by circuit actuation of a selected jet orifice **15**, or a selected combination of droplet ejection device jet orifices **15**. In this manner a spray pattern may be selected by means of a suitable finger control forming part of a suitable micro-electric circuit controlling means **16**. If all emitting orifices **15** are directed axially the spray pattern may be made selectively narrow or broad.

Alternatively control switch **26** may be adapted to select between a number of predetermined total dose dispensations or an additional control means may be provided to select total dose. In such manner, if the cartridge contains for example a liquid local anaesthetic, a surgeon can select a preset quantity and spray pattern of local anaesthetic to be applied during surgery. The surgeon could thus select between application of a small, medium or large dose, at each actuation of a switch **26** and could preselect between a narrow, medium, or broad spray pattern.

If desired the control circuit **16** may be provided with means to prevent inadvertent excessive use, for example by limiting the maximum dose of liquid which can be applied within a prespecified time period.

Also, if desired, the control circuit can be provided with security locking which overrides the on/off switch. For example the device might be provided with a programmable security code and might be incapable of issuing its contents unless and until a corresponding code is entered by an intending user.

For this purpose the device may have a plug **28**, socket or transmitter/receiver which permits the device to interface with an external computer. The external computer might then also record data indicative of use, doses issued, user identification, patient identification, or similar data. The external computer may also re-enter new data in one or more memories in the control circuit of the dispenser for example dose values, time parameters, security codes. This data is then used in controlling response of the device to actuation by the user.

Other forms of hand control, for example touch sensitive switches or rotary switches may be employed instead of touch pads **26**.

Control circuit **26** may utilise digital or analogue control and may employ a microprocessor, or discrete circuit components. In preferred embodiments the circuit includes a memory, preferably of type which is not erased due to lack of battery power such as a ramtron chip. The circuit further desirably includes a display screen such as a single line LCD **27**. The circuit may also employ a clock and be able to utilise and display date and time data and may have a key pad or equivalent input device or may rely for input upon communication with an external key pad. The LCD could be used to display data such as number of remaining doses or time and date of last dose.

Although the embodiment of FIG. **5** has been described with reference to dispensation of a liquid it will be appreciated that the material to be dispensed can be in the form of a gel, colloid, powder suspension or any other form suitable for dispensation via the device **14**.

In a further embodiment of the invention (not illustrated) the dispenser is provided with a plurality of cartridges or chambers each adapted to contain a respective medication in liquid or solution form. The control means may be programmed to provide an alarm (for example a beeper or flashing LED) at predetermined times or at predetermined times and dates. On next actuation of the device, it then delivers a predetermined dose of one medication or a combination or succession of medications each in a respective predetermined dose.

This embodiment is thus ideally suited for pre-programmed treatment of persons suffering from dementia or the like and for persons having to take a number of different medications each according to a schedule and who find self-administration confusing.

The device itself prompts the user to accept a dose and issues the appropriate doses of prescribed medication.

As will be apparent to those skilled in the art, features described in relation to one of the described embodiments may be combined with those of another.

Although the control signals have been described as pulses, those skilled in the art will appreciate that the signals can take a great variety of forms and may employ voltage or current signals, AC or DC signals, digital or analogue signals or the like, as required for operation of the DED selected. It is not necessary literally to count signals to eject a predetermined number of droplets and it will be understood that such expediencies as issuing eject signals at a predetermined frequency for a selected time interval are considered equivalent and within the scope hereof. Although the invention has been described in terms of electronic devices, fluidic devices and non electronic means of control may be employed.

Those skilled in the printing art will appreciate that with many DED devices a principal ejected droplet sometimes has trailing satellite droplets which are very much smaller. References herein to a predetermined number of droplets refer to the number of principal droplets ejected, but if necessary the DED can be calibrated to issue a desired dose taking account of satellite drops without departing from the inventive concept hereof. Likewise it will be understood that the control of liquid viscosity is important and that therefore the volume of one substance issued in response to a given set of "eject" signals will not necessarily be the same as for another substance. However those skilled in the art will have no difficulty based on the teaching hereof in programming devices according to the invention to take account of these factors.

As will be apparent to those skilled in the art from the description herein contained, the device may be embodied in other forms or arrangements and using other construction materials without departing from the scope of the invention herein disclosed.

I claim:

1. An inhaler, comprising:

an inhaler housing;

a mouthpiece coupled to the inhaler housing;

a dispenser housing defining a dispensing chamber adapted to house a flowable substance to be inhaled;

a bubble jet ejection device coupled to the dispensing chamber and including a plurality of dispensing nozzles and a plurality of heating elements, the plurality of heating elements creating bubbles of the flowable substance with sufficient momentum in the dispensing chamber to create an ejection of a portion of the flowable substance through at least one of the plurality of dispensing nozzles; and an actuation sensor coupled to the bubble jet ejection device, the actuation sensor generating an actuation signal in response to a detection of an inhalation to actuate the bubble jet ejection device.

2. The inhaler of claim 1, further comprising:

a controller coupled to the bubble jet ejection device.

3. The inhaler of claim 2, wherein the controller includes a microprocessor.

4. The inhaler of claim 2, wherein the controller includes a microelectronic circuit.

5. The inhaler of claim 2, wherein the controller includes a microprocessor coupled to a microelectronic circuit.

6. The inhaler of claim 2, wherein the controller is a programmable logic circuit.

7. The inhaler of claim 2, wherein the controller is positioned in the inhaler housing.

8. The inhaler of claim 2, wherein the controller produces a dose signal in response to the actuation signal.

9. The inhaler of claim 8, wherein the dose signal is selected from the group of a voltage, current, AC, DC, digital and analog signal.

10. The inhaler of claim 8, wherein the dispensing chamber ejects the portion of the flowable substance from at least one of the plurality of dispensing nozzles as droplets.

11. The inhaler of claim 10, wherein the controller provides an ejection of a redetermined number of droplets in a selected dose volume.

12. The inhaler of claim 10, wherein the controller provides a frequency of droplet ejection defining a dose rate.

13. The inhaler of claim 10, wherein the controller provides a synchronization of an inhalation detection and initiation of a droplet creation.

14. The inhaler of claim 10, wherein the controller provides a time spacing and frequency of droplet ejection.

15. The inhaler of claim 10, wherein the controller provides a delivery of a controlled volume of droplet ejection during a selected period of time.

16. The inhaler of claim 10, wherein the controller provides a selection of droplet delivery from at least one of the plurality of dispensing nozzles.

17. The inhaler of claim 10, wherein the controller provides a delivery of a predetermined number of droplets.

18. The inhaler of claim 10, wherein the controller provides a controlled rate of droplet delivery.

19. The inhaler of claim 10, wherein the controller counts and stores a number of dosage signals for a predetermined length of time.

20. The inhaler of claim 19, wherein the controller generates a dosage signal in response to a counting and storage of the number of dosage signals for the predetermined length of time.

21. The inhaler of claim 10, wherein the controller provides a time delay between a receipt of the actuation signal and an issuance of the dosage signal.

22. The inhaler of claim 10, wherein the controller provides a dosage complete signal.

23. The inhaler of claim 10, wherein the dosage signal is a plurality of ejection signals.

24. The inhaler of claim 23, wherein the plurality of ejection signals is directed serially to a heating element of the plurality of heating elements.

25. The inhaler of claim 23, wherein the plurality of ejection signals is directed in parallel to the plurality of heating elements.

26. The inhaler of claim 23, wherein the plurality of heating elements includes a plurality of resistors.

27. The inhaler of claim 23, wherein the plurality of heating elements includes a plurality of thin film resistors.

28. The inhaler of claim 1, wherein each of a dispensing nozzle of the plurality of dispensing nozzles is coupled to a heating element of the plurality of heating elements.

29. The inhaler of claim 28, wherein each heating element is positioned adjacent to a corresponding dispensing nozzle.

30. The inhaler of claim 10, wherein the droplets are ejected at a velocity of at least 10 meters/second.

31. The inhaler of claim 10, wherein at least a portion of the plurality of dispensing nozzles is sized to produce droplets with diameters of less then 10 microns.

32. The inhaler of claim 10, wherein at least a portion of the plurality of dispensing nozzles is sized to produce droplets with diameters of 1 to 5 microns.

33. The inhaler of claim 10, wherein the plurality of dispensing nozzles are arranged to direct the droplets at a converging angle.

34. The inhaler of claim 10, wherein the plurality of dispensing nozzles are arranged to direct the droplets at a diverging angle.

35. The inhaler of claim 10, wherein at least a portion of the plurality of dispensing nozzles have different cross-sectional diameters.

36. The inhaler of claim 10, further comprising:

a battery power source coupled to the bubble jet ejection device.

37. The inhaler of claim 36, wherein at least a portion of the battery power source is positioned in the inhaler housing.

38. The inhaler of claim 1, further comprising:

a reservoir chamber coupled to the dispensing chamber.

39. The inhaler of claim 1, wherein the flowable substance is selected from a liquid, gel, colloid and powder suspension.

40. The inhaler of claim 1, wherein the actuation sensor is an breath inhalation sensor.

41. An inhaler, comprising:

a dispenser housing defining a dispensing chamber adapted to house a flowable substance to be inhaled;

a mouthpiece coupled to the dispenser housing;

a bubble jet ejection device coupled to the dispensing chamber and including a dispensing nozzle and a heating element, the heating element generating sufficient energy to form bubbles in the dispensing chamber and effect an ejection of a portion of the flowable substance through the dispensing nozzle; and

an actuation sensor coupled to the bubble jet ejection device, the actuation sensor generating an actuation signal in response to a detection of an inhalation to actuate the bubble jet ejection device.

42. An inhaler, comprising:

a dispenser housing defining a first dispensing chamber adapted to house a first flowable substance and a second flowable substance;

a mouthpiece coupled to the dispenser housing;

a bubble jet ejection device coupled to the dispensing chamber and including a first dispensing nozzle, a second dispensing nozzle, a first heating element and a second heating element, the first heating element generating sufficient energy to form bubbles in the first dispensing chamber and effect an ejection of a portion of the first flowable substance through the first dispensing nozzle, the second heating element generating sufficient energy to form bubbles in the second dispensing chamber and effect an ejection of a portion of the second flowable substance through the second dispensing nozzle; and

an actuation sensor coupled to the bubble jet ejection device, the actuation sensor generating an actuation signal in response to a detection of an inhalation to actuate the bubble jet ejection device.

* * * * *

US006155268A

United States Patent [19]

Takeuchi

[11] **Patent Number: 6,155,268**

[45] **Date of Patent: Dec. 5, 2000**

[54] **FLAVOR-GENERATING DEVICE**

[75] Inventor: **Manabu Takeuchi**, Tokyo, Japan

[73] Assignee: **Japan Tobacco Inc.**, Tokyo, Japan

[21] Appl. No.: **09/120,457**

[22] Filed: **Jul. 23, 1998**

[30] **Foreign Application Priority Data**

Jul. 23, 1997 [JP] Japan 9-197033

[51] **Int. Cl.**[7] **A24F 47/00**

[52] **U.S. Cl.** **131/273**; 131/194

[58] **Field of Search** 131/335, 271, 131/273, 194, 336, 272

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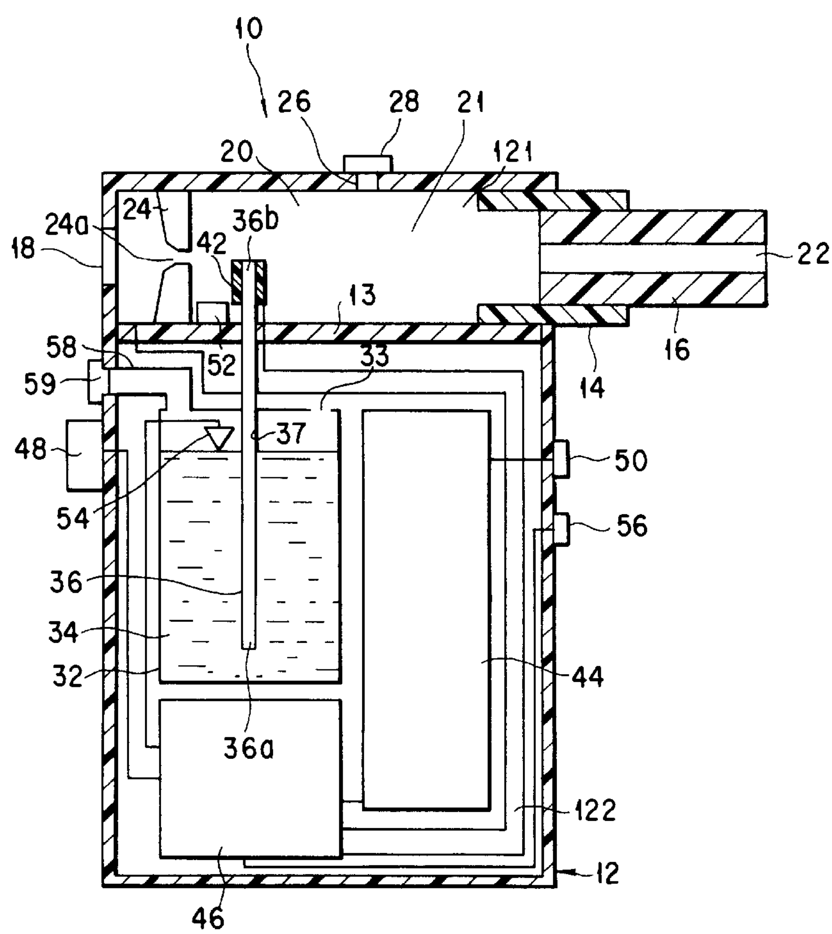
Primary Examiner—James Derrington
Assistant Examiner—Rob McBride
Attorney, Agent, or Firm—Birch, Stewart, Kolasch & Birch, LLP

[57] **ABSTRACT**

A flavor-generating device includes a chamber having an air inlet port and a flavor inhalation port, and defining a gas passageway between the air inlet port and the inhalation port. A liquid container for storing a liquid flavor source is provided, and is maintained at substantially an atmospheric pressure. At least one liquid passageway is provided in fluid communication with the liquid flavor source at its first end portion and with the gas passageway at its second end portion. The liquid passageway transports the liquid flavor source therethrough by capillary force. A heater heats and evaporates the liquid flavor source at the second end portion of the liquid passageway.

18 Claims, 8 Drawing Sheets



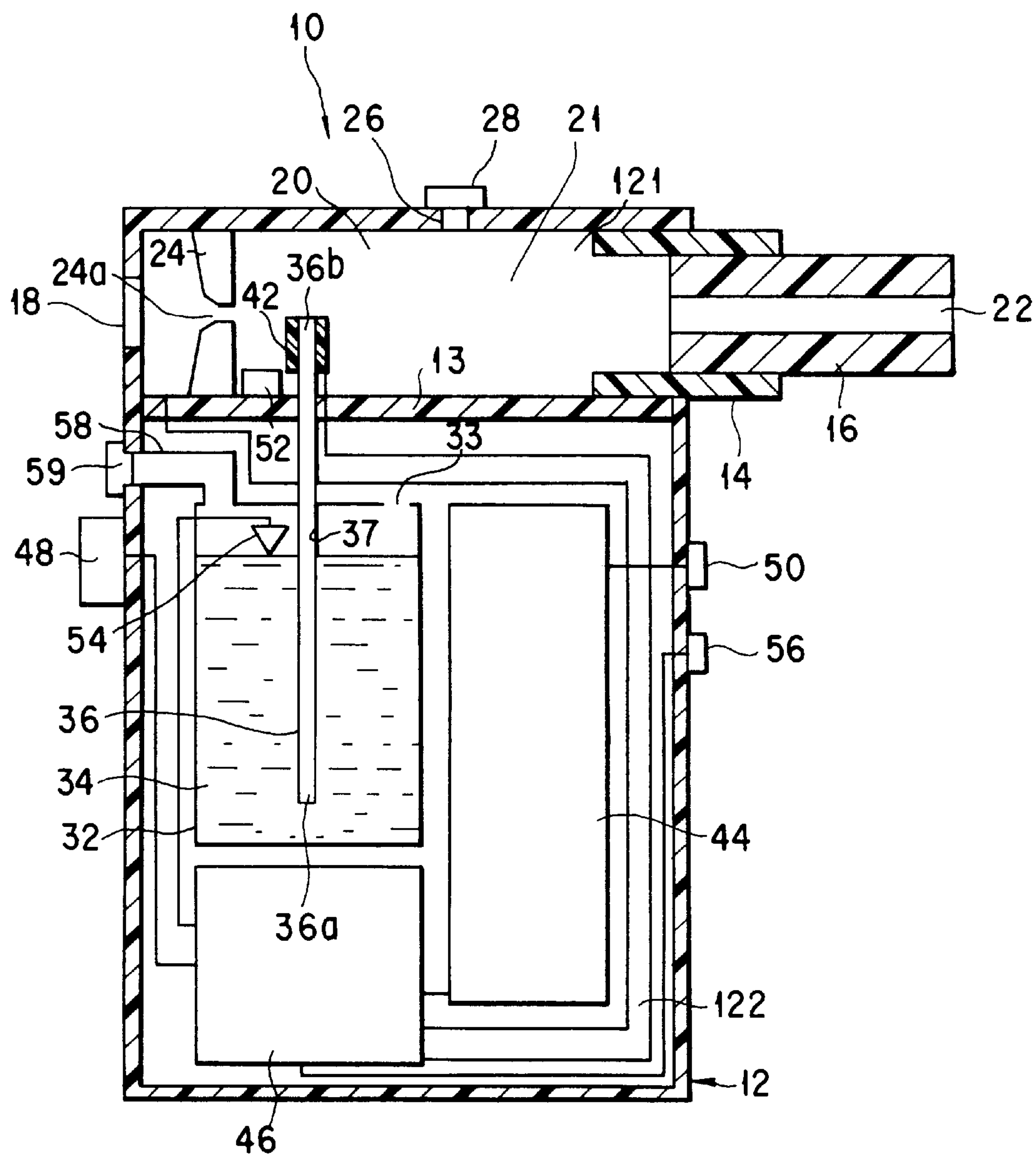

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FIG. 1

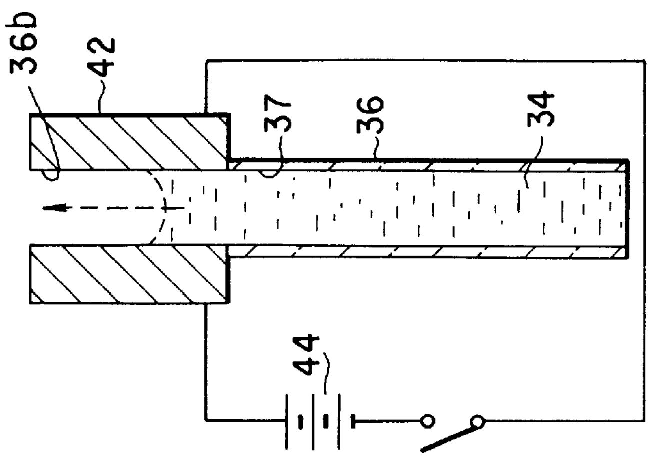

FIG. 2C

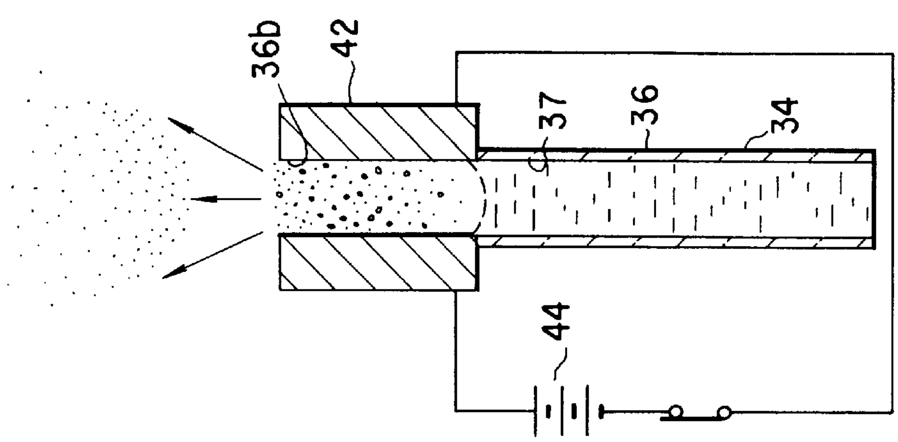

FIG. 2B

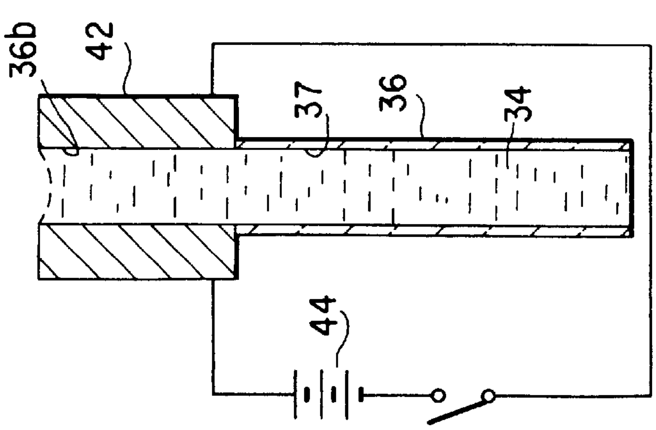

FIG. 2A

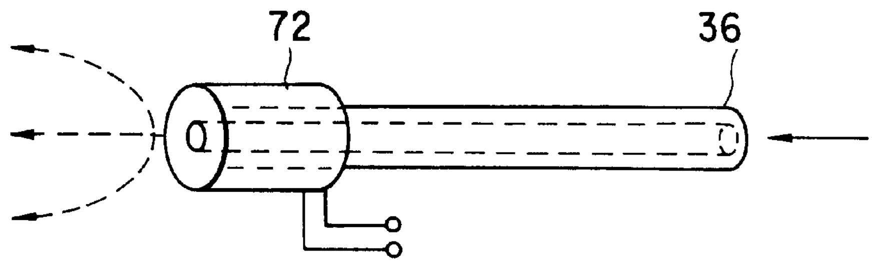

FIG. 3

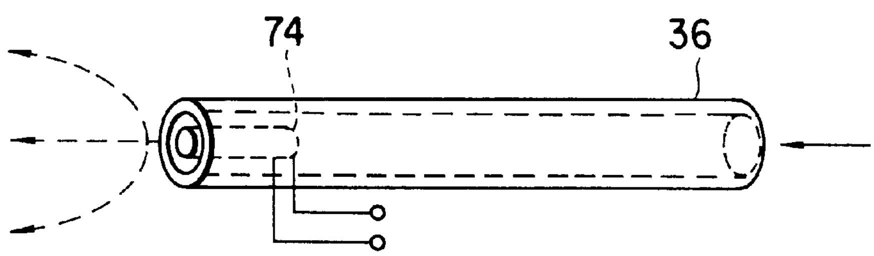

FIG. 4

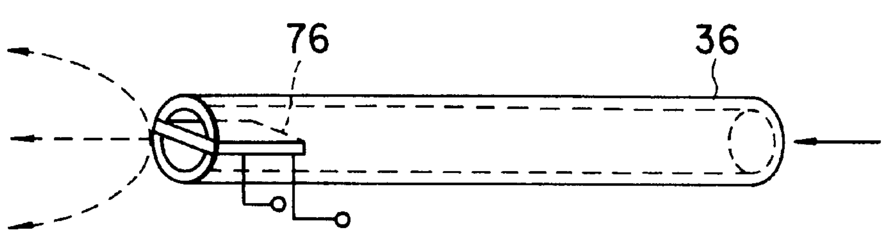

FIG. 5

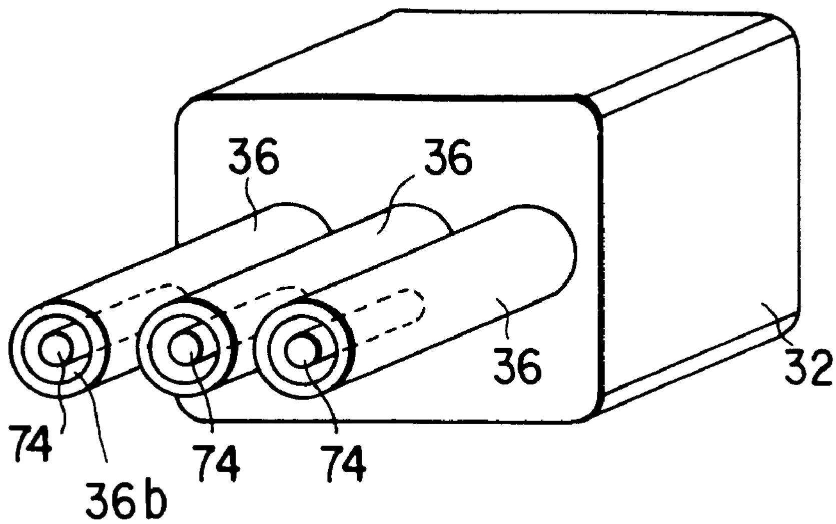

FIG. 6

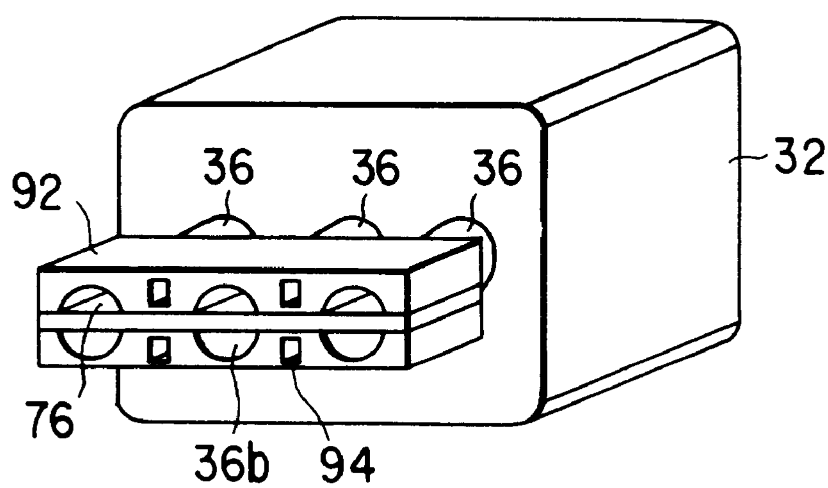

FIG. 7

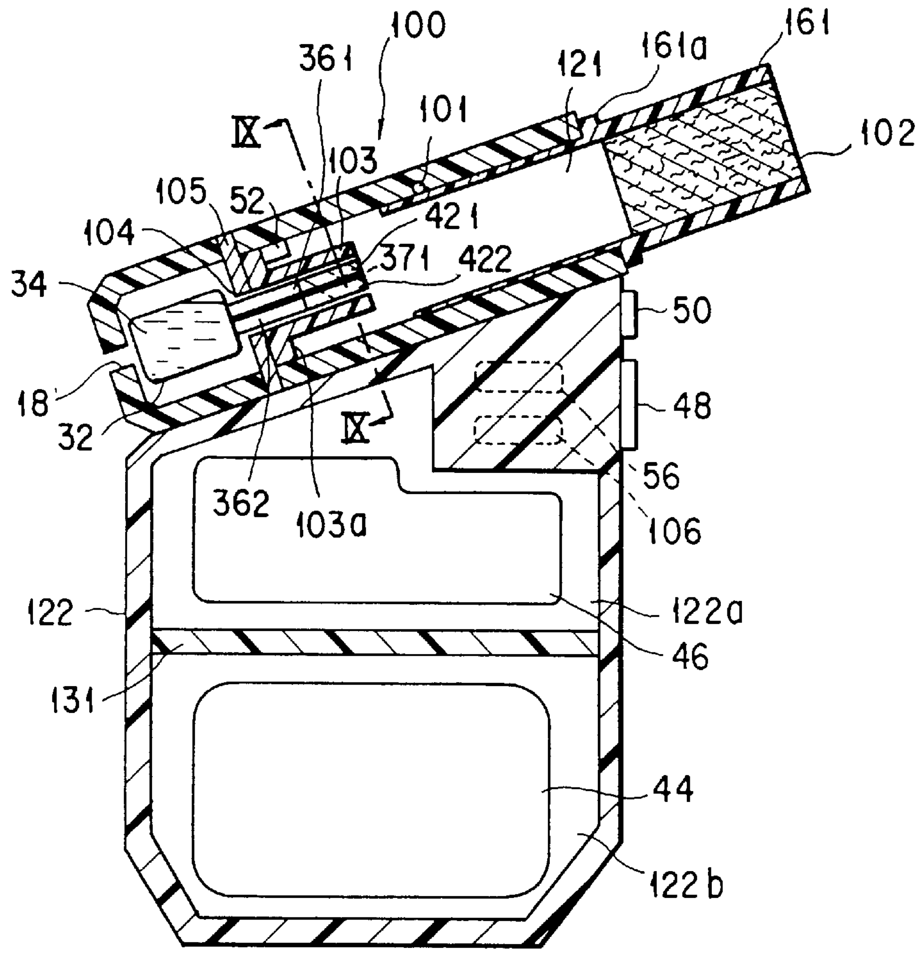
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FIG. 8

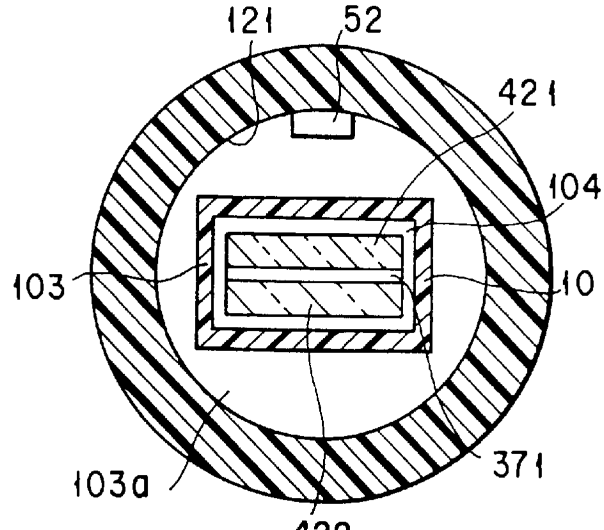
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FIG. 9

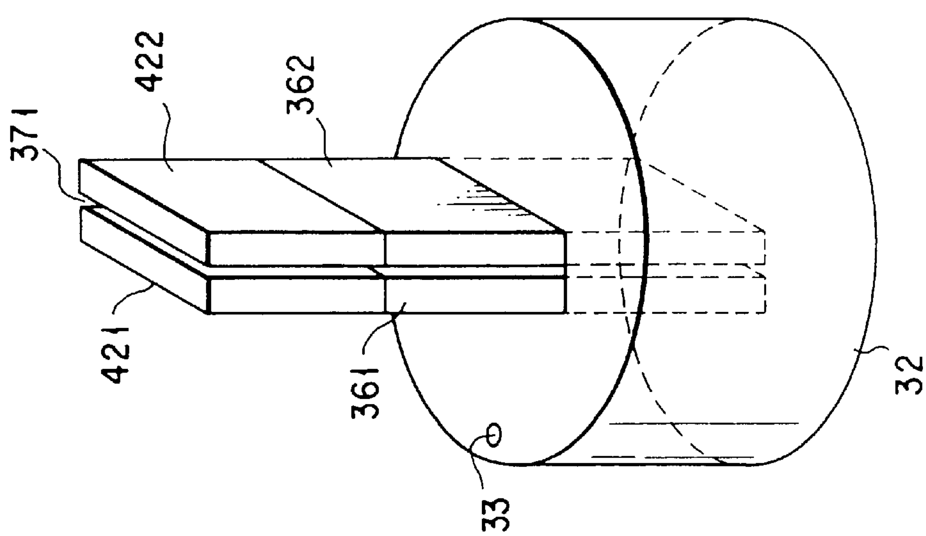

FIG. 10

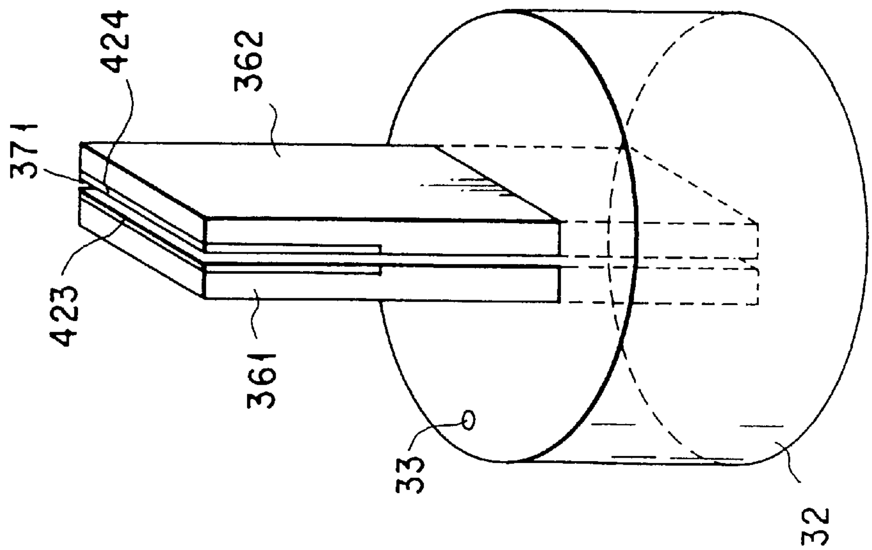

FIG. 11

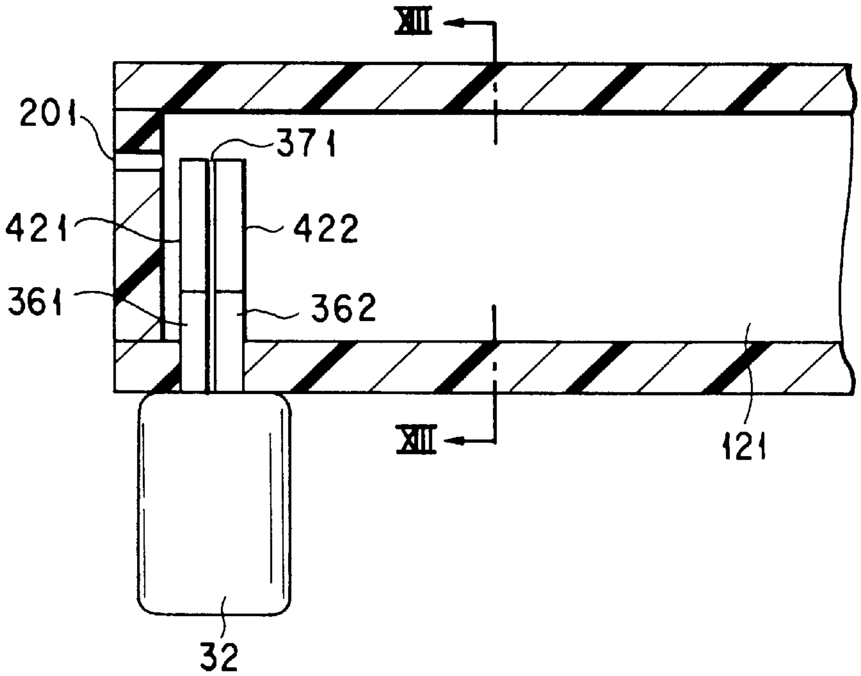
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FIG. 12

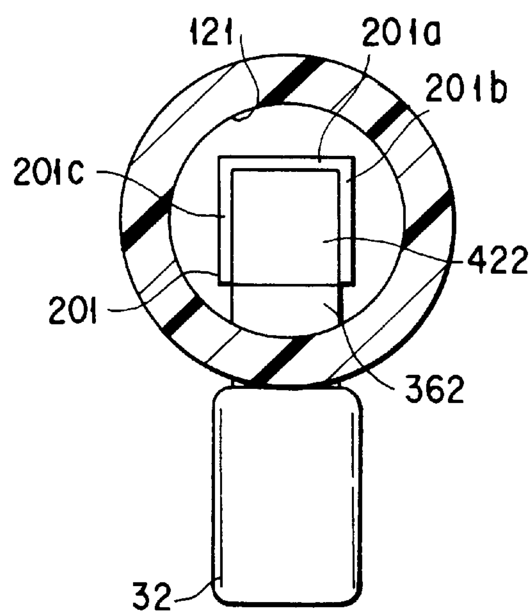
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FIG. 13

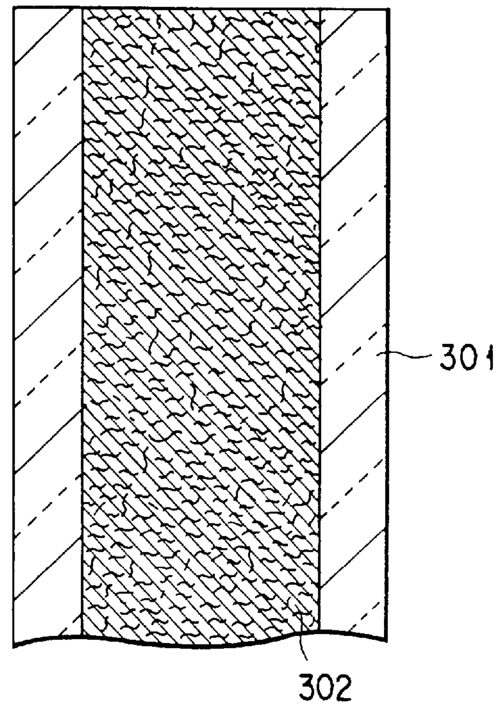

FIG. 14

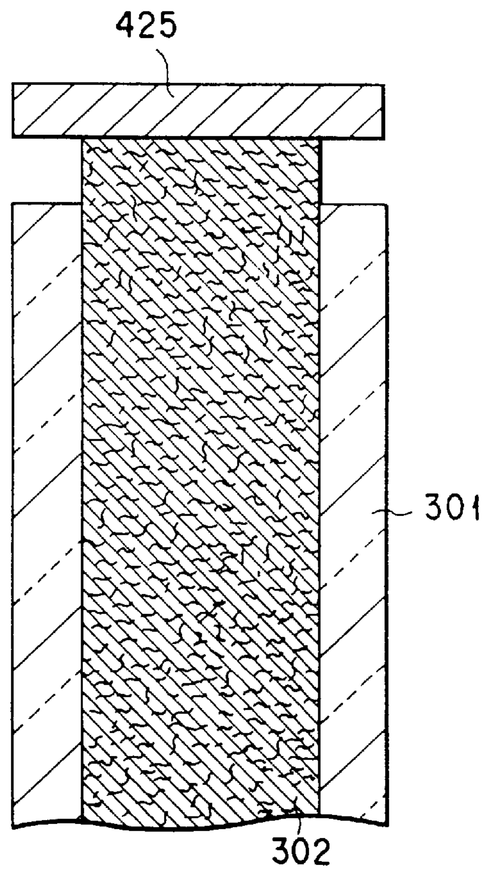

FIG. 15

FLAVOR-GENERATING DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a flavor-generating device for enjoying inhalation of flavor or for enjoying simulated smoking, and more particularly, to a flavor-generating device for generating flavor which is to be inhaled by a user by heating a liquid. flavor source without relying on combustion.

Various types of flavor-generating devices in which a flavor material is evaporated by heating for enjoying inhalation of flavor have been proposed to date.

For example, Japanese Patent Disclosure (Kokai) No. 3-232481 discloses a typical concept of a conventional simulated smoking article. In this flavor-generating device, a rod-like solid flavor material is used, and the flavor or inhalation target is generated by heating the solid flavor material with a heating element. In a flavor-generating device of this type, a large amount of solid flavor material is wasted where the flavor material is kept continuously heated. Disadvantageously, where the solid flavor generation material is heated when a user wishes to inhale the flavor generated from the flavor material, a large time lag is generated between the actual inhalation of the flavor by the user and the generation of the flavor.

A flavor-generating device capable of coping with the above-noted difficulty is disclosed in, for example, Japanese Patent Disclosure No. 3-277265. The disclosed device has a solid flavor material divided into a number of portions, wherein the divided portions of the solid flavor material are heated one by one every time a user takes one puff of the flavor so as to generate the flavor which is to be inhaled by the user. In this flavor-generating device, the solid flavor material and the heating element collectively constitute an integral flavor-generating means. It follows that, after consumption of the flavor material, it is necessary to replace or discard the heating element together with the flavor material. This may be expensive and give rise to an environment problem.

U.S. Pat. No. 4,945,931 discloses a simulated smoking article using a pressurized aerosol container. In this device, vanes are rocked in response to the inhaling action of a user so as to mechanically open the outlet port of the aerosol container and, thus, to release the aerosol. This prior art also discloses a modification in which a heating element for warming the aerosol cooled by the heat of evaporation is mounted at the outlet port of the aerosol container. In each of these devices, however, a pressurized aerosol is confined in the container by a valve which is opened or closed in response to the inhaling action of the user. It follows that a large amount of the aerosol may be leaked to the outside once the valve is opened. In other words, in each of these prior art articles, it is impossible to release continuously a predetermined suitable amount of the aerosol every time a user takes a single puff. Rather, all the pressurized aerosol tends to be released in two or three inhaling actions of the user.

BRIEF SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a flavor-generating device which can be driven with a low energy, which effectively prevents a flavor source from being wasted, and which permits generating flavor when a user takes a puff of the flavor, substantially without a time lag.

Another object of the invention is to provide a flavor-generating device which can be made small in size and light in weight.

According to the present invention, there is provided a flavor-generating device comprising a chamber having an air inlet port for introducing the air thereinto and an inhalation port through which a user inhales a flavor, and defining a gas passageway between the air inlet port and the inhalation port; a liquid container for storing a liquid containing a flavor substance, and maintained at substantially an atmospheric pressure; at least one liquid passageway having a first end portion which is in a fluid communication with the liquid and a second end portion which is in a fluid communication with the gas passageway, for transporting the liquid from the liquid container to the second end portion by capillary force; and a heater mounted at the second end portion of the liquid passageway, for heating and gasifying or evaporating the liquid transported from the liquid container.

In the flavor-generating device of the present invention, a liquid containing a flavor substance, i.e., a liquid flavor source, is transported from within a liquid container through the liquid passageway by a capillary force exerted by the liquid passageway. Thus, if the preceding liquid flavor source is gasified or evaporated at the outlet end portion of the liquid passageway, the succeeding liquid flavor source is supplied to the outlet end portion of the liquid passageway by the capillary force. It follows that the flavor-generating device of the present invention can be driven as a whole at a low energy. As a result, it is possible to suppress waste of the flavor source. In addition, the flavor can be generated when the user takes a puff of the flavor. It should be noted in particular that the heater can be controlled on the basis of a signal from a sensor for detecting the inhaling action of the user, with the result that the flavor can be supplied to the user with a high stability.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. **1** is a sectional view of a flavor-generating device according to one embodiment of the present invention;

FIGS. **2**A to **2**C illustrate the operation of the flavor-generating device shown in FIG. **1**;

FIG. **3** is a perspective view showing a modification of the mechanism for supplying and gasifying a liquid flavor source according to the invention;

FIG. **4** is a perspective view showing another modification of the mechanism for supplying and gasifying a liquid flavor source;

FIG. **5** is a perspective view showing still another modification of the mechanism for supplying and gasifying a liquid flavor source according to the invention;

FIG. **6** is a perspective view showing still another modification of the mechanism for supplying and gasifying a liquid flavor source according to the invention;

FIG. **7** is a perspective view showing still another modification of the mechanism for supplying and gasifying a liquid flavor source according to the invention;

FIG. **8** schematically shows a flavor-generating device according to another embodiment of the present invention;

FIG. **9** is a cross-sectional view taken along the line IX—IX of FIG. **8**;

FIG. **10** is a perspective view showing the mechanism for supplying and gasifying a liquid flavor source used in the flavor-generating device of FIG. **8**;

FIG. **11** is a perspective view showing still another modification of the mechanism for supplying and gasifying a flavor source;

FIG. **12** is a perspective view showing still another modification of the mechanism for supplying and gasifying a liquid flavor source according to the invention;

FIG. **13** is cross-sectional view taken along the line XII—XII of FIG. **12**;

FIG. **14** is a cross-sectional view showing another embodiment of the liquid passageway for a liquid flavor source used in a flavor-generating device according to the invention; and

FIG. **15** is a cross-sectional view showing still another embodiment of the liquid passageway for a liquid flavor source used in a flavor-generating device according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

One feature of the present invention resides in that the transportation of a liquid flavor source from the liquid container containing the same to the heater site is effected by the capillary force or capillarity.

In the present invention, the liquid passageway through which the liquid flavor source is transported by the capillary force can be constituted by the inner region of at least one capillary tube, a gap or space between at least two plates spaced apart from each other in substantially parallel, or an inter-communicating void or pore structure filled in an enclosure. The intercommunicating pore structure refers to a structure having intercommunicating voids or pores through which the liquid may be elevated from the inlet of the passageway which is in fluid communication with the liquid flavor source contained in the liquid container to the outlet of the passageway by the capillary force. Representative examples of the structure include open-cell foamed structure, and bundled fibers, but should not be limited thereto.

The height from the liquid level of the liquid flavor source to the outlet of the liquid passageway is a height or vertical distance within which the liquid flavor source may be elevated by the capillary force, and is determined by the properties of the liquid flavor source and the width of the liquid passageway (the diameter for the capillary tube, the gap distance for the substantially parallel plates, etc.). When the passageway is inclined, the height is not the length of the liquid passageway, but the vertical distance from the liquid level of the liquid flavor source to the outlet of the liquid passageway.

The height h can be calculated from the following equation:

$$h=2\upsilon \cos \theta/d\rho g \qquad (1)$$

where υ is the surface tension of the liquid flavor source, θ is the contact angle of the liquid flavor source with the material which constitutes the liquid passageway, d is the width of the liquid passageway, ρ is the density of the liquid flavor source, and g is the gravitational acceleration.

When the liquid passageway is defied by the intercommunicating pore structure as note above, the equation (1) is not directly applied. In such a case, the equation (1) can be applied, using, as d, an average diameter or size of the voids or pores in the intercommunicating pore structure.

Since the liquid level is lowered due to the gasification or evaporation, including the gasification by intentional heating, of the liquid flavor source, it is desirable that the height be determined taking the possible lowest level of the liquid flavor source into account. Further, it is preferred that the inlet of the liquid passageway reach the possible lowest level of the liquid flavor source in the container.

In the present invention, it is preferred that the liquid level of the liquid flavor source be under substantially atmospheric pressure because the liquid flavor source is elevated from the liquid container to the outlet of the liquid passageway by the capillary force as noted above. The inside of the container can be kept under the atmospheric pressure by providing, at the upper part of the container, a through hole, such as a pin hole, which communicates with the atmosphere outside the container.

There will now be described below some of the embodiments of the present invention.

FIG. **1** shows the construction of a flavor-generating device **10** according to one embodiment of the present invention. In the device **10**, the liquid passageway is constituted by a capillary tube.

As shown in FIG. **1**, the flavor-generating device **10** includes a casing **12** made of plastic, metal, ceramic, wood, etc. The inner space of the casing **12** is partitioned into an upper chamber **121** and a lower chamber **122** by a partition wall **13**. As will be described herein later, the upper chamber **121** is used as a gas passageway **20** for forming a gaseous stream of a flavor which is to be inhaled by a user. On the other hand, the lower chamber **122** is used as a housing for housing a liquid container **32**, a power source **44** and a control circuit.

An inhalation port holder **14** defining a cylindrical opening is mounted at one side end portion of the upper chamber **121** of the casing **12**. A mouth piece **16** having an inhalation port **22** through which a user inhales a flavor is detachably inserted into the holder **14**. The mouth piece **16**, which is directly taken in the mouth of a user, is made of, for example, a plastic material or wood. Incidentally, it is possible to insert a filter into the holder **14** in place of using the mouth piece **16**.

On the other hand, an air intake port **18** for introducing the air into the upper chamber **121** is formed on the other side portion of the upper chamber **121**. The gas passageway **20** is defined within the upper chamber **121** of the casing **12**, between the air intake port **18** and the inhalation port **22**. It is possible to set the air intake port **18** in a manner to have an opening area conforming with a predetermined air intake amount. It is also possible to arrange an adjusting ring (not shown) having a plurality of openings in a manner to surround the air intake port **18** of the casing **12**. In this case, the air flow rate into the gas passageway **20** can be adjusted by adjusting the position of the adjusting ring relative to the air intake port **18**.

A squeeze plate **24** having a squeeze hole **24***a* formed in the central portion is arranged within the gas passageway **20** and positioned close to the air intake port **18**. The squeeze hole **24***a* of the squeeze plate **24** act to regulate or direct the air introduced from the intake port **18** selectively toward a outlet portion **36***b* of a capillary tube **36** described in detail below.

The free space between the outlet portion **36***b* of the capillary tube **36** and the inhalation port **22** can act as a cooling chamber **21** which constitutes a part of the gas passageway. Corresponding to the cooling chamber **21**, an outer air introduction hole **26** is formed through the ceiling of the upper chamber **121** to permit the outer air to be introduced into the cooling chamber **21**. A gas containing a flavor, which is formed by the heating of the liquid flavor source with a heater **42**, is mixed with the outer air within the cooling chamber **21** so as to be cooled and, then, flows to reach the inhalation port **22**. The outer air introduction hole **26** can be set to have an opening area conforming with a predetermined outer air introduction amount. It is also possible to arrange an adjusting shutter **28** having a plurality of openings in the casing **12** in a manner to surround the outer air introduction hole **26**, as shown in the drawing. In this case, the amount of the outer air introduced into the cooling chamber **21** can be adjusted by adjusting the position of the adjusting shutter **28** relative to the outer air introduction hole **26**.

Further, a filter (not shown) can be arranged between the cooling chamber **21** and the inhalation port **22** in a manner to cover the inhalation port **22**. The filter serves to control the pressure loss to permit the gas containing the flavor to be inhaled comfortably by a user. The material of an ordinary tobacco filter such as cellulose acetate or pulp can be used for forming the filter.

On the other hand, the liquid container **32** housing a liquid flavor source **34** is fixed within the lower chamber **122** of the casing **12**. The liquid flavor source **34** is housed in the container **32** in an amount conforming with a plurality of puffs of a user. The liquid flavor source **34** contains at least a flavor substance. However, in order to add smoke to the flavor, it is possible for the liquid flavor source **34** to contain a substance forming aerosol when heated. As a substance for forming an aerosol, it is possible to use alcohols, sugars, water and a mixture of at least two of these materials. The alcohols used in the present invention include, for example, glycerin, propylene glycol, and a mixture thereof.

To be more specific, it is possible for the liquid flavor source **34** to contain extracts from various natural products and/or components thereof depending on the use of the flavor-generating device. For example, where the device is used as a simulated smoking article, it is possible for the liquid flavor source **34** to contain tobacco components such as tobacco extracts and a tobacco smoke condensate.

The capillary tube **36** for transporting the liquid flavor source by the capillary force is inserted within the liquid container. The capillary tube **36** defines a liquid passageway **37** for the liquid flavor source, and its lower end **36***a* is positioned in the vicinity of the bottom of the liquid container **32**.

In view of the liquid flavor source **34** mentioned above, preferably the inner diameter of the capillary tube **36** is set to fall within a range of 0.01 mm and 3 mm, more preferably a range of 0.05 mm to 1 mm, and particularly preferably 0.1 mm and 0.8 mm.

In order to ensure the transfer of the liquid flavor source **34** by the capillary force, the liquid container **32** is provided with an opening **33** communicating with the outer atmosphere so as to maintain the inner pressure of the liquid container **32** at an atmospheric pressure. It is desirable for the opening **33** to be formed at the highest position of the container **32** during the ordinary operation of the flavor-generating device and to have a sufficiently small diameter so that the liquid flavor source **34** may not leak to the outside therethrough even if the device is inadvertently turned upside down. For example, a pin hole extending through the wall of the container **32** satisfies the particular requirements of the opening **33**.

The upper end portion of the capillary tube **36** protrudes into the upper chamber **121** of the casing **12** somewhat downstream of the squeeze plate **24** and is equipped with the heater **42** serving to gasify the liquid flavor source **34**. In the embodiment shown in FIG. **1**, the heater **42** consists of a tubular body mounted to the capillary tube **36** and having an inner diameter equal to that of the capillary tube **36**. In other words, the outlet port **36***a* of the liquid passageway **36** is formed by the heater **42** itself. An electric power is supplied from a power source **44** detachably mounted within the lower chamber **122** of the casing **12** to the electric heater **42**. It is desirable to use as the power source **44** a DC power source available on the market such as a primary battery (dry battery), or a secondary battery (rechargeable battery). However, it is also possible to use an AC power source as the power source **44**. It is also possible to mount the power source **44** outside the casing **12** or to mount the power source **44** separately so as to use an electric wire connecting the power source **44** to the casing **12**.

The heater **42** and the power source **44** are driven. under the control of the control circuit **46** fixed within the lower chamber **122**. To the control circuit **46**, a switch **48** for the heater **42** which can independently turn the heater on, and a sensor **52** for detecting the inhalation action of a use are connected. Further, a switch **50** for the on/off operation of the power source **44** is connected to the power source **44**. The switches **48** and **50** are provided on the outer surface of the lower chamber **122** of the casing **12**.

When the device is not used, operation of the device can be ceased by turning the power source switch **50** off manually. Of course, when the device is used, firstly the power source switch is turned on. Further, the heater switch **48**, when turned on after the power source switch **50** is turned on, can drive the heater **42** independently of the detection, by the sensor **52**, of the inhalation action of a user. That is, after the power source **44** is driven, the heater can be made into a heated state by turning on the heater switch **48**. When the control circuit **46** detects the on state of the heater switch **48**, it ceases the operation of the sensor **52**.

Each of the switches **48** and **50** has a mechanism equal to a general small depression type switch such as a micro limit switch having an electrical contact.

The sensor **52** for detecting the inhaling action of the user is arranged within the upper chamber **121** of the casing **12**, and is positioned between the squeeze plate **24** and the heater **42**. It is possible to use as the sensor **52** a general pressure sensor for detecting a change in the pressure within the chamber **121** as a change in electrical resistance, as a change in electrical capacitance or as a piezoelectric electromotive force, or a rocking vane type sensor for detecting a gas stream within the chamber **121**.

The control circuit **46** serves to start up the heater **42** based on the signal from the heater switch **48** or in accordance with the inhaling action of the user based on the signal from the sensor **52** so as to gasify the liquid flavor source **34** at the outlet portion **36***b* of the capillary tube **36**. The signal processing and control are performed within the control circuit **46** in accordance with, for example, a known analog control, a two-position control or a combination thereof.

A liquid amount sensor **54** for detecting the remaining amount of the liquid flavor source **34** is arranged within the liquid container **32**. The sensor **54** may consist of a contact type sensor serving to detect a change in the electrical conductivity of the liquid container **32** accompanying a change in the remaining amount of the liquid flavor source **34**. Also, an electrical display means, e.g., a lamp **56** which may be constituted by a light emitting diode, is arranged on the outer surface of the lower chamber **122** of the casing **12** in order to inform the user that the remaining amount of the liquid flavor source **34** within the liquid container **32** is small. Each of the liquid amount sensor **54** and the lamp **56** is connected to the control circuit **46** so as to be operated under control of the control circuit **46**.

Also, it is possible to apply an electrical locking to the device so as to inhibit the inhaling action of the user in addition to the lighting of the lamp **56** in order to inform the user that the remaining amount of the liquid flavor source **34** is small. Incidentally, it is also possible to use as the sensor **54** a non-contact type sensor which detects a change in the remaining amount of the liquid flavor source **34** as a change in the reflectance of, for example, an ultrasonic wave.

A pouring port **58** for replenishing the liquid flavor source **34** is connected to the liquid container **32**. An end portion of the pouring port **58** is exposed to the outside of the casing **12** so as to permit pouring the liquid flavor source **34** into the liquid container **32**. Usually, a removable cap **59** is provided in the exposed end portion of the pouring port **58**. As described previously, the liquid container **32** has an inner volume large enough to store the liquid flavor source **34** in an amount corresponding to a plurality of puffs of the flavor enjoyed by the user. However, since the liquid flavor source **34** can be replenished, the flavor-generating device of the present invention can be used continuously without replacing or exchanging the liquid container **32**.

Incidentally, a transparent peeping window (not shown) can be formed in that portion of the side wall of the casing **12** which corresponds to the liquid container **32** in place of using the liquid amount sensor **54** in order to observe the remaining amount of the liquid flavor source **34** within the liquid container **32**. In this case, the liquid container **32** itself must be formed of a transparent or translucent material. Naturally, the remaining amount of the liquid flavor source **34** within the liquid container **32** can be observed through the peeping window so as to find the timing of replenishing the liquid flavor source **34**. It is also possible to employ an optical system using a prism for observing the remaining amount of the liquid flavor source **34** within the liquid container **32**.

The flavor-generating device **10** shown in FIG. **1** can operated as in the following manner, in which the heater switch **48** is kept turned off.

Specifically, where the device **10** is used for inhaling a flavor, the power source switch **50** is turned on first by a user. Then, the mouth piece **16** is taken in the mouth of the user for the inhaling action through the inhalation port **22**. As a result, an inhaling action signal is transferred from the sensor **52** to the control circuit **46**. Then, under the control of the control circuit **46**, an electric power is supplied from the power source **44** to the heater **42** so as to turn the heater **42** on.

In this step, the liquid flavor source **34** is already transported to the outlet port **36***a* of the capillary tube **36** by the capillary force of the capillary tube **36** as shown in FIG. **2**A. If the heater **42** is turned on under this condition, the liquid flavor source **34** within the outlet port **36***a* is instantly gasified by the heat generated from the heater **42** as shown in FIG. **2**B so as to be supplied into the gas passageway **20**. Upon gasification of the liquid flavor source **34** within the outlet port **36***a* by the heating with the heater **42**, the liquid flavor source **34** is newly supplied from the liquid container **32** into the outlet port **36***a* of the capillary tube **36** by the capillary force of the capillary tube **36**, as shown in FIG. **2**C. In this fashion, supply and gasification of the liquid flavor source **34** are repeated within the outlet port **36***a* of the capillary tube **36**.

The gasified flavor source is mixed with the main air introduced through the air intake port **18** and the squeeze hole **24***a* into a region around the outlet port **36***a* of the capillary tube **36** in accordance with the inhaling action of the user and, then, the mixture is transferred into the inhalation port **22**. The amount of the air introduced through the outer air inlet port **26** can be changed during the inhaling action, if necessary, by controlling the adjusting shutter **28**. It follows that the taste of the air containing a flavor, which is transferred to the inhalation port **22**, can be changed appropriately in accordance with the preference of the user.

FIGS. **3** to **5** are perspective views each showing a modification of the mechanism for supplying and gasifying the liquid flavor source **34**.

In the modification shown in FIG. **3**, a ring-shaped heater **72** is arranged to cover the outlet port **36***a* of the capillary tube **36**.

In the modification shown in FIG. **4**, a rod-like heater **74** is inserted into the outlet port **36***a* of the capillary tube **36**.

Further, in the modification shown in FIG. **5**, a plate-like heater **76** is inserted into the outlet port **36***a* of the capillary tube **36**.

Any of these modifications permits producing the particular function described previously in conjunction with the embodiment shown in FIG. **1**.

FIGS. **6** and **7** are oblique views each showing an additional modification of the mechanism for supplying and gasifying the liquid flavor source **34**.

In the modification shown in FIG. **6**, three capillary tubes **36** are inserted into the liquid container **32**. In addition, a rod-like heater **74** as shown in FIG. **5** is inserted into the outlet port **36***a* of each of the capillary tubes **36**.

In the modification shown in FIG. **7**, three capillary tubes **36** are inserted into the liquid container **32**. In addition, a heater frame **92** is mounted to the outlet ports **36***a* of these three capillary tubes **36**. To be more specific, the heater frame **92** is provided with three plate-like heaters **76** as shown in FIG. **6** in a manner to correspond to the three outlet ports **36***a* of the capillary tubes **36**. Further, air passageways **94** are formed between adjacent capillary tubes **36** arranged in the heater frame **94** in a manner to extend in the longitudinal direction of the capillary tube. Of course, the particular construction permits sufficiently mixing the gaseous flavor substance with the air.

FIG. **8** schematically shows the construction of a flavor-generating device according to another embodiment of the present invention. FIG. **9** is an enlarged cross-sectional view taken along the line IX—IX of FIG. **8**. FIG. **10** is a perspective view showing the liquid passageway and the heater together with the liquid container used in the device of FIG. **8**. The same or similar members of the device as in FIG. **1** are denoted by the same reference numerals and the detailed explanation thereof is omitted in the following description.

In the device **100** shown in FIG. **8**, the upper chamber **121** and the lower chamber **122** constitutes separate chamber unlike the device shown in FIG. **1** wherein one casing is partitioned by the partition wall **13** into the two chambers. The lower chamber **122** has an inclined upper wall. The upper chamber **121**, which has a hollow cylindrical shape closed at one end (lower end), is provided on the lower chamber **121** along the inclined upper wall of the lower chamber **122**. Thus, the upper chamber **121** is correspondingly inclined as a whole. The lower chamber **122** is partitioned by a partition wall **131** into an upper sub-chamber **122***a*, which houses the control circuit **46**, and a lower sub-chamber **122***b*, which houses the electric power source **14**. In the device shown in FIG. **8**, the electrical connections are essentially the same as those in the device shown in FIG. **1**, and thus are not shown in FIG. **8**.

The air intake port **18** like one shown in FIG. **1** is provided at the closed end (lower end) of the upper chamber **121**. A mouthpiece **161** may be detachably inserted directly, i.e., without through a holder, into the open end portion (upper end portion) of the upper chamber **121**. The mouthpiece **161** has on its periphery a protrusion **161***a* for engaging with the open end edge so as to prevent a further insertion thereof into the upper chamber **121**. A mouthpiece sensor **101** is provided on the upper wall of the upper chamber **121** for detecting the sufficient insertion of the mouthpiece **161**. Such a position sensor **101** is known per se. Further, a filter **102** may be inserted into the mouthpiece **161** over the region from the position corresponding to the protrusion **161***a* to the proximal end of the mouthpiece **161**, i.e. inhalation portion of the mouthpiece **161**, as shown in FIG. **8**.

Further, a small exchangeable liquid container **3**:**2** containing the liquid flavor source and having an opening (not shown) like the opening **33** in FIG. **1** is arranged in the upper chamber **121** so as not to clog the air intake port **18**. A liquid passageway **371** for the liquid flavor source is provided in fluid communication with the liquid flavor source **34** in the container **32**. In the device shown in FIG. **8**, the liquid passageway **371** is defined between two substantially parallel plates spaced apart from each other. The distal end portion (the outlet portion of the liquid flavor source) of the liquid passageway **371** is heated by plate-like heaters **421** and **422** mounted to the plate **361** and **362**, respectively.

More specifically, as shown in FIG. **10**, the two plates **361** and **362** are arranged in substantially parallel, and space apart from each other with a distance sufficient for the capillary force to be exerted therebetween. The distance is preferably 0.01 mm to 2.0 mm. In the embodiment shown in FIG. **10**, the plate heaters **421** and **422** have the same thickness as the plates **361** and **362**, respectively, and are spaced apart with the same distance as in the plates **361** and **362**. Thus, in this case, the outlet portion of the liquid passageway **371** is constituted by the heaters **421** and **422**.

It should be noted in the present invention that the liquid passageway defined by the substantially parallel plates is fluid-tightly sealed at its sides by a sealing material (not shown) such as a plastic film or a metal foil so as to prevent the leakage or the evaporation of the liquid flavor source from the sides of the plates.

Returning to FIG. **8**, that portions of the plates including the heaters which protrude from the container **32** are surrounded by a cylindrical body **103** spaced apart from the plates with a predetermined distance. The cylindrical body **103** has a flange at its lower end portion. The flange **103***a* engages with the inner peripheral wall of the upper chamber **121**. As shown in FIG. **9**, the cylindrical body may have a rectangular cross section, and defines an air passageway **104** between it and the plates. The air passageway (air guiding path) **104** guides, along it, the air introduced by the inhalation action of the user from the air intake port **18** provided at the closed end edge of the upper chamber **121**. The introduced air embraces or surrounds the gasified liquid flavor source at the outlet portion of the liquid passageway **371**, and is directed toward the inhalation port by the air passageway **104**. Thus, the gasified flavor source does not tend to be condensed or deposited on the inner wall of the upper chamber **121**, and if any, the gasified flavor source is condensed or deposited on the inner wall of mouthpiece **161**. Therefore, the deposited flavor source can be removed from the device by cleaning or exchanging the mouthpiece. Further, by providing the air guiding path **104** which can direct the air locally or selectively to the gasified flavor source at the outlet portion of the liquid passageway, an aerosol formation efficiency can be more enhanced when the liquid flavor source contains the aerosol generation material, since the mixing of the gasified flavor source with the air and the cooling of the gasified flavor source thereby can be simultaneously effected efficiently by means of the air stream passing through the air guiding path **104**.

Incidentally, it is possible to provide an air flow rate-adjusting dial **105**, which is known per se, arranged downstream of the cylindrical body **103** and upstream of the liquid container **32**. By means of the air flow rate-adjusting dial **105**, the user can set the air flow rate and hence the suction resistance in accordance with the user's preference. Further, a display mechanism **106** for indicating the remaining amount of the power source **44** connected to the control circuit may be provided as shown in FIG. **8**.

FIG. **11** is a perspective view illustrating a modification of the mechanism for supplying and gasifying the liquid flavor source shown in FIG. **10**. In FIG. **11**, plate heaters **423** and **424** are provided in the opposing surface regions of the plates **361** and **362** defining the liquid passageway therebetween.

FIG. **12** is a perspective view showing still another modification of the mechanism for supplying and gasifying a liquid flavor source used in the device according to the invention. FIG. **13** is a cross-sectional view taken along the line XIII—XIII of FIG. **12**. In the mechanism shown in FIG. **12**, the two plates **361** and **362** and the two plate heaters **421** and **422**, like the ones shown in FIG. **10**, which define the liquid passageway **371** in fluid communication with the liquid flavor source in the container **32** penetrate the peripheral wall of the upper chamber **121** from below the upper chamber into the inside the upper chamber **121**. One end of the upper chamber **121** is closed, and an air passageway **201** which communicates with the outer atmospheric air outside the upper chamber **121**. As shown in FIG. **13**, the air passageway **201** is formed along the outer contour of the heaters **421** and **422**, and consists of a laterally elongated upper passageway portion **201***a* having a length slightly larger than the width of the plates **361** and **362**, side passageway portions **201***b* and **201***c* which are connected to the upper portion **201***a* at its both end and extend to the positions corresponding to the lower ends of the heaters **421** and **422**. The passageway **201** can produce the same or similar effects noted above as those which the air passageway **104** shown in FIG. **9** or **8** produces.

FIG. **14** is a cross-sectional view showing another embodiment of the liquid passageway for a liquid flavor source used in a flavor-generating device according to the invention. In this case, a liquid passageway **372** is constituted by the intercommunicating pore structure **302** filled in an enclosure **301**, as mentioned earlier. The enclosure **301** may be provided by a tube, or two plates arranged spaced apart from each other wherein the both sides are sealed. In this embodiment, a heater or heaters (not shown) may be arranged as in FIG. **1**, **10** or **11**. Further, as shown in FIG. **15**, the intercommunicating pore structure **302** may protrude from the enclosure **301**. In such a case, a heater **425** can be provided on the protruded end of the intercommunicating pore structure **302**.

FIG. **15** is a cross-sectional view showing still another embodiment of the liquid passageway for a liquid flavor source used in a flavor-generating device according to the invention.

In order to facilitate the understanding of the present invention, the features of the present invention are described with reference to some embodiments and modifications of the present invention. However, these features can be combined appropriately depending on the object of the flavor-generating device. In other words, the present invention can be worked in various modes other than the embodiments shown in the drawing within the technical scope of the present invention.

As described above, the present invention provides a flavor-generating device, which can be driven with a low energy, which permits preventing the liquid flavor source from being wasted, and which permits generating a flavor substance when a user takes a puff of the flavor substance.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. A flavor-generating device comprising:

a chamber having an air inlet port for introducing the air thereinto and an inhalation port through which a user inhales a flavor, and defining a gas passageway between the air inlet port and the inhalation port;

a liquid container for storing a liquid containing a flavor substance, and maintained at substantially an atmospheric pressure;

at least one liquid passageway having a first end portion which is in a fluid communication with the liquid and a second end portion which is in a fluid communication with the gas passageway, for transporting the liquid from the liquid container to the second end portion by capillary force, the capillary force being created predominantly by the attraction between the liquid containing a flavor substance and an interior of the liquid passageway; and

a heater mounted at the second end portion of the at least one liquid passageway, for heating and gasifying the liquid transported from the liquid container, the heater heating and gasifying said liquid while it is disposed in said second end portion, thereby forming a gaseous stream of said liquid exiting said second end portion into said chamber for inhalation through said inhalation port.

2. The device according to claim **1**, wherein said at least one liquid passageway includes at least one capillary tube.

3. The device according to claim **1**, wherein said at least one liquid passageway includes at least one pair of substantially planar elements spaced apart from each other.

4. The device according to claim **1**, wherein said at least one liquid passageway includes an intercommunicating pore structure filled in an enclosure.

5. The device according to claim **1**, wherein said heater is mounted at the tip end of the at least one liquid passageway.

6. The device according to claim **1**, wherein said at least one liquid passageway includes a plurality of liquid passageways, each passageway including a capillary tube equipped with a heater.

7. The device according to claim **1**, further comprising detecting means for detecting the inhaling action of a user; and control means for controlling the heater such that said heater is driven upon inhaling action of the user.

8. The device according to claim **1**, wherein said air passageway is formed to permit the air to be introduced selectively toward the second end portion of the at least one liquid passageway.

9. The device according to claim **1**, wherein said liquid container is exchangeably mounted.

10. The device according to claim **2**, wherein said at least one capillary tube has a diameter of between about 0.01 mm and 3 mm.

11. The device according to claim **10**, wherein said at least one capillary tube has a diameter of between about 0.05 mm and 1 mm.

12. The device according to claim **2**, wherein said liquid container has an opening for access by said at least one capillary tube into said container, and an opening exposed to ambient atmospheric pressure, the opening to ambient atmospheric pressure allowing atmospheric pressure to be maintained within said container.

13. The device according to claim **2**, wherein said heater includes an annular element disposed at the second end portion of each at least one capillary tube.

14. The device according to claim **2**, wherein said heater is a cylindrical element.

15. The device according to claim **2**, wherein said heater includes at least one planar element, one planar element extending across a diameter of each said at least one capillary tube.

16. The device according to claim **6**, further comprising a heater frame partially surrounding the second end portion of each of said plurality of capillary tubes.

17. The device according to claim **3**, wherein the space between each said pair of substantially planar elements is partially closed by a film placed on sides of the planar elements, with the second end of the at least one liquid passageway remaining open.

18. The device according to claim **3**, wherein the heater includes heating elements provided on opposed faces of each said at least one pair of substantially planar elements.

* * * * *

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Cox et al.

(10) **Patent No.: US 6,234,167 B1**
(45) **Date of Patent: May 22, 2001**

(54) **AEROSOL GENERATOR AND METHODS OF MAKING AND USING AN AEROSOL GENERATOR**

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(73) Assignee: **Chrysalis Technologies, Incorporated**, Richmond, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/172,023**

(22) Filed: **Oct. 14, 1998**

(51) **Int. Cl.**[7] **A61M 11/00**

(52) **U.S. Cl.** **128/200.14**; 128/203.17; 128/203.23

(58) **Field of Search** 128/200.14, 200.19, 128/200.21, 200.22, 200.23, 201.13, 203.17, 203.23, 203.24, 203.26, 204.17

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Primary Examiner—Glenn K. Dawson
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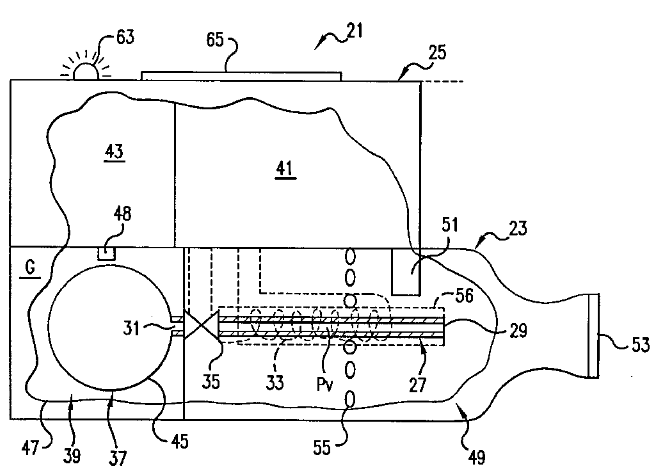
(57) **ABSTRACT**

An aerosol generator includes a tube having a first and a second end, a heater arranged relative to the tube for heating the tube, a source of material to be volatilized, the second end of the tube being in communication with the source of material, a valve operatively located between the source of material and the tube, the valve being openable and closeable to open and close communication between the source of material and the first end of the tube, and a pressurization arrangement for causing material in the source of material to be introduced into the tube from the source of material when the valve is in an open position. The aerosol generator further includes a source of power for operating the heater and the valve, and a control device for controlling supply of power from the source of power to the heater and the valve. A method of making and a method of using an aerosol generator are also disclosed.

68 Claims, 6 Drawing Sheets



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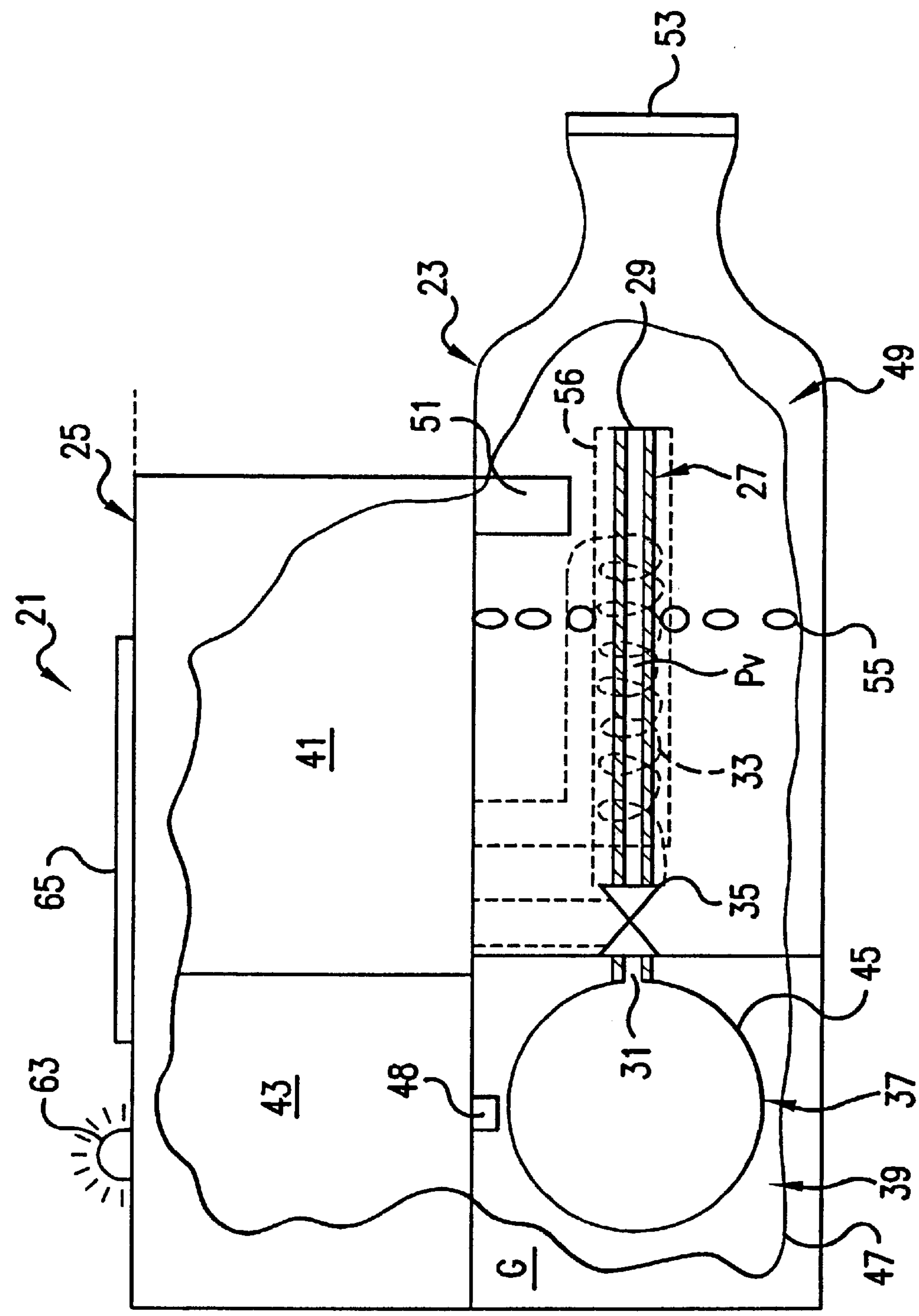
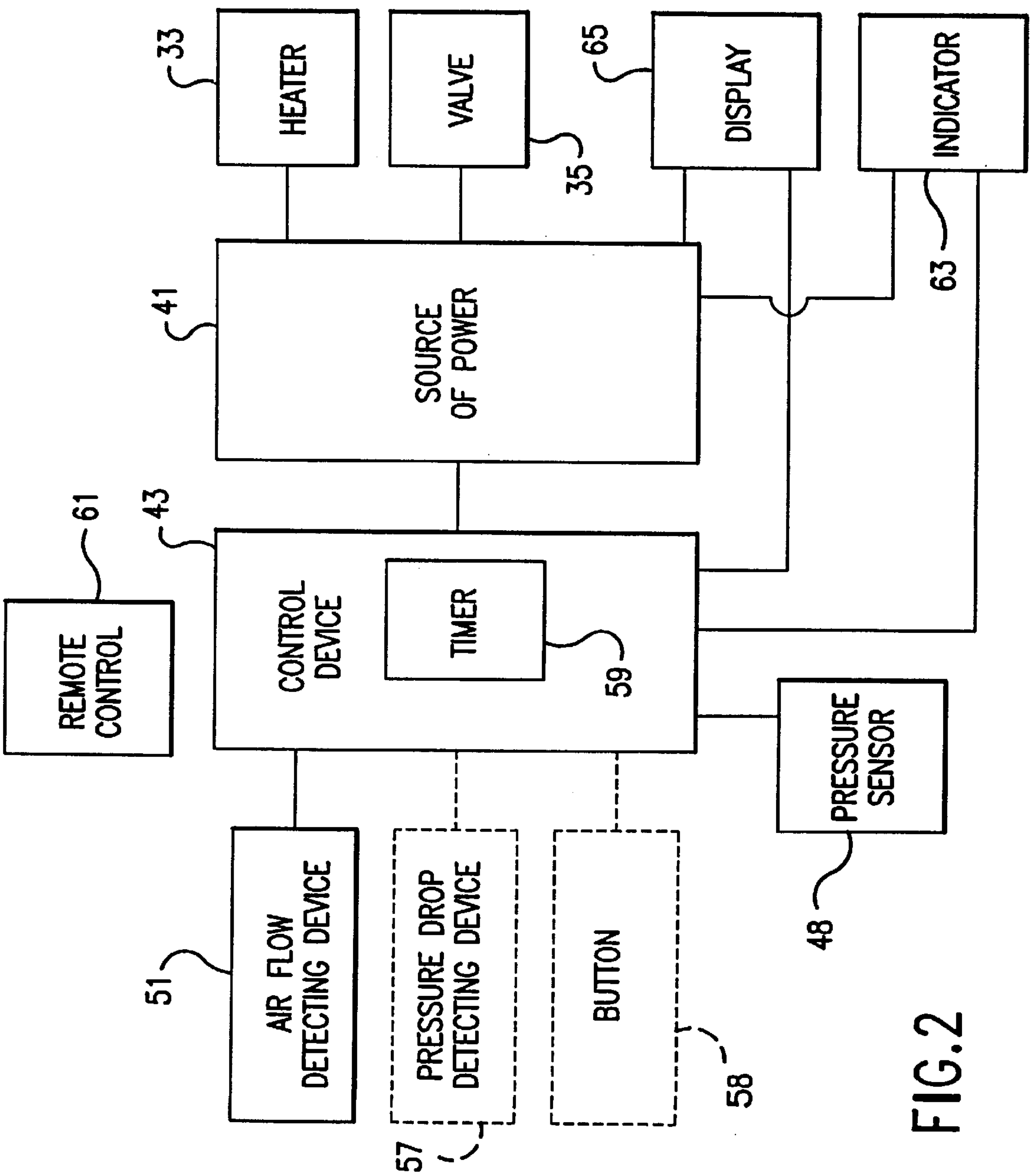


FIG.1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VALVE
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DISPLAY
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INDICATOR
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SOURCE OF POWER
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CONTROL DEVICE
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TIMER
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REMOTE CONTROL
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PRESSURE SENSOR
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AIR FLOW DETECTING DEVICE
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PRESSURE DROP DETECTING DEVICE
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BUTTON
58

FIG.2

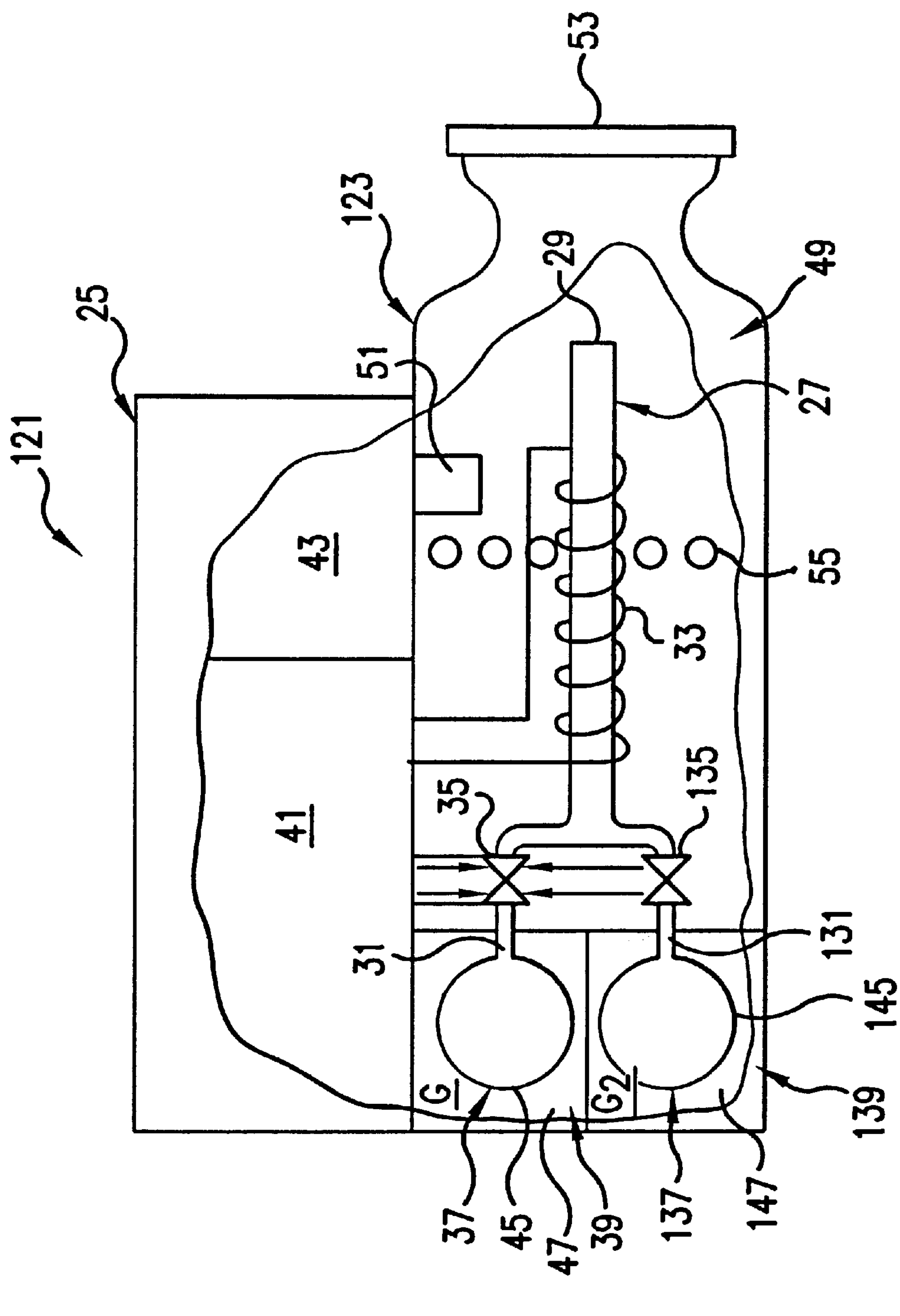
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FIG.3

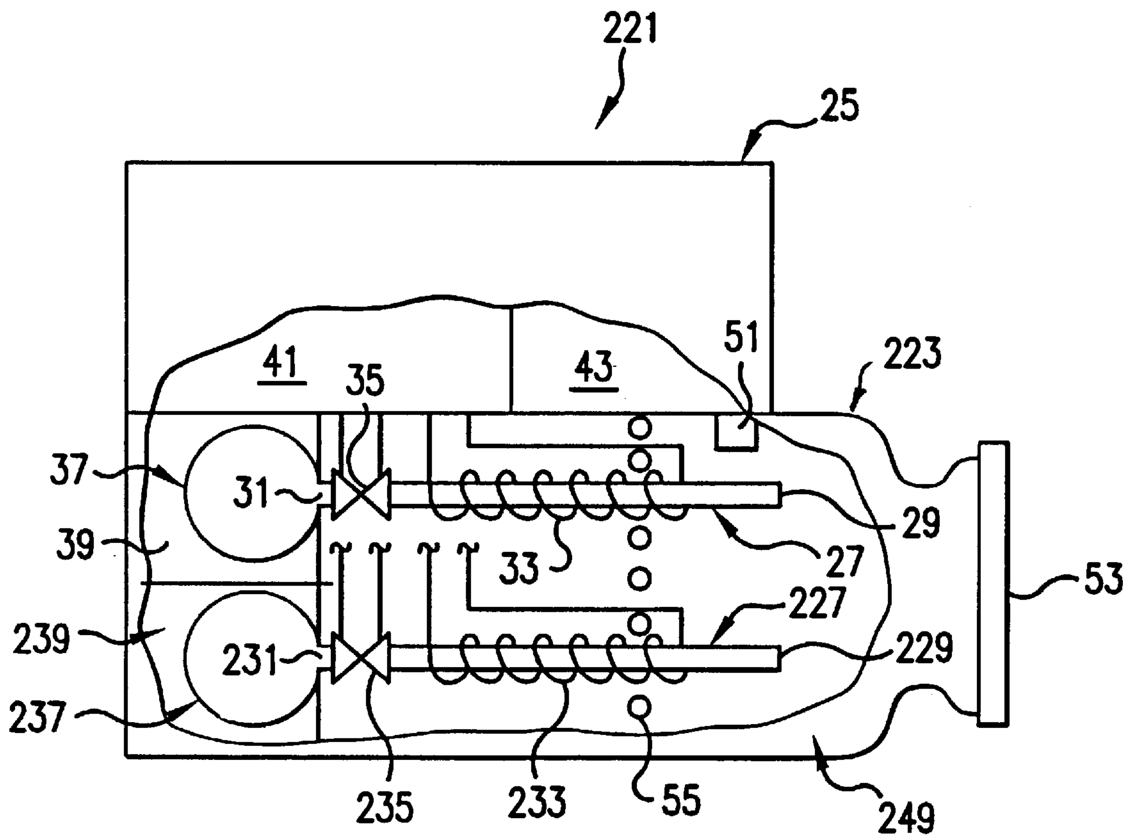
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FIG.4

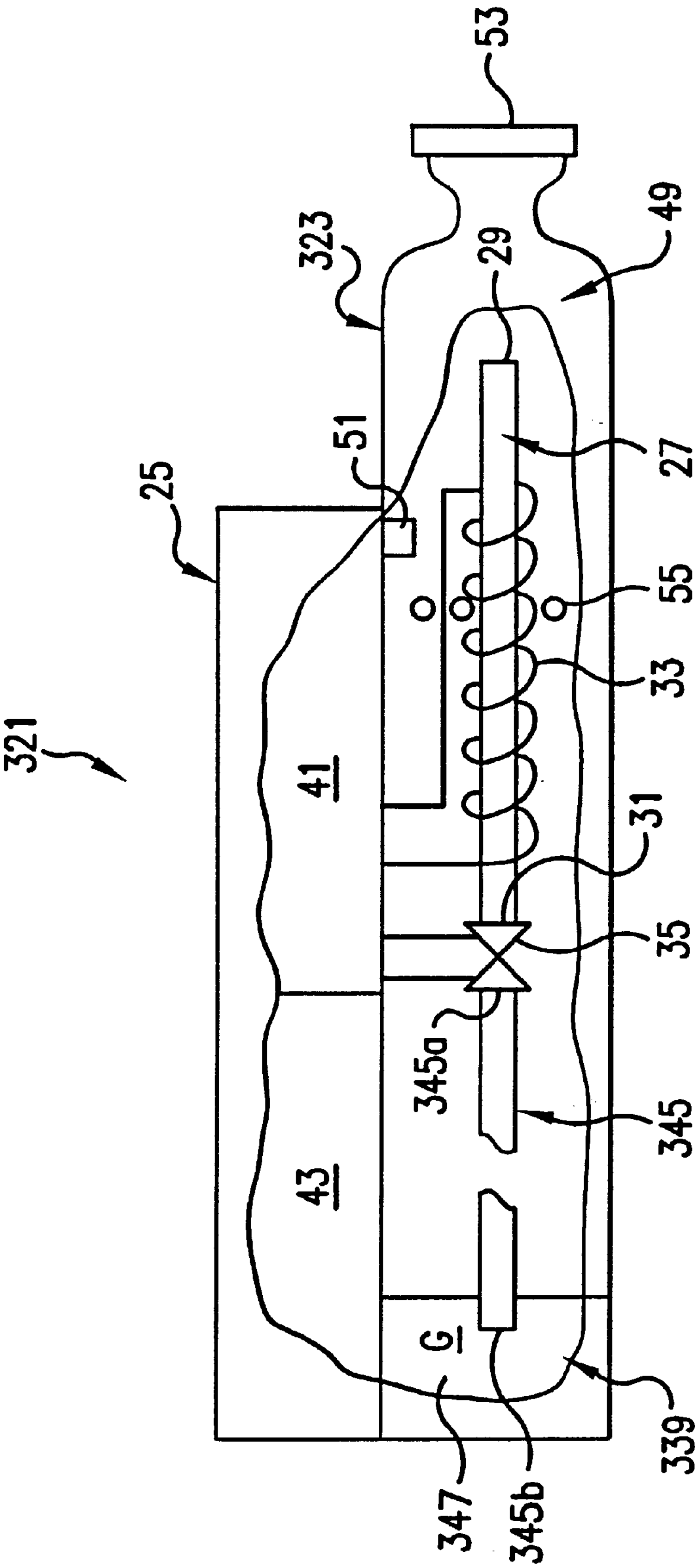

FIG.5

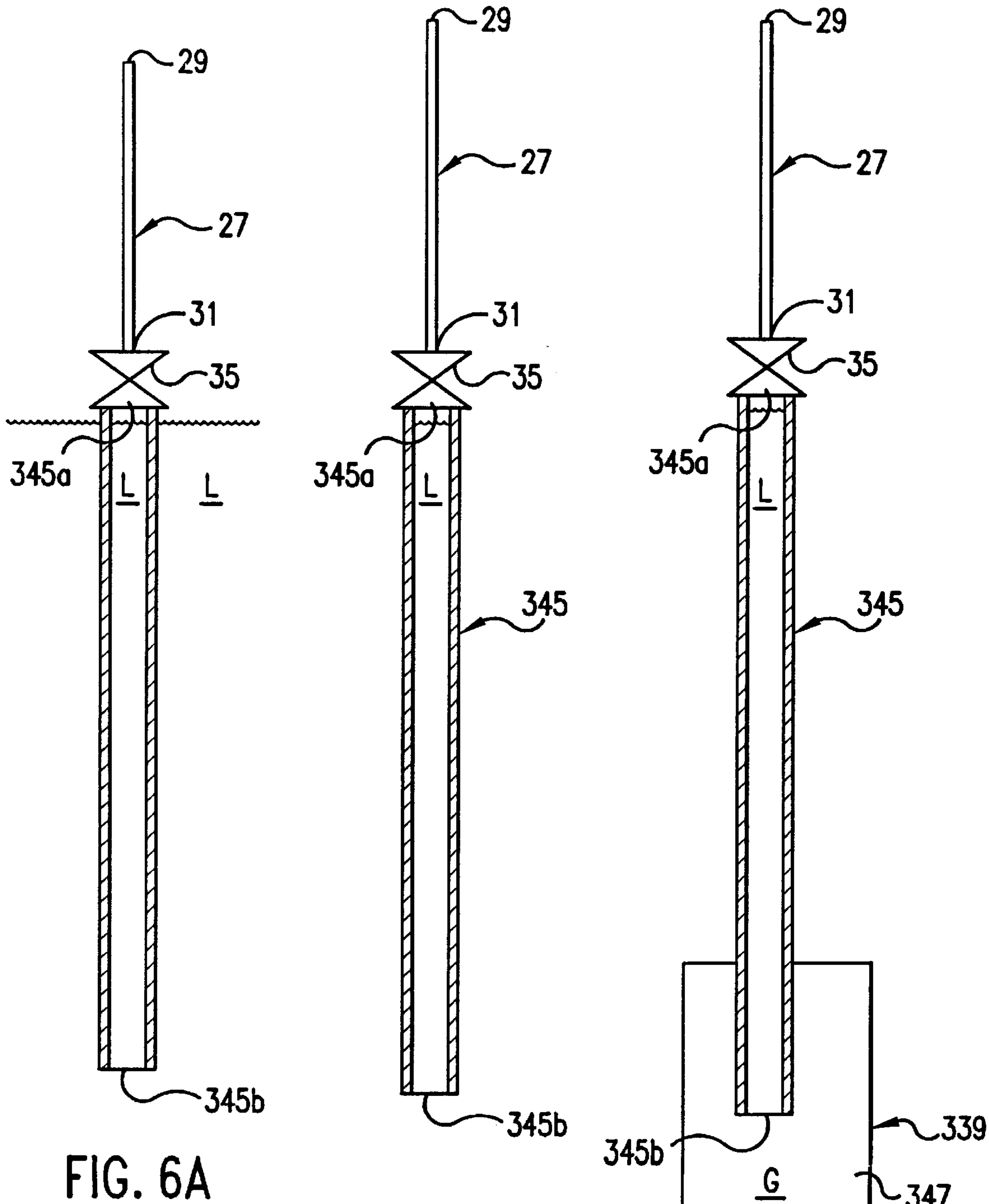

FIG. 6A

FIG. 6B

FIG. 6C

AEROSOL GENERATOR AND METHODS OF MAKING AND USING AN AEROSOL GENERATOR

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to aerosol generators and, more particularly, to aerosol generators able to generate aerosols without compressed gas propellants and methods of making and using such aerosol generators.

Aerosols are useful in a wide variety of applications. For example, it is often desirable to treat respiratory ailments with, or deliver drugs by means of, aerosol sprays of finely divided particles of liquid and/or solid, e.g., powder, medicaments, etc., which are inhaled into a patient's lungs. Aerosols are also used for purposes such as providing desired scents to rooms, applying scents on the skin, and delivering paint and lubricant.

Various techniques are known for generating aerosols. For example, U.S. Pat. Nos. 4,811,731 and 4,627,432 both disclose devices for administering medicaments to patients in which a capsule is pierced by a pin to release a medicament in powder form. A user then inhales the released medicament through an opening in the device. While such devices may be acceptable for use in delivering medicaments in powder form, they are not suited to delivering medicaments in liquid form. The devices are also, of course, not well-suited to delivery of medicaments to persons who might have difficulty in generating a sufficient flow of air through the device to properly inhale the medicaments, such as asthma sufferers. The devices are also not suited for delivery of materials in applications other than medicament delivery.

Another well-known technique for generating an aerosol involves the use of a manually operated pump which draws liquid from a reservoir and forces it through a small nozzle opening to form a fine spray. A disadvantage of such aerosol generators, at least in medicament delivery applications, is the difficulty of properly synchronizing inhalation with pumping. More importantly, however, because such aerosol generators tend to produce particles of large size, their use as inhalers is compromised because large particles tend to not penetrate deep into the lungs.

One of the more popular techniques for generating an aerosol including liquid or powder particles involves the use of a compressed propellant, often containing a chloro-fluoro-carbon (CFC) or methylchloroform, to entrain a material, usually by the Venturi principle. For example, inhalers containing compressed propellants such as compressed oxygen for entraining a medicament are often operated by depressing a button to release a short charge of the compressed propellant. The propellant entrains the medicament as the propellant flows over a reservoir of the medicament so that the propellant and the medicament can be inhaled by the user. Since the medicament is propelled by the propellant, such propellant-based arrangements are well-suited for those who might have difficulty inhaling. Nonetheless, aerosols generated by propellant-based arrangements have particles that are too large to ensure deep lung penetration.

In propellant-based arrangements, however, a medicament may not be properly delivered to the patient's lungs when it is necessary for the user to time the depression of an actuator such as a button with inhalation. Moreover, such arrangements tend to be poorly suited for delivery of materials in large quantities. Although propellant-based aerosol

generators have wide application for uses such as antiperspirant and deodorant sprays and spray paint, their use is often limited because of the well-known adverse environmental effects of CFC's and methylchloroform, which are among the most popular propellants used in aerosol generators of this type.

In drug delivery applications, it is typically desirable to provide an aerosol having average mass median particle diameters of less than 2 microns to facilitate deep lung penetration. Most known aerosol generators are incapable of generating aerosols having average mass median particle diameters less than 2 to 4 microns. It is also desirable, in certain drug delivery applications, to deliver medicaments at high flow rates, e.g., above 1 milligram per second. Most known aerosol generators suited for drug delivery are incapable of delivering such high flow rates in the 0.2 to 2.0 micron size range.

U.S. Pat. No. 5,743,251, which is hereby incorporated by reference in its entirety, discloses an aerosol generator, along with certain principles of operation and materials used in an aerosol generator, as well as a method of producing an aerosol, and an aerosol. The aerosol generator disclosed according to the '251 patent is a significant improvement over earlier aerosol generators, such as those used as inhaler devices. It is desirable to produce an aerosol generator that is portable and easy to use.

According to one aspect of the present invention, an aerosol generator includes a tube having a first and a second end, a heater arranged relative to the tube for heating at least a portion of the tube, a source of material to be volatilized, the second end of the tube being in communication with the source of material, and a valve operatively located between the source of material and the tube, the valve being openable and closeable to open and close communication between the source and the first end of the tube. A pressurization arrangement is provided for causing material in the source of material to be introduced into the tube from the source of material when the valve is in an open position. A source of power is provided for operating the heater and for the valve, and a control device is provided for controlling supply of power from the source of power to the heater and the valve.

According to a further aspect of the present invention, a method of making an aerosol generator is disclosed. According to the method, a heater is arranged relative to a tube for heating of the tube, the tube having first and second ends. The second end of the tube is connected to a source of material to be volatilized. An openable and closeable valve is provided between the source of material and the tube. A pressurization arrangement is provided for causing material in the source of material to be introduced into the tube from the source of material when the valve is in an open position. The valve is connected to a source of power for opening and closing the valve. The heater is connected to the source of power. The source of power is connected to a control device for controlling a supply of power from the source of power to the heater and the valve.

According to yet another aspect of the present invention, a method of using an aerosol generator is disclosed. According to the method, a first signal, indicative of a user's intention to use the aerosol generator, is provided to a control device. With the control device and in response to the first signal, a second signal is sent to a source of power to cause the source of power to open an openable and closeable valve, the valve being disposed between a source of material to be volatilized and a tube, opening of the valve permitting material from the source of material to flow from the source of material and into the tube. Material from the source of material is caused to flow from the source of material and into the tube. With the control device and in response to the first signal, a third signal is sent to the source of power to supply power to a heater disposed relative to the tube to heat the tube. Material from the source of material is heated in the tube with the heater to a vaporization temperature such that the material volatilizes and expands out of an open end of the tube.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the present invention are well understood by reading the following detailed description in conjunction with the drawings in which like numerals indicate similar elements and in which:

FIG. **1** is a schematic, partially broken, side view of an aerosol generator according to an embodiment of the present invention;

FIG. **2** is a logic diagram of powered components of an aerosol generator according to an embodiment of the present invention;

FIG. **3** is a schematic, partially broken, side view of an aerosol generator according to a second embodiment of the present invention;

FIG. **4** is a schematic, partially broken, side view of an aerosol generator according to a third embodiment of the present invention;

FIG. **5** is a schematic, partially broken, side view of an aerosol generator according to a fourth embodiment of the present invention;

FIGS. **6A–6C** show steps according to a method, according to a further aspect of the present invention, of manufacturing an aerosol generator according to the fifth embodiment of the present invention.

DETAILED DESCRIPTION

An aerosol generator **21** according to the present invention is shown in FIG. **1**. The principles of operation of the aerosol generator **21** and, where applicable, materials used in the aerosol generator are preferably similar to the principles of operation and materials used in the aerosol generator disclosed in U.S. Pat. No. 5,743,251, which is hereby incorporated by reference in its entirety.

A preferred application for the aerosol generator **21** is as an inhaler device, such as an inhaler for medicaments, such as asthma medication and pain killers. The aerosol generator **21** preferably includes a first component **23**, which preferably includes, for example, the material to be turned into an aerosol and which is preferably disposable after one or a predetermined plurality of uses, removably attached to a second component **25**, which preferably includes, for example, power source and logic circuitry structures and which is preferably permanent in the sense that it is reusable with successive ones of the first components. The first and second components **23** and **25** can be attachable to one another in end to end or side by side relationships. If desired or necessary, however, the aerosol generator can be a one-piece device.

The first component **23** preferably includes a tube **27** having a first and a second end **29**, **31**, and a heater **33** arranged relative to the tube for heating the tube. A valve **35** is provided either on the tube **27** or between the second end **31** of the tube and a source **37** of material, the valve preferably being openable and closeable to open and close communication between the first end **29** of the tube and the source of material. The valve **35** may define the second end **31** of the tube. The valve **35** is preferably electronically openable and closeable, preferably a solenoid-type valve. The first component **23** preferably further includes the source **37** of material to be volatilized. The first component **23** preferably also includes a pressurization arrangement **39** for causing material in the source **37** of material to be introduced into the tube **27** from the source of material when the valve **35** is in an open position.

The second component **25** is preferably attachable and detachable to the first component **23** and includes a source **41** of power for the heater **33** and for the valve **35**, and a control device **43**, such as a microchip, for controlling supply of power from the source of power to the heater and the valve. The source **41** of power is preferably a battery, more preferably a rechargeable battery, however, the source of power may, if desired or necessary, be a non-depleting source of power, such as a conventional power line. International Publication No. WO 98/17131 discloses a power controller and a method of operating an electrical smoking system that discloses a power source and a control device, particularly for heaters, the principles of operation and features of which are transferrable to the present invention, and is hereby incorporated by reference.

General operation of the aerosol generator **21** involves a user providing a signal, such as by compressing a button or performing some other action such as inhaling near the first end **29** of the tube **27** to actuate a flow sensing detector or a pressure drop sensing detector, which is received by the control device **43**. In response to the signal, the control device **43** preferably controls the supply of power from the power source **41** such that the valve **35** is opened and power is supplied to the heater **33** to cause it to heat up to its desired operating temperature. It may be desired or necessary, depending upon the application and the equipment employed, to open the valve **35** before or after supplying power to the heater **33**.

Upon opening the valve **35**, the pressurization arrangement **39** causes material in the source **37** of material to be introduced into the tube **27**. The material in the tube **27** is heated to a vaporization temperature in the tube, volatilizes, and expands out of the free first end **29** of the tube. Upon exiting the tube **27**, the volatilized material contacts cooler air and condenses to form an aerosol. Preferably, after a predetermined period of time, the control device **43** automatically closes the valve **35** and shuts off the supply of power to the heater **33**. After one or a plurality of uses, the first component **23** is preferably separated from the second component **25** and is disposed of, and a new first component is attached to the second component for further use.

Because presently preferred applications for the aerosol generator **21** include use as an inhaler, the aerosol generator is preferably as small as possible. The valve **35** is preferably a microvalve. More preferably, the valve **35**, the heater **33**, and the tube **27** are a single micoelectronic machine formed on a single chip. To the extent that other components of the aerosol generator **21** disclosed in the present application are subject to production as microelectronic devices, they may also be formed on a single chip with the valve **35**, the heater **33**, and the tube **27**, or on another chip.

According to the preferred embodiment, the source **37** of material includes a flexible container **45**, and the pressurization arrangement **39** includes a chamber **47** in which the flexible container is disposed. A pressurized gas G is preferably sealed in the chamber **47** and surrounds the flexible container **45**. The pressurization arrangement **39** is preferably a so-called sepra container of the type used for dispensing, for example, gel shaving creams, caulking compounds, and depilatories, although other pressurization arrangements for delivering the material, such as propellants and manual or automatic pumps, may be used if desired or necessary. The sepra container pressurization system is particularly preferred, however, particularly due to its capacity for resistance to surrounding temperature variations, as well as to variations in pressure of the gas G because the gas is not depleted. When it is desired to dispense material from the source **37** of material, and the valve **35** is opened, the pressure of the gas G, which is preferably about two atmospheres (about 30 psi) greater than ambient pressure, compresses the flexible container **45**, causing material to enter the tube **27** through the second end **31** of the tube in communication with the source of material. A preferred gas G is nitrogen because of its ready availability and comparatively low cost, although various other gases are also suitable and may be preferred for particular applications.

Displacement of material from the flexible container **45** means that there is more room in the chamber **47**, which means that the gas G enclosed in the chamber occupies a greater volume. Preferably, the size of the flexible container **45** relative to the size of the chamber **47** is selected such that pressure of the gas G is about ten percent lower when the flexible container is empty than when the flexible container is full.

A pressure sensor **48** may be provided to sense the pressure of the gas G in the chamber **47**. As seen in FIG. **2**, the pressure sensor **48** is preferably arranged to send a signal representative of the pressure in the chamber **47** to the control device **43**. The control device **43**, in turn, is preferably arranged to control the power source **41** to adjust a length of time that power is supplied to the valve **35**, and if desired or necessary, to the heater **33**, in response to the signal from the pressure sensor. In this way, pressure drops in the chamber **47**, which may result in a decrease in the rate at which material in the flexible container **45** is dispensed, can be compensated for by dispensing material for somewhat longer periods of time, i.e., by keeping the valve **35** open longer and, if desired or necessary, maintaining a supply of power to the heater **33**.

A signal to the control device **43** to supply power to the valve **35** and the heater **33** and, where provided, other features of the aerosol generator **21**, is preferably provided by a user of the aerosol generator. While the signal may be provided by, for example, pressing a button, turning a knob, or switching a switch, a preferred arrangement for providing a signal is based on a user causing some manner of air flow in the proximity of the free first end **29** of the tube **27**, such as by inhaling on a mouthpiece section **49** of the aerosol generator. The aerosol generator **21** preferably includes an air flow detecting device **51** for determining when a predetermined air flow rate exists proximate the first end **29** of the tube **27**. The air flow detecting device **51** is preferably arranged to send a signal to the control device **43** to indicate that the predetermined air flow rate exists, which may be indicative that a user is drawing on the open end **53** of the mouthpiece **49** section, and the controller is preferably arranged to control the power source to supply power to the valve **35** and the heater **33**, and any other components, in response to the signal from the air flow detecting device. As seen in FIG. **1**, the air flow detecting device **51** is preferably disposed transversely to and upstream of the first end **29** of the tube **27** so that the air flow detecting device will assist in ensuring that an adequate supply of air flow exists to produce and effectively deliver an aerosol from the volatilized material as it expands out of the first end of the tube.

Where the aerosol generator **21** is a multi-piece device, the air flow detecting device **51** is preferably permanently attached to the second component **25** and is, thus, preferably a permanent component, i.e., it is not disposed of. If desired or necessary, however, the air flow detecting device **51** can be a disposable component forming part of the first component **23** and can be removably connected, such as through an electrical connection, to the control device **43**.

The mouthpiece section **49** preferably has an open end **53**. The tube **27** is preferably disposed in the mouthpiece section **49** and the first end **29** of the tube is preferably disposed inside of the mouthpiece section at a distance from the open end **53** to permit complete mixing of volatilized material expanding out of the first end of the tube with surrounding air to form an aerosol. To ensure an adequate supply of air for mixing with the volatilized material, as well as to ensure an adequate supply of air for permitting a user to draw on the mouthpiece section and actuate the air flow detecting device **51**, the mouthpiece section **49** preferably has a plurality of vent holes **55**. To facilitate the flow of air past the first end **29** of the tube **27** and thereby facilitate formation of an aerosol, the first end of the tube is preferably disposed in the mouthpiece section **49** between the vent holes **55** and the open end **53** of the mouthpiece section. The vent holes **55** are preferably located relative to the tube **27**, preferably close to the end **29**, such that air passing through the vent holes has no or minimal cooling effect on the tube. The tube **27** may, of course, be insulated from air flowing through the vent holes **55**, such as by providing insulation material or a concentric tube **56** (shown in phantom) or the like around the tube to channel air away from the tube.

As an alternative to, or in addition to, using an air flow detecting device **51** to send a signal to the control device **43**, as seen in FIG. **2** in phantom, a pressure drop detecting device **57** for determining when a predetermined pressure drop occurs proximate the first end **29** of the tube **27** may be used. The pressure drop detecting device **57** is preferably arranged to send a signal to the control device **43** to indicate that the predetermined pressure drop is occurring, which may be indicative of a user drawing on the open end **53** of the mouthpiece section **49**, and the control device is arranged to control the power source **41** to supply power to the valve **35** and the heater **33**, and any other electrically powered components, in response to the signal from the pressure drop detecting device.

A suitable pressure drop detecting device is a puff-actuated sensor in the form of a Model 163PC01D35 silicon sensor, manufactured by MicroSwitch division of Honeywell, Inc., Freeport, Ill., or an SLP004D 0-4" H_2O Basic Sensor Element, manufactured by SenSym, Inc., Milpitas, Calif. Other known flow-sensing devices, such as those using hot-wire anemometry principles, are also believed to be suited for use with the aerosol generator **21**. The use of an air flow detecting device **51**, as compared to a pressure drop detecting device, is presently preferred for inhaler-type applications because it is anticipated that an air flow detecting device will be easier for users to actuate as compared to a pressure drop detecting device.

Presently anticipated applications for the aerosol generating device **21** include drug delivery applications. For such applications, as well as in other applications to which the aerosol generating device **21** might be applied, the control device **43** may include a timer **59** for controlling a frequency with which the control device controls the power supply **41** to supply power to the valve **35** and the heater **33** and other components. In this way, the aerosol generating device **21** can automatically limit the frequency with which a user can operate the aerosol generating device, thereby facilitating in preventing accidental misuse and overdosages. Moreover, to assist caregivers in treating their patients, the aerosol generator **21** can be associated with a remote control device **61** remote from the control device **43**. The remote control device **61** is preferably capable of adjusting the timer **59** to adjust the frequency with which the control device **43** controls the power supply **41** to supply power to the valve **35** and the heater **33**, and other components. In this way, when a caregiver desires to increase or decrease the frequency with which the user is able to operate the aerosol generator, the caregiver can do so in situations where the caregiver and the user are separated by some distance. In this way, users who might otherwise be required to personally see their caregivers to have their treatment schedules adjusted have greater mobility.

The control device **43** and, if provided, the remote control device **61**, may also be configured to permit adjustment or remote adjustment of other powered components of the aerosol generator **21**, such as the length of time that the valve **35** is open, and the length of time that power is supplied to the heater from the power source **41**. In this manner, it is possible to adjust dosages up or down, as well as to adjust operating conditions of the aerosol generator **21** to maintain the same operation where, for example, pressure of the gas G in the chamber **47** drops or the rate at which power is supplied from the power source **41** reduces, such as where the aerosol generator is used in different temperatures, material in the flexible container **45** is used up, or the charge of a battery forming the power source diminishes.

The timer **59** of the control device preferably is associated with an indicator **63**, such as a beeper or light forming part of the timer or, for example, electrically connected to the timer, for indicating that the control device **43** is available to control the power supply **41** to supply power to the valve **35** and the heater **33** and other components. Where, for example, the aerosol generator **21** is used to dispense medication, the indicator **63** serves to remind the user that it is time for the medication. The indicator **63** may also, if desired or necessary, be operable by the remote control device **61**. The indicator **63** may also be used to indicate to a user a length of time since the aerosol generator **21** was actuated, such as where the aerosol generator is used as an inhaler, and the user is supposed to hold his or her breath for a length of time after inhaling, with the indicator **63** indicating when a period of time has elapsed.

The aerosol generator **21** may also include a display device **65**, such as an LCD display, for displaying information such as a number of times that the control device **43** controls the power supply **41** to supply power to the valve and the heater. The display device **65** may display, for example, a number of times that the aerosol generator **21** has been operated, e.g., 1 or 2 or 3, or a number of operations remaining, which may be based on, for example, the size of the source **37** of material and the amount of material dispensed each time that the valve **35** is opened and closed, or the life of the power supply **41**, such as the remaining life of a battery. The same or additional display devices can be provided to display other information, such as pressure in the pressure chamber **47** and power level of the power source **41**. Further, the aerosol generator **21** may be equipped with various sensors and displays to provide feedback to be displayed in a display device **65** to, for example, assist a user in learning how to use the aerosol generator properly as an inhaler, such as sensors to measure the volume and duration of an inhalation after completion of an inhalation, and even to provide feedback during an inhalation to assist the user in employing an optimum inhalation profile. The display device **65** is preferably controlled by the control device **43** and powered by the power supply **41**.

The control device **43** may be individually programmable, such as by a pharmacist, to control the aerosol generator **21** to dispense medications according to a prescription, i.e., quantity of medication, frequency, etc., as well as programming in the information that would prevent improper use of the aerosol generator. In this manner, fewer types of aerosol generators **21** may be useful for a wide range of medications. The particular aerosol generator **21** would preferably be optimized for different classes of medications and then "fine tuned" by, for example, the pharmacist, for a specific drug or prescription.

The aerosol generator **21** may also be programmed to permanently prevent use after a set period of time. In this way, it would be possible to prevent the use of expired medications. This may be accomplished by, for example, having a battery power source **41** be non-replaceable, or by incorporating a battery and/or control device that keeps track of date and time and prevents operation past a particular date and time.

While not wishing to be bound by theory, depending upon selection of factors presently understood to primarily include a rate of power supplied from the source of power **41** to the heater **33**, a diameter of the tube **27**, and the material to be volatilized and delivered as an aerosol, the aerosol generator **21** is preferably specifically designed to generate an aerosol having certain desired characteristics. For many applications, particularly for medication delivery applications, the aerosol generator **21** according to the present invention is preferably designed to produce an aerosol having a mass median particle diameter of less than 3 microns, more preferably less than 2 microns, still more preferably between 0.2 and 2 microns, and still more preferably between 0.5 and 1 microns. While not wishing to be bound by theory, depending upon selection of factors presently understood to primarily include a length of the tube **27**, a pressure with which the pressurization arrangement **39** supplies the material from the source **37** of material, and a rate at which power is supplied from the source **41** of power, the rate at which the material is supplied and volatilized in the tube is established. The aerosol generator **21** is preferably designed to supply and volatilize material at a rate greater than 1 milligram per second.

It may be desirable to produce an aerosol formed from different liquid components that, for a variety of reasons, may be best kept separated until the moment that it is desired to form the aerosol. As seen in FIG. **3**, another embodiment of the aerosol generator **121** may, in addition to the features described with respect to the aerosol generator **21**, include, preferably as part of a modified first component **123**, a source **137** of a second material in liquid form that is supplied to the tube **27** together with the material from the first source of material **37**. The source **137** of second material preferably communicates with the tube **27** at a point **171** before the heater **33**. A separate valve **135** is preferably powered by the power source **41** and controlled by the control device **43** to permit the pressurization arrangement **39** to cause material in the source **137** of second material to be introduced into tube **27** from the source of second material when the valve **35** is in an open position. If desired or necessary, the valve **35** and the valve **135** can be opened and closed at different times.

The source **137** of second material preferably includes a second flexible container **145**. The pressurization arrangement **39** preferably includes a second chamber **147** in which the second flexible container **145** is disposed, and a second pressurized gas G_2 sealed in the second chamber and surrounding the second flexible container. The pressurized gas G and the second pressurized gas G_2 may be pressurized to different pressures to facilitate delivery of the material and the second material to the tube **27** at different rates. If desired or necessary, the flexible container **45** and the second flexible container **145** may be disposed in the same pressurized chamber. Additional sources of material and other components may be provided to produce an aerosol having still further components.

As seen with respect to FIG. **4**, a third embodiment of the aerosol generator **221** may include, preferably as part of a modified first component **223**, a structure, or several structures, that is substantially entirely parallel to the structure of the first component to permit generation of an aerosol formed from two or more components. The aerosol generator **221** preferably includes a second tube **227** having a first and a second end **229**, **231**. A second heater **233** is preferably arranged relative to the second tube **227** for heating the second tube. A second valve **235** is preferably provided on the second tube **227** and is openable and closeable to open and close communication between the first and the second ends **229** and **231** of the second tube. A source **237** of second material to be volatilized is provided and the second end **231** of the second tube **227** communicates with the source of second material. A second pressurization arrangement **239** is provided for causing material in the source **237** of second material to be introduced into the second tube **227** from the source of second material when the second valve **235** is in an open position. If desired or necessary, the pressurization arrangement **39** can be used to cause material in the source **237** of second material to be introduced into the second tube **227**. Preferably, the source **41** of power supplies power for the second heater **233** and for the second valve **235**, as well as to any other electrically powered components of the aerosol generator, and the control device **43** controls supply of power from the source of power to the second heater and the second valve.

The aerosol generator **221** preferably includes a chamber **249**, such as a mouthpiece section. The first ends **29** and **229** of the tube **27** and the second tube **227** are preferably disposed in the chamber **249** proximate each other. The chamber **249** is preferably of sufficient size and configuration to permit mixture of volatilized material and volatilized second material that expands out of the tube **27** and the second tube **227** together with ambient air such that the volatilized material and the volatilized second material form first and second aerosols, respectively, the first and second aerosols being mixed with each other to form a combination aerosol including the first and second aerosols.

In the embodiment described with reference to FIG. **1**, a combination aerosol can be formed by providing material in the source **37** of material that includes two or more components mixed together before the material is volatilized. While the components in the source **37** of material may be two or more liquids, it is also possible to suspend solid particles in solution in a liquid material, or to dissolve solid particles in a liquid material. If desired or necessary, the solid particles, when suspended in solution, may be of a larger average diameter than particles of the material in aerosol form. The solid particles, when they form a part of the aerosol, may be of a larger average diameter than particles of the material in aerosol form. Solid particles can, of course, also be suspended in solution in liquid materials in the embodiments described with reference to FIGS. **3** and **4**.

As noted, a preferred pressurization arrangement **39** for the aerosol generator **21** includes a sepra container type of arrangement. An aerosol generator **321** having an alternative pressurization arrangement **339** is shown in FIG. **5**. In this embodiment, the source **337** of material preferably includes a second tube **345** having first and second ends **345***a*, **345***b*. The first end **345***a* of the second tube **345** is connected to the second end **31** of the tube **27**. The pressurization arrangement **339** includes a chamber **347** filled with a pressurized gas G. The second end **345***b* of the second tube **345** is disposed in the chamber **347** and is open to the chamber. The source **337** of material, the second tube **345**, and the tube **27** preferably form part of a modified first component **323**.

As seen in FIGS. **6A–6C**, the source **337** of material is preferably filled with material by first opening the valve **35** in the tube **27**, then immersing the open second end **345***b* of the second tube **345** in liquid material L (FIG. **6A**). After the liquid material in which the second tube **345** is immersed fills the second tube, the valve **35** is then shut. The second tube **345** is withdrawn from the liquid material, with the liquid material that filled the second tube remaining in the second tube due to closure of the valve (FIG. **6B**), i.e., air is unable to get behind the liquid material in the second tube. The second tube **345** is then positioned in the chamber **347** and the chamber is pressurized (FIG. **6C**). When the valve **35** is opened, the pressure in the chamber forces the liquid material in the second tube **345** to enter the tube **27** where it can be volatilized by the heater **27**.

In a method of making the aerosol generator **21** described with reference to the embodiment shown in FIG. **1**, the heater **33** is arranged relative to the tube **27** to permit heating of the tube. The second end **31** of the tube **27** is connected to the source **37** of material to be volatilized. The openable and closeable valve **35** is provided to allow and stop communication between the source **37** of material and the tube **27**.

The pressurization arrangement **39** for causing material in the source **37** of material to be introduced into the tube **27** from the source of material when the valve **35** is in an open position is provided. The valve **35** is connected to the source **41** of power for opening and closing the valve. The heater **35** is connected to the source **41** of power. The source **41** of power is connected to the control device **43** for controlling the supply of power from the source of power to the heater **33** and the valve **35**, as well as to any other components of the aerosol generator.

The step of providing the pressurization arrangement **39** preferably includes positioning the source **37** of material in a chamber **47** and pressurizing the chamber, preferably to about two atmospheres. The source **37** of material preferably includes a flexible container **45**. However, other embodiments are also possible. For example, as described with reference to FIGS. **5** and **6A–6B**, the source **337** of material may include a second tube **345** having first and second ends **345***a*, **345***b*, the first end of the second tube being connected to the second end **31** of the tube **27** and the second end **345***b* of the second tube being positioned in the chamber **345**.

In making the aerosol generator **21** according to the present invention, it is particularly preferred that the heater **33**, the tube **27**, the valve **35**, the source **37** of material, and the pressurization arrangement **39** are arranged relative to each other to form a first component **23**, and that the source **41** of power and the control device **43** are arranged relative to each other to form a second component **25**, and that the second component is attachable to and detachable from the first component. In this way, the second component **25** can be made as a permanent device, with most or all of the more expensive features of the aerosol generator being associated with the second component, and the first component **23**, which preferably includes the depletable or less expensive components of the aerosol generator, can be disposable. The different features of the aerosol generator **21** can be provided on whichever one of the components **23** and **25** seems appropriate for a particular application. However, according to the presently envisioned preferred application of the aerosol generator as a medical inhaler device, it is believed that the arrangement of features on the components **23** and **25** properly distributes the more and less disposable features.

The aerosol generator **21** is preferably used by a user providing a first signal, indicative of a user's intention to use the aerosol generator, to the control device **43**. The first signal may be provided by the user pressing a button **58** (FIG. **2**, in phantom) but, particularly where the aerosol generator **21** is intended to be used as an inhaler device, it is preferred that the first signal be provided by some form of draw-actuated device, such as a pressure drop detecting sensor **53** or, more preferably, an air flow detecting sensor **51**.

The control device **43**, in response to the first signal, sends a second signal to the source of power **41** to cause the source of power to open the openable and closeable valve **35**. The valve **35** is preferably disposed between the tube **27** and the source **37** of material. Opening of the valve **35** permits material from the source **37** of material to flow from the source of material and into the tube **27**.

Material from the source **37** of material is caused to flow from the source of material and into the tube **27**, preferably by means of the pressurization arrangement. The source **37** of material preferably includes the flexible container **45**, and material in container is caused to flow from the source of material by a pressurization arrangement **39**. The pressurization arrangement **39** preferably includes the chamber **47** filled with gas G under pressure and in which the flexible container **45** is disposed. In an alternative embodiment, as described with reference to FIGS. **5** and **6A–6C**, the source **337** of material includes the second tube **345** having first and second ends **345***a*, **345***b*. The first end **345***a* of the second tube **345** is connected to the second end **31** of the tube **27**, and material in the source **337** of material is caused to flow from the source of material by the pressurization arrangement **339**. The pressurization arrangement **339** includes a chamber **347** filled with gas G under pressure and in which the second end **345***b* of the second tube **345** is disposed.

A third signal is sent by the control device **43** and in response to the first signal to the source **41** of power to supply power to the heater **33** disposed relative to the tube **27** to heat the tube. Material from the source **37** of material is heated in the tube **27** with the heater **35** to a vaporization temperature such that the material volatilizes and expands out of the first end **29** of the tube.

The aerosol generator according to the present invention is preferably constructed in accordance with certain design principles that the inventors have recognized. These design relationships permit design of the aerosol generator with a certain robustness, particularly with respect to ambient temperature and container pressure variations, such that it is possible to ensure that the rate of aerosol delivery is substantially constant. While not wishing to be bound by theory, one relationship involves the rate at which aerosol is delivered (D), which is understood to be substantially linearly related to the power delivered to the liquid to be volatilized, i.e., the power (P), according to the relationship: $D=k_1P$, where k_1 is substantially constant and depends upon design factors peculiar to the particular aerosol generator.

While not wishing to be bound by theory, the amount of aerosol delivered (d), or the aerosol delivery rate D multiplied by the time that the aerosol is delivered, is understood to be substantially linearly related to the pressure drop (p) of the liquid material through the tube **27**, which is usually the difference between whatever pressure at which the liquid is maintained in the source **37** of material (e.g., container pressure) and atmospheric pressure, and substantially linearly related to the inverse of the length (L) of the tube from the beginning of the tube to the point PV along the tube where the liquid material has completely volatilized, according to the relationship: $D=k_2p/L$, where k_2 is substantially constant and, like k_1, depends upon factors peculiar to the particular aerosol generator.

Further to the foregoing relationships, and while not wishing to be bound by theory, the value L will tend to increase with increasing pressure drop p or, conversely, decreases with decreasing pressure drop p. Accordingly, the capillary aerosol generator tends to maintain delivery rate D despite changes in p, which might result from, for example, changes in ambient temperature or pressure or container pressure or other causes, at least over a usable range.

The aerosol generator **21** according to the present invention is preferably designed according to the relationships discovered by the inventors. For example, while not wishing to be bound by theory, when a desired delivery amount and a delivery rate are known beforehand, such as where the aerosol generator **21** is to be used as an inhaler for predetermined dosages of medication, a designer can provide an appropriately sized battery as the power source **41** and can allow for a certain pressure drop of the gas G in the chamber **47** as material is depleted from the container **45** and still be certain that the desired delivery amount is achieved. If the pressure is too low, the consequence will be too low a delivery rate. If the pressure is too high, the consequence is that material emerges from the tube **27** as a liquid.

According to one potential sequence of events in a design process, and while not wishing to be bound by theory, the pressure drop p of the material prior to complete volatilization is a function of factors such as the diameter of the tube **27**, and the nature of the material to be volatilized. Changing tube diameter can affect where the point P_v occurs, i.e., affect the the length L. If it is desired to have a tube with a certain length, and to accommodate changes in battery power, e.g., due to the battery losing its charge, and changes in pressure of the gas G, the length of the tube **27** can be designed with certain factors of safety in view of calculations for the length L involving different tube diameters that affect the pressure drop p. Similarly, if it is known that a particular battery loses a charge at a certain predetermined rate, the length of the tube **27** can be selected to ensure that volatilization of the material occurs in the tube at all intended operating levels of the battery.

According to another potential sequence of events in a design process, and while not wishing to be bound by theory, for a given delivery rate D, tube diameter d should be chosen taking into account the effect of tube diameter upon particle size. Tube length and the pressure in the container should then be adjusted to ensure that P_v occurs prior to the first end **29** of the tube **27**, particularly in view of the likelihood of some variation in container pressure p.

Moreover, the control device **43** can be programmed to ensure that, as the pressure of the gas G drops, or the power level of the source **41** of power drops, certain changes in operation to accommodate these changes will take place. For example, as power levels drop, delivery of the same amount of material will take a longer time. Accordingly, the control device **43** can be programmed to, for example, keep the valve **35** open for a longer time as drops in power levels are detected.

While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims. For instance, the aerosol generator could include arrangements for manually operating the valve **35**, i.e., instead of actuation by detection of air flow or pressure drop, with the controller **43** being configured to execute a scheduled heating cycle upon receipt of a signal indicating actuation of the valve. Such arrangements might further include devices (electrical or mechanical) to maintain the valve **35** in an opened position for a predetermined amount of time once it is mechanically actuated.

What is claimed is:

1. An aerosol generator, comprising:

a tube having a first and a second end;

a heater arranged relative to the tube for heating at least a portion of the tube;

a source of material to be volatilized, the second end of the tube being in communication with the source of material;

a valve operatively located between the source of material and the tube, the valve being openable and closeable to open and close communication between the source and the first end of the tube;

a pressurization arrangement for causing material in the source of material to be introduced into the tube from the source of material when the valve is in an open position;

a source of power for operating the heater and for the valve; and

a control device for controlling supply of power from the source of power to the heater and the valve.

2. The aerosol generator as set forth in claim **1**, wherein the source of material includes a flexible container, and the pressurization arrangement includes a chamber in which the flexible container is disposed, and a pressurized gas sealed in the chamber and surrounding the flexible container.

3. The aerosol generator as set forth in claim **2**, wherein the gas is nitrogen.

4. The aerosol generator as set forth in claim **2**, wherein the gas is pressurized to about 2 atmospheres.

5. The aerosol generator as set forth in claim **2**, wherein pressure of the gas is about ten percent lower when the flexible container is empty than when the flexible container is full.

6. The aerosol generator as set forth in claim **2**, further comprising a pressure sensor arranged to sense pressure in the chamber, the pressure sensor being arranged to send a signal representative of the pressure in the chamber to the control device, and the control device being arranged to control the power source to adjust a length of time that power is supplied to the valve in response to the signal from the pressure sensor.

7. The aerosol generator as set forth in claim **1**, further comprising an air flow detecting device for determining when a predetermined air flow rate exists proximate the first end of the tube, the air flow detecting device being arranged to send a signal to the control device to indicate that the predetermined air flow rate exists, and the control device being arranged to control the power source to supply power to the valve and the heater in response to the signal from the air flow detecting device is disposed in a position transverse to and upstream of the first end of the tube.

8. The aerosol generator as set forth in claim **7**, wherein the air flow detecting device includes a flow sensor.

9. The aerosol generator as set forth in claim **7**, further comprising a mouthpiece section, the mouthpiece section having an open end, the tube being disposed in the mouthpiece section and the first end of the tube being disposed inside of the mouthpiece section at a distance from the open end.

10. The aerosol generator as set forth in claim **9**, wherein the mouthpiece section has a plurality of vent holes.

11. The aerosol generator as set forth in claim **10**, wherein the first end of the tube is disposed in the mouthpiece section between the vent holes and the open end of the mouthpiece.

12. The aerosol generator as set forth in claim **1**, further comprising a pressure drop detecting device for determining when a predetermined pressure drop occurs proximate the first end of the tube, the pressure drop detecting device being arranged to send a signal to the control device to indicate that the predetermined pressure drop is occurring, and the control device being arranged to control the power source to supply power to the valve and the heater in response to the signal from the pressure drop detecting device.

13. The aerosol generator as set forth in claim **12**, further comprising a mouthpiece section, the mouthpiece section having an open end, the tube being disposed in the mouthpiece section and the first end of the tube being disposed inside of the mouthpiece section at a distance from the open end.

14. The aerosol generator as set forth in claim **1**, wherein the control device includes a timer for controlling a frequency with which the control device controls the power supply to supply power to the valve and the heater.

15. The aerosol generator as set forth in claim **14**, further comprising a remote control device remote from the control device, the remote control device being adapted to adjust the timer to adjust the frequency with which the control device controls the power supply to supply power to the valve and the heater.

16. The aerosol generator as set forth in claim **14**, wherein the timer includes an indicator for indicating that the control device is available to control the power supply to supply power to the valve and the heater.

17. The aerosol generator as set forth in claim **1**, further comprising a display device, the display device being controlled by the control device and being adapted to display a number of times that the control device controls the power supply to supply power to the valve and the heater.

18. The aerosol generator as set forth in claim **17**, wherein the control device includes a timer for controlling a frequency with which the control device controls the power supply to supply power to the valve and the heater.

19. The aerosol generator as set forth in claim **18**, further comprising a remote control device remote from the control device, the remote control device being adapted to adjust the timer to adjust the frequency with which the control device controls the power supply to supply power to the valve and the heater.

20. The aerosol generator as set forth in claim **18**, wherein the display indicates when the timer will permit the control device to control the power supply to supply power to the valve and the heater.

21. The aerosol generator as set forth in claim **1**, wherein the control device is arranged to permit adjustment of at least one of an amount of time that the valve is in an open condition and an amount of time that power is supplied to the heater.

22. The aerosol generator as set forth in claim 21, further comprising a remote control device remote from the control device, the remote control device being adapted to adjust at least one of the amount of time that the valve is in an open condition and the amount of time that power is supplied to the heater.

23. The aerosol generator as set forth in claim 22, wherein the control device includes a timer for controlling a frequency with which the control device controls the power supply to supply power to the valve and the heater.

24. The aerosol generator as set forth in claim 23, wherein the remote control device is adapted to adjust the timer to adjust the frequency with which the control device controls the power supply to supply power to the valve and the heater.

25. The aerosol generator as set forth in claim 1, wherein a rate of power supplied from the source of power to the heater and a diameter of the tube are selected to cause the aerosol generator to produce an aerosol having a mass median particle diameter of less than 3 microns.

26. The aerosol generator as set forth in claim 25, wherein the aerosol has a mass median particle diameter of less than 2 microns.

27. The aerosol generator as set forth in claim 25, wherein the aerosol has a mass median particle diameter of between 0.2 and 2 microns.

28. The aerosol generator as set forth in claim 25, wherein the aerosol has a mass median particle diameter between 0.5 and 1 microns.

29. The aerosol generator as set forth in claim 1, wherein a length of the tube, a pressure with which the pressurization arrangement supplies the material from the source of material, and a rate at which power is supplied from the source of power are selected so that the material is supplied and volatilized in the tube at a rate greater than 1 milligram per second.

30. The aerosol generator as set forth in claim 1, further comprising a source of a second material in liquid form to the tube together with the material, the source of second material communicating with the tube at a point before the heater, the pressurization arrangement causing material in the source of second material to be introduced into the tube from the source of material when the valve is in an open position.

31. The aerosol generator as set forth in claim 30, wherein the source of material includes a flexible container and the source of second material includes a second flexible container, and the pressurization arrangement includes a chamber in which the flexible container is disposed, and a pressurized gas sealed in the chamber and surrounding the flexible container, and a second chamber in which the second flexible container is disposed, and a second pressurized gas sealed in the chamber and surrounding the second flexible container.

32. The aerosol generator as set forth in claim 31, wherein the pressurized gas and the second pressurized gas are pressurized to different pressures.

33. The aerosol generator as set forth in claim 1, further comprising

a second tube having a first and a second end,

a second heater arranged relative to the second tube for heating at least a portion of the second tube,

a source of second material to be volatilized, the second end of the second tube being in communication with the source of second material, and

a second valve operatively located between the source of second material and the second tube, the second valve being openable and closeable to open and close communication between the source of second material and the first end of the second tube,

a second pressurization arrangement for causing material in the source of second material to be introduced into the second tube from the source of second material when the second valve is in an open position, and

wherein the source of power supplies power for operating the second heater and the second valve, and the control device controls supply of power from the source of power to the second heater and the second valve.

34. The aerosol generator as set forth in claim 33, further comprising a chamber, the first ends of the tube and the second tube being disposed in the chamber proximate each other, the chamber being of sufficient size and configuration to permit mixture of volatilized material and volatilized second material that expands out of the tube and the second tube together with ambient air such that the volatilized material and the volatilized second material form first and second aerosols, respectively, the first and second aerosols being mixed with each other to form a combination aerosol including the first and second aerosols.

35. The aerosol generator as set forth in claim 1, wherein material in the source of material includes two or more components mixed together before the material is volatilized.

36. The aerosol generator as set forth in claim 35, wherein solid particles are suspended in solution in the material.

37. The aerosol generator as set forth in claim 36, wherein the solid particles, when suspended in solution, are of a larger average diameter than particles of the material after the material is volatilized and is in aerosol form.

38. The aerosol generator as set forth in claim 37, wherein the solid particles, when they form a part of the aerosol, are of a larger average diameter than particles of the material after the material is volatilized and is in aerosol form.

39. The aerosol generator as set forth in claim 36, wherein the solid particles, when they form a part of the aerosol, are of a larger average diameter than particles of the material after the material is volatilized and is in aerosol form.

40. The aerosol generator as set forth in claim 1, wherein the valve is a microvalve.

41. The aerosol generator as set forth in claim 1, wherein the valve, the heater, and the tube are a single microelectronic machine formed on a single chip.

42. The aerosol generator as set forth in claim 1, wherein the aerosol generator includes a first component and a second component, the second component being attachable and detachable to the first component, the first component including the tube, the heater, the valve, the source of material, and the pressurization arrangement, and the second component including the source of power and the control device.

43. The aerosol generator as set forth in claim 42, further comprising an air flow detecting device for determining when a predetermined air flow rate exists proximate the first end of the tube, the air flow detecting device being arranged to send a signal to the controller to indicate that the predetermined air flow rate exists, and the controller being arranged to control the power source to supply power to the valve and the heater in response to the signal from the air flow detecting device.

44. The aerosol generator as set forth in claim 43, wherein the air flow detecting device is permanently attached to the second component.

45. The aerosol generator as set forth in claim **43**, further comprising a mouthpiece section forming part of the first component, the mouthpiece section having an open end, the tube being disposed in the mouthpiece section and the first end of the tube being disposed inside of the mouthpiece section at a distance from the open end.

46. The aerosol generator as set forth in claim **45**, wherein the mouthpiece section has a plurality of vent holes.

47. The aerosol generator as set forth in claim **45**, wherein the first end of the tube is disposed in the mouthpiece section between the vent holes and the open end of the mouthpiece.

48. The aerosol generator as set forth in claim **42**, further comprising a pressure drop detecting device for determining when a predetermined pressure drop occurs proximate the first end of the tube, the pressure drop detecting device being arranged to send a signal to the controller to indicate that the predetermined pressure drop is occurring, and the controller being arranged to control the power source to supply power to the valve and the heater in response to the signal from the pressure drop detecting device.

49. The aerosol generator as set forth in claim **48**, further comprising a mouthpiece section forming part of the first component, the mouthpiece section having an open end, the tube being disposed in the mouthpiece section and the first end of the tube being disposed inside of the mouthpiece section at a distance from the open end.

50. The aerosol generator as set forth in claim **42**, wherein the first component includes

a second tube having a first and a second end,

a second heater arranged relative to the second tube for heating the second tube,

a second valve operatively located between the source of second material and the second tube, the second valve being openable and closeable to open and close communication between the source of second material and the first end of the second tube,

a source of second material to be volatilized, the second end of the second tube being in communication with the source of second material, and

a second pressurization arrangement for causing material in the source of second material to be introduced into the second tube from the source of second material when the second valve is in an open position, and

wherein the source of power supplies power for operating the second heater and the second valve, and the control device controls supply of power from the source of power to the second heater and the second valve.

51. The aerosol generator as set forth in claim **50**, further comprising a chamber, the first ends of the tube and the second tube being disposed in the chamber proximate each other, the chamber being of sufficient size and configuration to permit mixture of volatilized material and volatilized second material that expands out of the tube and the second tube together with ambient air such that the volatilized material and the volatilized second material form first and second aerosols, respectively, the first and second aerosols being mixed with each other to form a combination aerosol including the first and second aerosols.

52. The aerosol generator as set forth in claim **1**, wherein the source of material includes a second tube having first and second ends, the first end of the second tube being connected to the second end of the tube, and wherein the pressurization arrangement includes a chamber filled with a pressurized gas, the second end of the second tube being disposed in the chamber.

53. A method of making an aerosol generator, comprising the steps of:

arranging a heater relative to a tube for heating of the tube, the tube having first and second ends;

connecting the second end of the tube to a source of material to be volatilized;

providing an openable and closeable valve between the source of material and the tube;

providing a pressurization arrangement for causing material in the source of material to be introduced into the tube from the source of material when the valve is in an open position;

connecting the valve to a source of power for opening and closing the valve;

connecting the heater to the source of power;

connecting the source of power to a control device for controlling a supply of power from the source of power to the heater and the valve.

54. The method as set forth in claim **53**, wherein the step of providing a pressurization arrangement includes positioning of the source of material in a chamber and pressurizing the chamber.

55. The method as set forth in claim **54**, wherein the chamber is pressurized to about two atmospheres.

56. The method as set forth in claim **54**, wherein the source of material includes a flexible container.

57. The method as set forth in claim **54**, wherein the source of material includes a second tube having first and second ends, the method comprising the further steps of connecting the first end of the second tube to the second end of the tube and positioning the second end of the second tube in the chamber.

58. The method as set forth in claim **53**, wherein the source of power is selected such that it is adapted to deliver power at a sufficient rate to the heater and the tube is selected to have an appropriate diameter such that the aerosol generator produces an aerosol having a mass median particle diameter of less than 3 microns.

59. The method as set forth in claim **53**, wherein a length of the tube, a pressure with which the pressurization arrangement supplies the material from the source of material, and a rate at which the source of power is adapted to supply power to the heater are selected so that the material is supplied and volatilized in the tube at a rate greater than 1 milligram per second.

60. The method as set forth in claim **53**, wherein the heater, the tube, the valve, the source of material, and the pressurization arrangement are arranged relative to each other to form a first component, and the source of power and the control device are arranged relative to each other to form a second component, the second component being attachable and detachable to the first component.

61. A method of using an aerosol generator, comprising the steps of:

providing a first signal, indicative of a user's intention to use the aerosol generator, to a control device;

sending, with the control device and in response to the first signal, a second signal to a source of power to cause the source of power to open an openable and closeable valve, the valve being disposed between a source of material to be volatilized and a tube, opening of the valve permitting material from the source of material to flow from the source of material and into the tube;

causing material from the source of material to flow from the source of material and into the tube;

sending, with the control device and in response to the first signal, a third signal to the source of power to supply power to a heater disposed relative to the tube to heat the tube; and

heating material from the source of material in the tube with the heater to a vaporization temperature such that the material volatilizes and expands out of an open end of the tube.

62. The method as set forth in claim **61**, wherein the first signal is provided by a user pressing a button.

63. The method as set forth in claim **61**, wherein the first signal is provided by a user drawing on a mouthpiece in such a manner as to operate an air flow detecting device disposed proximate the first end of the tube.

64. The method as set forth in claim **61**, wherein the first signal is provided by a user drawing on a mouthpiece in such a manner as to operate a puff actuated sensor disposed proximate the first end of the tube.

65. The method as set forth in claim **61**, wherein the source of material includes a flexible container, and wherein material in the source of material is caused to flow from the source of material by a pressurization arrangement.

66. The method as set forth in claim **65**, wherein the pressurization arrangement includes a chamber filled with gas under pressure and in which the flexible container is disposed.

67. The method as set forth in claim **61**, wherein the source of material includes a second tube having first and second ends, the first end of the second tube being connected to the second end of the tube, and wherein material in the source of material is caused to flow from the source of material by a pressurization arrangement.

68. The method as set forth in claim **67**, wherein the pressurization arrangement includes a chamber filled with gas under pressure and in which the second end of the second tube is disposed.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,234,167 B1
DATED : May 22, 2001
INVENTOR(S) : Kenneth A. Cox et al.

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

Title page,
Item [56], **References Cited**, FOREIGN PATENT DOCUMENTS delete the references "EP 358114 issued 3/1990" and "EP 642802 issued 3/1995", first occurrence of each;

Column 12,
Line 13, delete "PV" and insert therefor -- P_v --;

Column 16, claim 43,
Line 60, delete "controller" and insert therefor -- control device --;

Column 17, claim 48,
Lines 17 and 18, delete "controller" and insert therefor -- control device --.

Signed and Sealed this

Sixteenth Day of April, 2002

Attest:

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

Attesting Officer

US006250132B1

(12) **United States Patent**
Drzewiecki

(10) **Patent No.: US 6,250,132 B1**

(45) **Date of Patent: Jun. 26, 2001**

(54) **METHOD AND APPARATUS FOR REAL TIME GAS ANALYSIS**

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(73) Assignee: **metaSENSORS, Inc.**, Rockville, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/468,792**

(22) Filed: **Dec. 21, 1999**

Related U.S. Application Data

(62) Division of application No. 09/104,997, filed on Jun. 26, 1998, now Pat. No. 6,076,392.

(60) Provisional application No. 60/069,422, filed on Dec. 18, 1997, and provisional application No. 60/055,982, filed on Aug. 18, 1997.

(51) **Int. Cl.**[7] **G01N 11/04**; G01N 29/02; G01F 1/20; G01F 25/00; G01P 1/00

(52) **U.S. Cl.** **73/23.2**; 73/24.05; 73/53.04; 73/54.11; 73/61.43; 73/861.43; 73/861.19; 73/861.61; 137/92; 137/835; 340/632; 340/603; 422/82; 422/68.1

(58) **Field of Search** 73/23.2, 24.05, 73/24.01, 53.01, 61.43, 61.44, 61.52, 64.45, 23.35, 23.22, 204.21, 861.61, 861.63, 861.19, 54.11, 53.04, 23.24, 23.27; 422/82, 84, 68.1; 340/603, 632; 137/91–93, 835

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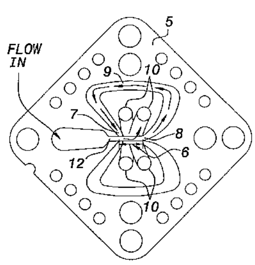
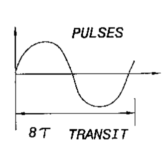
Primary Examiner—Hezron Williams
Assistant Examiner—David J. Wiggins

(57) **ABSTRACT**

A modular apparatus for analyzing a fluid includes a disposable fluidic sensor module, a replaceable transducer module, and an expendable electronics package. The disposable fluidic sensor includes a fluidic flowmeter and a capillary structure formed in a plate-like member which receives a sample fluid flow. The fluidic flowmeter is responsive to the fluid flow to generate an output indicative of the flow rate of the fluid, and the capillary structure restricts the fluid flow such that a pressure drop across the capillary structure is related to the viscosity of the fluid. The fluidic flowmeter can be a fluidic oscillator whose oscillation frequency is related to the fluid flow rate. The oscillator flowmeter also serves as an orifice, with the pressure drop across the oscillator being related to the density of the fluid. The replaceable transducer module is connectable to the fluidic sensor module via a separable interface, and includes transducers for measuring physical conditions of the fluid flowing through the fluidic sensor module. The expendable electronics package includes a processor responsive to transducer signals generated by the transducers for determining properties and conditions of the fluid, such as flow rate, density and viscosity, and for determining individual concentrations of fluid constituents of the fluid from these parameters.

18 Claims, 19 Drawing Sheets





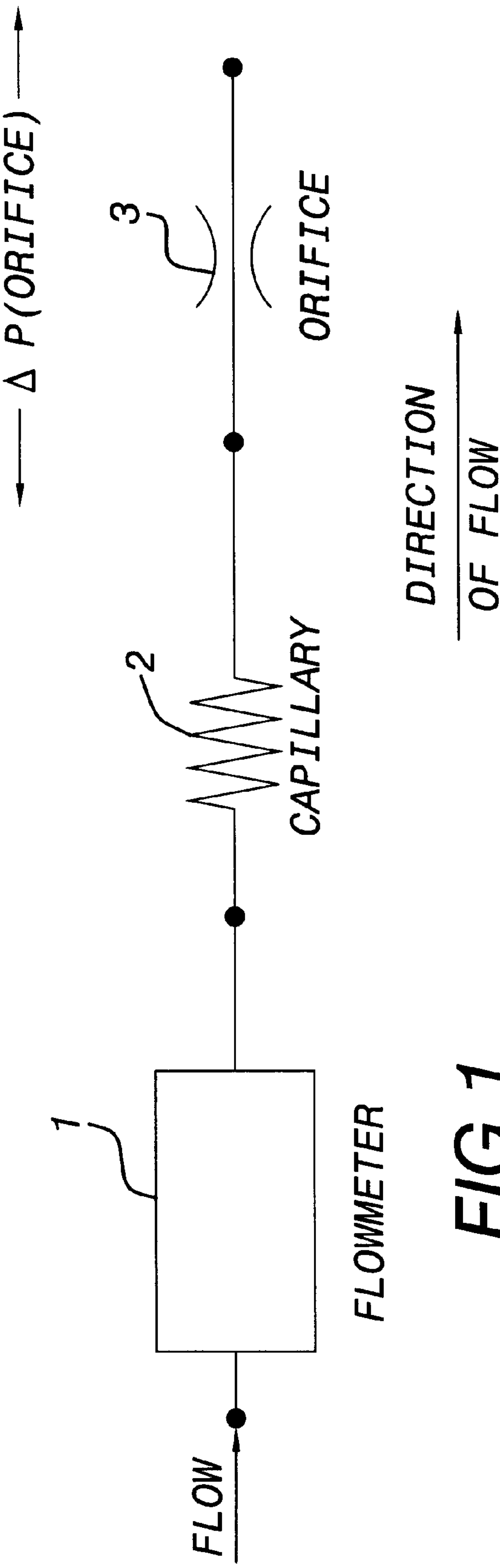
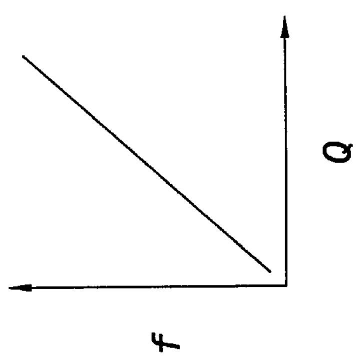

Δ P(ORIFICE)
3
ORIFICE
DIRECTION OF FLOW
2
CAPILLARY
1
FLOWMETER
FLOW

FIG. 1


f
Q

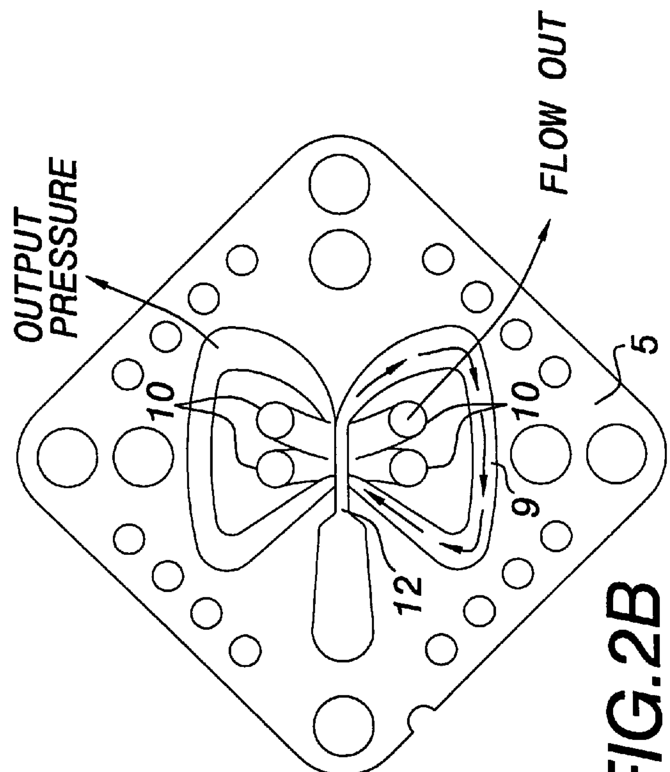

OUTPUT PRESSURE
FLOW OUT
10
10
9
12
5

FIG.2B

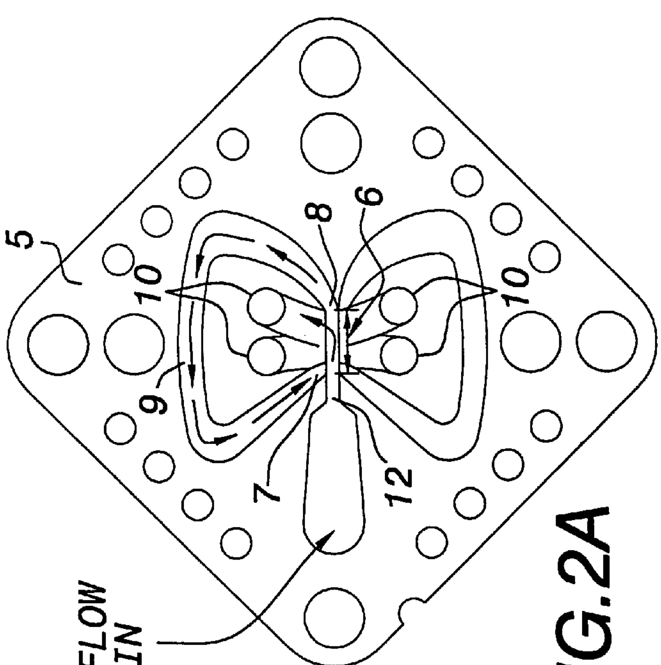

5
10
8
6
10
9
7
12
FLOW IN

FIG.2A

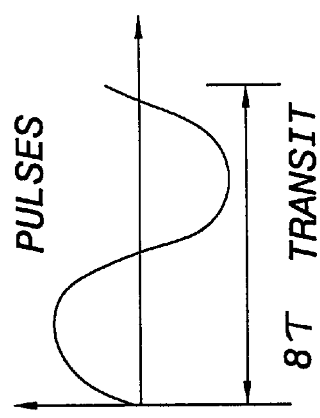
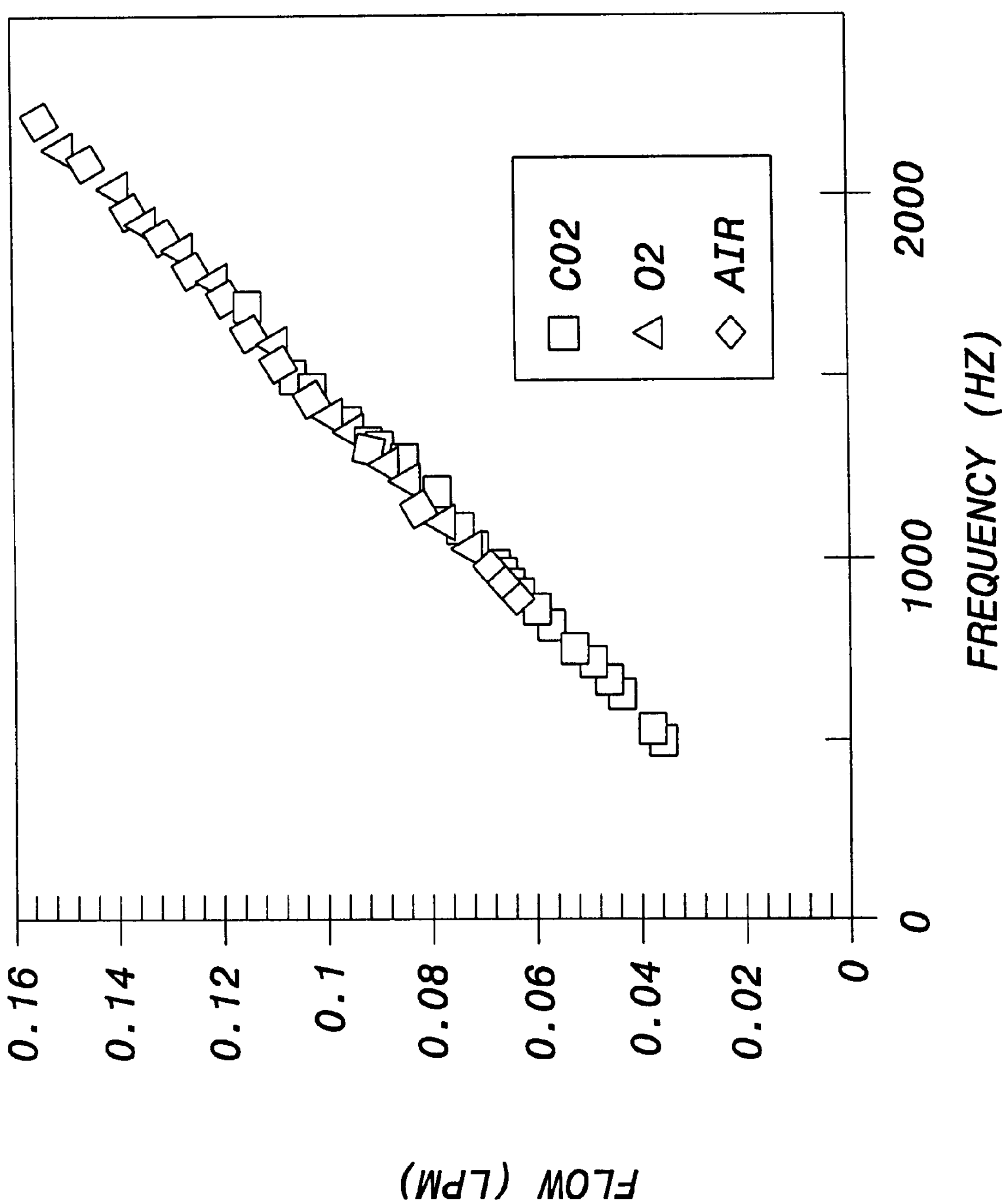
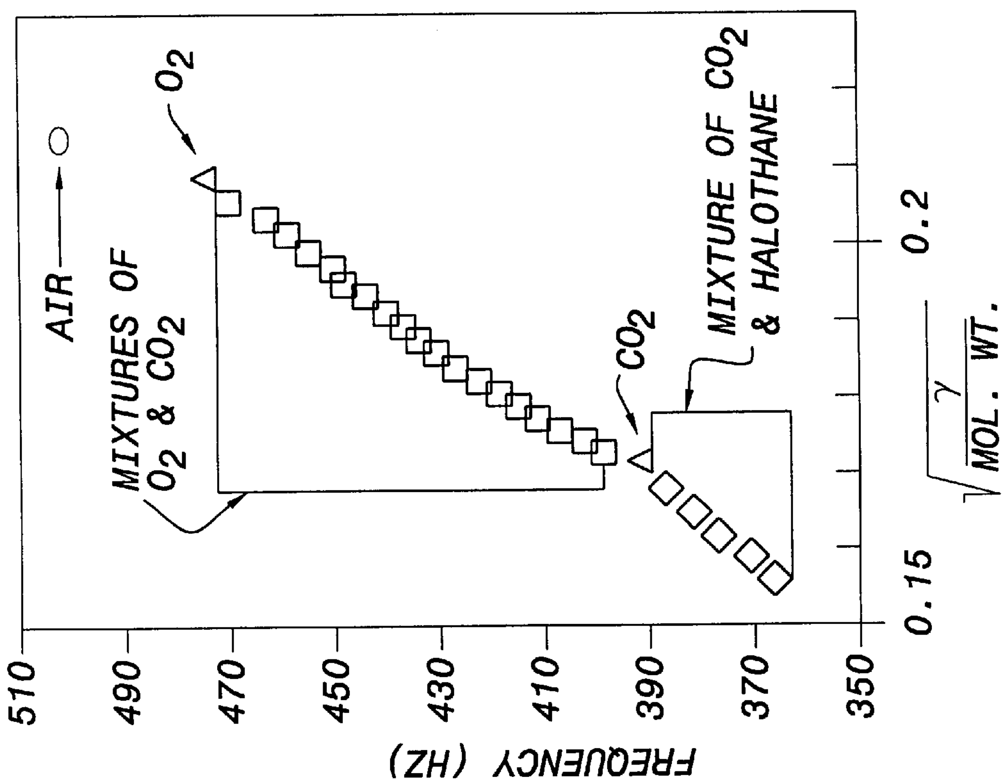

PULSES
TRANSIT
8T

FIG.3



CO2
O2
AIR
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
FLOW (LPM)
0
1000
2000
FREQUENCY (HZ)

FIG.8


AIR
MIXTURES OF O_2 & CO_2
O_2
CO_2
MIXTURE OF CO_2 & HALOTHANE
FREQUENCY (HZ)
510
490
470
450
430
410
390
370
350
0.15
0.2
$\sqrt{\frac{\gamma}{MOL.\ WT.}}$

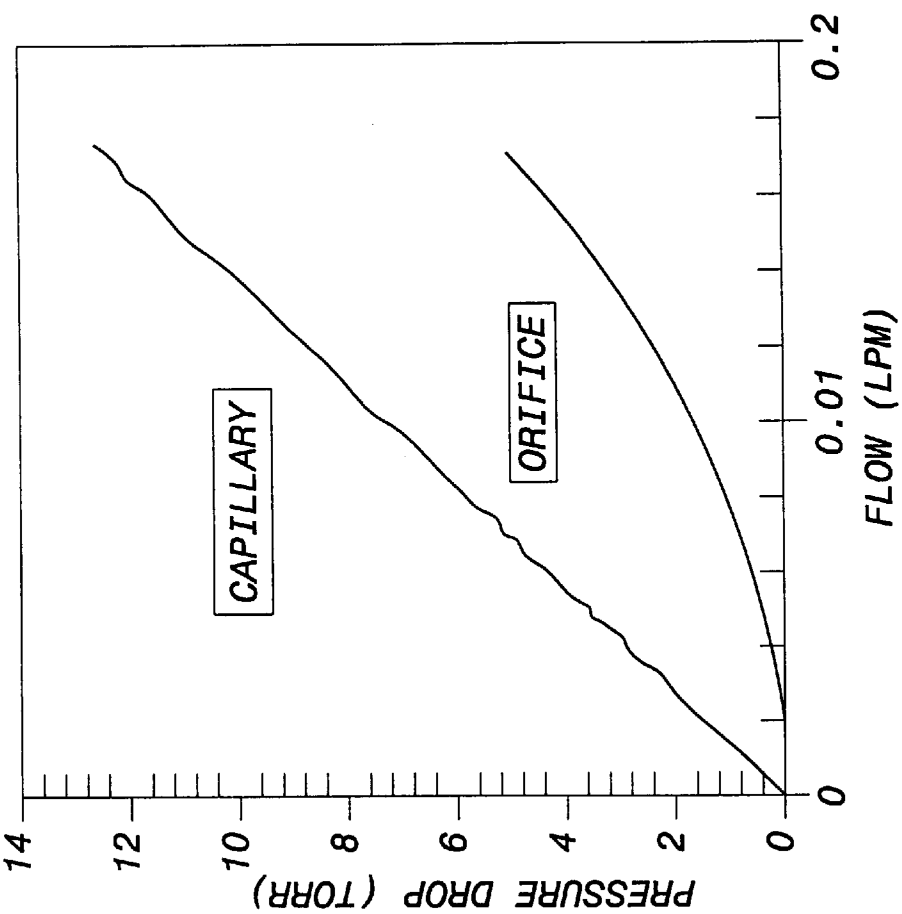
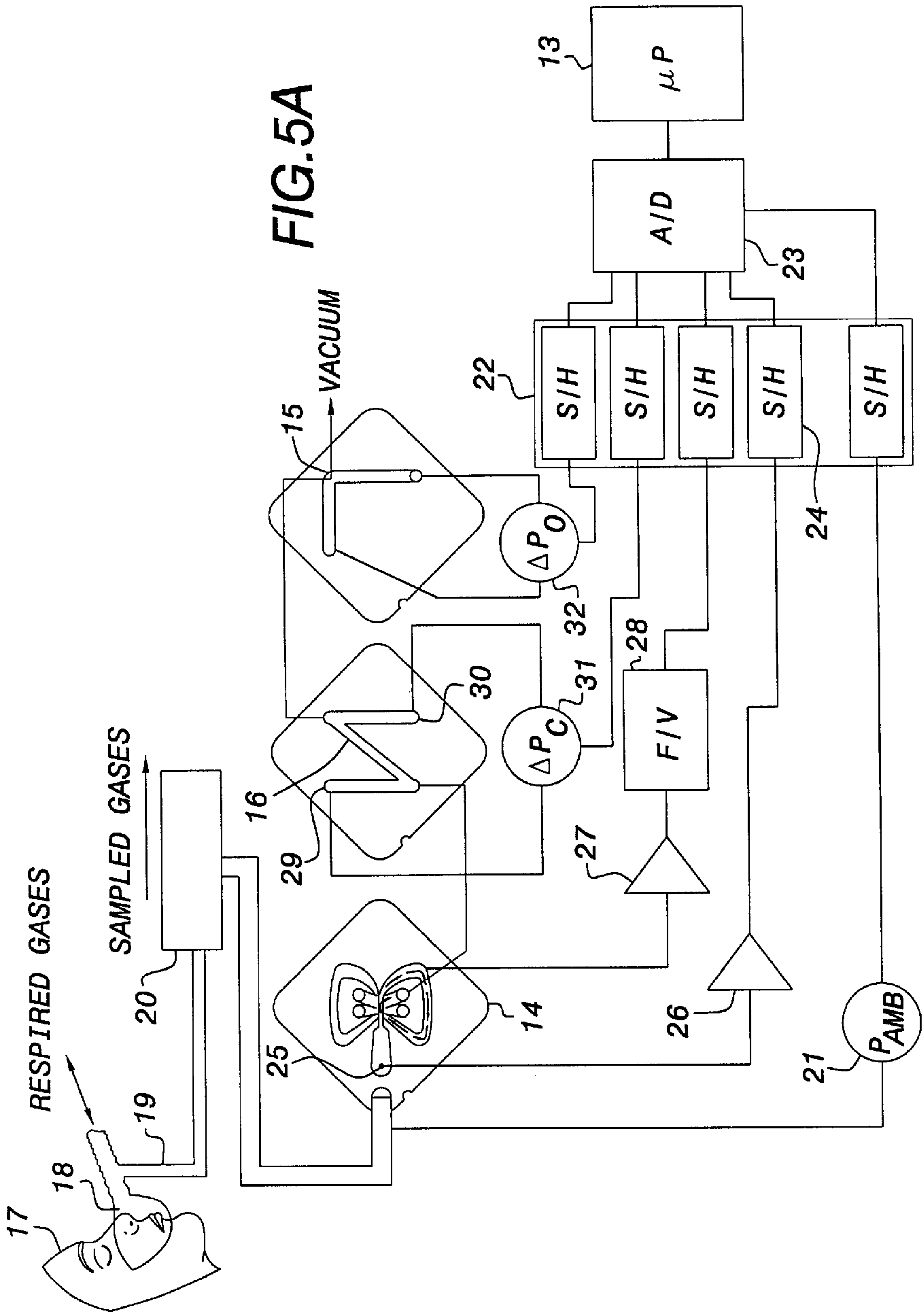

CAPILLARY
ORIFICE
PRESSURE DROP (TORR)
14
12
10
8
6
4
2
0
0
0.01
0.2
FLOW (LPM)

FIG.4



RESPIRED GASES
SAMPLED GASES
VACUUM
μP
A/D
S/H
S/H
S/H
S/H
S/H
F/V
ΔP_O
ΔP_C
P_{AMB}
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

FIG.5A

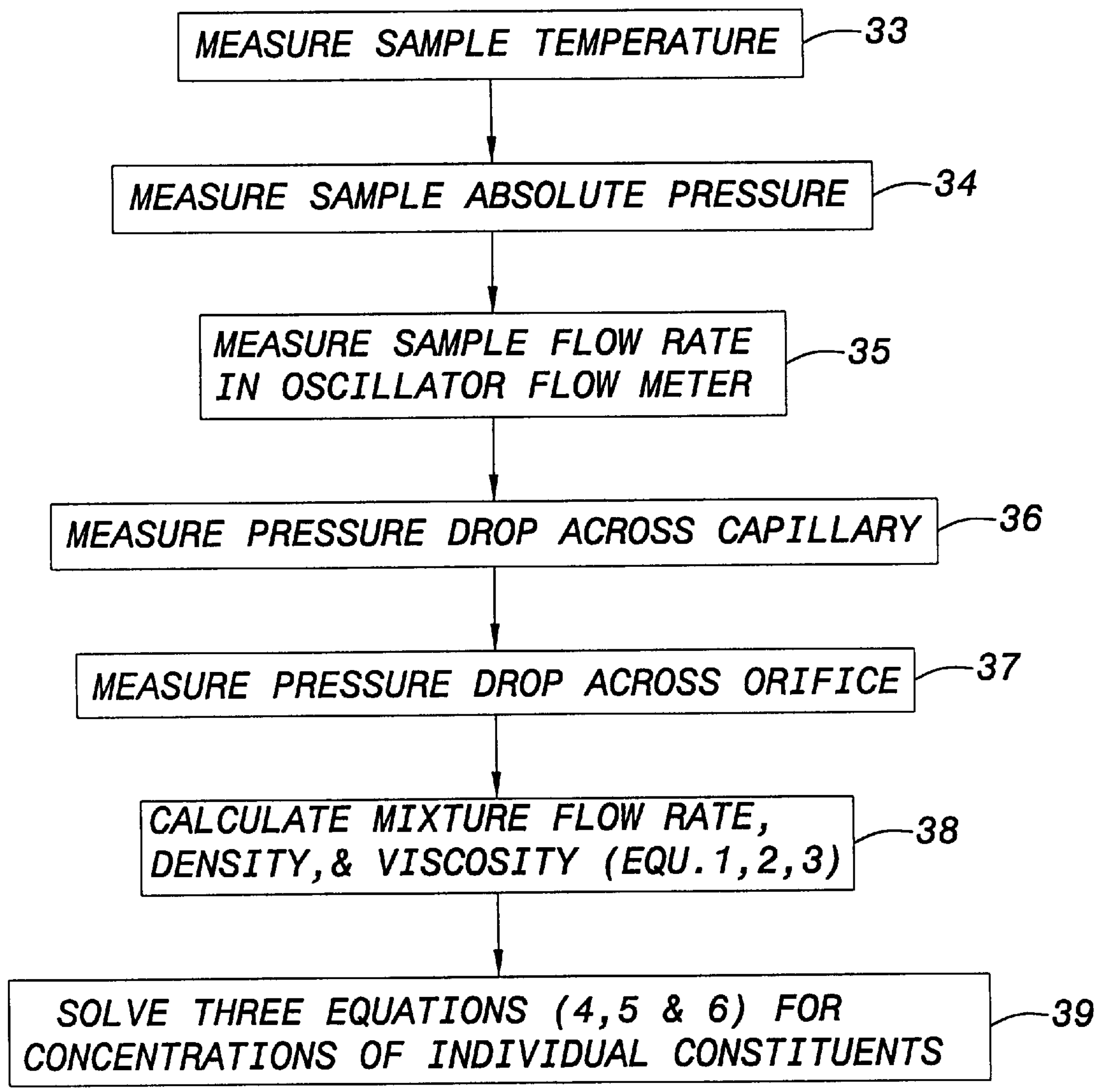

MEASURE SAMPLE TEMPERATURE
33
MEASURE SAMPLE ABSOLUTE PRESSURE
34
MEASURE SAMPLE FLOW RATE IN OSCILLATOR FLOW METER
35
MEASURE PRESSURE DROP ACROSS CAPILLARY
36
MEASURE PRESSURE DROP ACROSS ORIFICE
37
CALCULATE MIXTURE FLOW RATE, DENSITY,& VISCOSITY (EQU.1,2,3)
38
SOLVE THREE EQUATIONS (4,5 & 6) FOR CONCENTRATIONS OF INDIVIDUAL CONSTITUENTS
39

FIG.5B

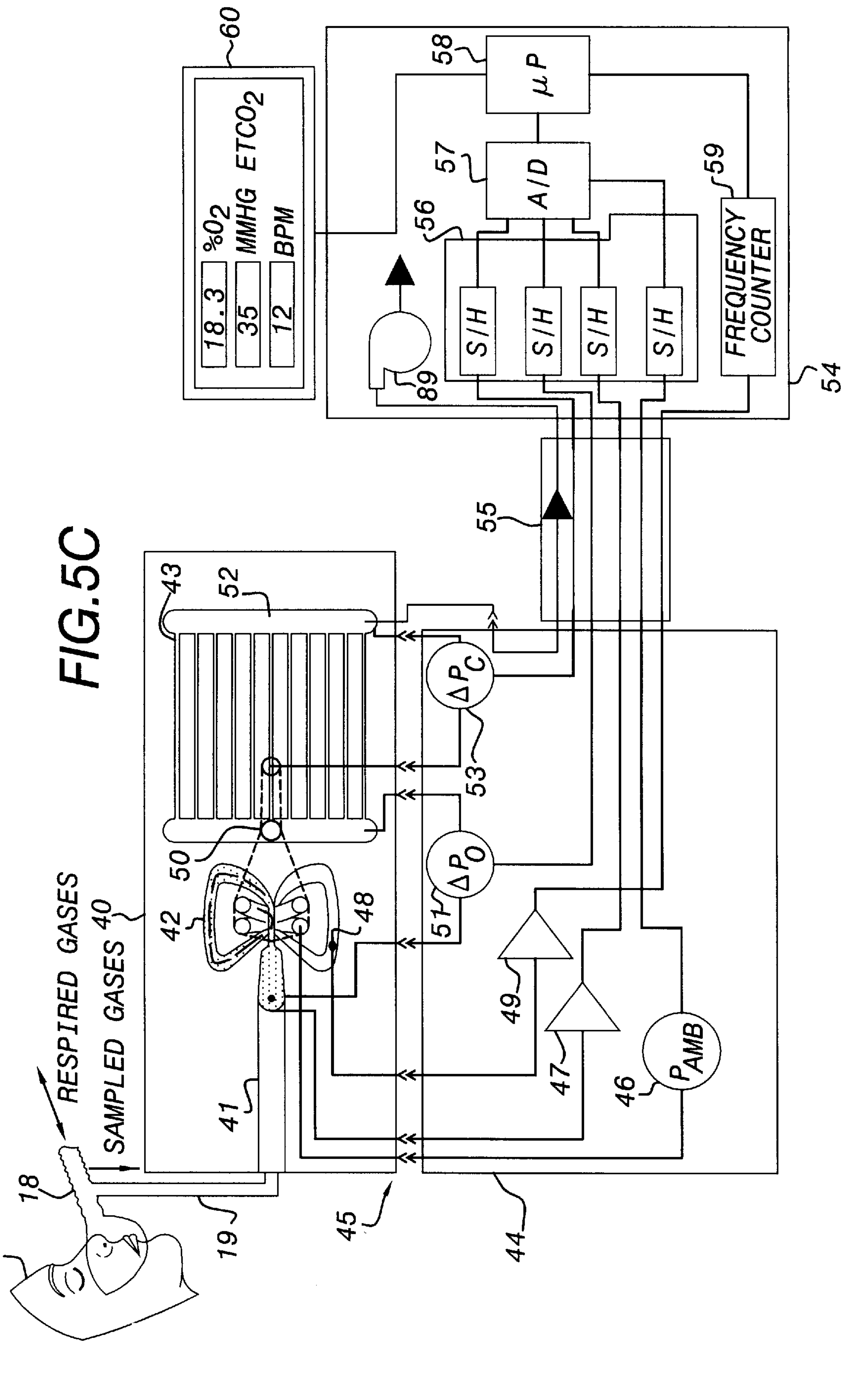

%O2
MMHG ETCO2
BPM
18.3
35
12
60
58
μP
57
A/D
56
S/H
S/H
S/H
S/H
59
FREQUENCY COUNTER
89
54
55
43
52
ΔPC
53
ΔPO
50
51
RESPIRED GASES
SAMPLED GASES
40
42
48
49
47
46
PAMB
41
18
17
19
45
44

FIG.5C

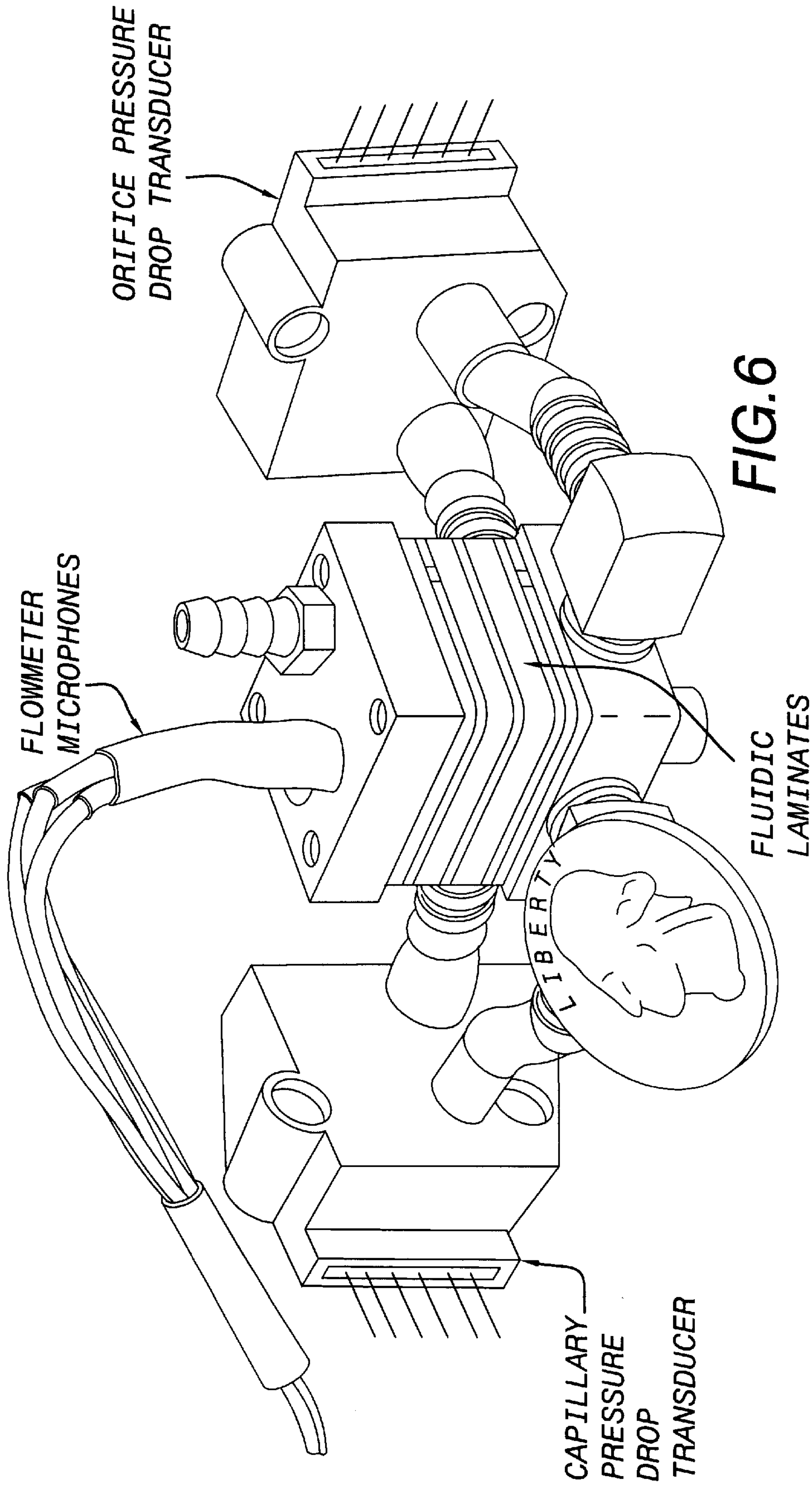

ORIFICE PRESSURE DROP TRANSDUCER
FLOWMETER MICROPHONES
FLUIDIC LAMINATES
LIBERTY
CAPILLARY PRESSURE DROP TRANSDUCER

FIG.6

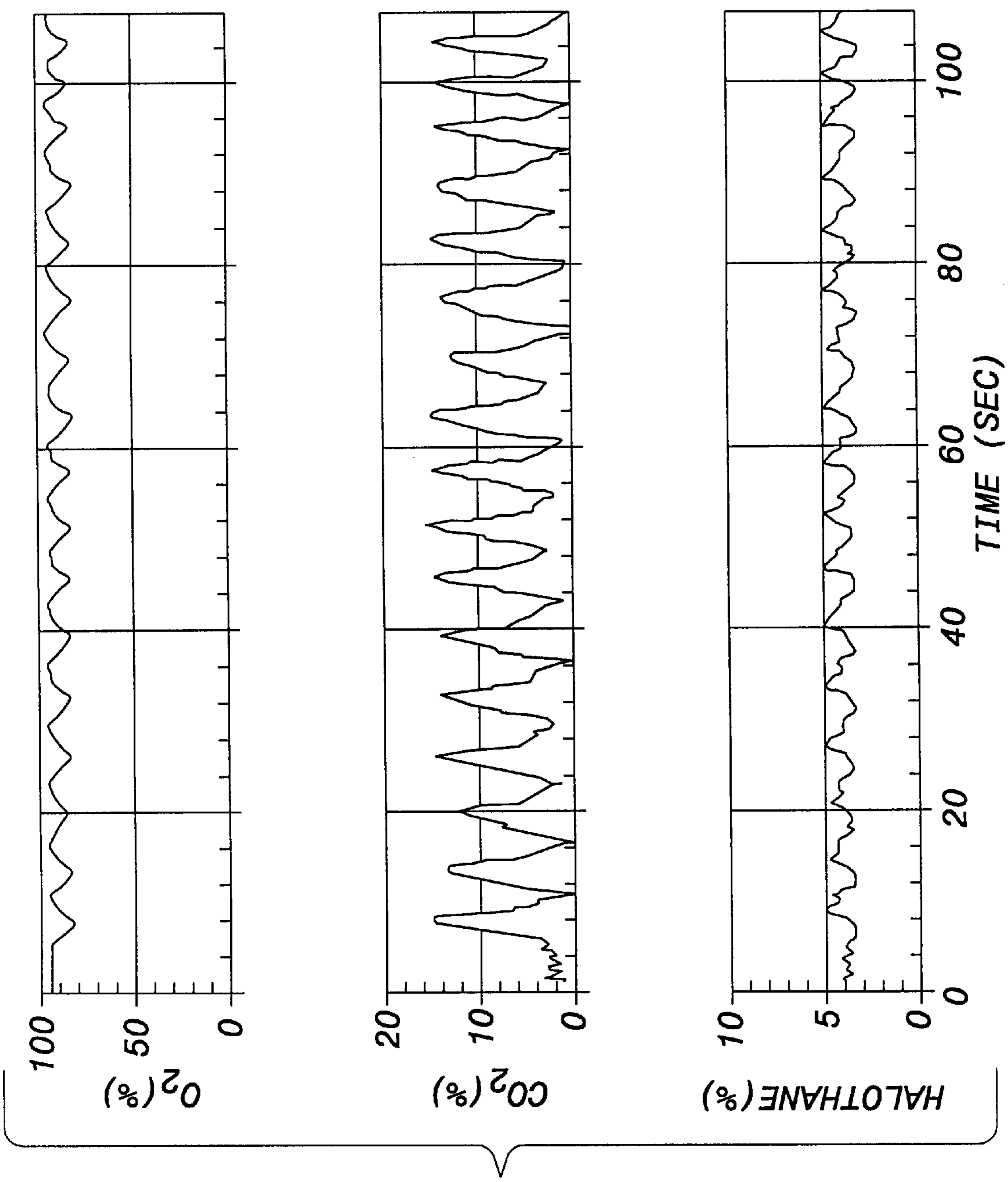


FIG.7A

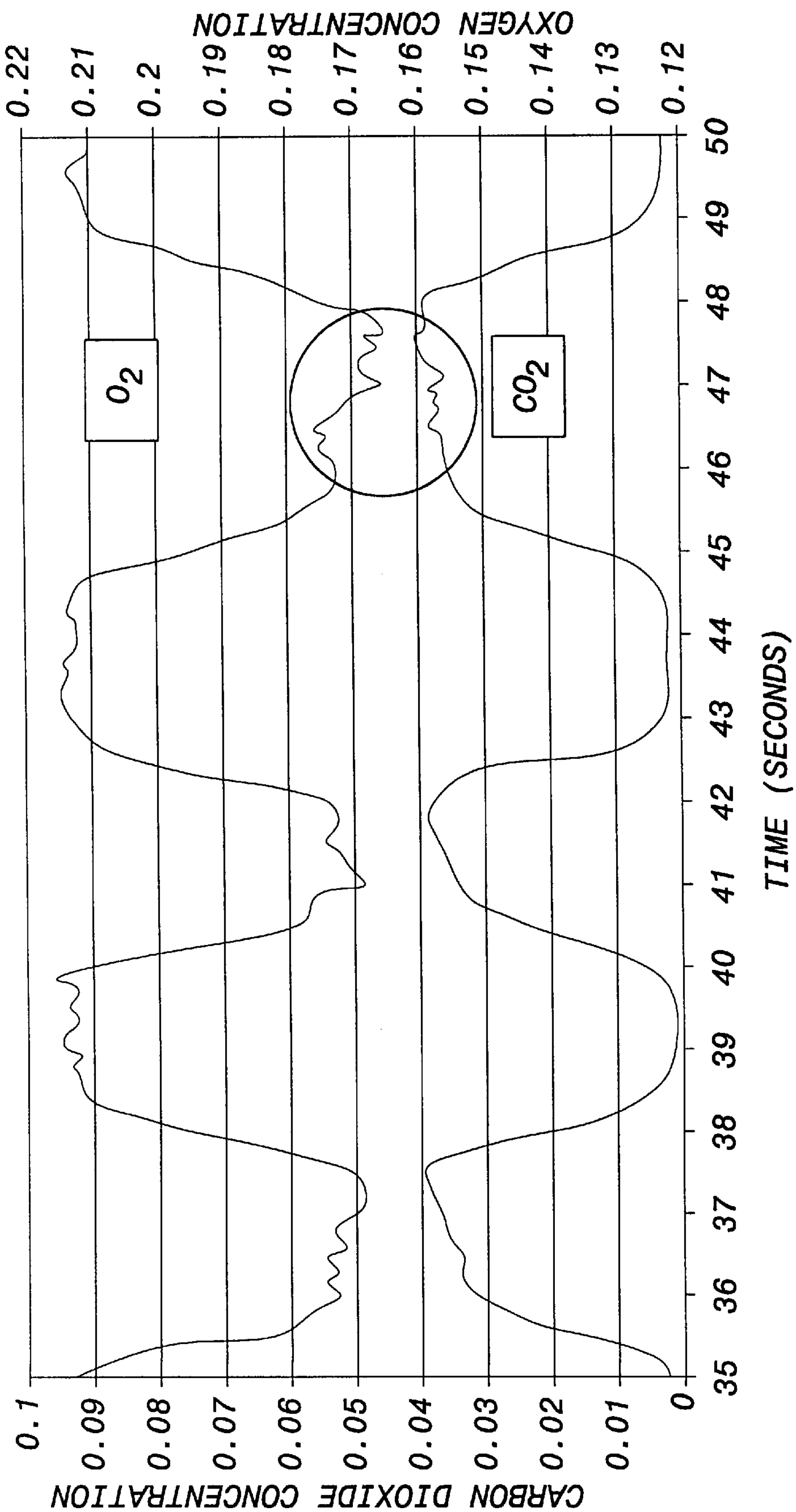

OXYGEN CONCENTRATION
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
O_2
CO_2
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
TIME (SECONDS)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
CARBON DIOXIDE CONCENTRATION

FIG.7B

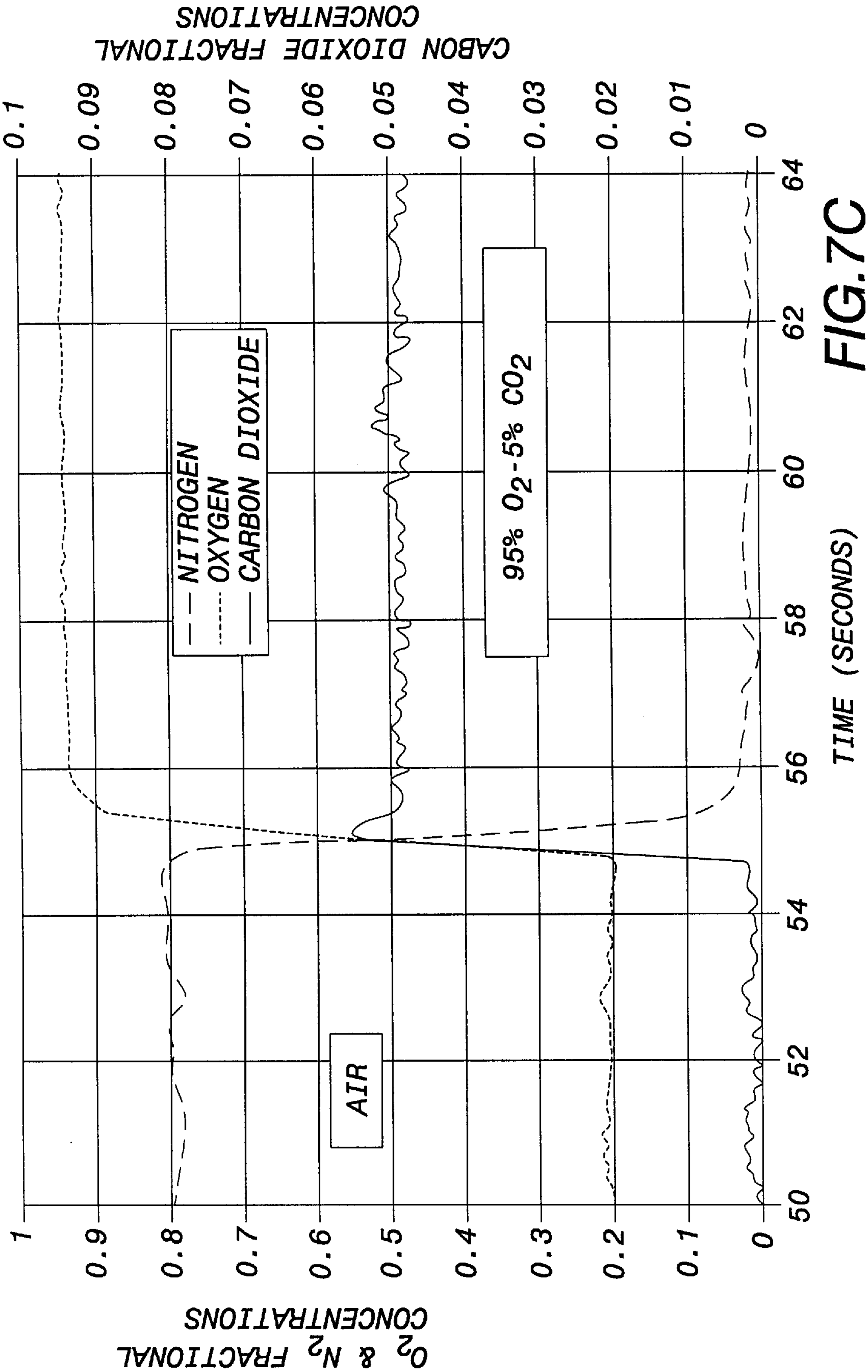

CABON DIOXIDE FRACTIONAL CONCENTRATIONS
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
NITROGEN
OXYGEN
CARBON DIOXIDE
95% O_2-5% CO_2
AIR
50
52
54
56
58
60
62
64
TIME (SECONDS)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
O_2 & N_2 FRACTIONAL CONCENTRATIONS

FIG.7C

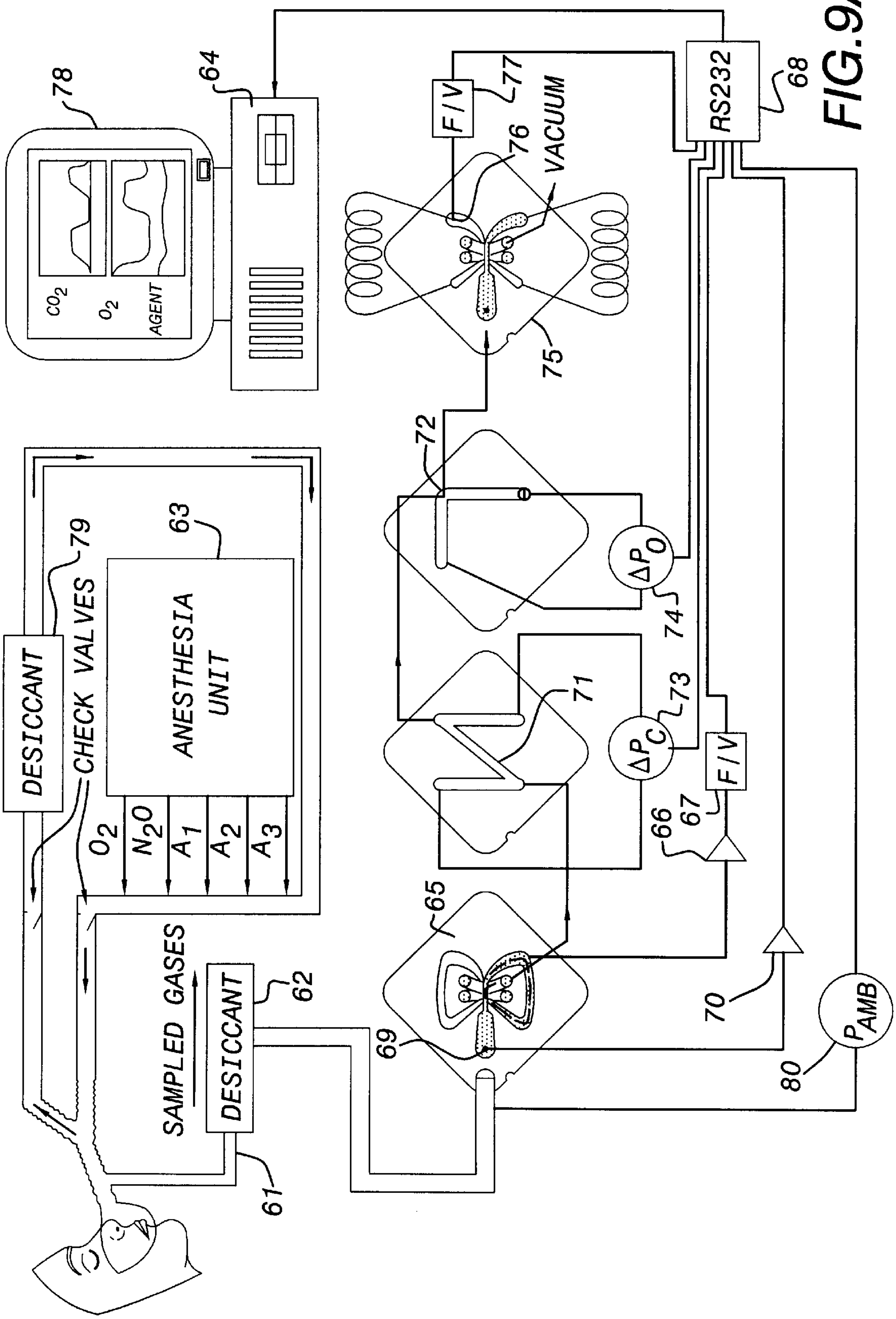

78
64
CO_2
O_2
AGENT
RS232
68
F/V
77
76
VACUUM
75
72
DESICCANT
79
CHECK VALVES
63
ANESTHESIA UNIT
O_2
N_2O
A_1
A_2
A_3
ΔP_O
74
71
ΔP_C
73
F/V
67
66
65
SAMPLED GASES
DESICCANT
62
69
70
P_{AMB}
80
61

FIG.9A

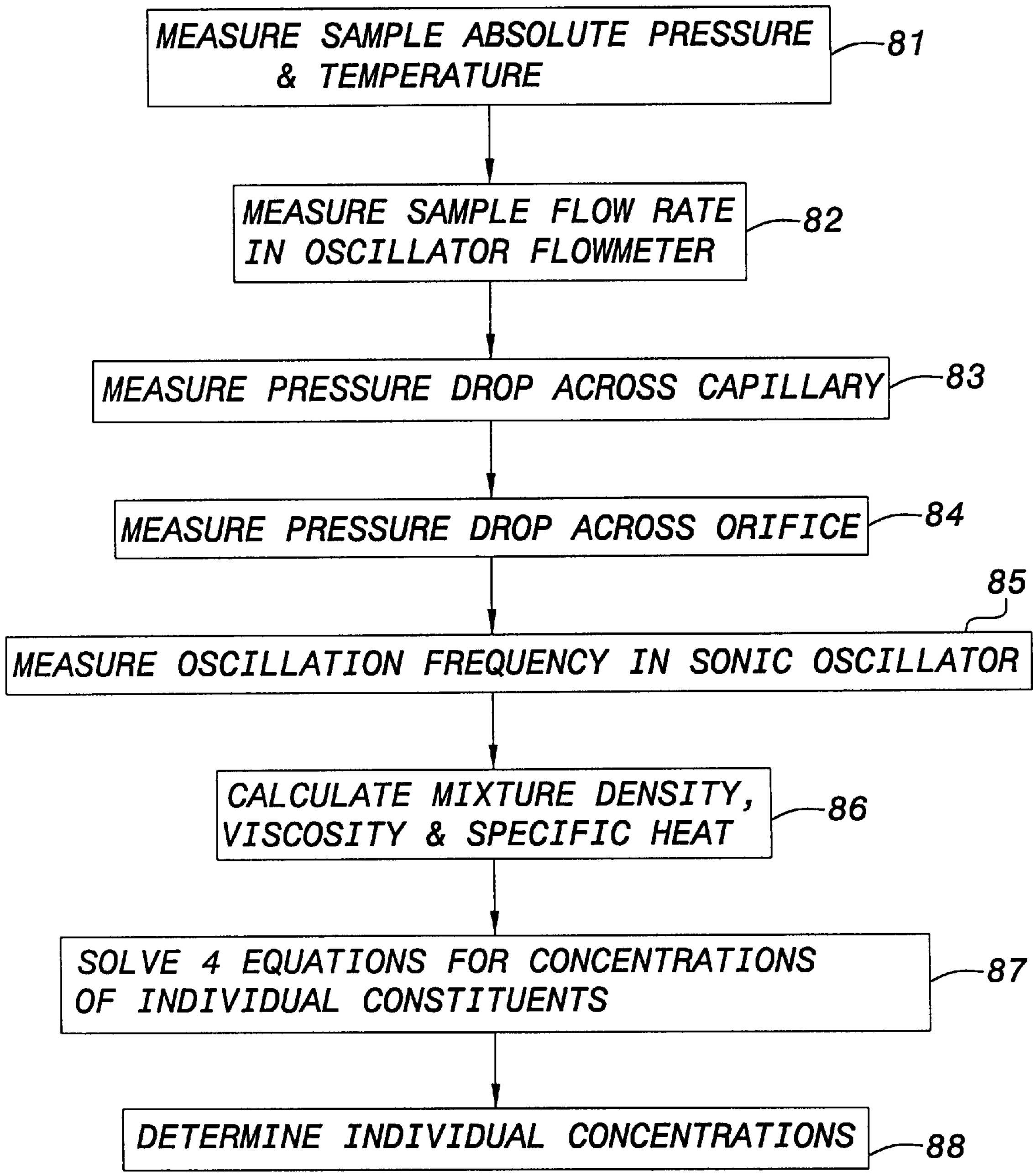

MEASURE SAMPLE ABSOLUTE PRESSURE & TEMPERATURE
81
MEASURE SAMPLE FLOW RATE IN OSCILLATOR FLOWMETER
82
MEASURE PRESSURE DROP ACROSS CAPILLARY
83
MEASURE PRESSURE DROP ACROSS ORIFICE
84
85
MEASURE OSCILLATION FREQUENCY IN SONIC OSCILLATOR
CALCULATE MIXTURE DENSITY, VISCOSITY & SPECIFIC HEAT
86
SOLVE 4 EQUATIONS FOR CONCENTRATIONS OF INDIVIDUAL CONSTITUENTS
87
DETERMINE INDIVIDUAL CONCENTRATIONS
88

FIG.9B

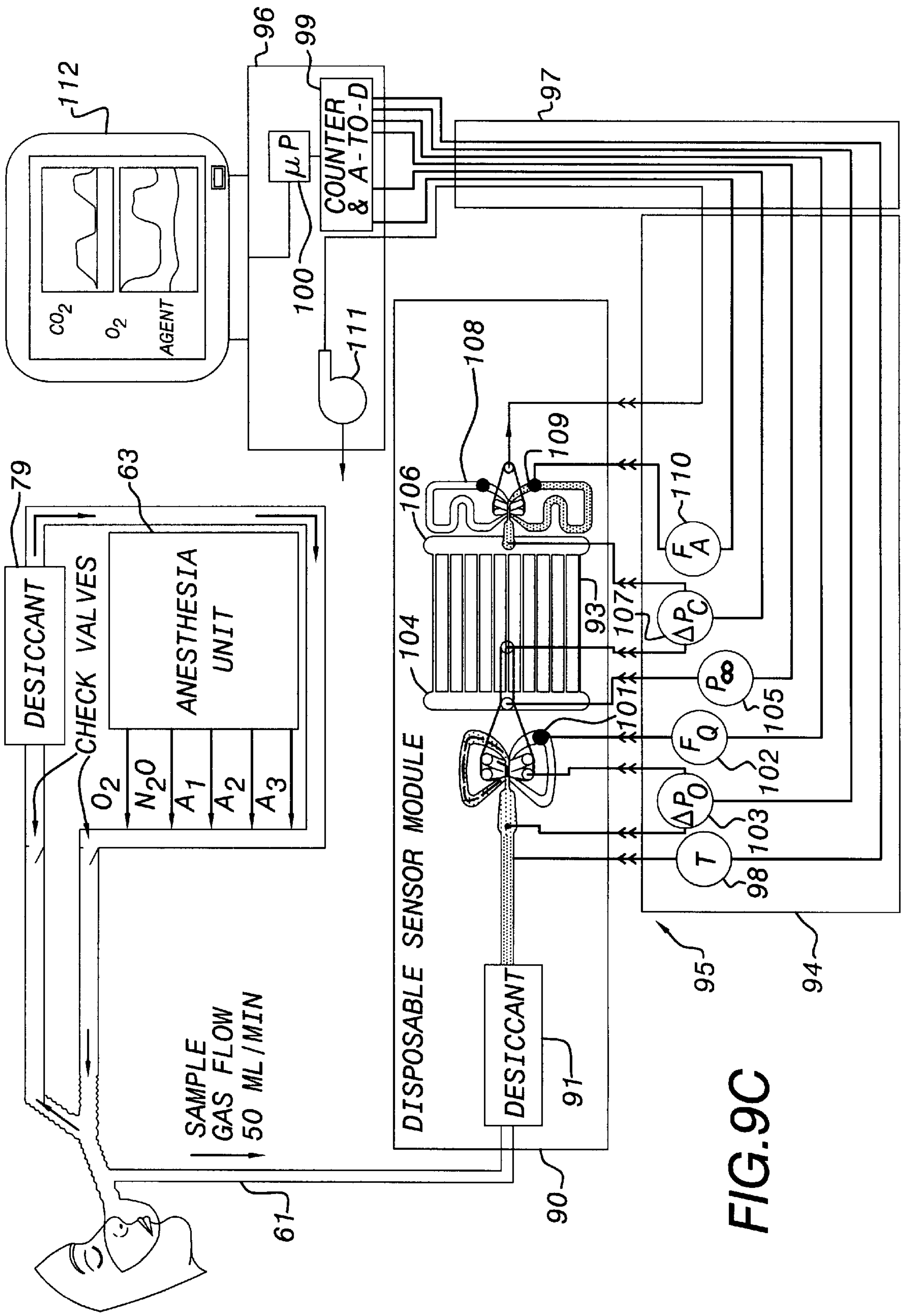

112
96
99
97
μP
COUNTER & A-TO-D
CO_2
O_2
AGENT
100
111
108
109
110
106
79
63
DESICCANT
CHECK VALVES
ANESTHESIA UNIT
104
93
107
F_A
ΔP_C
P_∞
105
101
F_Q
102
ΔP_O
103
T
98
O_2
N_2O
A_1
A_2
A_3
DISPOSABLE SENSOR MODULE
95
94
SAMPLE GAS FLOW 50 ML/MIN
DESICCANT
91
90
61

FIG.9C

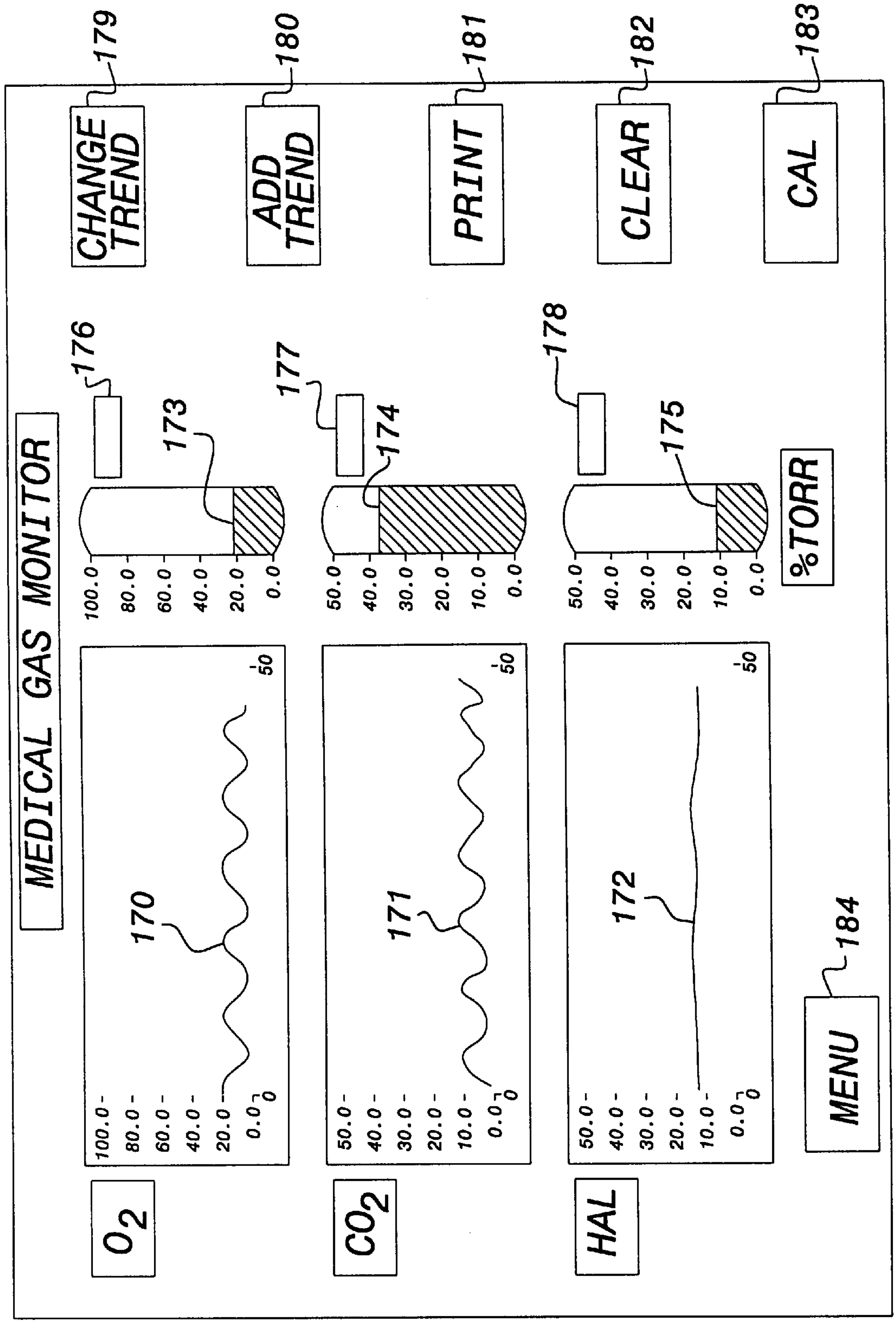
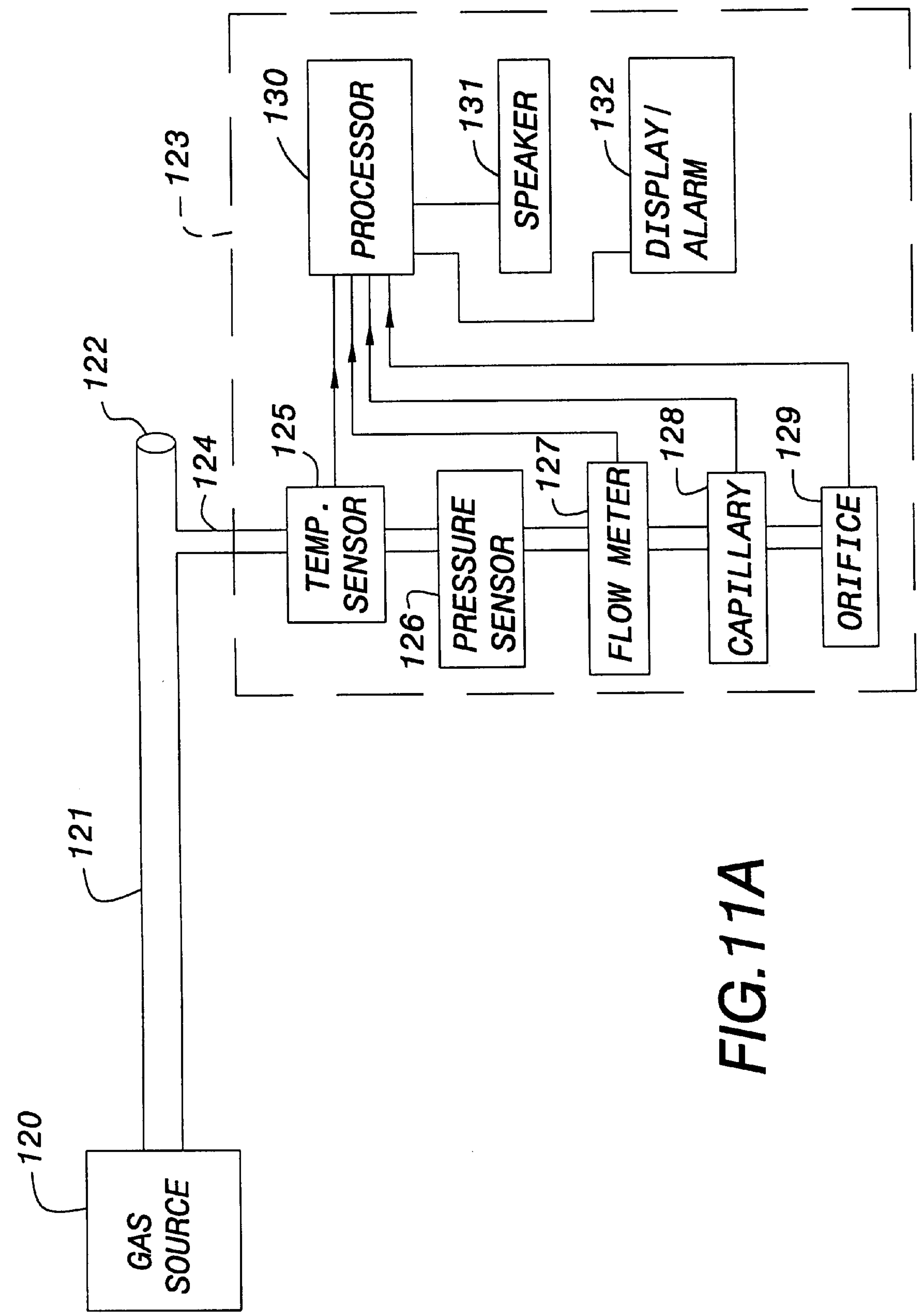

MEDICAL GAS MONITOR
CHANGE TREND
ADD TREND
PRINT
CLEAR
CAL
MENU
O_2
CO_2
HAL
%TORR
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184

FIG.10



GAS SOURCE
120
121
122
123
124
TEMP. SENSOR
125
PRESSURE SENSOR
126
FLOW METER
127
CAPILLARY
128
ORIFICE
129
PROCESSOR
130
SPEAKER
131
DISPLAY/ ALARM
132

FIG.11A

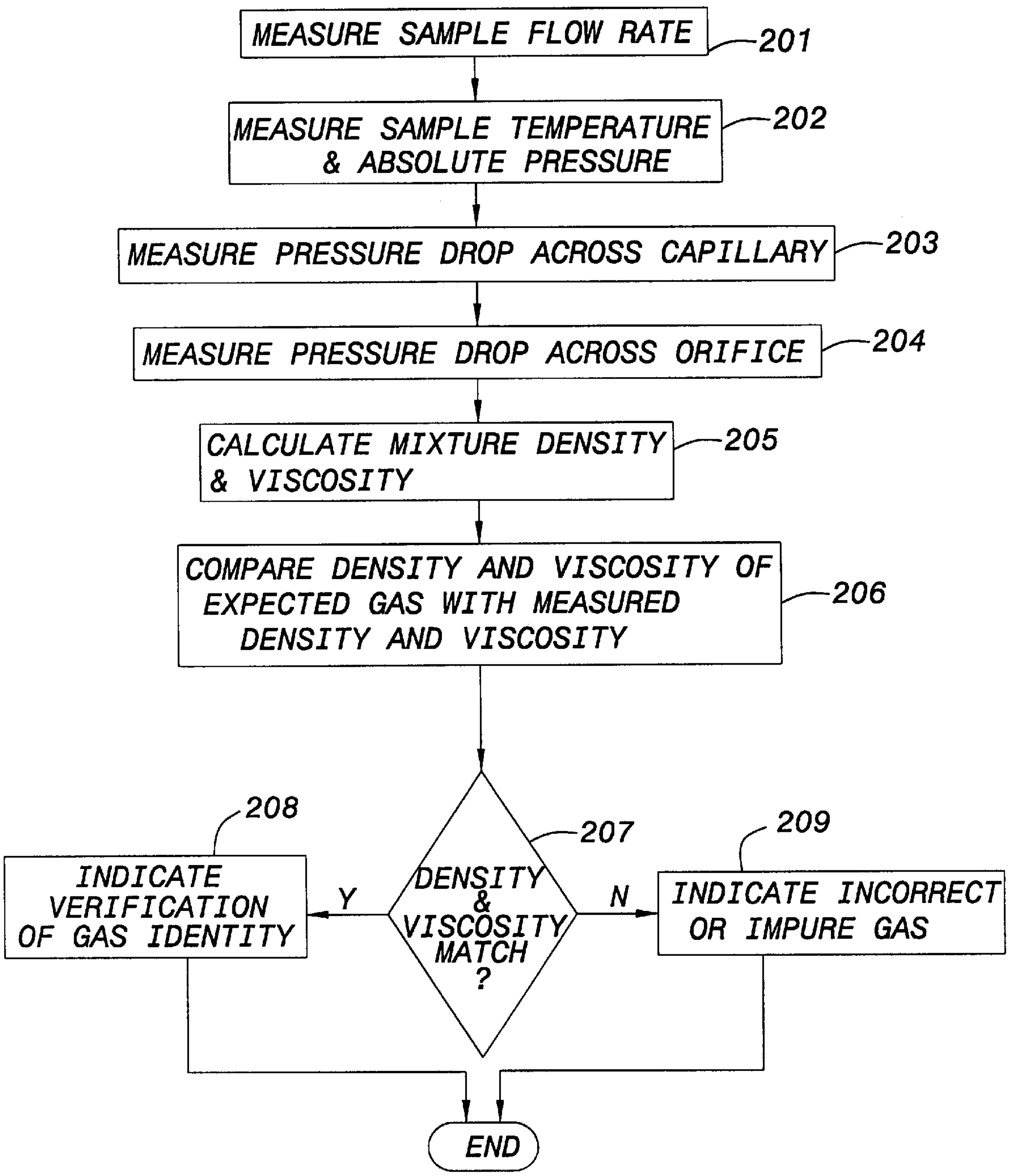

MEASURE SAMPLE FLOW RATE
201
MEASURE SAMPLE TEMPERATURE & ABSOLUTE PRESSURE
202
MEASURE PRESSURE DROP ACROSS CAPILLARY
203
MEASURE PRESSURE DROP ACROSS ORIFICE
204
CALCULATE MIXTURE DENSITY & VISCOSITY
205
COMPARE DENSITY AND VISCOSITY OF EXPECTED GAS WITH MEASURED DENSITY AND VISCOSITY
206
DENSITY & VISCOSITY MATCH ?
207
Y
N
INDICATE VERIFICATION OF GAS IDENTITY
208
INDICATE INCORRECT OR IMPURE GAS
209
END

FIG.11B

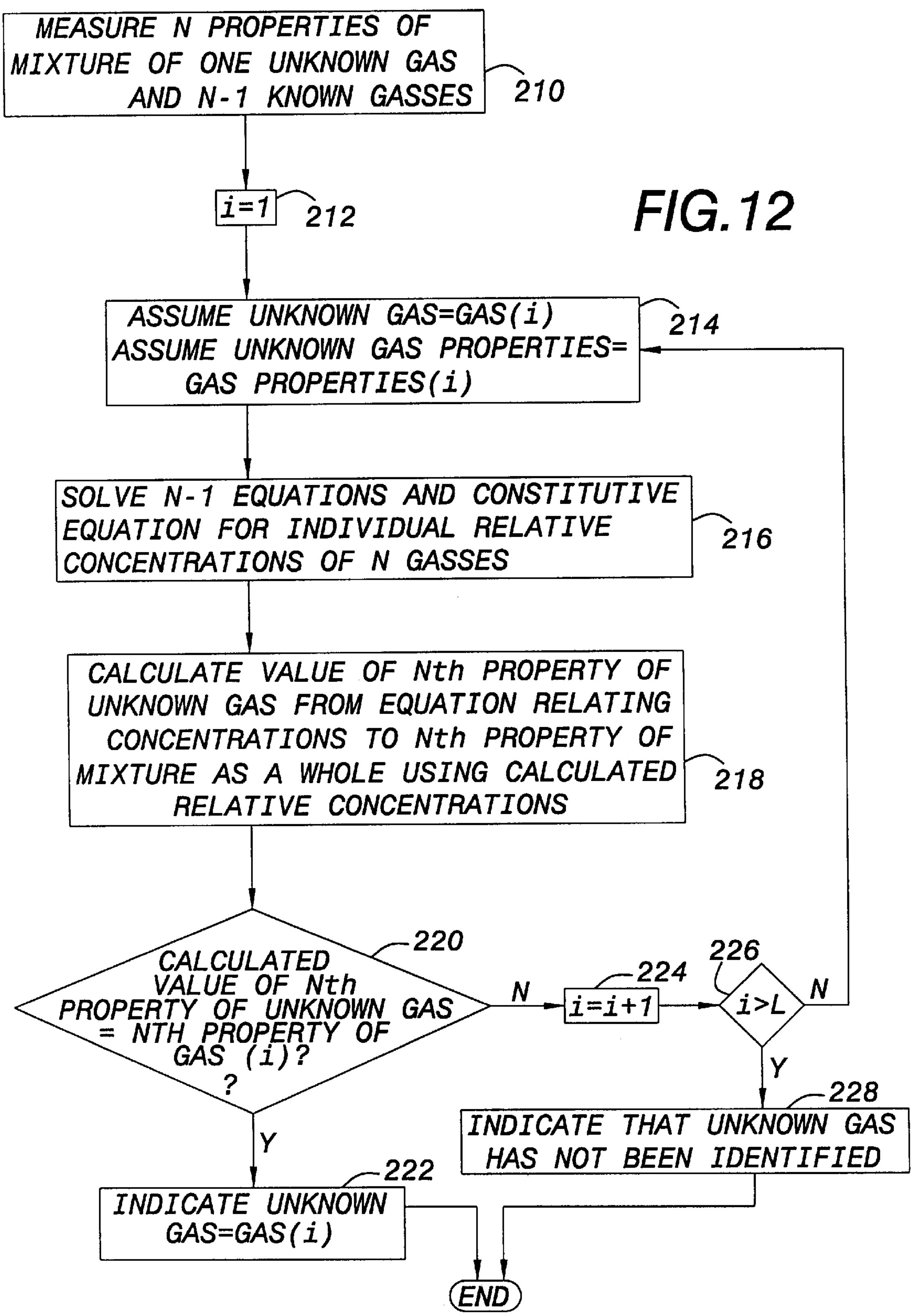

MEASURE N PROPERTIES OF MIXTURE OF ONE UNKNOWN GAS AND N-1 KNOWN GASSES
210
i=1
212
ASSUME UNKNOWN GAS=GAS(i) ASSUME UNKNOWN GAS PROPERTIES= GAS PROPERTIES(i)
214
SOLVE N-1 EQUATIONS AND CONSTITUTIVE EQUATION FOR INDIVIDUAL RELATIVE CONCENTRATIONS OF N GASSES
216
CALCULATE VALUE OF Nth PROPERTY OF UNKNOWN GAS FROM EQUATION RELATING CONCENTRATIONS TO Nth PROPERTY OF MIXTURE AS A WHOLE USING CALCULATED RELATIVE CONCENTRATIONS
218
CALCULATED VALUE OF Nth PROPERTY OF UNKNOWN GAS = NTH PROPERTY OF GAS (i)? ?
220
N
i=i+1
224
226
i>L
N
Y
228
INDICATE THAT UNKNOWN GAS HAS NOT BEEN IDENTIFIED
Y
222
INDICATE UNKNOWN GAS=GAS(i)
END

FIG.12

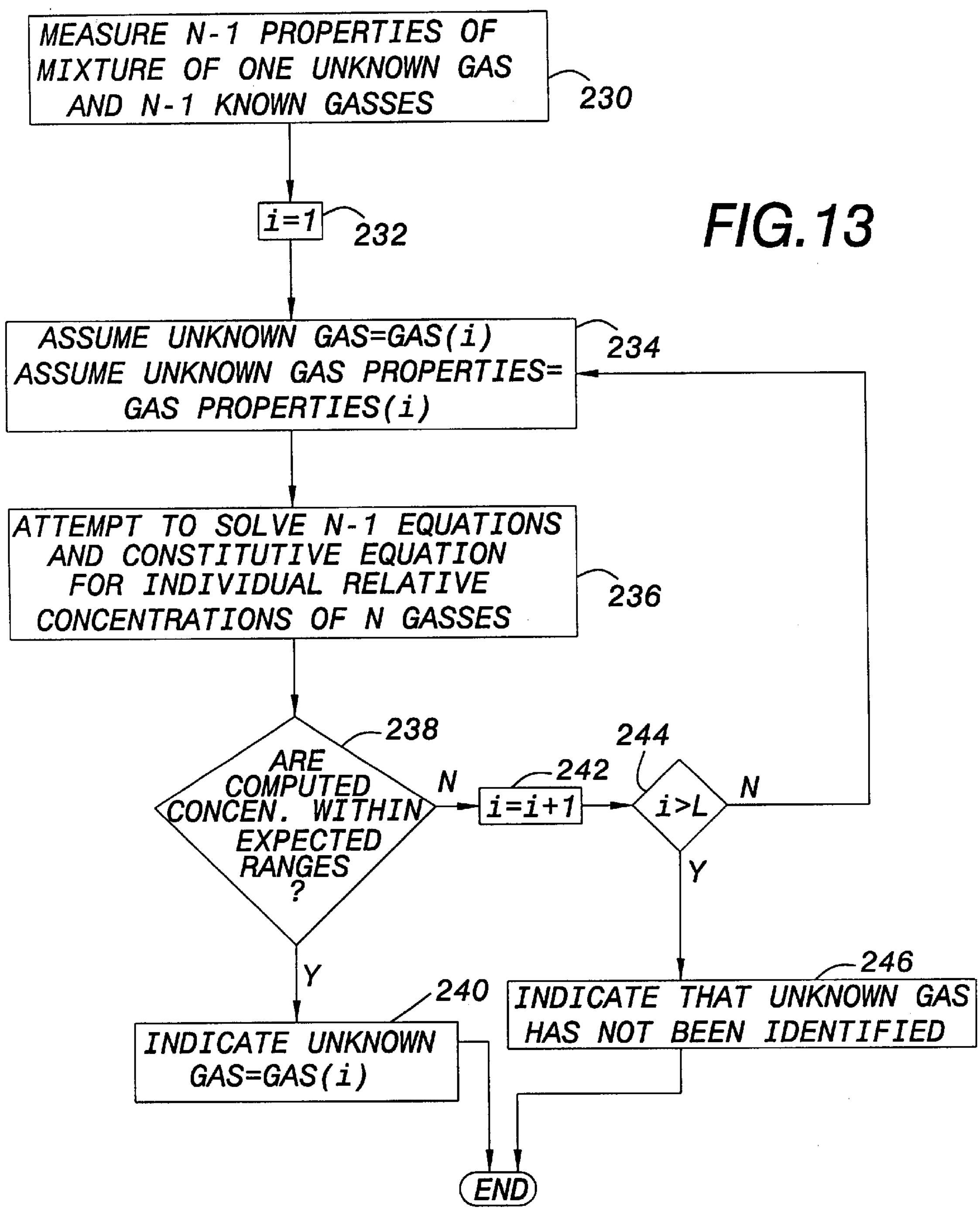

MEASURE N-1 PROPERTIES OF MIXTURE OF ONE UNKNOWN GAS AND N-1 KNOWN GASSES
230
i=1
232
ASSUME UNKNOWN GAS=GAS(i)
ASSUME UNKNOWN GAS PROPERTIES= GAS PROPERTIES(i)
234
ATTEMPT TO SOLVE N-1 EQUATIONS AND CONSTITUTIVE EQUATION FOR INDIVIDUAL RELATIVE CONCENTRATIONS OF N GASSES
236
ARE COMPUTED CONCEN. WITHIN EXPECTED RANGES ?
238
N
i=i+1
242
244
i>L
N
Y
Y
240
INDICATE UNKNOWN GAS=GAS(i)
246
INDICATE THAT UNKNOWN GAS HAS NOT BEEN IDENTIFIED
END

FIG. 13

METHOD AND APPARATUS FOR REAL TIME GAS ANALYSIS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of U.S. patent application Ser. No. 09/104,997, entitled "Method and Apparatus for Real Time Gas Analysis", filed Jun. 26, 1998, now U.S. Pat. No. 6,076,392 issued Jun. 20, 2000. The disclosure of the aforementioned patent application is incorporated herein by reference in its entirety.

This application claims priority from U.S. Provisional Patent Application Serial No. 60/055,982, entitled "Fluidic Real Time Multiple Gas Analyzer", filed Aug. 18, 1997, and from U.S. Provisional Patent Application Serial No. 60/069,422, entitled "Method and Apparatus for Real Time Gas Analysis Using Fluidic Sensors", filed Dec. 18, 1997. The disclosures of these provisional patent applications are incorporated herein by reference in their entirety.

GOVERNMENT LICENSE RIGHTS

This invention was made with Government support under Grant No. 5 R44 HL53092-03 awarded by the National Institute of Health. The Government has certain rights in the invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a universal method and apparatus for determining, in real time, the individual concentrations of fluid constituents of any mixture of a predetermined number of fluids using, in the preferred embodiment, fluidic sensors. Further, the invention relates to a method and apparatus for determining or verifying the identity and/or purity of a single gas or an unknown gas in a mixture of gasses.

2. Description of the Prior Art

The determination of the relative concentrations of gasses in a mixture has been the subject of numerous inventions and intensive research over the years. Particularly, when noxious, poisonous or otherwise hazardous gasses are present, knowledge of the amount of such gasses is important to alert personnel in the area of any potential danger. In medical and clinical settings, awareness of the concentrations of respired gasses is important in the determination of patient metabolic conditions, especially the relative and absolute amounts of oxygen and carbon dioxide which provide information on the metabolization of oxygen as well as respiratory functioning. Under operating room conditions, anesthesiologists must be careful in administering anesthesia gasses and do so as a function of metabolic rate, and also must be aware of the absolute amount of anesthetic being provided in order to prevent overdosing or underdosing which would cause a patient to be aware during an operation. Also, when several different potent anesthetics must be administered during a procedure, the net amounts of the anesthetics need to be monitored to prevent overdosing.

Multiple medical gas monitors (MMGMs) continuously sample and measure inspired and exhaled (end-tidal) concentrations of respiratory gasses, including anesthetic gasses during and immediately following administration of anesthesia. These monitors are required since an overdose of anesthetic agent, and/or too little oxygen, can lead to brain damage and death, whereas too little agent results in insufficient anesthesia and subsequent awareness. The current

development of these monitoring devices is described in the extensive anesthesia and biomedical engineering literature. Complete and specific information about the principles and applications of these devices is well reviewed in several recent texts (see, e.g., Lake, *Clinical Monitoring*, WB Saunders Co., pp. 479–498 (ch. 8),1990, incorporated herein by reference in its entirety), manufacturer's and trade publications (see, e.g., ECRI, "Multiple Medical Gas Monitors, Respired/Anesthetic", August 1983, incorporated herein by reference in its entirety), and in extensive anesthesia literature describing this equipment and its principles, methods and techniques of operation.

Medical gas monitoring provides the clinician with information about the patient's physiologic status, verifies that the appropriate concentrations of delivered gases are administered, and warns of equipment failure or abnormalities in the gas delivery system. These monitors display inspired and exhaled gas concentrations and may sound alarms to alert clinical personnel when the concentration of oxygen (O_2), carbon dioxide (CO_2), nitrous oxide (N_2O), or anesthetic agent falls outside the desired set limits.

Most MMGMs utilize side-stream monitoring wherein gas samples are aspirated from the breathing circuit through long, narrow-diameter tubing lines. A water trap, desiccant and/or filter may be used to remove water vapor and condensation from the sample before the gas sample reaches the analysis chamber. Gas samples are aspirated into the monitor at either an adjustable or a fixed flow rate, typically from 50 to 250 ml/min. Lower rates minimize the amount of gas removed from the breathing circuit and, therefore, from the patient's tidal volume; however, lower sampling flow rates increase the response time and typically reduce the accuracy of conventional measurements. These gas monitors eliminate the exhaust gas through a scavenging system or return certain gas constituents to the patient's breathing circuit.

There are several methods and techniques of anesthetic gas monitoring that are currently used. These methods and techniques are briefly reviewed below to distill their intrinsic advantages and disadvantages. A brief comparison is provided that includes both stand-alone and multi-operating room gas monitors that can determine concentrations of anesthetic and respiratory gases in the patient breathing circuit during anesthesia. Much of the research and development of these monitors have followed the long use of similar detector principles from analytical chemistry.

Because of the chemically diverse substances that they measure, MMGMs commonly combine more than one analytical method. Most MMGMs measure concentrations of halogenated anesthetic agents, CO_2, and N_2O using nondispersive infrared (IR) absorption technology; however, there are others that use photoacoustic spectroscopy, based on the sound produced when an enclosed gas is exposed to pulsed optical energy. Other MMGMs use a piezoelectric method to measure anesthetic agent concentration. Electrochemical (e.g., galvanic) fuel cells and/or paramagnetic sensors are typically used to measure oxygen concentration, primarily because of their performance characteristics. Some MMGMs also have built-in or modular pulse oximeters to monitor tissue oxygen perfusion, although there is a major problem with the ambiguity between the presence of oxygen and carbon monoxide because hemoglobin bonds with both oxygen and carbon monoxide and conventional single wavelength pulse oximeters cannot distinguish between the two.

Infrared analyzers have been used for many years to identify and assay compounds for research applications.

More recently, they have been adapted for respiratory monitoring of CO_2, N_2O and halogenated agents. Dual-chamber nondispersive IR spectrometers pass IR energy from an incandescent filament through the sample chamber and an identical geometry but air-filled reference chamber. Each gas absorbs light at several wavelengths, but only a single absorption wavelength is selected for each gas to determine the gas concentration. The light is filtered after it passes through the chambers, and only that wavelength selected for each gas is transmitted to a detector. The light absorption in the analysis chamber is proportional to the partial pressure (e.g., concentration) of the gas. To detect halothane, enflurane, isoflurane, and other related potent anesthetics, most manufacturers use a wavelength range around 3.3 μm, the peak wavelength at which the hydrogen-carbon bond absorbs light. In one monitor that identifies and quantifies halogenated agents, the analyzer is a single-channel, four-wavelength IR filter photometer. In this monitor, each of four filters (i.e., one for each anesthetic agent and one to provide a baseline for comparison) transmits a specific wavelength of IR energy, and each gas absorbs differently in the selected wavelength bands. In another monitor, the potent anesthetic agent is assayed by determining its absorption at three different wavelengths of light. The (Vickers Medical) Datex Capnomac, a multi-gas anesthetic agent analyzer, is based on the absorption of infrared radiation. This unit accurately analyzes breath-to-breath changes in concentrations of CO_2, NO_2, and N_2O and anesthetic vapors (See, McPeak et al., "Evaluation of a multigas anaesthetic monitor: the Datex Capnomac", Anaesthesia, Vol. 43, pp.1035–1041, 1988, incorporated herein by reference in its entirety). It is accurate with CO_2 for up to 60 breaths/min, and 30 breaths/min for O_2, but N_2O and anesthetic vapors show a decrease in accuracy at frequencies higher than 20 breaths/min. The use of narrow wave-band filters to increase specificity for CO_2 and N_2O makes the identification of the anesthetic vapors which are measured in the same wave band more difficult. The Inov 3100 near-infrared spectroscopy monitor has been offered as a monitor for intracerebral oxygenation during anesthesia and surgery. Studies done on this monitor indicate that it needs a wide optode separation and the measurements are more likely those of the external carotid flow rather than the divided internal carotid circulation (see Harris et al., "Near infrared spectroscopy in adults", Anaesthesia Vol. 48, pp. 694–696, 1993, incorporated herein by reference in its entirety). Almost all nondispersive infrared (NDIR) devices suffer from cross-sensitivities that may be present, thereby requiring extensive calibration and correction when mixture of gasses flow. The presence of O_2, in particular, presents a major problem.

Photoacoustic spectroscopy measures the energy produced when a gas is expanded by absorption of optical radiation; the energy is pulsed by rotating a disk with three concentric slotted sections between the optical source and the measurement chamber. The acoustic pressure fluctuations created occur with a frequency between 20 and 20,000 Hz, producing sound that is detected with a microphone and converted to an electrical signal. Each gas (e.g., anesthetic agent, CO_2, N_2O) exhibits a pronounced photoacoustic effect at a different wavelength of incident light energy. This method, however, cannot distinguish which halogenated agent is present. A similar microphone can to used to detect the pulsating pressure changes in a paramagnetic oxygen sensor (e.g., magnetoacoustics). The microphone detects the pulsating pressures from all four gases simultaneously and produces a four component signal. A monitor using IR photoacoustic technology has been developed that can quantify all commonly respired/anesthetic gasses except N_2 and water vapor (the presence of which adversely affects accuracy). The Bruel & Kjaer Multigas Monitor 1304 uses photoacoustic spectroscopy and also incorporates a pulse oximeter. It has some advantages over the Data Capnomac since it uses the same microphone for detection of all gases, displaying gas concentration with a real-time relationship. There has been found to be a considerable decrease in accuracy when a hybrid sampling tube was used rather than a nafion tube, indicating the need for the additional expense of using a nafion sampling tube to ensure the elimination of water vapor (see McPeak et al., "An Evaluation of the Bruel and Kjaer monitor 1304", Anaesthesia, Vol. 47, pp. 41–47, 1992, incorporated herein by reference in its entirety).

The piezoelectric method is also used to measure the concentration of a selected halogenated agent. The sample is pumped through a chamber containing two crystals: a reference crystal and a second crystal that has been coated with an organophillic compound to adsorb the anesthetic gas. The resulting increase in mass changes the coated crystal's resonant frequency in direct proportion to the concentration of anesthetic gas in the sample, thereby generating a voltage that is displayed as a percentage of vapor. One piezoelectric-based unit has a separate nondispersive IR sensor that differentiates inhalation and exhalation to detect breaths, as well as an integral galvanic fuel cell that measures oxygen concentration before the sampled gas is returned to the breathing circuit. These devices also demonstrate cross-sensitivity to other gasses that may be present.

Mass and Raman spectrometers can measure and identify all respiratory and anesthetic gasses including N_2 and in some cases helium. The application of mass spectrometry to the field of monitoring anesthetic gases allows real-time measurement of all inspired and exhaled gasses. Unfortunately, the cost and complexity of this instrumentation has necessitated its being used in a time-sharing fashion among multiple operating rooms. Raman scattering was first heralded as an improvement to mass spectrometry (see Westenskow et al., "Clinical evaluation of a Raman scattering multiple gas analyzer", Anesthesiology, Vol. 70, pp. 350–355, 1989, incorporated herein by reference in its entirety), although there have been some reservations about this technique (see Severinghaus et al, "Multi-operating room monitoring with one mass spectrometer", Acta Anaesthesiol Scan [Suppl] 70:186–187, 1987, incorporated herein by reference in its entirety). The (Ohmeda) Rascal II multigas analyzer, with pulse oximeter, uses a Raman scattering of laser light to identify and quantify O_2, N_2, CO_2, N_2O and anesthetic agents. It is stable and can monitor the gasses including N_2 and CO_2 accurately for a wide range of concentrations. However, there is a possibility of some destruction of volatile agent during the analysis since the concentration of Halothane does appear to fall when recirculated and there is a gain of the volatile agent of as much as fifteen percent. There is some concern over the reliability of the hardware, software and laser light source (see Lockwood et al., "The Ohmeda Rascall II", Anaesthesia, Vol. 49, pp. 44–53, 1994, incorporated herein by reference in its entirety) which is currently being addressed by others, which necessitates frequent and costly calibration and adjustment.

Other related medical gas monitoring approaches include specific techniques for monitoring oxygen concentration. As described in the above-referenced text by Lake, a commonly used oxygen analyzer detector is based on a polarographic method. In yet another analyzer which uses a galvanic cell, oxygen diffuses through a semipermeable membrane, reaches a reducing electrode, and is carried as a reaction product to another (e.g., reference) electrode, where it frees electrons. The rate at which oxygen diffuses into the cell and generates voltage is directly proportional to the partial pressure of oxygen diffusing through the membrane. Several factors affect the output and lifetime of the cells. During its life, the electrode loses water, some water diffuses out as oxygen which enters the cell while some water is consumed through oxidation, and eventually requires replacement.

Paramagnetic sensors are typically used specifically for measuring oxygen concentration. The design of this sensor is based on oxygen's high degree of sensitivity (e.g., compared to other gasses) to magnetic forces. The sensor includes a symmetrical, two chambered cell with identical chambers for the sample and reference gas (e.g., air). These cells are joined at an interface by a differential pressure transducer or microphone. Sample and reference gases are pumped through these chambers in which a strong magnetic field surrounding the region acts on the oxygen molecules to generate a pressure difference between the two sides of the cell, thereby causing the transducer to produce a voltage proportional to the oxygen concentration. This device, as is the case with most devices, requires frequent calibration, is costly in and of itself, and depends on certain operator skills for proper operation.

Table 1, derived from Eisenkraft et al., "Monitoring Gases in the Anesthesia Delivery System", Anesthesia Equipment: Principles and Applications, Mosby-Year Book, pp. 201–220, 1993, incorporated herein by reference in its entirety, provides a summary of methods and techniques to monitor respiratory gasses.

TABLE 1

METHOD	O_2	CO_2	N_2O	Anes	N_2	He	Ar
Mass Spectroscopy	YES	YES	YES	YES	YES	YES	YES
Raman Spectroscopy	YES	YES	YES	YES	YES	YES	YES
IR - Light Spectroscopy	NO	YES	YES	YES	NO	NO	NO
IR - Photo Acoustics	NO	YES	YES	YES	NO	NO	NO
Piezoelectric Resonance	NO	NO	NO	YES	NO	NO	NO
Polarography	YES	NO	NO	NO	NO	NO	NO
Fuel Cell	YES	NO	NO	NO	NO	NO	NO
Paramagnetic Analysis	YES	NO	NO	NO	NO	NO	NO
Magnetoacoustics	YES	NO	NO	NO	NO	NO	NO

A review of the background and significance of MMGM would be incomplete without an expression of the impact that patient safety has had on the impetus for recent gains in technology and the need for additional improvements. Clearly, the intrinsic dangers in the conduct of anesthesia have been long understood. However, it has not been until the Department of Anesthesia at the Harvard Teaching Hospital decided to create a set of basic monitoring standards that non-invasive respiratory gas monitoring became widely available and its use common place. The Harvard Medical School Standard for Anesthesia requires:

1) the ability to assure safety and effectiveness of the application of anesthetic agents;
2) simplicity of methods and techniques which translate directly into reliability, low acquisition cost, low cost to service, operate and maintain;
3) appropriate accuracy, precision and stability to monitor relative concentrations of necessary anesthetic gases particularly CO_2, O_2, and the potent anesthetic gas agents; and
4) appropriate time response and acceptable delays in monitoring changes in relative concentrations of gasses with respect to respiration rates during anesthesia.

Medical malpractice liability insurance companies have lowered their risk liabilities and premiums to anesthesiologists who guarantee to use pulse oximetry and end-tidal CO_2 tension monitoring whenever possible (see Swedlow, "Respiratory Gas Monitoring", Monitoring in Anesthesia, pp. 27–50, Boston, Butterworth-Heinemann, 3rd edition, 1993, incorporated herein by reference in its entirety). The argument for providing additional patient safety continues to be a powerful incentive to improve and enhance the methods and techniques to provide increased knowledge of the monitoring of anesthetic gasses.

Safety considerations require that the presence of nitrogen be detected as this provides warning of air embolisms, as well as alerting to possible loss of integrity of the breathing circuit, as air (with N_2) is introduced. A major disadvantage of most conventional gas monitors is that they do not measure N_2. A major disadvantage of present-day MMGMs which use one or a combination of the above-cited techniques is their high cost. A further disadvantage is that many of these sensors can determine the concentrations of only certain types of gasses or a limited number of gasses.

Fluidic gas concentration sensors offer a low-cost alternative to the devices that use the above techniques. However, known fluidic gas concentration sensors, either oscillators or orifice-capillary pairs, have been capable of detecting concentrations of gasses in a mixture of at most two gasses, and, until only recently, the pressures could not be measured with sufficient accuracy at low cost, to make systems practical.

More particularly, prior fluidic gas concentration sensors, either oscillators (for example, that disclosed in U.S. Pat. No. 3,765,224 to Villarroel et al., the disclosure of which is incorporated herein by reference in its entirety) whose frequency is a function of the speed of sound, and hence, the ratio of specific heats of a gas mixture, or orifice-capillary pairs (for example, that disclosed in U.S. Pat. No. 3,771,348 to Villarroel, the disclosure of which is incorporated herein by reference in its entirety) where the pressure at the junction between the two is a function of density and viscosity of the mixture, were based on measuring the relative concentrations of two gasses in a mixture. Multiple gas analysis may subsequently be accomplished only by physically or chemically separating multiple gas mixtures into multiple two-gas mixtures which may then be separately analyzed. Multiple scrubber approaches, however, cannot be implemented in real time because of the very long delay times associated with passing the gas samples through the volume of a scrubber at the relatively low flow rates associated with the sample streams. Thus, despite the affordability of fluidic sensors, they have not been widely used in MMGMs to measure concentrations of medical gasses during the administration of anesthesia.

Another application for gas analysis in the medical field is the determination or verification of the identity and purity of a gas flowing from a source. Gasses such as oxygen, nitrous oxide, and volatile anesthesia gasses are supplied from sources to patients in operating rooms, intensive care units and hospital rooms. For example, oxygen is often supplied through a wall outlet which is fed from a remotely located oxygen tank. Anesthesia is typically stored in a vaporizer and dispensed by imposing a carrier gas (e.g., O_2) through a flow meter which is used to control the amount of anesthesia vapor being supplied. An anesthesia machine may contain several volatile anesthetic agents, each in a separate container with a separate flow meter. While precautions are generally taken to ensure that the correct type of gas is flowing from a source, it is possible for an incorrect gas or a contaminated gas to be supplied. For example, it may be possible for a nitrous oxide tank to be erroneously connected to an oxygen supply line or for one type of anesthesia to be erroneously stored in an anesthesia container labeled as another type of anesthesia. Further, the purity of a gas may be compromised between the source and the point of delivery. For example, an oxygen supply line could be damaged or ruptured, thereby allowing atmospheric gasses to enter the supply line and to be delivered along with a reduced concentration of oxygen.

Use of known gas analyzers to verify the identity and purity of gasses at a source or at a point of delivery would be expensive and impractical in many circumstances. For example, it would be prohibitively expensive to integrate a conventional gas analyzer into every oxygen supply outlet in a hospital. Likewise, it would be expensive to incorporate a conventional gas analyzer into each container of anesthesia gas in a hospital. Further, conventional gas analyzers require periodic calibration which would make such gas analyzers impractical in large numbers. Thus, a low maintenance, lost cost gas analyzer is needed to verify the identity and purity of gasses at a source or point of delivery.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, in light of the above, and for other reasons that become apparent when the invention is fully described, an object of the present invention is to provide an improved technique for determining the concentrations of fluids, both gaseous and liquid, in mixtures of more than two fluids.

It is another object of the present invention to provide a method and apparatus for augmenting the gas analysis capabilities of conventional gas analyzers using low-cost, reliable fluidic devices, whereby concentrations of a greater number of gasses, including gasses whose concentrations are difficult to determine by conventional means, can be determined.

It is a further object of the present invention to verify the identity and purity of a gas being supplied from a source (either alone or in combination with other gasses) using fluidic devices capable of being integrated with low cost electronic pressure and temperature sensors in order to ensure very low cost and high reliability.

It is yet a further object of the present invention that the fluidic system operate with a minimum of moving mechanical parts requiring no user calibration so that the entire process itself can operate virtually indefinitely.

It is still a further object of the present invention to provide a plurality of utilization modes ranging from permanent installations in operating rooms to portable home-use devices that can be used in residences or temporary situations.

It is another object of the present invention to provide for techniques for providing gas concentration information in a manner conducive to easy readout and compatible with personal computers and other forms of microprocessors.

Another object of the present invention is to provide a disposable fluidic sensor module which can affordably be replaced after each use to simplify sterilization of the gas analyzer.

Yet another object of the present invention is to provide for a universal sensing mechanism which is independent of the gasses being analyzed, use specificity of the analysis being provided only by changes in parameters provided to the analysis software by the user.

Still another object of the present invention is to provide for a means of determining gas concentrations entirely from first physical principles, thereby resulting in a system that never requires calibration or adjustment.

According to the present invention, the individual concentrations of fluid constituents in a mixture of N fluids can be determined in real time by measuring independent properties of the mixture. In particular, N equations, which from first principles, relate the individual fluid concentrations to measured properties of the mixture, are solved for the N unknown individual concentrations of the fluids in the mixture. N−1 properties of the mixture are measured by N−1 sensors, which from cost considerations are preferably fluidic sensors, but may be any other technology devices, and N−1 of the N equations are formed from the determined properties. The Nth equation is the constitutive equation which requires that the sum of the unknown concentrations of the N known constituents be equal to unity.

In an exemplary embodiment, the individual concentrations of three gasses in a mixture of three known gasses are determined by measuring the ambient pressure, temperature and flow rate of the sample flow of the mixture and the subsequent pressure drop of the mixture sample flow across a capillary and across an orifice which may be the supply nozzle of the flowmeter oscillator. The sample flow rate is preferably measured by passing the flow through a fluidic feedback oscillator and measuring the output frequency period which is proportional to transit time. From these measurements, the density and viscosity of the mixture are computed, and the three unknown concentrations of the three known gasses are determined by solving in real time three independent equations (i.e., an equation relating mixture density to the concentrations, an equation relating mixture viscosity to the concentrations, and the constitutive equation). The three-gas analyzer is suitable for monitoring respired, desiccated air (e.g., a three-gas mixture Of O_2, CO_2 and a pseudo-gas composed of N_2 with traces of atmospheric inert gasses) and can be used in validation of respiration in critical care medicine, validation of emergency intubation, patient transport (e.g., between care administration areas) and home and out patient respiratory therapy.

By additionally measuring the acoustic velocity in the mixture by using a sonic oscillator, the mixture specific heat may also be calculated. This additional property of the mixture can be related to concentrations of the individual gasses, thereby augmenting the above-described three independent equations with an additional equation. Thus, four independent equations can be solved in real time for unknown concentrations of four gasses in a mixture of four known gasses. In the context of monitoring respired, desiccated anesthesia medical gasses, the four gas analyzer is useful for measuring the concentrations of five gasses. In particular, since the density and viscosity of carbon dioxide and nitrous oxide are virtually indistinguishable, the four independent equations can be solved for the concentrations of O_2, N_2, a volatile anesthetic and the combined concentration of N_2O and CO_2. Since the anesthesia machine removes CO_2 from the inspired gasses, the individual concentrations of N_2O and CO_2 can be determined by comparing their combined concentration in the exhaled gasses with their combined concentration in the inspired gasses (which is entirely N_2O), the difference being the real time concentration of CO_2. Thus, the fifth gas is determined from a fifth known condition, that is, that the inspired gas is CO_2-free. In the event of loss of the CO_2 scrubber (e.g., due to poor maintenance) a breath-to-breath increase will occur; however, having kept track of the minimum value of the combined gas will still provide the value of total CO_2 as well as the inspired-to-exhaled ratio.

Preferably, the oscillator flowmeter, sonic oscillator and the capillary are formed as a disposable sensor module comprising a single small, thin, plastic lamination. By attaching (in a separable manner) pressure and temperature sensors at appropriate points, all necessary measurements can be performed. Any one of the oscillator nozzles can serve as the orifice, thereby eliminating the need for a separate orifice. The disposable sensor module is connected via a separable interface to a replaceable transducer module containing the transducers and amplifiers used to measure the characteristics of the mixture, as well as containing the vacuum line for drawing a sample.

Advantageously, low cost, fluidic sensors measure the flow, density, viscosity and speed of sound in gas mixtures. Low-cost micro-electro-mechanical systems (MEMS)-based electronic pressure transducers, low-cost integrated circuit temperature transducers, and ultra-low cost piezoelectric film microphones provide electronic inputs to a microprocessor.

While fluidic measurement of the properties of a gas mixture offers a low-cost alternative to more expensive conventional sensors, the principles of the present invention (i.e., determining individual gas concentrations by solving N equations related to bulk properties of the mixture) can be extended to include any device which measures properties of the mixture as a whole. For example, piezo-electrically-driven surface acoustic wave (SAW) devices have been used to determine density and speed of sound, ultrasonic devices can density, and electrochemical devices can measure viscosity. Depending on their relative cost and accuracy advantages, these devices may be advantageously used in place of fluidic sensors.

In accordance with the present invention, the capabilities of an existing sensor system for measuring M gas concentrations can be extended to measure N additional gas concentrations by measuring N−1 properties of the gas mixture as a whole, regardless of what the gasses are, provided the identities of the gasses in the mixture are known. For example, many existing anesthesia machines capable of measuring five gasses cannot measure the concentrations of nitrogen, carbon monoxide and helium. By augmenting such a five-gas monitor with the fluidic sensors of the present invention, concentrations of these additional gasses can be measured with little additional expense.

The introduction of a new anesthetic agent to the market normally requires the development of a new sensor or at least the identification of a new absorption wavelength with attendant costly changes in hardware. With the universal sensor of the present invention, only the new agent's physical properties need to be programmed into the software, thereby requiring no hardware changes.

Formation and solution of the N equations for the individual concentrations of N gasses typically require that the identity of the N gasses be known, together with their inherent individual properties of the gasses, such as density, viscosity, and specific heat. However, while determining individual concentrations of gasses, the sensor system of the present invention can also determine or verify the identity of an unknown gas in a pure form or in a mixture of other, known gasses.

In accordance with one embodiment, the fluidic sensors of the present invention can be used to determine or verify the identity of a gas flowing from a source. Specifically, the identity of a single, unknown gas can be determined by fluidically measuring properties of the gas, such as density and viscosity, and comparing the measured values to known properties of a gas (e.g., in a look-up table). The identity of the unknown gas can be verified or determined by matching the measured values to those of a known gas.

In accordance with another embodiment of the present invention, the same fluidic measurement device can be used to determine the identity of one unknown gas in a mixture of N gasses of unknown concentrations, where the identities of the other N−1 gasses in the mixture are known. According to one approach for identifying the unknown gas, N properties of the gas mixture are measured; N−1 of the properties are used to generate N−1 equations which, together with the constitutive equation, are solved for N concentrations, where the properties of the unknown constituent are assumed to be those of a particular gas; the computed N concentrations and the measured value of the Nth property of the mixture are used to calculate the Nth property of the unknown gas which is then compared to the known Nth property of the gas assumed to be the unknown gas (for purposes of calculating the concentrations); and different gasses are tried (i.e., assumed to be the unknown gas) in this process until the comparison yields a match or all potential gasses have been tried without a successful match. This approach provides an absolute identification of the unknown gas, since a match cannot occur with an incorrect gas.

According to another approach, where there is a sufficient concentration of the unknown gas, only N−1 (rather than N) properties of the gas mixture are measured and used to generate N−1 equations which, together with the constitutive equation, are solved for N concentrations, where the properties of the unknown constituent are assumed to be those of a particular gas. If the unknown gas was assumed to be a gas other than the correct gas, the solution to the equations will yield concentrations that are not within predetermined expected ranges for at least one of the gasses; conversely, if the unknown gas was assumed to be the correct gas, the solution to the equations will yield values of individual concentrations that are within expected ranges (i.e., a match). Different gasses are tried (assumed to be the unknown gas) in this process until a match is found or all potential gasses have been tried. This approach provides a probable identification of the unknown with a very low probability of error and, relative to the previously-described approach, requires one less property of the mixture to be determined (or can identify an unknown gas in a mixture having one additional gas).

All of the above gas analyses can be performed with the same sensors; only the processing software varies with the different applications. The mixture properties are preferably calculated from measurements made with fluidic sensors that output pressure, acoustic frequency, and temperature, which can be transduced electronically with very small, rugged, durable, low cost transducers. Further, no user calibration of the sensors is required, thereby further reducing the manufacturing and operational costs.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following definitions, descriptions and descriptive figures of specific embodiments thereof wherein like reference numerals in the various figures are utilized to designate like components. While these descriptions go into specific details of the invention, it should be understood that variations may and do exist and would be apparent to those skilled in the art based on the descriptions herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of an analog circuit of a flowmeter, capillary and orifice arranged in series.

FIG. 2*a* schematically depicts half of a cycle of the operation of a conventional fluidic oscillator flowmeter.

FIG. 2*b* schematically depicts the second half of a cycle of the operation of a conventional fluidic oscillator flowmeter.

FIG. **3** presents data in graphical form showing the linear dependence of oscillator frequency on through flow in one flowmeter that is used in the present invention, illustrating that the linear flow-frequency characteristic of the flowmeter is independent of which gas is flowing.

FIG. **4** graphically shows the relationships between the pressure drop and flow for a capillary resistor and orifice used in one embodiment of a three-gas analyzer.

FIG. **5***a* is a schematic representation of a three-gas analyzer in accordance with the present invention.

FIG. **5***b* is a flow chart summarizing the processing steps involved in determining the individual concentrations of the constituent gasses in a mixture of three known gasses.

FIG. **5***c* is a schematic representation of a modular three-gas analyzer including a disposable sensor module.

FIG. **6** is a perspective view of a three-gas analyzer constructed with fluidic integrated circuit laminations and external, separable, pressure transducers in accordance with the present invention.

FIG. **7***a* shows in graphical form actual real time data of the outputs of a three-gas analyzer measuring oxygen, carbon dioxide and halothane (i.e., a potent volatile anesthetic), from a three gas analyzer.

FIG. **7***b* shows exemplary real time traces of oxygen and carbon dioxide during actual respiration in an air monitoring mode of operation.

FIG. **7***c* shows the response of the system of the present invention to a calibration gas composed of 95% O_2 and 5% CO_2.

FIG. **8** shows data in graphical form of frequency versus the square-root of ratio of specific heats to molecular weight for a long feedback line fluidic oscillator.

FIG. **9***a* is a schematic representation of a four-gas analyzer according to the present invention.

FIG. **9***b* is a flow chart summarizing the processing steps involved in determining the individual concentrations of the constituent gasses in a mixture of five known gasses.

FIG. **9***c* is a schematic representation of a four-gas analyzer including a disposable sensor module.

FIG. **10** is a schematic illustration of an exemplary visual output from a virtual instrumentation package.

FIG. **11***a* is a diagrammatic representation of a gas identification device in accordance with an exemplary embodiment of the present invention.

FIG. **11***b* is a flow chart summarizing the processing steps involved in determining or verifying the identity of a single, pure gas supplied from a source.

FIG. **12** is a function flow diagram illustrating the processing steps required to determine the absolute identity of an unknown gas in a mixture of gasses in accordance with one embodiment of the present invention.

FIG. **13** is a function flow diagram illustrating the processing steps required to determine the probable identity of an unknown gas in a mixture of gasses in accordance with another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed explanations of FIGS. **1**–**13** and of the preferred embodiments reveal the method and apparatus

of the present invention. Although the following description is primarily concerned with medical gas analyzers, the present invention is not limited to the preferred embodiment but is applicable to other gas analysis applications, including, but not limited to, industrial production of gasses, atmospheric analysis, pollution tracking and other applications for the detection and analysis of chemical and biological agents. In addition, the present invention is not limited to a specific number of gasses that are in a mixture or for that matter only fluidic sensors, but rather, since properties of gasses can be measured using a variety of low cost electronic and hybrid electro-fluidic devices, the present invention may extend to low cost scientific gas analysis of large numbers of gasses. Furthermore, the present invention is not limited to the analysis of only gasses, because it should be recognized that substantially the same methods and apparatus may be applied to the analysis of mixtures of liquid fluids as well, as long as sufficient differences in mixture properties occur due to the changes of concentrations of the constituents of the fluids.

In accordance with the present invention, individual concentrations of fluid constituents of a mixture of N known fluids are determined by measuring characteristics of the mixture flowing through a number of sensing devices, determining N−1 properties of the mixture from the measured characteristics, establishing N−1 equations relating the individual concentrations of the fluid constituents to the N−1 properties of the mixture, and solving the N−1 equations and a constitutive equation in real time for the individual concentrations of the fluid constituents.

More particularly, individual concentrations of constituent gasses in a mixture of three known gasses can be determined by fluidically measuring any two independent properties of the mixture. For example, by determining the density and viscosity of the mixture (or viscosity and specific heat, or density and specific heat), the three unknown concentrations of the three known gasses in the three-gas mixture can be determined by solving three independent equations which express relationships of the unknown concentrations to the properties of the mixture.

FIG. **1** is a schematic representation of a gas concentration sensor comprising a property-independent flowmeter **1**, a capillary **2** and an orifice **3**, which can be used to determine individual concentrations of constituent gasses in a mixture of three known gasses. The viscosity (μ) and density (ρ) of the mixture can be determined by measuring: the ambient pressure (P_{atm}); the frequency (f_Q) of a fluidic flowmeter oscillator when flowmeter **1** is a fluidic feedback oscillator flowmeter; the pressure drop (ΔP_o) across capillary **2**; and the pressure drop (ΔP_o) across orifice **3** in accordance with the following equations:

$$\Delta P_c = k_1 \mu Q + k_2 \rho Q^2 \tag{1}$$

where: $k_1 = 12L_c\left(b_c / h_c + h_c / b_c + \frac{1}{2}\right) \Big/ [b_c h_c]^2$;

$k_2 = 1 / [2(h_c b_c)^2]$;

$$\Delta P_o = k_3 \mu Q + k_4 \rho Q^2; \tag{2}$$

where: $k_3 = 12L_o\left(b_o / h_o + h_o / b_o + \frac{1}{2}\right) \Big/ [b_o h_o]^2$;

$k_4 = 1 / [2(h_o b_o)^2]$;

and

-continued

$$Q = k_Q \Big/ \left[1/f_Q - k_a \rho^{\frac{1}{2}}\right] \tag{3}$$

where: $k_Q = 32b_a^2 h_a$;

$$k_a = 2L_a \Big/ (P_{atm}\gamma)^{\frac{1}{2}}$$

where b_c, h_c, and L_c are respectively the width, height and length of capillary **2** with rectangular cross-section, b_o, h_o, and L_o are respectively the width, height and length of orifice **3** with rectangular cross-section, Q is the volumetric flow rate through the flowmeter **1**, b_a, ha, and L_a are respectively the width, height and acoustic path length through an oscillator flowmeter **1**, and y is the mixture ratio of specific heats which is assumed to be constant. This is valid because the acoustic correction ($k_a\rho^{1/2}$) is very small, and the variation of the correction is also small, resulting in a virtually indiscernible error. In the three-gas analyzer embodiment, the ratio of specific heats is not determined from measurements and must be estimated. For example, for respired gasses (not containing anesthesia), the ratio of specific heat can be estimated to be ≈1.4.

Pressure may be measured by any number of state-of-the-art electronic pressure transducers, but in order to keep the cost low, a low-cost, integrated circuit (IC) semi-conductor strain gage pressure transducer (MEMS-based) can be used (which have only recently become available, i.e., in the last two years), provided the transducer has sufficient dynamic range, that is, that the minimum resolvable pressure should be approximately 1/10,000th to 1/40,000th of the maximum measurable pressure. This pressure measurement is, of course, performed independent of the properties of the gas.

Equations 1–3 contain three unknowns (flow rate Q, viscosity μ, and density ρ); thus, these three equations can be solved for the unknowns, and the viscosity μ and density ρ of the mixture can be determined therefrom. It should be understood that equations 1–3 describe the inherent relationships between the characteristics of the mixture in flow devices of a particular geometry (i.e., the frequency in an oscillator and the pressure drops in a capillary and in an orifice) and the physical properties of the mixture (i.e., density, viscosity and flow rate). It will be understood that these equations vary with different sensor geometries (e.g., non-rectangular cross-sections). Further, higher order terms can be included for greater precision. Conversely, the equations can be simplified to include only first order terms at the potential expense of some precision. See for example, equations (1) and (2) in the aforementioned provisional patent applications 60/055,982 and 60/069,422 which do not include higher order terms. In these simplified equations, the pressure drop across the orifice is assumed to be proportional to the density and to the square of the flow rate (and independent of viscosity), and the pressure drop across the capillary is assumed to be proportional to the viscosity and to the flow rate (and independent of density), where the flow rate is assumed to be proportional to the oscillator frequency (and totally independent of gas properties, including density and specific heat). Thus, while the density and viscosity (and flow rate) are determined from the oscillator frequency and the orifice and capillary pressure drops based on inherent relationships, it will be understood that the present invention is not limited to any particular set of equations for determining the density and viscosity or any other properties of the mixture.

FIGS. **2**a and **2**b illustrate the operation of a fluidic amplifier feedback oscillator flowmeter which can be used as flowmeter **1** in the system of the present invention. Referring to FIG. **2**a, the mixture flow passes into the amplifier **5** through a supply nozzle **12**, and the jet oscillates by using negative feedback. Fluid flow transit time measurement using a fluidic amplifier feedback oscillator flowmeter **5** has been the subject of numerous previous inventions (e.g., U.S. Pat. No. 3,640,133 to Adams, the disclosure of which is incorporated herein by reference in its entirety) where the period of oscillation is proportional mainly to the transit time of the gas across the transit distance **6** of the fluidic amplifier **5**. In general, the period is made up of two parts; the transit time of the fluid flow from the inputs **7** to the outputs **8** (transit distance **6**) and the feedback time of the acoustic signal through the outputs back to the inputs through the feedback line **9**. Vents **10** collect the fluid flow and pass the fluid to an exhaust port or, in the present implementation, connect to the downstream orifice and capillary. By making the fluid transit time long compared with the acoustic feedback (i.e., by making the acoustic feedback path **9** short and the flow velocity low), the frequency is essentially inversely proportional to only transit time and thus directly proportional to the velocity or flow rate. Since fluid transit time does not depend at all on any gas properties, frequency is therefore largely independent of density and viscosity and is essentially dependent only on flow which is the product of the nozzle area times the transit distance divided by the transit time which in the period of the oscillation frequency. FIG. **2**b shows the second half of the oscillation cycle. FIG. **3** shows the calibration for one such oscillator with feedback around a 2.1:1 aspect ratio, ten mil nozzle width, standard Government C/2-format 51021 fluidic amplifier. The calibration is the same regardless of the gas (e.g. air, oxygen or carbon dioxide). In fact, it is the same if the fluid is water. The frequency is completely linear up to flow rates of as much as 100 mL/minute for all gasses.

Note that, strictly speaking, even under the foregoing conditions, the oscillator frequency depends at least to some degree on the density and the ratio of specific heats of the sample gas (due to the acoustic feedback time component), as seen from equation (3). Thus, where the ratio of specific heats can be accurately estimated, it is desirable to use equation (3) to determine the flow rate. However, where the ratio of specific heats is not measured and is difficult to estimate (e.g., where anesthetic gas is present), the assumption that flow rate is proportional to the oscillator frequency and independent of gas properties still may provide acceptable results albeit with some small loss of accuracy.

The equations from which the constitute gas volume concentrations are determined are formulated as described in the following paragraphs.

The density of a mixture of gasses, ρ_{mix}, is equal to the sum of the products of the concentrations, C_i, and the specific densities, ρ_i, as determined by applying the law of conservation of matter:

$$\rho_{mix} = \Sigma \rho_i C_i. \tag{4}$$

The viscosity of a gas mixture is related to the concentrations of the individual gas components, as determined from the principles of the kinetic theory of gasses, and as shown by the relationship between mixture viscosity and individual concentrations (see Golubev, "Viscosities of Gasses and Mixtures", NTIS Doc. TT70-50022, 1970, incorporated herein by reference in its entirety), which relationship is given by:

$$\mu_{mix} = \Sigma[C_i\mu_i/[C_i + \Sigma C_j \phi_{ij}]];\ i=1, \ldots, k;\ j \neq i \tag{5}$$

where

$$\phi_{ij} = [1 + (\mu_i/\mu_j)^{1/2}(M_j/M_i)^{1/4}]^2 / 2.828[1 + M_i/M_j]^{1/2},$$

k is the number of constituents, and M_i is the known molecular weight of the ith component of the mixture.

If only three-gas mixtures are of interest, the third equation relating the constituent concentrations is the constitutive equation, which states that the sum of the volume concentrations of all of the gasses must equal unity,

$$\Sigma C_i = 1. \quad (6)$$

The resulting system of three algebraic equations can be uniquely solved, in real-time, for the individual concentrations, C_i. A microprocessor, or other computational mechanism (e.g., a personal computer, etc.) can be readily programmed to solve this set of equations.

The characteristics of the sensing capillary and orifice are typically shown in FIG. **4**, and are chosen in such a manner to minimize the amount of flow that needs to be sampled under operating room conditions (i.e., 50–60 ml/min, or less than half that sampled by conventional IR devices).

Equations (1)–(6) may be programmed on a microprocessor or computer, and voltage data from pressure transducers for, ΔP_o and ΔP_c, and the output of a frequency-to-voltage (F/VN) converter (e.g., Burr-Brown monolithic frequency-to-voltage IC chip), which gives a voltage proportional to flowmeter frequency, $f_{flowmeter}$, may be acquired using appropriate analog-to-digital converters. In addition, since the values of the density and viscosity of the known constituents depend on absolute pressure and temperature (e.g., ρ_i and μ_i in equations 4 and 5), these two parameters must also be measured, giving rise to two additional voltages that must be provided to the microprocessor. The resultant concentrations may be plotted in real time on a computer CRT or LCD screen in multiple colors in separate traces, or in any other convenient manner.

An example of a gas analysis system including a flowmeter-capillary-orifice structure capable of three-gas analysis in a monitor for determining concentrations of constituents within respired gasses is illustrated in FIG. **5***a*. The monitor essentially includes a microprocessor board **13** (e.g., stand alone or within a computer) and a multi-use fluidic gas sensor having a fluidic circuit with an oscillator flowmeter **14** in series with an orifice **15** and a capillary **16**. A patient **17** inspires and exhales into a face mask **18**, and a side stream sampling port **19** samples the gas near the face mask **18**. Sample gas passes through a desiccant **20** which removes any water vapor (which comprises of a fourth gas) that might affect readings. Prior to entering the oscillator flowmeter **14**, the ambient fib absolute pressure of the sample is measured by a pressure sensor **21** and directed to microprocessor **13** via a multiplexer **22** and an analog-to-digital (A/D) converter **23**. Multiplexer **22** includes sample and hold registers **24** corresponding to each signal sent to microprocessor **13** from the sensors.

Temperature sensor **25** outputs a voltage proportional to the ambient gas temperature, wherein the output is amplified by electronic amplifier **26** and directed to microprocessor **13** via multiplex **22** and A/D converter **23**. The densities and viscosities of the individual gasses are precisely known functions of temperature and pressure; thus, the measured absolute pressure and temperature are utilized to determine the densities and viscosities of the constituent gasses which are needed to determine the gas concentrations (e.g., see equations (4) and (5)).

The sample flow rate is then measured in the oscillator flowmeter **14**. A pair of low-cost electret microphones (not shown) or ultra-low cost piezo-electric film microphones pick up two 180° out-of-phase oscillating pressure signals in each feedback leg and are electrically differenced (in order to cancel out ambient noise which is in phase on both microphones) and amplified by an electronic amplifier **27**. This amplified periodic signal may be fed into a frequency-to-voltage (F/V) converter **28**, and a voltage proportional to the flow rate is applied to the microprocessor **13** via multiplexer **22** and A/D converter **23**. Alternatively, a high speed frequency counter may read the frequency directly in the microprocessor.

The flow exits the flowmeter **14** and enters into a capillary resistor **16**. The pressures at the ports **29** and **30** at either end of the capillary are fed into a differential pressure transducer **31**, such as a low-cost micro-electro-mechanical systems (MEMS)-based electronic pressure transducer (e.g., Data Instruments SURSENSE transducer), and the output voltage is transmitted to the microprocessor **13** via multiplexer **22** and A/D converter **23**. The flow then continues through orifice **15** and the pressure at the ports, representing the upstream and downstream pressures across the orifice **15**, is measured by yet another differential pressure transducer **32**. The voltage from transducer **32** is transmitted to microprocessor **13** via multiplexer **22** and A/D converter **23**. In the embodiment shown in FIG. **5***a*, a vacuum source downstream of orifice **15** provides the negative pressure to sample breath through the sensors. Alternatively, the flow may be driven through the circuit by the patient's breath pressure provided sufficient pressure can be guaranteed (this is not always possible with respiratorily compromised patients or those who are not breathing spontaneously).

Microprocessor **13** can drive a display (not shown), such as a CRT which continuously may display the concentrations of any or all of the three gasses as well as providing any desired numeric outputs, such as respiration rate, numeric values of concentrations, as well as any limits. Optionally, the display may be a liquid crystal display (LCD), wherein the device is a compact battery-operated device with a detachable disposable sensor, wherein the sensors are small enough to be located right on a patient mask or tube. This permits the device to check exhaled oxygen and carbon dioxide at any desired location. Use of electronics with memory provides for recall of previous data for comparison. Also, the microprocessor may be programmed to provide visual and aural alarms in the event of particular occurrences such as overdosing, poor metabolization of oxygen, low or high respiration rates and any other functions as may be desired.

The system produces a real time output of individual concentrations of constituent gasses with no artifacts. The response time of less than 100 ms is fast enough and the side stream sample size is small enough for accurate monitoring of neonates and children.

The embodiment of FIG. **5***a* may be utilized in various locations, such as the home within a home therapy device, or ambulances and other locations experiencing field trauma within an emergency medicine device for validating ventilation and checking for proper intubation of a patient. In this case, the three respired gasses are oxygen, carbon dioxide, and a known, fixed mixture of nitrogen, argon and other trace gasses. This nitrogen mixture gas remains constant in its constituent concentrations, none being metabolized. The three-gas monitor may be used with ventilator-dependent patients, patients with respiratory insufficiencies or patients having or suspected of having a compromised respiratory system wherein the monitor may be used in various locations, such as ambulances, hospitals and/or sub-acute care facilities, and during patient transport between these facilities.

FIG. **5***b* is a flow chart summarizing the above-described processing steps (steps **33–39**) involved in determining the individual concentrations of the constituent gasses in a mixture of three known gasses.

In another more efficient embodiment, the nozzle of the flowmeter itself is used as an orifice instead of a separate orifice so that the measurement of the pressure drop across flowmeter nozzle serves the same purpose. That is, the fluidic amplifier feedback oscillator serves as both a flowmeter and an orifice.

Preferably, the flowmeter, capillary and orifice are formed on a plate-like module that is disposable after each use to eliminate the possibility of contamination and to simply sterilization of the gas analyzer system. FIG. **5***c* illustrates a modular three-gas respiration monitor utilizing a disposable sensor module **40**. Preferably, disposable sensor module **40** comprises a small, thin, plastic chip containing fluidic sensors. The disposable sensor module **40** receives respired gasses sampled from a side-stream sampling port **19**. An on-chip desiccant **41** removes any water vapor that might affect readings, and the desiccated gas mixture flows through a flowmeter **42** and then through a set of substantially parallel capillaries **43**. The capillary comprises multiple parallel channels to facilitate accurate manufacture (fabrication errors are thus self-canceling) as well as to provide for a low resistance, thereby minimizing vacuum requirements.

The disposable sensor module **40** is connected to a replaceable transducer module **44** by a separable interface **45**. The cost of the replaceable transducer module **44** is low enough to permit it to be discarded in the event of a catastrophic contamination by infected fluids or damage in the field. The transducer module **44** contains the transducers necessary for sensing the temperature and pressures of the gas mixture in the fluidic devices in the disposable sensor module **40**. The separable interface **45** conveys electric signals from temperature and microphone sensors, connects pressure transducers to appropriate points in the fluidic sensors, and receives the sample flow exhausted from the set of capillaries **43**. The transducer module **44** is connected to a low cost expendable electronics module **54** via a replaceable vacuum line and electrical wire umbilical **55**. The expandable electronics are low enough in cost so that they would not constitute a separate budget item but, rather, would be a regularly stocked item.

Prior to entering the oscillator flowmeter **42**, the ambient pressure of the gas sample is measured by an absolute pressure transducer **46** on board transducer module **44**. The eta voltage from transducer **46** is transmitted via umbilical **55** to a sample and hold circuit of a multiplexer **56** on board the electronics module **54**. An A/D converter **57** converts the analog signals generated by the sample and hold circuit of multiplexer **56** into a digital signal that is supplied to a microprocessor **58**.

A temperature sensor provides a voltage proportional to the ambient gas temperature, and the output voltage is amplified by electronic amplifier **47** on board transducer module **44** and transmitted via umbilical **55** to the multiplexer **56**, A/D converter **57** and microprocessor **58**.

The sample flow rate is then measured in the oscillator flowmeter **42**. A microphone **48** picks up the oscillating pressure signals which are amplified by an electronic amplifier **49** on board transducer module **44**. The output of amplifier **49** is supplied via umbilical **55** to a frequency counter **59** in electronics module **54**. Frequency counter **59** may employ a high-frequency electronic oscillator which is gated by the frequency signal from amplifier **49** to produce a real-time digital frequency measurement which is provided directly to microprocessor **58**. This simplified arrangement advantageously eliminates the need for a frequency-to-voltage converter and the need for subsequent A/D conversion of the frequency signal. The flow exiting flowmeter **42** enters into a capillary entrance **50**.

In the exemplary embodiment shown in FIG. **5***c*, the oscillator **42** functions as both the flowmeter and the orifice. Specifically, a differential pressure transducer **51** on board transducer module **44** measures the pressure drop across the oscillator flowmeter (orifice) **42** by measuring the difference between the pressure upstream of the amplifier nozzle at the entrance to the flowmeter oscillator **42** and the pressure downstream in the amplifier vent region at the capillary entrance **50**. The output voltage from pressure transducer **51** is transmitted via umbilical **55** to multiplexer **56**, AND converter **57** and then to microprocessor **58** on board electronics module **54**.

The structure and operation of the parallel capillary arrangement will now be described. As shown in FIG. **5***c*, a single capillary entrance **50** and a single capillary exit **52** are connected via a plurality of substantially parallel capillaries **43**. Capillary entrance **50** extends longitudinally in a direction substantially perpendicular to the longitudinal direction of the capillaries **43**, with each of the capillaries **43** extending from one longitudinal side of entrance **50**. Capillary entrance **50** receives the sample gas flow from the output of flowmeter **42** and distributes the flow to the plurality of capillaries **43**. Capillary exit **52** extends longitudinally in a direction substantially perpendicular to the longitudinal direction of the capillaries **43**, with each of the capillaries terminating on one longitudinal side of the capillary exit **52**. A differential pressure transducer **53** on board transducer module **44** measures the pressure drop across all of the capillaries by measuring the difference between the upstream pressure at a point within a capillary and the downstream pressure at the capillary exit **52**. The output voltage from pressure transducer **53** is transmitted via umbilical **55** to multiplexer **56**, A/D converter **57** and then to microprocessor **58** on board electronics module **96**.

The parallel capillary structure provides a number of advantages. Specifically, each individual narrow capillary has a relatively high level of flow resistance, which is desirable for accurately measuring the pressure drop across one of these capillaries and minimizing entrance flow effects. However, the multiple capillaries allow a relatively high overall flow rate to be maintained. That is, in a manner analogous to electrical resistance, while the flow resistance in a single capillary is relatively high, the overall flow resistance is significantly lower due to the parallel arrangement of the capillaries, which collectively allow a much greater flow.

Additionally, by reducing the flow (and consequently the Rayleigh number) in each channel, the parallel capillary arrangement significantly reduces the length over which non-linear entrance effects are felt before the flow becomes fully developed in the capillary. By reducing this entrance effect, the length of the capillary required for an accurate linear pressure measurement relative to flow is reduced.

The parallel capillary arrangement also makes manufacturing repeatability simpler, cheaper and more feasible. Specifically, required manufacturing tolerances are a function of the required accuracy of the pressure measurements, since the dimensions of the capillary are assumed to have certain values (geometric constants) in the computation of viscosity and density (see equation 1). However, with the multiple capillary arrangement, the impact of random variations in the dimensions of individual capillaries diminishes with an increasing number of capillaries. By way of example, in the case of a single capillary with a nominal width of 0.25 mm, in order to ensure that device-to-device differences in air flow resistance are no greater than in the fifth significant digit, the manufacturing tolerances would have to be in the nanometer range. However, since deviations in width occur randomly, the deviations tend to cancel out if sufficient numbers of capillaries are used in parallel. For example, putting two capillaries in parallel reduces the effects of fabrication errors by a factor of ten. Four capillaries in parallel will reduce the effects of fabrication errors by another factor of ten, and eight capillaries in parallel will reduce the effects by yet another factor of ten. Thus, by using eleven capillaries in parallel, as shown in FIG. **5***c*, the effects of dimensional variations can be reduced by well over three orders of magnitude, providing effective nanometer tolerances (and the manufacturing repeatability associated therewith) with actual tolerances on the order of microns, which are readily achievable with standard precision manufacturing methods such as precision injection molding.

The aforementioned manufacturing repeatability is an important aspect of producing a low-cost device, since it obviates the need for individual unit characterization during manufacturing and eliminates the need for user calibration prior to or during use of the system. Specifically, the aforementioned fabrication tolerances allow the geometric constants used in equations 1–3 to be known a priori or to be characterized during production in the factory. By measuring the pressure-flow (P-Q) characteristics of a single unit using calibration gasses with precisely known properties traceable to primary standards and fitting the known functional relationships to the data, extremely accurate regressions can be used to evaluate the geometric constants which can then be used for other units; thus, geometric characterization of a single unit can obviate the need for individual unit characterization. Given electronic pressure transducer stability and the fact that the equations to be solved are derived from first principles, no user calibration is ever required throughout the lifetime of the system.

While shown in FIG. **5***c* as being physically parallel, capillaries **43** can be arranged in any convenient manner, provided that they produce parallel flow resistance between a common entrance and a common exit. Thus, as used herein, the term "parallel" connotes parallel air flow resistivity but not necessarily a physically parallel arrangement, while the terms "physically" or "substantially" "parallel" connote the actual physical arrangement of the capillaries.

From capillary exit **52**, the sample gas is routed through a gas exhaust passage of separable interface **45** to transducer module **44** and then through umbilical **55** to a vacuum pump **89** located inside the enclosure holding the electronics module **54**, from which the gas is exhausted to the atmosphere through an appropriate filtering mechanism.

Microprocessor **58** controls a liquid crystal display **60** which displays medical information derived from the measurements processed by microprocessor **58**, including individual concentrations of the gasses of interest of the sample gas mixture.

Referring now to FIG. **6**, a perspective view of actual hardware is shown illustrating the small size (shown relative to a coin, i.e., a U.S. quarter dollar), compactness and simplicity of the device which provides a low cost. FIG. **6** shows a stack of fluidic metal laminations held together with screws which may be replaced by diffusion-bonded stack or injection molded assemblies in production devices.

As disclosed in the above-mentioned provisional applications, the above-described three-gas analyzer can be used to determine concentrations of respired anesthesia gasses. In this case, after analysis, the exhaled gasses may be scrubbed of carbon dioxide in a scrubber filter and returned to the anesthesia machine. By way of example, the present invention may be utilized to analyze a set of gas mixtures that are typically encountered in actual anesthesia practice, such as oxygen, O_2, carbon dioxide, CO_2, and the potent anesthesia agent, halothane, $C_2HBrClF_3$. This gas mixture is one that occurs after a short time (e.g., about 7 minutes) after a patient has expelled all residual dissolved nitrogen and, under a relatively common situation, where the potent anesthetic is administered alone without nitrous oxide (e.g., standard practice is to reduce the concentration of potent anesthetic by providing a high dose of nitrous oxide, N_2O, which is thought to mitigate side effects of the potent anesthetic). This simpler mixture is now often used with children and obstetric cases as it is advantageous because the danger of suffocation in nitrous oxide in the event of a loss of oxygen is reduced. The administration of a single anesthesia agent without nitrous oxide, however, is still typically not standard general practice.

FIG. **7***a* shows three exemplary real time traces of the concentration histories during simulated respiration of an anesthetic mixture. Respiration is simulated by periodically adding about ten percent carbon dioxide. When CO_2 is added, the concentrations of oxygen and halothane decrease (e.g., if the gas was actually respired, the concentration of halothane remains approximately constant because the amount of oxygen and carbon dioxide relative to the halothane is fixed since the oxygen is metabolized into carbon dioxide, that is, only O_2 and CO_2 are out of phase). Halothane is resolved to about ±0.05% volume concentration. By specifically measuring the physical properties of the mixture, specificity of the individual concentrations is automatically ensured.

FIG. **7***b* shows exemplary real time traces of oxygen and carbon dioxide during actual respiration of an adult male when the monitoring mode is for air (a three-gas mixture Of O_2, CO_2 and pseudo-nitrogen (N_2+Ar+traces)). The typical capnographic trace of CO_2 shown a well-defined sharp rise to a plateau with an end-tidal value just preceding inhalation. The noise represents less than 0.5% volume upon concentration. As seen in the circled portion of the traces, irregularities in the traces indicate premature ventricular contractions.

FIG. **7***c* shows the system response to a calibration gas composed of 95% O_2 and 5% CO_2. This time trace begins with the sensor sampling dry air and initially shows the constituents of air as 79% N_2+traces, 21% O_2, and approximately 0% CO_2, as is expected. When the calibration gas is turned on, the nitrogen concentration goes to zero, the oxygen concentration rises to approximately 95%, and the CO_2 concentration rises to almost exactly 5%. Noteworthy here is the accuracy and resolution of CO_2. The accuracy is ±0.25 volume % as shown by the average value of CO_2, and the resolution is also ±0.25 volume % as demonstrated by the noise of the measurement. It is instructive to note that the accuracy and resolution is the same for all three gasses measured. This is because of the way the concentrations are reconciled by the constitutive equation (concentrations sum to one). This has a very important implication on the measured values of O_2. Since the accuracy is independent of concentration value, this measurement technique gives rise to significantly better accuracy at high concentration levels than conventional sensors which normally have an accuracy which is a fixed percentage of the concentration. Thus, a conventional O_2 sensor that provides readings accurate to

±2% of reading may be quite accurate at low concentration levels (at 10% concentration the accuracy would be 0.2 volume percent) but less accurate at high concentration levels (at 95% concentration, the accuracy is 2 volume percent). In contrast, the device of the present invention maintains its ±0.1 volume percent accuracy over the entire range of concentrations, e.g., 95±0.25% and 10±0.25%.

In order to determine the individual concentrations of four gas constituents in a mixture of four gasses, an additional property, independent of density and viscosity, must be measured. The specific heat at constant pressure, c_p, is one such property. It is a unique gas property independent of density and viscosity and is normally determined by measuring the speed of sound in the gas. From the kinetic theory of gasses, the speed of sound, a, is defined as:

$$a=[yR_oT/M]^{1/2} \tag{7}$$

where R_o is the universal gas constant, T is the absolute temperature, M is the molecular weight and y is the ratio of specific heats, c_p/c_v, c_v being the specific heat at a constant volume. Molecular weight, being directly proportional to density, is available from the sensor densitometer function. The specific heats c_p and c_v are related by the gas constant and molecular weight:

$$c_p = c_v + \frac{R_o}{M} \tag{7a}$$

From equations (7) and (7a), the following expression for c_p can be derived:

$$c_p = \frac{1}{\frac{M}{R_0} - \frac{T}{a^2}} \tag{8}$$

Since density ρ is related to molecular weight M and absolute pressure P_{amb} (terms that are measured), equation (8) can be rewritten as:

$$C_p32\ 1/[T(\rho mix/Pamb-1/a^2)] \tag{8a}$$

As noted previously in the design of the fluidic flowmeter oscillator, the frequency of a fluidic feedback oscillator depends on the transit time of the fluid from the input ports to the output ports of the interaction region, and the acoustic feedback time from the output ports back to the input ports. In general, frequency f_{sonic} of the sonic oscillator and the flow rate Q are related to the speed of sound by:

$$a=2L_{fbA}/[1/f_{sonic}-4x_{spA}b_Ah_A/Q] \tag{9}$$

where L_{fbA} is the path length of the feedback lines, x_{spA} is path length from the input ports to the output ports of the oscillator interaction region, and b_A and h_A are the oscillator supply nozzle width and height, respectively. By making the path length of the feedback lines long, the acoustic delay becomes the dominant term relative to the transit time. In general, therefore, if the frequency f of a sonic oscillator is proportional only to the speed of sound,

$$a=kf_{sonic},$$

then the ratio of specific heats (and consequently the specific heat, c_p) of a mixture can be determined from the relationship,

$$y_{mix}=[kf_{sonic}]^2M_{mix}/R_oT \tag{10}$$

FIG. **8** shows a plot of the frequency of an early DRT model 51009 sonic oscillator with approximately ten inch long feedback lines as a function of the square root of y/M. The data is roughly linear. The data points corresponding to different ratios of y and molecular weights are obtained by operating the oscillator with various gas mixtures of known concentrations.

The relationship between the concentrations of the various gasses and the specific heat is a similarly simple linear relationship as was the case with density and molecular weight. The specific heats of the mixture are related to the individual component specific heats by weight fraction of each component; thus,

$$c_{p\,mix} = C_1M_1c_{p1} + C_2M_2c_{p2} + \dots \tag{11}$$

$$c_{p\,mix} = \sum_i^N C_iM_ic_{pi} \tag{12}$$

and

$$c_{v\,mix} = C_1M_1c_{v1} + C_2M_2c_{v2} + \dots \tag{13}$$

or

$$c_{v\,mix} = \sum_i^N C_iM_ic_{vi} \tag{14}$$

Thus, by measuring the three properties of density, viscosity and a specific heat of a mixture of four gasses, four independent equations (equations 4, 5, 6 and 12 or 14) can be solved for the four unknown concentrations of the individual four gasses.

In the context of anesthesia gas administration, determination of the concentrations o of five gasses can be achieved without measuring an additional independent property (i.e., by measuring only these three properties) by adding an additional piece of information to solve for the fifth gas. Five-gas mixtures typify modern anesthesia administration. The five gasses are typically: nitrogen, oxygen, carbon dioxide, nitrous oxide, and a potent, volatile anesthetic agent. Nitrogen is the primary component of air and is typically present in respired gasses, and even when the administered gasses are free of nitrogen (which is typically the case during administration of anesthesia) nitrogen remains present as a residual for several minutes from previously having breathed air. The ability to measure nitrogen is a major safety benefit during administration of anesthesia, since a sudden small presence of nitrogen may indicate an air embolism, and a large presence may indicate a loss of breathing circuit integrity (e.g., a leak in the system).

Measurement of the concentration of oxygen, which is administered or present in air, provides redundancy to the breathing circuit O_2 sensor (e.g., a Clark electrode) and eliminates any pulse oximeter CO ambiguity. Measurement of the concentration of CO_2, which is a product of the body's metabolic processes, can be combined with the oxygen measurement to provide a respiratory quotient and to validate respiration.

Nitrous oxide is typically administered in combination with a volatile anesthetic agent, and measurement of its concentration prevents overdosing and asphyxiation. Volatile halogenated anesthetic agents are administered to induce anesthesia and include: halothane, desflurane, sevoflurane, enflurane, and isoflurane. Monitoring of two volatile potent anesthetic agents simultaneously when one is discontinued and a new one is started is possible after the nitrogen disappears some 7–15 minutes into most normal procedures. This capability can be provided by allowing the user to identify the known makeup of the five gasses, that is, when nitrogen is no longer physiologically present (i.e., when the system shows that it is no longer present), and only four gasses remain. At that point another, different gas component (e.g., helium used during laser surgery or a second anesthetic agent), can be additionally considered and/or measured.

Importantly, however, carbon dioxide and nitrous oxide have almost exactly the same molecular weight, density and viscosity and very similar specific heats. Thus, these two gasses, typically present in respired anesthesia gasses, cannot readily be distinguished by these properties. Given sufficient pressure transducer and flow sensor resolution, these two gasses can be resolved; however, from a practical aspect, resolution would have to be improved by an order of magnitude from the current state-of-the-art. However, anesthesia machines typically remove carbon dioxide from the stream of air that is inspired by the patient under anesthesia; thus, the concentration of carbon dioxide in the inspired gasses is known to be zero. This fact can be used to extend the capabilities of a four gas analyzer to determine the concentrations of five gasses in a typical mixture of anesthesia gasses.

Specifically, for purposes of solving the four equations relating properties of the mixture to individual gas concentrations, carbon dioxide and nitrous oxide are considered to be a single gas, and it is assumed that their properties cannot be distinguished and are the same. Thus, for example, equations (4), (5), (6) and (12) are solved for the concentrations of oxygen, nitrogen, a potent anesthetic gas, and the combination of carbon dioxide and nitrous oxide. The individual concentrations of nitrous oxide and carbon dioxide can then be determined in the following manner. The combined concentration of nitrous oxide and carbon dioxide varies cyclically with respiration, as the concentration of carbon dioxide varies from near zero in the inspired gasses to a maximum during exhalation. Thus, the minimum combined concentration in each cycle can be assumed to be the concentration of nitrous oxide, while the concentration of carbon dioxide can be assumed to be the difference between the combined carbon dioxide-nitrous oxide concentration (which is varying throughout each respiration cycle) and the most recent minimum combined concentration (i.e., the nitrous oxide concentration). According to this approach, the carbon dioxide concentration is computed and updated throughout each cycle (as is the concentration of oxygen, nitrogen and the anesthetic agent), while the nitrous oxide concentration is updated once during each respiration cycle.

Referring now to FIG. **9***a*, a five-gas analyzer is shown. This analyzer is designed to generally be utilized in operating rooms, outpatient surgery centers or any facility that uses anesthetic gasses and/or sedation, to analyze concentrations of multiple respired anesthetic gasses simultaneously. FIG. **9***b* is a flow chart illustrating the processing steps involved in determining the individual concentrations of the constituent gasses in a mixture of five known gasses.

As before in the three-gas analyzer shown in FIG. **5***a*, the respired gasses are side-stream sampled through a sampling port **61** and passed through a desiccant **62** to remove all traces of water and water vapor. The majority of the respired gasses are passed through a soda lime filter and desiccant **79** to remove carbon dioxide and water vapor and then recirculated through the breathing circuit. The anesthetic gasses (e.g., nitrous oxide and a volatile potent anesthetic) are supplied from an anesthesia machine **63** to the inspired gasses. Since many anesthesia machines permit only a single potent anesthetic to be dispensed, the opening of an interlocked valve may be electronically monitored and a signal identifying which anesthetic is being dispensed is transmitted to a microprocessor **64** via an electrical connection (not shown) so that the appropriate gas parameters are used in the equations solving for the concentrations.

Prior to entering the oscillator flowmeter **65**, the ambient pressure of the sample is measured (step **81**) by a pressure sensor **80** and directed to microprocessor **64** via a multiplexed RS232 port **68**. Temperature sensor **69** within flowmeter **65** provides a voltage proportional to the ambient gas temperature, which is amplified by electronic amplifier **70** and directed to microprocessor **64** via RS232 port **68**.

The sampled gas then passes through the flowmeter **65** (step **82**) and generates a voltage at a frequency proportional to flow which is amplified by electronic amplifier **66**, and the frequency is converted to a voltage proportional to the frequency in F/V converter **67**. This voltage is passed to the microprocessor **64** via RS232 port **68**. As with the three-gas analyzer, the sampled flow passes through a viscosity sensing capillary **71** (step **83**) and a density sensing orifice **72** (step **84**). Differential pressures across the capillary **71** and orifice **72** are measured by pressure transducers **73** and **74**, respectively. The respective transducer output voltages are transmitted to microprocessor **64** via RS232 port **68**. The sampled gas continues through the sonic oscillator **75** (step **85**) which generates an acoustic frequency proportional to the square root of the ratio of specific heats and inversely proportional to the square root of the molecularweight. Microphone **76** (or a pair of microphones as in the three-gas analyzer) picks up this frequency which is fed into a frequency-to-voltage (F/V) converter **77** which provides a voltage proportional to the square root of the ratio of specific heats y, divided by molecular weight. This voltage is sent to microprocessor **64** via RS232 port **68**. The sampled gas is finally exhausted to a vacuum source (not shown).

In step **86**, using the assumption that carbon dioxide and nitrous oxide are a single constituent, the microprocessor **64** solves the four simultaneous equations, three involving the three measured properties, equations (4), (5), and (12), and the fourth being the constitutive equation, equation (6), that requires that the sum of the concentrations be unity.

$$\rho_{mix} = \sum \rho_i C_i. \tag{4}$$

$$\mu_{mix} = \sum \mu_i / \left[1 + (1/C_i) \sum C_j \phi_{ij}\right],\ j \neq i \tag{5}$$

$$c_{p\,mix} = \sum_i^4 C_i M_i c_{pi} \tag{12}$$

$$\Sigma C_i = 1. \tag{6}$$

In step **88**, the individual concentrations of carbon dioxide and nitrous oxide are then determined by microprocessor **64** in the previously-described manner. The resultant concentrations and any other derived outputs may be presented on display **78** which is controlled by microprocessor **64**.

In most recirculating anesthesia administration systems, exhaled gasses are scrubbed of carbon dioxide in a scrubber filter (not shown) and returned to the anesthesia machine **63**.

Preferably, the gas analysis is performed by a flowmeter oscillator (also serving as an orifice), a capillary and a sonic oscillator formed on a plate-like single chip module that is disposable after each use to eliminate the possibility of contamination and to simplify sterilization of the gas analyzer system.

FIG. 9*c* illustrates a modular four-gas (five-gas for anesthesia administration) respiration monitor utilizing a disposable sensor module **90**. Preferably, disposable sensor module **90** comprises a small, thin, plastic lamination containing the fluidic sensors. The disposable sensor module **90** receives respired gasses sampled from a side-stream sampling port **61**. An on-board desiccant **91** removes any water vapor that might affect readings, and the desiccated gas mixture flows through a flowmeter oscillator **92** and then through a set of parallel capillaries **93**.

The disposable sensor module **90** is connected to a replaceable transducer module **94** by a separable interface **95**. The cost of the replaceable transducer module **94** is low enough to permit discarding in the event of a catastrophic contamination by infected fluids or damage in the field. The transducer module **94** contains the transducers and amplifiers necessary for sensing the characteristics of the gas mixture in the fluidic devices on board the disposable sensor module **90**. The separable interface **95** conveys electric signals from temperature and microphone sensors, connects pressure transducers to appropriate points in the fluidic sensors, and receives the sample flow exhausted from the sonic oscillator **108**. The transducer module **94** is connected to an electronic computational module **96** via a replaceable vacuum line and electrical cable umbilical **97**.

Prior to the sample gas entering the oscillator flowmeter **92**, a temperature sensor measures the sample gas temperature at the flowmeter entrance and provides a voltage proportional to the measured temperature. The output voltage is amplified by electronic amplifier **98** on board transducer module **94**, and the amplified voltage is transmitted via umbilical **97** to an A/D converter **99** which converts the signal into a digital signal that is supplied to a microprocessor **100**.

The sample flow rate is then measured in the oscillator flowmeter **92**. A microphone **101** picks up the oscillating pressure signals which are amplified by an electronic amplifier **102** on board transducer module **94**. The output of amplifier **102** is supplied via umbilical **97** to a frequency counter **99** in electronics module **96** which provides a real-time digital frequency measurement directly to microprocessor **100**.

In the exemplary embodiment shown in FIG. 9*c*, the oscillator flowmeter **92** functions as both the flowmeter and the orifice. Specifically, a differential pressure transducer **103** on board transducer module **94** measures the pressure drop across the oscillator flowmeter (orifice) **92** by measuring the difference between the pressure upstream of the amplifier nozzle at the entrance to the flowmeter oscillator **92** and the pressure downstream of the nozzle at output of oscillator **92**. The output voltage from pressure transducer **103** is transmitted via umbilical **97** to A/D converter **99** and then to microprocessor **100** on board electronics module **96**. Alternatively, sonic oscillator **108** supply nozzle may be used as the densitometer orifice. This may be advantageous, as the pressure drop in generally higher, and a less sensitive, lower cost differential pressure transducer may be used to measure the pressure drop.

The flow exiting flowmeter **92** enters into a capillary entrance **104**. The absolute pressure of the gas sample at the capillary entrance **104** is measured by an absolute pressure transducer **105** mounted in the transducer module **94**. The voltage from transducer **105** is transmitted via umbilical **97** to A/D converter **99** and then to microprocessor **100** in the electronics module **96**.

As shown in FIG. 9*c*, a single capillary entrance **104** and a single capillary exit **106** are connected via a plurality of substantially parallel capillaries **93**. The structure and operation of the parallel capillary arrangement are the same as those described in relation to FIG. 5*c*. A differential pressure transducer **107** in transducer module **94** measures the pressure drop across one of the capillaries **93** by measuring the difference between the upstream pressure at a point within the capillary **93** and the downstream pressure at the capillary exit **106**. The output voltage from pressure transducer **107** is transmitted via umbilical **97** to A/D converter **99** and then to microprocessor **100** on board electronics module **96**.

The sampled gas continues from the capillary exit **106** through sonic oscillator **108** which generates an acoustic frequency proportional to the square root of the ratio of specific heats and inversely proportional to the square root of the molecular weight. Microphone **109** picks up the oscillating pressure signals (i.e., the acoustic frequency) which are amplified by an electronic amplifier **110** in transducer module **94**. The output of amplifier **110** is supplied via umbilical **97** to a flow counter **99** on board electronics module **96**, which produces a digital frequency signal that is provided to microprocessor **100**.

From the exit of sonic oscillator **108**, the sample gas is routed through a gas exhaust passage of separable interface **95** to transducer module **94** and then through umbilical **97** to a vacuum pump **111** on board electronics module **96**, which exhausts the sample gas.

Microprocessor **100** controls a display **112** which displays medical information derived from the measurements processed by microprocessor **100**, including individual concentrations of the constituent gasses of the sample gas mixture.

Referring now to FIG. **10**, an exemplary virtual instrumentation screen output is shown. Three displays of real time traces of oxygen concentration **170**, carbon dioxide concentration **171** and halothane (i.e., potent anesthetic) concentration **172**, are shown (although the number and orientation of traces may of course be adjusted as desired). The instantaneous value of the concentrations are also shown as vertical bars **173**, **174**, and **175**, and also as numeric values **176**,**177** and **178**. A variety of visual display options can be made available which are illustrated by "Change Trend" **179**, "Add Trend" **180**, "Print" **181**, "Clear" **182**, "Cal" (i.e., calculate) **183**, and "Menu" **184**. It is to be understood that many different screen formats for the data outputs may be utilized and that this one is merely exemplary.

By the addition of a sensor capable of measuring a fourth independent property of a mixture, the system can be extended to determine the concentrations of five gasses in the general case, and a six-gas mixture in the case of anesthetic gasses, where the individual concentrations of carbon dioxide and nitrous oxide are determined in the previously-described manner. Six-gas mixtures occur when water vapor is not removed, or when air is used as the anesthesia carrier. Air additionally introduces argon at about one percent concentration to the gas mixture. The presence of the inert gas argon, however, may be treated as a known constant concentration, in which case properties need be measured. The other trace gasses are in such small concentrations that they do not materially affect the bulk properties of the overall mixture to a discernable amount within the desired clinical accuracy of the system. Water vapor normally occurs at 100% humidity, if not desiccated, and under certain circumstances may also be treated as a known fixed constituent. Removal of watervapor is desirous, however, as it may condense in the fluid passages thereby changing the fluid resistance properties and thus affecting output readings. Operation of the system at elevated temperature to avoid condensation would require a separate heater which, from an energy consumption stand point, is not desirable.

To further reduce costs, special purpose digital signal processing electronics can be used (rather than a general purpose personal computer), and the use of virtual instrumentation techniques with a color display provides outputs in a format that physicians are familiar with, similar to the ubiquitous hospital vital signs monitors. Touch-screen virtual knobs and dials may provide the user with instant and user-friendly reconfiguration capabilities to adjust the output format to one with which a particular user is most comfortable.

The gas concentration monitoring system of the present invention requires no user calibration or maintenance and may be integrated into existing monitoring systems. For example, the sensors shown in FIGS. **5**a/**5**c or FIGS. **9**a/**9**c can be added along the same flow path as other sensors or can be added in a separate flow path. Importantly, the concentration measurements of the other sensors must be provided to the microprocessor along with the measured properties of the mixture in order to solve for the unknown gas concentrations. A Low cost is one of the main attributes of the present invention. Cost for a full-function, four-gas, fluidic multiple medical gas monitor, is determined by the low cost (about $2.00) of the injection molded fluidic circuit and the low cost (about $10.00 each), high accuracy pressure transducers. Since viscosity, density and specific heat are affected by temperature, ambient temperature measurement is required to maintain accuracy. The temperature sensors described above may be implemented by a simple, ultra low cost electronic temperature sensor, as exemplified by the previously-mentioned Analog Devices AD590 device (at a cost of about $3.00), to provide the required accurate temperature input to the computational processor.

One of the important advantages of the present invention is the ability to simultaneously determine the individual concentrations of N gasses in a mixture of N known gasses by using inexpensive sensors to measure properties of the mixture as a whole and by solving N independent equations relating to the properties of the mixture. Although the above examples describe the invention with three to five gasses, the invention is not limited to the determination of concentrations of only five gasses. If additional properties of the mixture can be independently measured by any means and related to unknown concentrations, concentrations of additional gasses can be determined. In general, if N−1 independent properties of the mixture of gasses can be measured, then N equations can be developed and solved for N gas concentrations (the Nth equation being the constitutive equation (6)).

Other independent thermodynamic properties include, but are not limited to: heats of formation and critical temperature. It should be noted that properties such as thermal conductivity are dependent on specific heat and viscosity and hence are not independent. Other physical properties such as refractive index and absorptivity may also be useful.

Further, while fluidic measurement of the properties of a gas mixture offers a low-cost alternative to more expensive conventional sensors, the principles of the present invention can be extended to include any device which measures properties of the mixture as a whole or concentrations of individual gasses. For example, assume that a particular sensor is capable of determining the concentration of oxygen in a mixture of gasses. The information provided by this separate sensor (i.e., the oxygen concentration) is, in effect, an equation relating to a gas concentration, which equation can be used to solve other equations relating to gas concentrations. Thus, if the oxygen concentration measurement is supplied to the microprocessor **64** in FIG. **9**a along with the fluidically measured properties, the concentrations of six gasses in a six gas mixture can be determined (i.e., the oxygen concentration and the concentration of any other five known gasses).

Importantly, fluidic and thermodynamic measurements can be used to determine the unknown gas concentrations in the mixture, regardless of what these gasses are, provided that the identity of the gasses is known and that each gas is distinguishable from all others by at least one of the measured properties. For example, it is desirable to be able to monitor the concentration of nitrogen in a mixture of exhaled gasses while a patient is being anesthetized. During the initial minutes during administration of anesthesia, nitrogen is present in the exhaled gasses, as nitrogen is liberated from lipids and fatty tissues. After approximately ten minutes, nitrogen is not normally present in a significant amount. A leak or break in a supply line would result in the continued presence of nitrogen in the exhaled gasses and can be detected by determining the concentration of nitrogen. However, nitrogen concentrations cannot be measured with conventional IR techniques; thus, more expensive techniques, such as mass spectroscopy typically have been required when it is desirous to determine nitrogen concentrations. According to the present invention, nitrogen concentration can be measured in a three gas mixture by measuring two gas properties and in a five gas mixture (during anesthesia administration) by measuring three gas properties. Further, with the addition of M other sensors which respectively measure the concentrations of M individual gasses, the nitrogen concentration can be measured in a mixture of M+5 gasses, where three gas mixture properties have been measured. Thus, for example, two sensors which measure the concentrations of two gasses can be combined with the three-property measurement device shown in FIGS. **9**a/**9**c to determine the concentration of seven gasses (e.g. nitrogen, oxygen, water vapor, carbon dioxide, nitrous oxide and two anesthesia agents) in real time at very low cost.

More generally, in accordance with the present invention, the capabilities of an existing sensor system for measuring M gas concentrations can be extended to measure N additional gas concentrations by measuring N−1 properties of the gas mixture as a whole, regardless of what the gasses are, provided the identity of the gasses is known. Knowledge of the individual concentrations of certain gasses in the mixture reduces the number of unknowns; thus, N unknown individual concentrations in a mixture of N+M fluids can be determined by solving N equations, where individual concentrations of M fluids are known or determined by other means. For example, many existing anesthesia machines capable of measuring five gasses cannot measure the concentrations of nitrogen, carbon monoxide and helium. By augmenting such a five-gas monitor with the fluidic sensors shown in FIGS. **5**a/**5**c, concentrations of these additional gasses can be measured with little additional expense.

In accordance with another embodiment, the fluidic sensors of the present invention can be used to determine or verify the identity of a gas flowing from a source. Specifically, the identity of a single, unknown gas can be determined by fluidically measuring properties of the gas, such as density and viscosity, and comparing the measured values to known properties of a gas. The identity of the unknown gas can be verified or determined when the fluidically measured values match those of a known gas.

FIG. **11**a is a diagrammatic view illustrating a gas identification system according to the present invention. As shown in FIG. **11***a*, the gas identification system includes a gas source **120**. The gas source **120** may be any type of container, or generator from which a single, pure gas (i.e., a gas consisting of a single constituent) is provided. For example, the source can be a pressurized tank of oxygen or nitrous oxide, or an oxygen generator. The gas from gas source **120** flows through gas supply line **121** (optional) to a gas outlet **122**. The gas outlet **122** can be a wall outlet for providing oxygen or nitrous oxide or a coupler that connects a source of gas to an anesthesia delivery system. A portion of the gas flowing through gas supply line **121** is supplied to gas identifier **123** through a side stream sampling port **124**.

The gas identifier **123** includes essentially the same sensors used in the three gas analyzer shown in FIG. **5***a* or FIG. **5***c*. Specifically, a temperature sensor **125** measures the temperature of the sample gas, a pressure sensor **126** measures the ambient pressure of the sample gas, a flow meter **127** measures the flow rate of the sample gas, and the pressure changes of the sample gas in a capillary **128** and across an orifice **129** are measured (of course, the oscillator can be used as the flowmeter and orifice as shown in FIG. **5***c*). The temperature sensor **125**, pressure sensor, **126**, flow meter **127**, capillary **128** and orifice **129** each provide their respective measurements to processor **130** which determines the density and viscosity of the gas in accordance with equations 1–3 (or other equations relating density, viscosity and flow rate to temperature, oscillator frequency, and pressure drops across a capillary and an orifice).

The processor **130** includes a memory (e.g., a read-only memory) in which is stored the density and viscosity of the pure gas which is expected to be supplied (hereinafter, the expected gas) at outlet **122**. The processor **130** compares the density and viscosity of the sample gas calculated from the measured temperature, flow rate and pressures with the stored density and viscosity values of the expected gas adjusted by the measured ambient conditions. If the calculated density value and the stored density value are essentially the same (i.e., their difference is less than a predetermined threshold value) and if the calculated viscosity value and stored viscosity value are essentially the same, the processor determines that the expected gas is being supplied at outlet **122**. The gas identifier **123** can include a speaker **131** which produces an audible indication that the identity of the expected gas has been verified and/or a display **132** which produces a visible indication that the identity of the expected gas has been verified.

If either the density or viscosity calculated for the sample gas differs from the corresponding stored value of the expected gas, the processor **130** determines that the gas being supplied at outlet **122** is not a pure form of the expected gas. That is, a deviation of the density or viscosity of the sample gas from the known density or viscosity of the expected gas signifies that either the gas being supplied is not the expected gas or the gas being supplied contains other gasses in addition to the expected gas in a quantity sufficient to change the overall density and viscosity. For example, if nitrous oxide is erroneously supplied to an oxygen outlet, the processor **130** determines from the calculated density and viscosity that the sample gas is not the expected gas (oxygen). Likewise, if atmospheric air leaks into an otherwise pure oxygen supply through a rupture or faulty connection, the processor **130** determines that sample gas is not the expected gas (oxygen). When the processor **130** determines that the sample gas is not a pure form of the expected gas, the speaker **131** produces an audible alarm signal indicating that the gas being supplied differs from the expected gas, and the display **132** produces a corresponding visible indication. Optionally, the gas identifier **123** includes a mechanism for preventing the flow of the gas when such an error condition occurs, e.g., an automatic solenoid shut off value.

While it is possible to distinguish certain gasses based on only one fluidically determined property (i.e., density or viscosity), the fluidic measurement of two properties is preferable in order to ensure sufficient discrimination between different gasses. For example, several gasses, including some hydrocarbons, having molecularweights that are similar to that of oxygen (**32**). However, the viscosities of these gasses are significantly different from that of oxygen; thus, by measuring the density and viscosity of the sample gas, the identity of a gas such as oxygen can more readily be verified with accuracy.

FIG. **11***b* is a flow chart summarizing the above-described processing steps (steps **201–209**) involved in determining or verifying the identity of a single, pure gas supplied from a source.

In the above example, it is assumed that a particular gas is expected at the outlet **122**, and the fluidically measured properties are compared to those of the expected gas to determine whether or not the actual gas is the expected gas. More generally, the gas identifier of the present invention can be programmed, such that the identity of any one of a number of gasses can be verified. Specifically, the memory of processor **130** can include a look-up table containing the densities and viscosities of all of the gasses that could be supplied to a point of delivery. An input device, such as a keyboard, touchpad or the like, can be used by an operator to select one of the gasses in the look-up table as the expected gas. The above-described density and viscosity comparisons are then performed using the stored density and viscosity values for the selected gas. Thus, the same gas identifier can be used to verify the identity of any one of several pure gasses.

Further, the gas identifier of the present invention can be used to determine the identity of an unknown pure gas. Specifically, the calculated density and viscosity of the measured sample gas is compared to the density and viscosity of each of the gasses stored in the look-up table. If the density and viscosity of the sample gas match those of one of the gasses in the look-up table, the gas identifier indicates the identity of the gas on the display **132**.

In the above example, the density and viscosity of the single gas being analyzed are used to uniquely identify the gas, since these two properties clearly distinguish most gasses from one another and can be determined using measurement from inexpensive fluid sensors. It will be understood, however, that other combinations of gas properties can be used to identify a single gas. In particular, where certain gasses are more easily distinguishable from particular properties, those properties of the gas can be determined to identify the gas more readily. Table 2 provides a summary of properties (i.e., molecular weight, viscosity and specific heat) of selected respired gasses which can be used to distinguish various gasses.

TABLE 2

GAS	MOLECULAR WEIGHT	VISCOSITY (20° C.) (kg/ms × 10^{-5})	SPECIFIC HEAT (J/(kg ° K.))
OXYGEN	32.000	2.0238	906.853
NITROGEN	28.016	1.7390	1031.35
NITROGEN w/air traces	28.155	1.7702	1055.24

TABLE 2-continued

GAS	MOLECULAR WEIGHT	VISCOSITY (20° C.) (kg/ms × 10^{-5})	SPECIFIC HEAT (J/(kg ° K.))
CARBON DIOXIDE	44.010	1.4660	844.348
NITROUS OXIDE	44.016	1.4607	850.716
CARBON MONOXIDE	28.010	1.6609	1057.11
WATER VAPOR	18.016	1.0522	1881.43
HALOTHANE	197.40	1.1191	524.479
DESFLURANE	168.04	TBD	TBD
ISOFLURANE	184.49	1.0273	750.797
SEVOFLURANE	200.05	TBD	TBD

For example, in the case of CO_2 and N_2O, the properties of viscosity and specific heat at a constant pressure or at a constant volume (calculated from the sonic oscillator frequency measurement) more clearly distinguish these gasses from each other than the properties of density and viscosity. Thus, measurements from a sonic oscillator could be used instead of measurements from a densitometer orifice. Of course, using a sensor package such as that shown in FIG. **9***a* or **9***c*, any set of measured properties which sufficiently distinguishes the possible gasses being supplied can be used to identify the gas. Thus, it should be understood that the sensor package can be used in a variety of contexts without any hardware modifications; only the software used to analyze the measured results is modified for different applications.

In the medical field, the gas identifier of the present invention can be used to identify any of a number of pure gasses. For example, gasses such as oxygen, nitrous oxide, and volatile anesthesia gasses are supplied from sources to patients in operating rooms, intensive care units and hospital rooms. The gas identifier can be positioned at any point in the system where the gas to be identified should be present in a pure form. For example, where oxygen is supplied from a remote source to a wall outlet, the gas identifier may be directly integrated into the wall outlet.

Alternatively, the gas identifier can be a separate unit which can be connected to an existing wall outlet. According to this alternative, the gas identifier includes an upstream terminal which couples to the wall outlet and a downstream terminal which is similar to the wall outlet, so that the gas identifier can be connected in series between the wall outlet and a local supply line which mates with the downstream terminal of the gas identifier.

Since only a small fraction of the gas being supplied is required to determine or verify the identity of the gas, it is preferable in some circumstances that the gas identifier operate continuously while the gas is actually being supplied rather than "off-line" or prior to actual delivery of the gas. For example, in the case of a wall outlet oxygen supply, continuous operation of the gas identifier during gas delivery is desirable, since a leak of atmospheric air into the oxygen supply can be detected at any time during oxygen delivery. Optionally, the pressure in the main gas flow stream can be used to run a turbine or other electrical generator that generates the electricity necessary to operate the sensors and processor of the gas identifier. Alternatively, the electricity can be provided by a battery, an AC power source or other conventional power source.

The gas identifier of the present invention advantageously prevents errors in administering gasses in medical settings. Because the present invention uses fluidic sensors (which are inexpensive), the gas identifier of the present invention can be implemented at a fraction of the cost of a gas identifier that uses conventional techniques, such as spectroscopy. Thus, the gas identifier of the present invention can affordably be incorporated in oxygen supply outlets and anesthesia delivery devices throughout a hospital. Further, unlike gas analyzers that use one or more of the aforementioned conventional techniques, the gas identifier of the present invention does not require periodic servicing for calibration, and therefore requires less maintenance.

Extending the principles used to identify a single constituent gas, in accordance with the present invention, the above-described sensors can be used to identify an unknown gas mixed with other, known gasses. By way of illustrative example, consider a two-gas mixture, such as the gas mixture produced by a vaporizer, consisting of an anesthetic agent and oxygen which is used as a carrier gas to drive the vaporizer. The following process can be used to verify or determine the identity of the anesthetic agent to prevent inadvertent administration of the wrong agent. Using, for example, the flow meter-capillary-orifice arrangement shown in FIG. **5***a* or FIG. **5***c* (i.e., a three-gas analyzer), the density and viscosity of the gas mixture as a whole are determined (see equations 1–3). One of the two constituents is known to be oxygen. The other constituent is then assumed to be a particular default anesthetic agent (A_1) (in general one of four: halothane, isoflurane, desflurane and sevoflurane). Using this assumption, the concentrations of oxygen and agent A_1 are determined by solving only the density equation (using equation 4 with the assumption that the density of the unknown gas is that of agent A_1) and the constitutive equation (equation 6) for the two unknown concentrations. Next, the viscosity equation (equation 5) together with the computed concentrations are used to compute the absolute viscosity of the unknown anesthetic agent. The computed viscosity of the unknown agent is compared to the known (stored in memory) viscosity of the anesthetic agent A_1. If the computed and known viscosities match (i.e., their difference falls within a predetermined threshold value), it is determined that the anesthetic agent is, in fact, agent A_1. If the computed viscosity and the known viscosity for agent A_1 do not match, it is determined that the unknown agent is not agent A_1, and the process is repeated with other agents A_2, A_3, . . . , A_L until a match is found.

In general, in a mixture of N gasses in unknown concentrations, where the identities of N−1 gasses are known and the identity of one gas is unknown, the identity of the one unknown gas can be determined with an N+1 gas analyzer in accordance with the process summarized in the flow chart illustrated in FIG. **12**. In a first step **210**, N properties of the mixture are determined. For example, the density, viscosity and specific heat of the mixture (N=3) as a whole can be determined using the above-described oscillator-capillary-sonic oscillator sensors. Further, concentrations of individual gasses can be determined using other, conventional sensors or other independently measured properties of the mixture as whole, which properties relate to relative concentrations. For example, the mixture could consist of three (N=3) gasses: oxygen, carbon dioxide and an anesthesia agent, where the anesthesia agent is assumed to be initially unknown. The three properties measured by a four-gas analyzer could be, for example: density, viscosity, and specific heat.

The unknown gas is then assumed to be one of a set of possible gasses. Specifically, a list of L gasses and their known properties are stored in a memory. For example, where the unknown gas is an anesthetic agent, a list of five or six anesthesia agents (e.g., halothane, enflurane, isoflurane, methoxyflurane, desflurane, sevoflurane) and their properties (e.g., density, viscosity and ratio of specific heats) are stored in a look-up table in a memory. In step **212**, a counter i, which indexes the look-up table, is initialized to a value of one, corresponding to a first anesthetic agent A_1 in the look-up table (i.e., the default agent, which can be, for example, anesthesia agent marked on the label of the container).

In step **214**, the value of counter i (initially equal to one) is used to retrieve the name and properties of gas i in the look-up table, and the identity of the unknown gas is assigned (i.e., temporarily assumed to be) that of gas i, with the properties of the unknown gas being assigned the values of the properties of gas i retrieved from the look-up table. Initially, the value of i is set to one; thus, the unknown gas is assumed to be the default gas A_1 in the look-up table, and the properties of the unknown gas are assumed to be those of the default gas A_1.

In step **216**, N−1 of the N properties are used to form N−1 equations relating to the relative concentrations, which, together with the constitutive equation (equation 6) are solved for the N relative concentrations of the N gasses in the mixture, using the assumption that the unknown gas has the properties of the gas A_i. For example, the equations for density, specific heat, and the constitutive equation can be used to calculate the relative concentrations of the oxygen, carbon dioxide and gas A_i. Note that the viscosity information (in this example) is not used in this step.

At this point, the only unknown in the equation which relates the Nth property of the mixture as a whole to the individual constituent concentrations is the Nth property of the unknown gas. Thus, in step **218**, this equation can be solved for the Nth property of the unknown gas by inserting the calculated concentrations and the measured Nth property of the mixture as a whole (note that this equation was not used to determine the relative concentrations). For example, using equation (5), the viscosity of the unknown gas (assumed to be agent A_i for purposes of computing concentrations) can be calculated from the viscosity equation (equation (5)) of the mixture and the computed concentrations of oxygen, carbon dioxide and gas A_i.

In step **220**, the calculated Nth property of the unknown gas is compared to the known (stored) Nth property of gas A_i. If the value of the calculated property N of the unknown gas matches the value of (known) property N of gas A_i, it is determined that the unknown gas is gas A_i. In this case, it is indicated (on a display or the like) in step **222** that the unknown gas is gas A_i, and the identification process ends.

If the value of the calculated property N of the unknown gas does not match the value of (known) property N of gas A_i, it is determined that the unknown gas is not gas A_i. In this case, in step **224**, the index counter i is incremented, and, in step **226**, the index counter i is compared to the number L of gasses in the look-up table. If the index counter i is not greater than L, processing returns to step **214**, and the process is repeated with the incremented value of i. If, on the other hand, the index counter i is determined to be greater than L in step **226**, it is indicated in step **228** (on a display and/or by aural alarm) that the unknown gas has not been identified, and the identification process ends. Optionally, even where the identity of the gas is determined, an alarm (visual and/or aural) can be set off when the unknown gas is determined to be other than the default gas to indicate that the identity of the gas is other than the expected (default) gas.

Importantly, the above method of identifying an unknown constituent in a mixture can be carried out with the same hardware used to determine the concentrations of N known gasses (e.g., the sensor suites shown in FIGS. **5***a*/**5***c* and **9***a*/**9***c*). Only the processing software run on the signal processor is different. That is, to determine concentrations of known constituents, N−1 properties of the gas mixture are measured and N equations (including the constitutive equation) are solved for N unknown concentrations of N known constituents. In contrast, to identify an unknown constituent: N properties of the gas mixture are measured; N−1 of the properties are used to generate N−1 equations which, together with the constitutive equation, are solved for N concentrations, where the properties of the unknown constituent are assumed to be those of a particular gas; the N concentrations and the Nth property of the mixture are used to calculate the Nth property of the unknown gas which is then compared to the known Nth property of the gas assumed to be the unknown gas (for purposes of calculating the concentrations); and different gasses are tried (assumed to be the unknown gas) in this process until the comparison yields a match or all potential gasses have been tried without a successful match.

Note that the process of identifying an unknown, pure (single constituent) gas (FIG. **11***b*) is essentially a special case of the process shown in FIG. **12**, where N=1, although more than one property is preferably measured to provide greater discrimination between different gasses (also, it is unnecessary in this case to solve for the concentrations, since the concentration of the single constituent is unity).

The same hardware may also be used to identify a mixture of two unknown gasses. In this case, the process is essentially the same as that described above; however, the trial and error technique of trying each potential gas as the unknown gas until a match is found is expanded, such that the calculations are performed by substituting a pair of gasses for the two unknown gasses until a match is found or every potential combination of two gasses has been tried. For example, where the two unknown gasses are two of five (six) possible gasses, at most 10 (15) iterations are necessary to try every combination. Given that the two unknown gasses are two members of a set of gasses whose properties are known (and distinguishable), the identities and concentrations of the two unknown gasses in a mixture can be determined by measuring three properties of the mixture, since four equations (including the constitutive equation) can be uniquely solved for four unknowns (two unknown concentrations and two unknown identities). In general, in a mixture of fluids where concentrations of L fluids are unknown and identities of M fluids are unknown, the unknown concentrations and identities can be determined by measuring N−1 bulk properties of the mixture and by solving N equations (inclusive of the constitutive equation), where N=L+M (as used here, N does not necessarily represent the number of fluids in the mixture).

According to another embodiment of the present invention, the same hardware can be used to identify an unknown gas in a mixture of N gasses (including N−1 known gasses) using an N-gas analyzer measuring N−1 gas properties (i.e., by measuring one less property than in the gas identification method described above). This technique is particularly useful where the unknown gas is known to have a value of at least one property that is significantly different from the value of that property of the other gasses in the mixture. For example, the technique is suitable for identifying an anesthetic agent in a mixture of respired gasses, where the anesthetic agent has a significantly higher density than the other gasses.

More specifically, as shown in FIG. **13**, according to this embodiment, in a first step **230**, N−1 properties of the mixture are determined using an N-gas analyzer. For example, the density, viscosity and specific heat of the mixture as a whole can be determined using the above-described oscillator-capillary-sonic oscillator sensors. Further, concentrations of individual gasses can be determined using other, conventional sensors or other properties of the mixture as whole, which properties relate to relative concentrations. Also, in the case of anesthesia administration, the above described technique for discriminating carbon dioxide and nitrous oxide can be employed. For example, the mixture could consist of five (N=4) gasses: nitrogen, oxygen, carbon dioxide/nitrous oxide, and an anesthesia agent, where the anesthesia agent is assumed to be initially unknown. The three properties measured by the gas analyzer could be, for example: density, viscosity and the specific heat.

The unknown gas is then assumed to be one of a set of possible gasses. Specifically, a list of L gasses and their known properties are stored in a memory. For example, where the unknown gas is an anesthetic agent, a list of five or six anesthesia agents (e.g., halothane, enflurane, isoflurane, methoxyflurane, desflurane, sevoflurane) and their properties (e.g., density, viscosity, specific heat) are stored in a look-up table in a memory. In step **232**, a counter i, which indexes the look-up table, is initialized to a value of 1, corresponding to a first anesthetic agent A_1 in the look-up table (i.e., the default agent).

In step **234**, the value of counter i (initially equal to one) is used to retrieve the name and properties of gas i in the look-up table, and the identity of the unknown gas is assigned (i.e., temporarily assumed to be) that of gas i, with the properties of the unknown gas being assigned the values of the properties of gas i retrieved from the look-up table. Initially, the value of i is set to one; thus, the unknown gas is assumed to be the default gas A_1 in the look-up table, and the properties of the unknown gas are assumed to be those of the default gas A_1.

In step **236**, using the assumption that the unknown gas has the properties of the gas A_i, the N−1 properties are used to form N−1 equations relating to the relative concentrations, which, together with the constitutive equation (equation 6) form N equations, and an attempt is made to solve the N equations for the relative concentrations of the constituents of the mixture. For example, the equations for density, viscosity, specific heat and the constitutive equation can be used to calculate the relative concentrations of nitrogen, oxygen, carbon dioxide/nitrous oxide and gas A_i.

It has been found by the present inventor that, provided that a sufficient concentration (e.g., at least approximately 2–5%) of the unknown gas is present, the equations yield individual gas concentrations that fall within expected or reasonable ranges only when the properties of the unknown gas are assumed to be those of the correct gas in the equations. If the properties of the wrong gas are used, the equations yield at least one gas concentration that is not within its expected range or, mathematically, is not between zero and one. Thus, if the solution of the equations yield concentrations within expected ranges, it is assumed that the unknown gas is indeed the gas A_i. In practice, expected ranges of concentrations of individual gasses can be stored or pre-programmed into the system for comparison with the computed concentrations in order to determine whether the computed concentrations are reasonable. Other out of bounds conditions may be very high CO_2 or agent concentrations.

In step **238**, if the solution to the equations yields concentrations that are within expected ranges, it is determined that the unknown gas is gas A_i. In this case, in step **240**, it is indicated (on a display or the like) that the unknown gas is gas A_i, and the identification process ends.

If the solution to the equations fails to converge to meaningful concentration values (i.e., at least one constituent concentration is outside its expected range), it is determined that the unknown gas is not gas A_i. In this case, in step **242**, the index counter i is incremented, and in step **244**, the index counter i is compared to the number L of gasses in the look-up table. If the index counter i is not greater than L, processing returns to step **234**, and the process is repeated with the incremented value of i. If, on the other hand, the index counter i is determined to be greater than L in step **244**, it is indicated in step **246** (on a display and/or by aural alarm) that the unknown gas has not been identified, and the identification process ends.

The approach of the present invention provides a simple apparatus and method to measure concentrations of several medical gasses and to identify individual gasses at a relatively low cost. Although the above description is primarily concerned with medical gas analyzers, the present invention is not limited to the preferred embodiment but is applicable to other gas analysis applications, including, but not limited to, industrial production of gasses, atmospheric analysis, pollution tracking and other applications for the detection and analysis of chemical and biological agents. In addition, the present invention is not limited to a specific number of gasses that are in a mixture or for that matter only fluidic sensors, but rather, since bulk properties of gasses can be measured using a variety of low cost electronic and hybrid electro-fluidic devices, the present invention may extend to low cost scientific gas analysis of large numbers of gasses.

Furthermore, the present invention is not limited to the analysis of only gasses because it should be recognized that substantially the same methods and apparatus may be applied to the analysis of mixtures of liquid fluids as well, as long as sufficient differences in mixture bulk properties will occur due to the changes of concentrations of the constituents of the fluids. More specifically, the density and viscosity of a liquid can be measured and determined in accordance with equations (1)–(3) with measurements from the fluidic sensors (flow meter, capillary and orifice) described herein. Other suitable sensors can be used to measure other properties of a mixture of liquids which relate to constituent concentrations or which can be used to uniquely identify an unknown liquid constituent in accordance with the above described techniques.

Having described preferred embodiments of a new and improved method and apparatus for real time gas analysis using fluidic sensors, it is believed that other modifications, variations and changes will be suggested to those skilled in the art in view of the teachings set forth herein. It is therefore to be understood that all such variations, modifications and changes are believed to fall within the scope of the present invention as defined by the appended claims.

What is claimed is:

1. A disposable fluidic sensor module for an apparatus for analyzing a fluid, the disposable fluidic sensor comprising:

a plate-like member having an inlet adapted to receive a flow of the fluid and an outlet for exhausting the flow of the fluid;

a fluidic flowmeter formed in said plate-like member in a path between the inlet and the outlet, said fluidic flowmeter being responsive to the flow of the fluid to generate an output indicative of a flow rate of the fluid;

a capillary structure formed in said plate-like member in a path between the inlet and the outlet, said capillary structure restricting a flow of the fluid such that a pressure drop across said capillary structure is related to a viscosity of the fluid; and

a sonic oscillator formed in said plate-like member in a path between the inlet and the outlet, said sonic oscillator generating flow oscillations having a frequency related to the specific heat of the fluid.

2. A modular apparatus for analyzing a fluid, comprising:

a disposable fluidic sensor module comprising: a plate-like member having an inlet adapted to receive a flow of the fluid and an outlet for exhausting the flow of the fluid; a fluidic flowmeter formed in said plate-like member in a path between the inlet and the outlet, said fluidic flowmeter being responsive to the flow of the fluid to generate an output indicative of a flow rate of the fluid, and a capillary structure formed in said plate-like member in a path between the inlet and the outlet said capillary structure restricting a flow of the fluid such that a pressure drop across said capillary structure is related to a viscosity of the fluid;

a replaceable transducer module connectable to said fluidic sensor module via a separable interface, said replaceable transducer module comprising transducers for measuring physical conditions of the fluid flowing through said fluidic sensor module;

an expendable electronics package connectable to said replaceable transducer module, said expendable electronics comprising a processor responsive to transducer signals generated by said transducers for determining properties of the fluid; and

a sonic oscillator formed in said plate-like member in a path between the inlet and the outlet, said sonic oscillator generating flow oscillations having a frequency related to the specific heat of the fluid.

3. A disposable fluidic sensor module for an apparatus for analyzing a fluid, the disposable fluidic sensor comprising:

a plate-like member having an inlet adapted to receive a flow of the fluid and an outlet for exhausting the flow of the fluid;

a fluidic oscillator formed in said plate-like member in a path between the inlet and the outlet and having a period of oscillation substantially proportional to a transit time of the fluid from an input of the fluidic oscillator to an output of the fluidic oscillator, wherein the period of oscillation of the fluidic oscillator is substantially independent of the density and viscosity of the fluid, said fluidic oscillator being responsive to the flow of the fluid to generate an output indicative of a flow rate of the fluid; and

a capillary structure formed in said plate-like member in a path between the inlet and the outlet, said capillary structure restricting a flow of the fluid such that a pressure drop across said capillary structure is related to a viscosity of the fluid.

4. The disposable fluidic sensor module according to claim **3**, wherein a pressure drop from an input of said fluidic oscillator to an output of said fluidic oscillator is related to a density of the fluid.

5. The disposable fluidic sensor module according to claim **4**, wherein said fluidic oscillator is a fluidic amplifier feedback oscillator flowmeter.

6. The disposable fluidic sensor module according to claim **3**, wherein said capillary structure comprises a plurality of capillaries arranged to provide parallel resistance to flow of the fluid through said capillary structure.

7. A replaceable transducer module for interfacing with the disposable sensor module of claim **3**, comprising:

a temperature sensor for measuring the absolute temperature of the fluid passing through said disposable sensor module;

a pressure sensor for measuring the absolute pressure of the fluid passing through said disposable sensor module;

two differential pressure transducers for respectively measuring pressure drops across the fluidic oscillator and the capillary of said disposable sensor module;

a plurality of microphones for measuring oscillation frequencies in the fluidic oscillator of said disposable sensor module; and

a vacuum line connection configured to connect said disposable sensor module to a vacuum source to draw sample fluid through said disposable sensor module.

8. An expendable electronics package adapted to receive transducer signals generated by the replaceable transducer module of claim **7**, comprising:

a multiplexer providing analog signals corresponding to signals received from said temperature sensor, said pressure sensor, and said two differential pressure transducers;

an analog-to-digital converter for converting the analog signals to digital signals;

a flow counter for generating a digital frequency signal in response to an output signal from said microphone; and

a microprocessor responsive to the digital signals and the digital frequency signal, for computing individual concentrations of constituents of said fluid.

9. A modular apparatus for analyzing a fluid, comprising:

a disposable fluidic sensor module comprising: a plate-like member having an inlet adapted to receive a flow of the fluid and an outlet for exhausting the flow of the fluid; a fluidic oscillator formed in said plate-like member in a path between the inlet and the outlet and having a period of oscillation substantially proportional to a transit time of the fluid from an input of the fluidic oscillator to an output of the fluidic oscillator, wherein the period of oscillation of the fluidic oscillator is substantially independent of the density and viscosity of the fluid, said fluidic flowmeter being responsive to the flow of the fluid to generate an output indicative of a flow rate of the fluid; and a capillary structure formed in said plate-like member in a path between the inlet and the outlet, said capillary structure restricting a flow of the fluid such that a pressure drop across said capillary structure is related to a viscosity of the fluid;

a replaceable transducer module connectable to said fluidic sensor module via a separable interface, said replaceable transducer module comprising transducers for measuring physical conditions of the fluid flowing through said fluidic sensor module; and

an expendable electronics package connectable to said replaceable transducer module, said expendable electronics comprising a processor responsive to transducer signals generated by said transducers for determining properties of the fluid.

10. The modular apparatus according to claim **9**, wherein said capillary structure comprises a plurality of capillaries arranged to provide parallel resistance to flow of the fluid through said capillary structure.

11. The modular apparatus according to claim **9**, wherein a pressure drop from an input of said fluidic oscillator to an output of said fluidic oscillator is related to a density of the fluid.

12. The modular apparatus according to claim **11**, wherein said replaceable transducer module comprises:

a temperature sensor for measuring the absolute temperature of the fluid passing through said disposable sensor module;

a pressure sensor for measuring the absolute pressure of the fluid passing through said disposable sensor module;

two differential pressure transducers for respectively measuring pressure drops across the fluidic oscillator and the capillary of said disposable sensor module;

a plurality of microphones for measuring oscillation frequencies in the fluidic oscillator of said disposable sensor module; and

a vacuum line connection configured to connect said disposable sensor module to a vacuum source to draw sample fluid through said disposable sensor module.

13. The modular apparatus according to claim **12**, wherein said expendable electronics package comprises:

a multiplexer providing analog signals corresponding to signals received from said temperature sensor, said pressure sensor, and said two differential pressure transducers;

an analog-to-digital converter for converting the analog signals to digital signals;

a flow counter for generating a digital frequency signal in response to an output signal from said microphone; and

a microprocessor responsive to the digital signals and the digital frequency signal, for computing individual concentrations of constituents of said fluid.

14. A disposable fluidic module for sensing plural characteristics of a flowing medium, said module comprising:

an inlet port for receiving the flowing medium at said module;

a flowmeter for receiving the flowing medium from said inlet port and configured in the form of a fluidic oscillator for transversely oscillating said flowing medium at an oscillation frequency that varies as a function of the velocity of said flowing medium, said fluidic oscillator being defined as a plurality of flow channels; and

a capillary member for receiving output flow from said fluidic oscillator and establishing a pressure drop in said output flow, said capillary member comprising a common flow entrance, a common flow exit and a plurality of capillary passages extending in flow communication between said entrance and exit, said capillary passages having transverse cross-sections that are very much smaller than transverse cross-sections of said flow channels in said fluidic oscillator;

wherein said module is a rigid member, and wherein said fluidic oscillator and said capillary passages are formed as flow passages defined in said rigid member.

15. The disposable fluidic module of claim **14** wherein said module is molded plastic, and wherein said flow channels and said capillary passages are molded in said module.

16. The disposable fluidic module of claim **14** wherein said rigid member includes at least one plastic molded body having a surface in which said capillary passages and said flow channels of said fluidic oscillator are defined as recesses.

17. The fluidic module of claim **14** wherein said flowing medium is a gas having multiple gaseous constituents.

18. The disposable fluidic module of claim **14** further comprising:

first and second ports defined in said rigid member, said first port being defined upstream of said fluidic oscillator, said second port being defined downstream of said fluidic oscillator to permit measurement of pressure drops in said medium across said first and second ports; and

third and fourth ports defined in said rigid member for permitting measurement of the pressure drops in said medium across said capillary member.

* * * * *

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(12) **United States Patent**
Hon

(10) **Patent No.: US 8,365,742 B2**
(45) **Date of Patent: Feb. 5, 2013**

(54) **AEROSOL ELECTRONIC CIGARETTE**

(75) Inventor: **Lik Hon**, Hong Kong (CN)

(73) Assignee: **Ruyan Investment (Holdings) Limited**, Hong Kong (HK)

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(21) Appl. No.: **13/079,937**

(22) Filed: **Apr. 5, 2011**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
A24F 47/00 (2006.01)

(52) **U.S. Cl.** **131/273**; 131/194; 131/360; 128/202.21

(58) **Field of Classification Search** 131/360, 131/194, 273; 128/202.21
See application file for complete search history.

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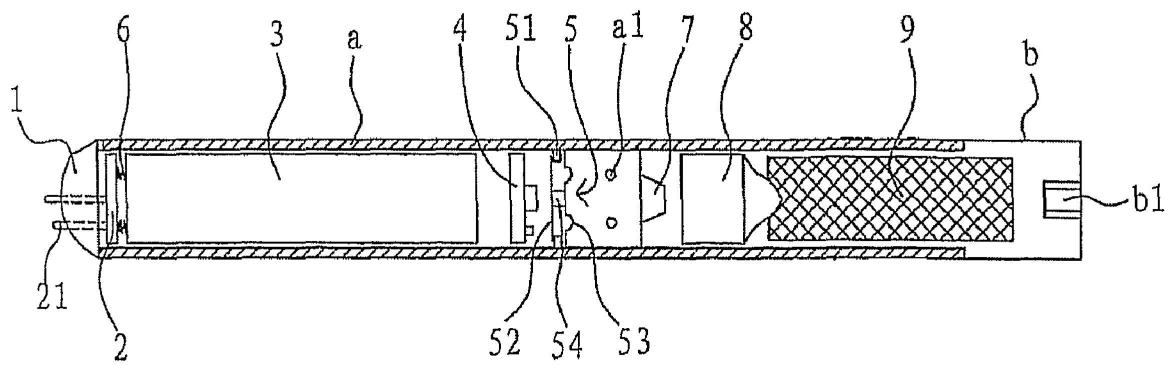
(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(57) **ABSTRACT**

An aerosol electronic cigarette includes a battery assembly, an atomizer assembly and a cigarette bottle assembly and also includes a shell (a) which is hollow and integrally formed. Said battery assembly connects with said atomizer assembly and both are located in said shell (a). Said cigarette bottle assembly is located in one end of the shell (a), which is detachable. Said cigarette bottle assembly fits with said atomizer assembly. Said shell (a) has through-air-inlets (a1).

3 Claims, 8 Drawing Sheets



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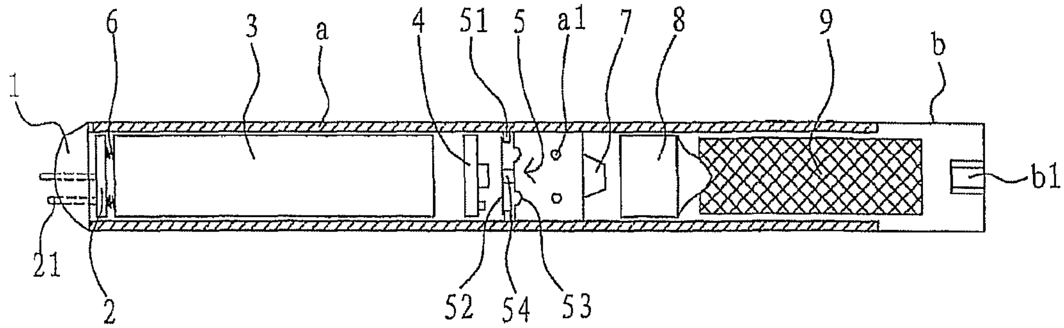

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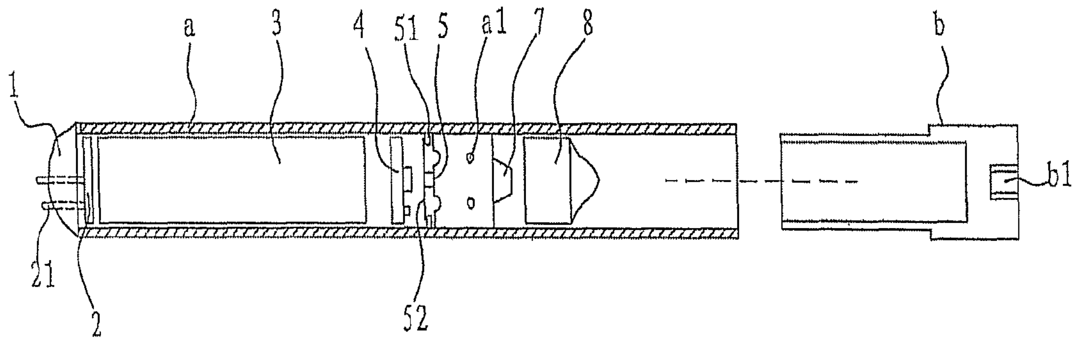

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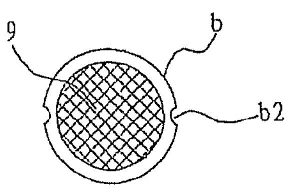

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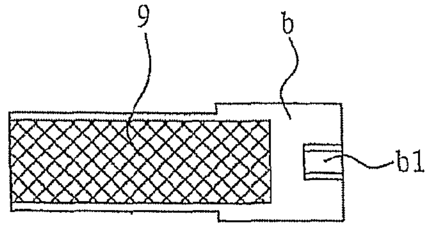

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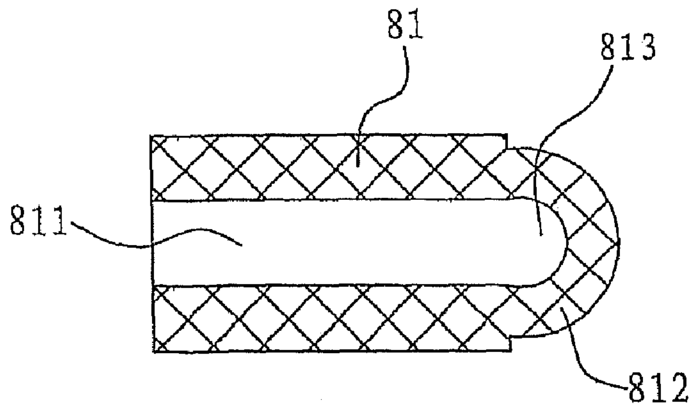

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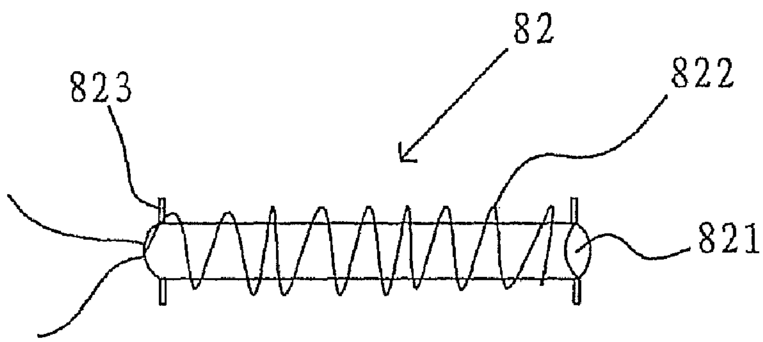

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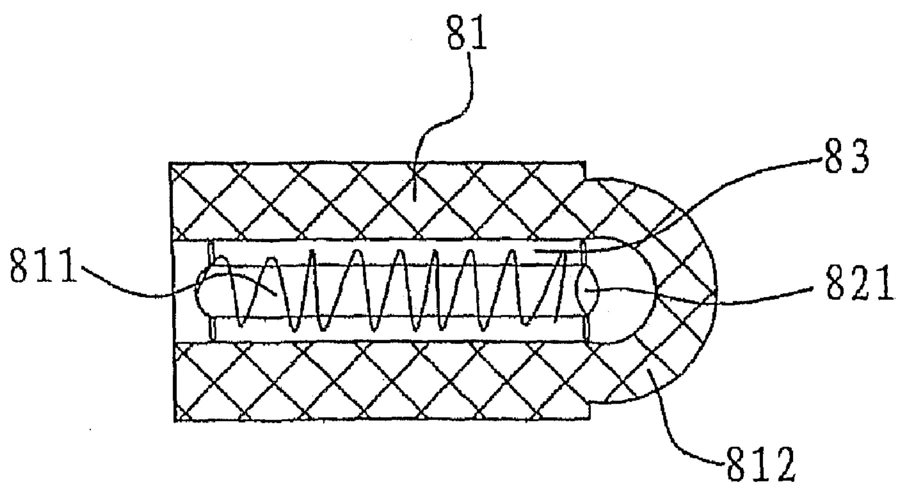

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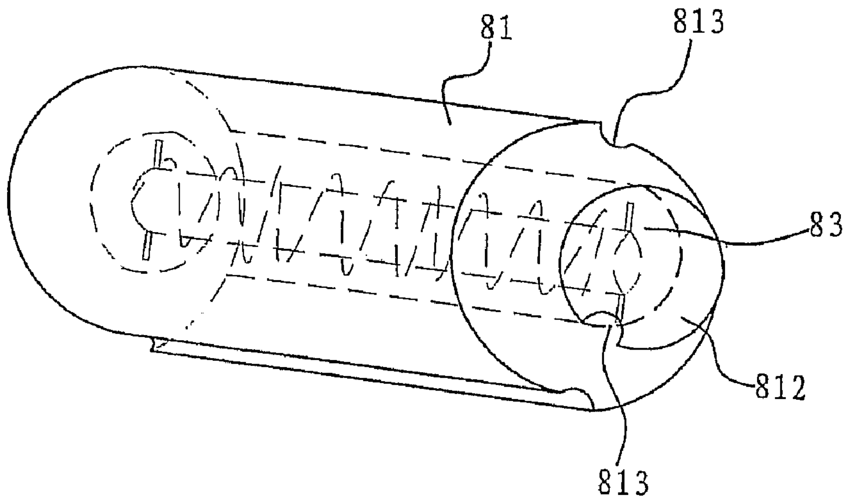

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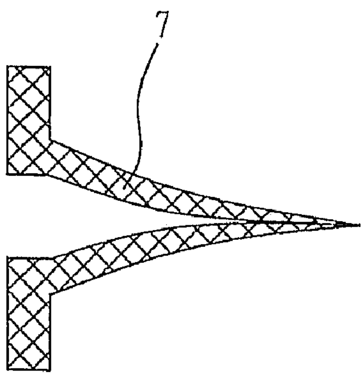

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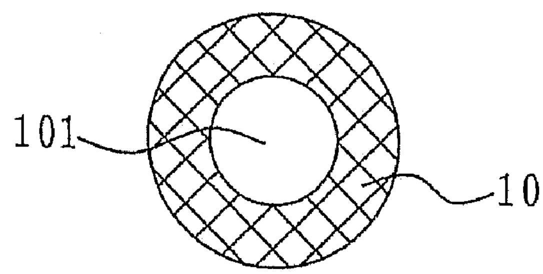

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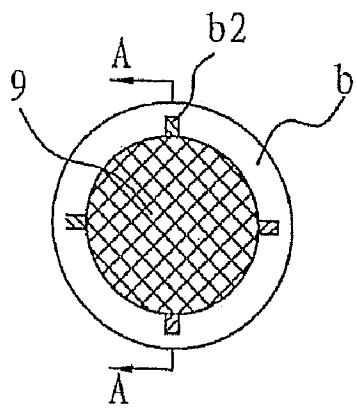

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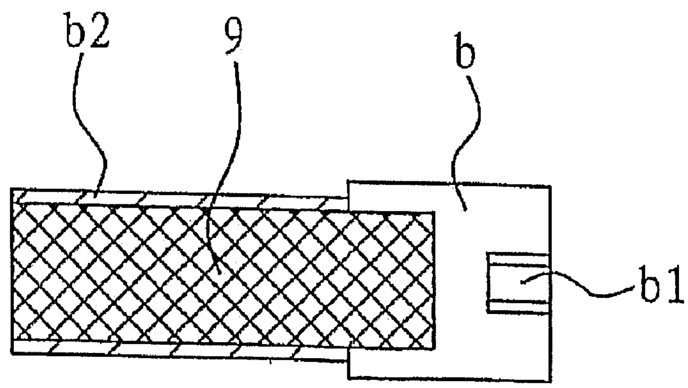

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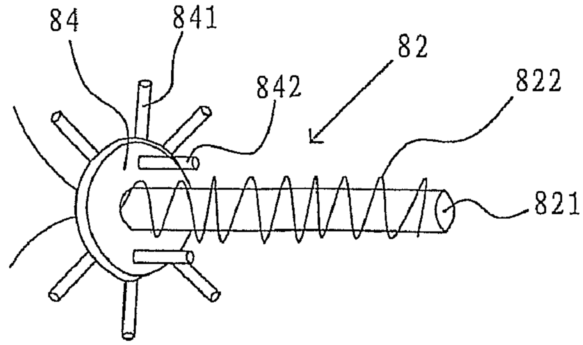

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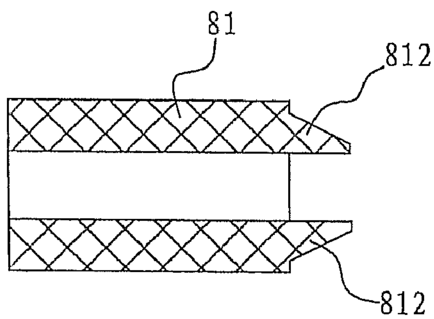


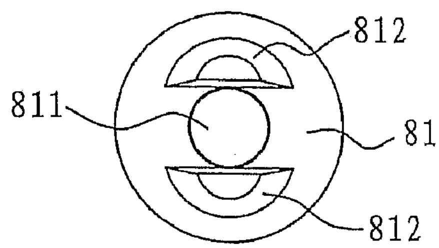
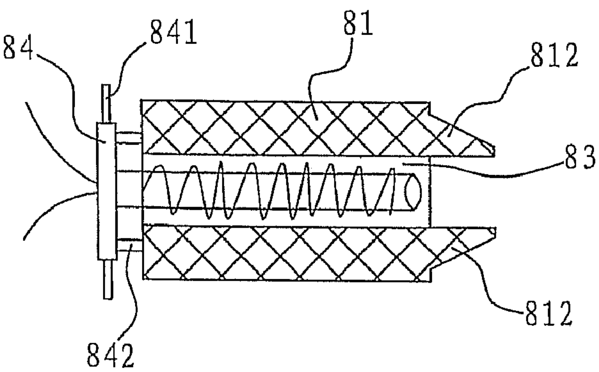


Figure 14

Figure 15



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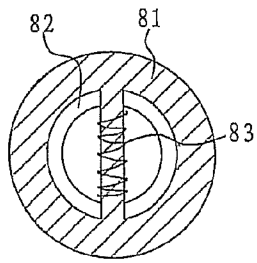

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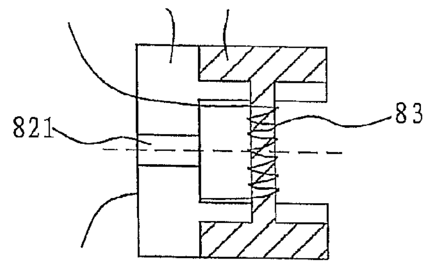

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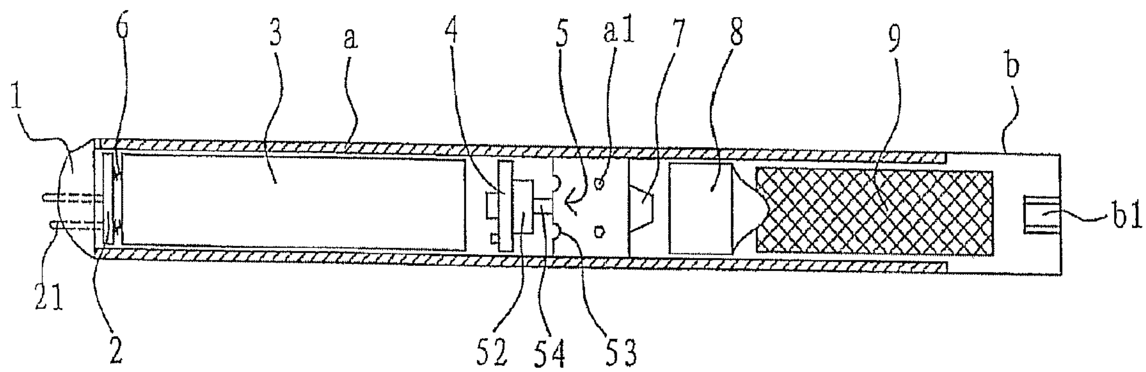

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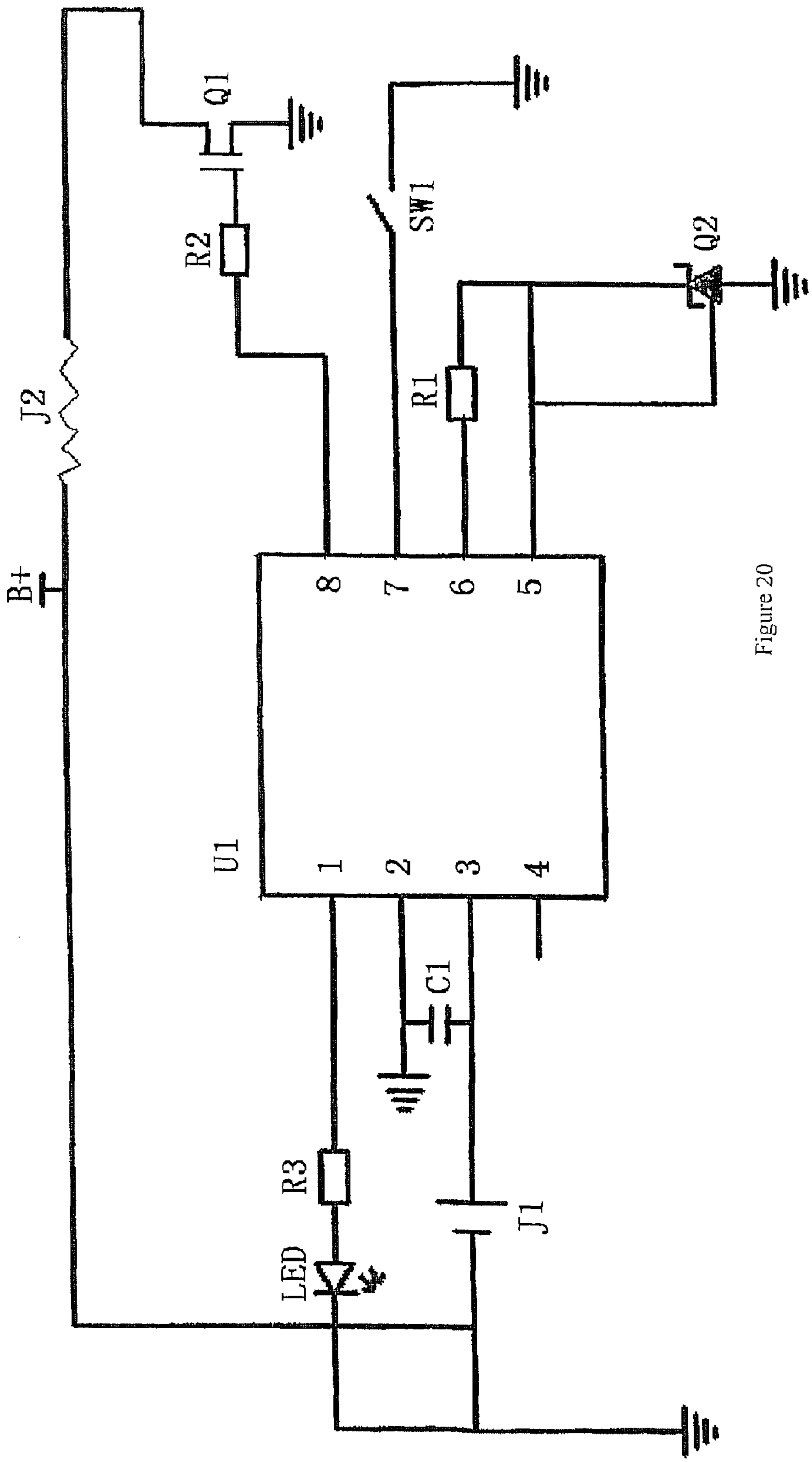

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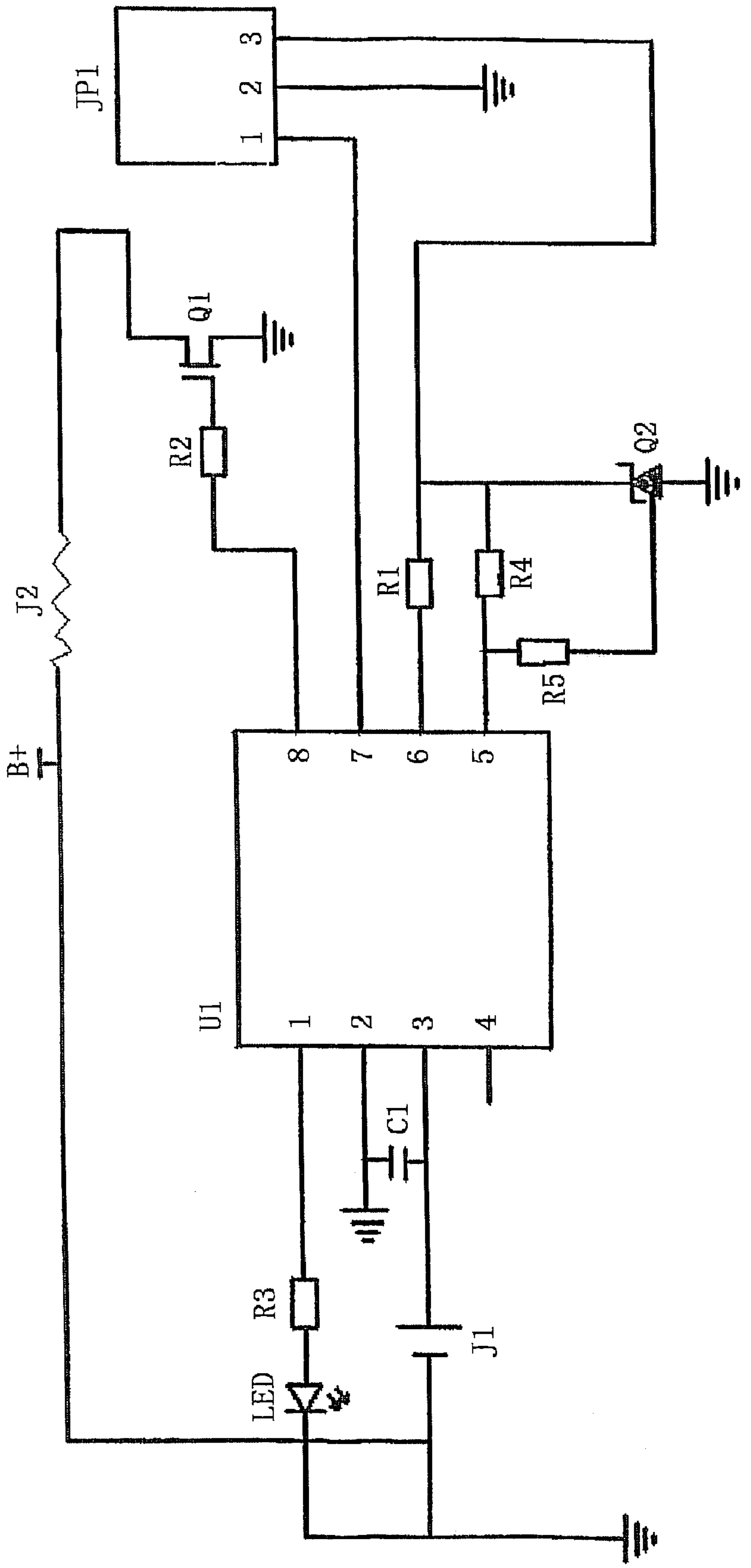

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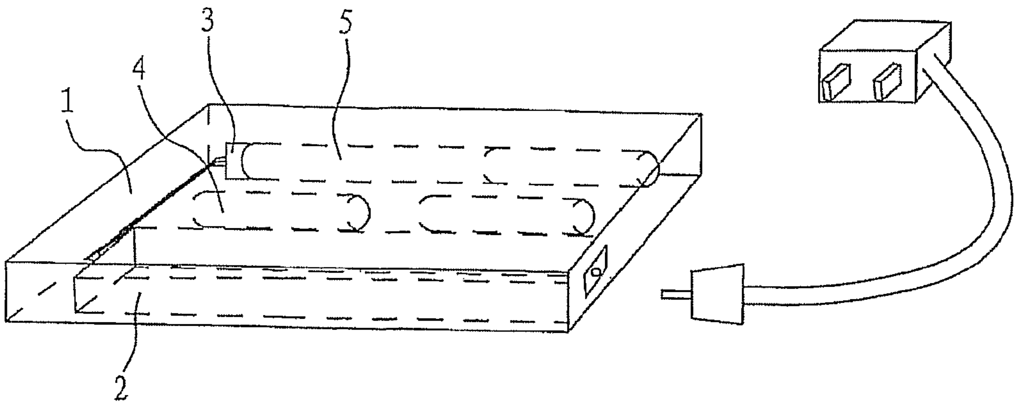

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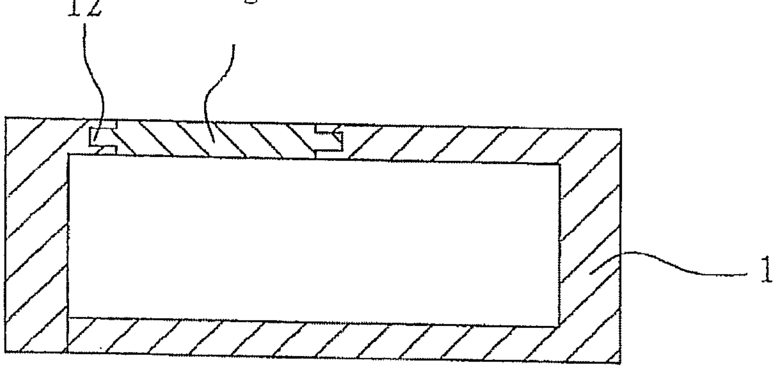

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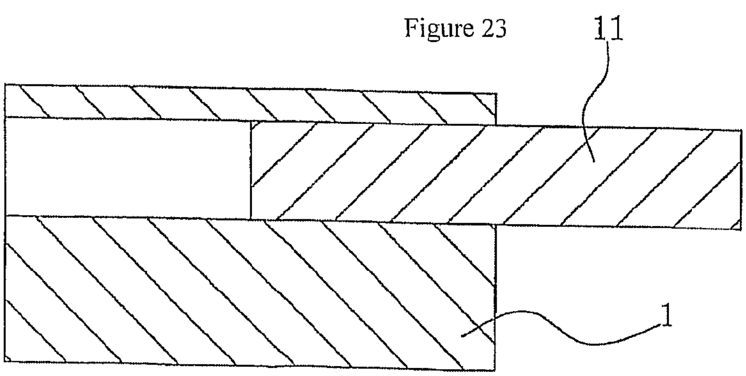

Figure 24

AEROSOL ELECTRONIC CIGARETTE

BACKGROUND ART

Smoking causes serious respiratory system diseases and cancer, though it is hard to persuade the smokers to completely quit smoking.

Nicotine is the effective ingredient in cigarettes. Nicotine acts on the receptor of the central nervous system.

Nicotine is a micromolecular alkaloid, which is basically harmless to human bodies at a small dosage. Plus, its half life period is extremely short in blood. Tar is the major harmful substance in tobacco. Tobacco tar comprises several thousands of ingredients, dozens of which are carcinogenic substances.

To provide cigarette substitutes that contain nicotine but not harmful tar, many products have been used. These products are not as harmful as tar, but are absorbed very slowly. As a result, smokers can't be satisfied in full. In addition, the smokers are deprived of the "smoking" habit.

The electronic cigarettes currently available on the market may resolve the above-mentioned issue, though they are complicated in structure. They don't provide the ideal aerosol effects, and their atomizing efficiency is not high.

SUMMARY OF INVENTION

To overcome the above-mentioned disadvantages, an aerosol electronic cigarette includes a battery assembly, an atomizer assembly and a bottle assembly. The battery assembly connects with the atomizer assembly and both are located in a housing. The bottle assembly is located in one end of the housing and fits with the atomizer assembly.

The battery assembly may include the battery, an operating indicator, electronic circuit board, and airflow sensor, which are connected with the battery, and with the signal output of the airflow sensor connected the electronic circuit board.

A component for liquid storage of the cigarette bottle assembly stores the nicotine liquid. Smokers can enjoy the feel of smoking, with no fire hazard since there is no need for igniting.

DESCRIPTION OF DRAWINGS

FIG. **1** is the side section view of an electronic cigarette.

FIG. **2** is the section view of the housing (a) separated from the cigarette bottle assembly.

FIG. **3** is the diagram of the axial structure of the cigarette bottle assembly, illustrating the ventilating groove on the peripheral surface of the cigarette holder housing.

FIG. **4** is the side section view of the cigarette bottle assembly, illustrating the structure of the air channel.

FIG. **5** is the side section view of a porous component of the atomizer.

FIG. **6** is the diagram of the structure of an electric heating rod of the atomizer.

FIG. **7** is the side section of the atomizer, illustrating the locations of and connection relation between the electric heating rod and porous component.

FIG. **8** is the diagram of the atomizer, illustrating the locations of and connection relation between the electric heating rod and porous component.

FIG. **9** is the section view of a check valve.

FIG. **10** is the front section view of a restriction component in a second embodiment.

FIG. **11** is a diagram of the axial structure of the cigarette bottle assembly in another embodiment.

FIG. **12** is a sectional view taken along line A-A of FIG. **11**.

FIG. **13** is a diagram of the structure of the electric heating rod of the atomizer in another embodiment.

FIG. **14** is a section view of the porous component of the atomizer in the embodiment shown in FIG. **13**.

FIG. **15** is a diagram of the axial structure of FIG. **14**.

FIG. **16** is a side section view of the atomizer in the embodiment of FIG. **13**, illustrating the locations of and connection relation between the electric heating rod and porous component.

FIG. **17** is a diagram of the axial structure of the atomizer in another embodiment.

FIG. **18** is the side section view of the atomizer shown in FIG. **17**.

FIG. **19** is the side section view of another electronic cigarette embodiment.

FIG. **20** is the electric circuit diagram of an electronic cigarette.

FIG. **21** is another electric circuit diagram of an electronic cigarette.

FIG. **22** is a diagram of a charging device, illustrating the locations of and connection relation of various internal parts.

FIG. **23** is the side section view of the charging device.

FIG. **24** is the diagram of the front structure of the charging device.

SPECIFIC MODE FOR CARRYING OUT THE INVENTION

As shown in FIGS. **1-10**, an aerosol electronic cigarette includes a battery assembly, an atomizer assembly and a cigarette bottle assembly, and also includes a shell or housing (a), which is hollow and integrally formed. The battery assembly connects with the atomizer assembly and both are located in the shell. The cigarette bottle assembly is located in one end of the shell, which is detachable. The cigarette bottle assembly fits with the atomizer assembly. The shell has through-air-inlets (a**1**).

In this specific embodiment, the battery assembly includes the battery, and the operating indicator (**1**), electronic circuit board (**4**), and airflow sensor (**5**), which are connected with the battery. It also includes a check valve (**7**). The signal output of the airflow sensor (**5**) is connected with the said electronic circuit board (**4**). The battery is a rechargeable battery (**3**), which may be either a rechargeable polymer lithium ion battery or a rechargeable lithium ion battery. The airflow sensor (**5**) may be alternatively a semiconductor force-sensitive chip capacitance sensor or an inductance sensor.

The rechargeable battery (**3**) has a flexibly connected charging plug (**2**). The blades (**21**) of the charging plug (**2**) come out of the other end of the shell (a). Between the charging plug (**2**) and rechargeable battery (**3**) is a spring (**6**), which lies against the body of the rechargeable battery (**3**) on one end, while its free end lies against the charging plug (**2**), forming a flexible structure, which buffers the charging plug (**2**) when plugged for charging, thus protecting the rechargeable battery against any damage. Of course, the rechargeable battery (**3**) in this embodiment has a charging slot on it, which replaces the structure of charging plug (**2**) to perform the charging function and protect the rechargeable battery (**3**) against any damage. The operating indicator (**1**) is a LED. In this embodiment, there are two LEDs. The electronic circuit board (**4**) includes an electronic switch circuit, which controls the electric circuit according to the input signals, so that the rechargeable battery (**3**) electrifies the electric heating rod (**82**) inside the atomizer (**8**) and the LEDs as well.

As shown in FIGS. **1** and **2**, the airflow sensor (**5**) has a silica gel corrugated membrane (**53**), which connects with magnetic steel (**54**) with a reed relay (**52**) on one of its ends. Both ends of the said reed relay (**52**) correspond to the relay electrodes (**51**) respectively.

As shown in FIGS. **5-8**, the atomizer assembly is an atomizer (**8**), which includes a porous component (**81**) and a heating rod (**82**). The body of the porous component (**82**) has a run-through atomizing chamber (**811**). The diameter of the electric heating rod (**82**) is less than the diameter of the atomizing chamber (**811**). The electric heating rod (**82**) enters into the atomizing chamber (**811**), and there is a clearance between the electric heating rod (**82**) and interior wall of the atomizing chamber (**811**), which forms a negative pressure cavity (**83**). One end of the porous component (**81**) fits with the cigarette bottle assembly. As FIGS. **5**, **7** and **8** show, the porous component (**81**) has a protuberance (**812**) on the other end, and the protuberance (**812**) fits with the cigarette bottle assembly. The protuberance (**812**) is a protruding half sphere, on the side of which there is a run-through hole (**813**) connecting to the atomizing chamber (**811**). Of course, the protuberance (**812**) may also be a taper, rectangle or any other shape. The porous component (**81**) is made of foamed nickel, stainless steel fiber felt, macromolecular polymer foam or foamed ceramics, providing the remarkable capabilities in liquid absorption and diffusion, and the ability to absorb the liquid stored in the cigarette bottle assembly.

As shown in FIG. **6**, the electric heating rod (**2**) includes a cylinder (**821**). The heating wire (**822**) is wound on the wall of the cylinder (**821**). On the wall of both ends of the cylinder (**821**), there are mandrils (**823**) respectively, which lie against the interior wall of the atomizing chamber (**811**) of the porous component (**81**). There is a negative pressure cavity (**83**) between the electric heating rod and interior wall of the atomizing chamber.

The heating wire is made of platinum wire, nickel-chromium alloy wire or iron-chromium alloy wire containing rare earth, or is flaked. The electric heating rod (**82**) may alternatively have on its peripheral wall the heating layer made of electrically conductive ceramic PTC material, to replace the heating wire.

In this embodiment, the battery assembly and atomizer assembly are mutually connected and then installed inside the integrally formed shell (a) to form a one-piece part. The rechargeable battery (**3**) may be charged without frequent change of battery. The user just needs to plug the cigarette bottle assembly into the open end of the shell (a), for easy use and very easy change.

As shown in **3** and **4**, the cigarette bottle assembly includes a hollow cigarette holder shell (b), and a perforated component for liquid storage (**9**) inside the shell (b). The perforated component for liquid storage (**9**) is made of such materials as PLA fiber, terylene fiber or nylon fiber, which are suitable for liquid storage. Alternatively, it may be plastic foam molding or column of multi-layer plates made through plastic injection with polyvinyl chloride, ploypropylene and polycarbonate. One end of the cigarette holder shell (b) plugs into the shell (a), and the outer peripheral surface of the cigarette holder shell (b) has an inward ventilating groove (b**2**). On one end surface of the cigarette holder shell (b), there is an air channel (b**1**) extending inward. The air channel (b**1**) is located in the center on the surface of one end of shell (b).

As shown in FIGS. **1-9**, one end of the porous component (**81**) lies against one end surface of the perforated component for liquid storage (**9**), and contacts the perforated component for liquid storage (**9**). It absorbs the cigarette liquid from the perforated component for liquid storage (**9**). When the smoker smokes, the cavity of the cigarette holder shell (b) is in the negative pressure state. In the shell (b), one end of the airflow sensor (**5**) forms a normal pressure cavity, while the other end forms a negative pressure cavity. The air pressure difference between the normal pressure cavity and negative pressure cavity or the high-speed airflow enables the magnetic steel (**54**) of the airflow sensor (**5**) to drive the reed relay (**52**) to contact the relay electrode (**51**).

As shown in FIG. **20**, the electric circuit is electrified, and the electronic switch circuit on the electronic circuit board (**4**) is electrified. Thus, the rechargeable battery (**3**) starts to electrify the electric heating rod (**82**) inside the atomizer (**8**), and at the same time, the LEDs, which are electrified by the rechargeable battery (**3**), emit light. The air enters the normal pressure cavity through the air inlet (a**1**), passes the check valve (**7**) via the airflow passage in the airflow sensor (**5**), and flows to the negative pressure cavity (**83**) in the atomizer (**8**). Since the negative pressure cavity (**83**) provides the negative pressure compared with the outside, the air flow sprays into it, bringing the cigarette liquid from the porous component (**81**) to spray into the negative pressure cavity (**83**) in the form of fine drops.

In the meantime, the electric heating rod (**82**) is electrified by the rechargeable battery (**3**) under the control of electronic circuit board (**4**), to heat the fine drips for atomization. After atomization, the big-diameter fine drips are re-absorbed by the porous component (**81**) under the action of vortex, while the small-diameter fine drips are suspended in the airflow to form aerosol, which is discharged through the negative pressure cavity (**83**) and run-through hole (**813**), flows into the cigarette holder shell (b) of the cigarette bottle assembly, and is absorbed by the air channel (b**1**). When the aerosol enters the cigarette holder shell (b), multiple small liquid drops are condensed into bigger ones, which fall into the clearance between the cigarette holder shell (b) and air channel (b**1**) without being absorbed by the air channel (b**1**). The perforated component for liquid storage (**9**) of the cigarette bottle assembly and the porous component (**81**) of the atomizer (**8**) contact each other to achieve the capillary impregnation for liquid supply.

The unit and its connecting structure of this invention may also be loaded with drugs for delivery to the lung.

As shown in FIGS. **22**, **23** and **24**, the electronic cigarette (**5**) is held in a charging device. The charging device includes a case (**1**), which contains an auxiliary charging storage battery (**2**) inside it, and holds the electronic cigarette (**5**) and the charger (**3**) for the rechargeable battery embedded in the electronic cigarette (**5**), as well as the power supply circuit. The power inputs of the auxiliary charging storage battery (**2**) and charger (**3**) are connected with the power supply respectively. The charger (**3**) in this embodiment is a constant voltage & current charger. It may be a GY5210 charger, or any other constant voltage & current charger. The case (**1**) has a spare liquid supply bottle (**4**) in it. The power output of the auxiliary charging storage battery (**2**) is connected with the power input of the charger (**3**). The power output of the charger (**3**) is a charging slot (**31**), which fits with the charging plug of the rechargeable battery inside the electronic cigarette, or a charging plug, which fits with the charging slot of the rechargeable battery.

As shown in FIGS. **23** and **24**, on the body of the shell (**1**), there is a pair of slide ways (**12**) corresponding to the position of the electronic cigarette, and on the slide ways, there is a slide cover (**11**).

In the second preferred embodiment, a restriction component (**10**), which is detachable, is set on one end of the porous component (**81**). There is a restriction hole (**101**) on the body of the restriction component (**10**). The restriction hole (**101**) corresponds to the atomizing chamber (**811**). The pore diameter of the restriction hole is less than the inner diameter of the atomizing chamber (**811**) to the extent that the size of the restriction component (**10**) installed on the porous component (**81**) varies, for the purpose of airflow capacity control. On the basis of different applications, the restriction component of different sizes and pore diameters may be used.

In the third preferred embodiment of this utility model, as shown in **11** and **12**, on the outer peripheral wall of the cigarette shell (b), there is a protruding rib (b**2**) that is evenly partitioned. The perforated component for liquid storage (**9**) enters the cigarette holder shell (b) and lies against the protruding rib (b**2**). Thus, there appears a clearance between the outer peripheral surface of the perforated component for liquid storage (**9**) and the interior wall of the shell (b). The clearance is for connection the shell (a) and cigarette holder shell (b). When the user smokes, the air channel (b**1**) absorbs the air to cause airflow inside the shell (a), thus triggering the airflow sensor (**5**) and eventually starting the electronic cigarette. Also, the atomizer (**8**) works to atomize the cigarette liquid and produce gas flow, which enters the cigarette holder shell (b).

In the fourth preferred embodiment, as shown in FIGS. **13**, **14**, **15** and **16**, on one end of the cylinder (**821**), there is a fixed plate (**84**), whose outer peripheral wall has partitioned supports (**841**). The outer ends of the supports (**841**) lie against the interior wall of the shell (a), thus suspending the cylinder (**821**), which is connected with the fixed plate (**84**), in the cavity of the shell (a). On the surface of the fixed plate (**84**), there is a mandril (**842**), whose front end lies against one end of the porous component (**81**), so that the fixed plate (**84**) is separated from the atomizing chamber (**811**) of the porous component (**81**). As a result, the run-through hole on one end of the atomizing chamber (**811**) won't be blocked, and the mist generated in the atomizing chamber (**811**) can be dispersed. One end of the porous component (**81**) has two protuberances (**812**) at the outlet of the atomizing chamber (**811**). Between the two protuberances (**812**) is a clearance. The two protuberances (**812**) lie against the perforated component for liquid storage (**9**).

In the fifth preferred embodiment, as shown in FIGS. **17** and **18**, the atomizer assembly is an atomizer (**8**), which includes a frame (**82**), the porous component (**81**) set on the frame (**82**), and the heating wire (**83**) wound on the porous component (**81**). The frame (**82**) has a run-through hole (**821**) on it. The porous component (**81**) is wound with heating wire (**83**) in the part that is on the side in the axial direction of the run-through hole (**821**). One end of the porous component (**81**) fits with the cigarette bottle assembly. The porous component (**81**) is made of foamed nickel, stainless steel fiber felt, macromolecular polymer foam or foamed ceramics.

In the sixth preferred embodiment, as shown in FIG. **19**, the airflow sensor (**5**) has a silica gel corrugated membrane (**53**), which connects with magnetic steel (**54**) with a Hall element (**52**), or a magneto-diode or a magneto-triode on one of its ends. FIG. **21** shows the electric circuit of the electronic cigarette of this solution.

What is claimed is:

1. An aerosol electronic cigarette, comprising:

a battery assembly, an atomizer assembly and a cigarette bottle assembly, and a shell that is hollow and integrally formed;

the battery assembly electrically connected with the atomizer assembly, and both are located in the shell;

the cigarette bottle assembly is detachably located in one end of the shell, and fits with the atomizer assembly inside it;

the shell has through-air-inlets;

the atomizer assembly is an atomizer, which includes a porous component and a heating body;

the heating body is heating wire;

the atomizer includes a frame;

the porous component is supported by the frame;

the heating wire is wound on the porous component;

the frame has a run-through hole;

a heating wire wound on a part of the porous component that is substantially aligned with the run-through hole; and with the porous component also positioned substantially within the cigarette bottle assembly.

2. An electronic cigarette, comprising:

a battery assembly and an atomizer assembly within a housing with the battery assembly electrically connected to the atomizer assembly;

a liquid storage component in the housing;

with the housing having one or more through-air-inlets;

the atomizer assembly including a porous component supported by a frame having a run-through hole;

a heating wire wound on a part of the porous component in the path of air flowing through the run-through hole; and

the porous component substantially surrounded by the liquid storage component.

3. An electronic cigarette, comprising:

a battery assembly and an atomizer assembly within a housing with the battery assembly electrically connected to the atomizer assembly;

with the housing having one or more through-air-inlets and an outlet;

the atomizer assembly includes a frame having a run through hole, and a porous component between the frame and the outlet;

a heating wire wound on a part of the porous component which is substantially aligned with the run-through hole; and

with the porous component in contact with a liquid supply in the housing.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,365,742 B2
APPLICATION NO. : 13/079937
DATED : February 5, 2013
INVENTOR(S) : Lik Hon

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

On the Title page, in Item (54), under "Title", in column 1, line 1, and in specification, column 1, line 1, delete "AEROSOL ELECTRONIC CIGARETTE" and insert -- ELECTRONIC CIGARETTE --, therefor.

In the Specifications:

In column 1, line 2, below "Title" insert -- This application is divisional of U.S. Patent Application No. 12/226,818, filed Oct. 29, 2008, which is the U.S. national stage application to International Patent Application No. PCT/CN2007/001575, filed on May 15, 2007, which claims priority, under 35 U.S.C. § 119, to Chinese Patent application No.: 200620090805.0, filed on May 16, 2006, the disclosures of which are incorporated by reference herein in their entireties. --.

In column 3, line 28, delete "(2)" and insert -- (82) --, therefor.

In column 3, line 49, after "shown in" insert -- FIGS. --.

In column 3, line 56, delete "ploypropylene" and insert -- polypropylene --, therefor.

In the Claims:

In column 6, lines 45-46, in claim 3, delete "run through" and insert -- run-through --, therefor.

Signed and Sealed this
Second Day of July, 2013

Teresa Stanek Rea
Acting Director of the United States Patent and Trademark Office

US008375957B2

(12) United States Patent
Hon

(10) Patent No.: US 8,375,957 B2
(45) Date of Patent: Feb. 19, 2013

(54) **ELECTRONIC CIGARETTE**

(75) Inventor: **Lik Hon**, Hong Kong (CN)

(73) Assignee: **Ruyan Investment (Holdings) Limited**, North Point (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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A24F 1/22 (2006.01)

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(58) **Field of Classification Search** 131/194, 131/273, 271; 128/202.21

See application file for complete search history.

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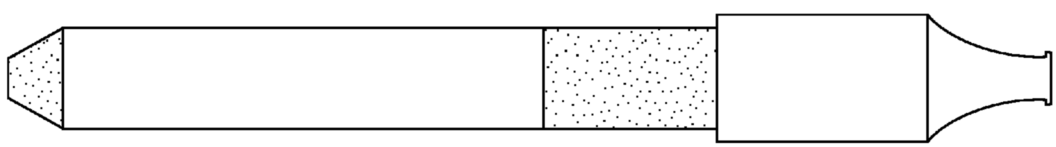
(57) **ABSTRACT**

An emulation aerosol sucker includes a battery assembly, an atomizer assembly and a cigarette bottle assembly. An external thread electrode is located in one end of battery assembly. An internal thread electrode is located in one end of atomizer assembly. Said battery assembly and said atomizer assembly are connected by the screwthread electrode. Said cigarette bottle assembly is inserted into the other end of said atomizer assembly and both form one cigarette type or cigar type body.

24 Claims, 10 Drawing Sheets



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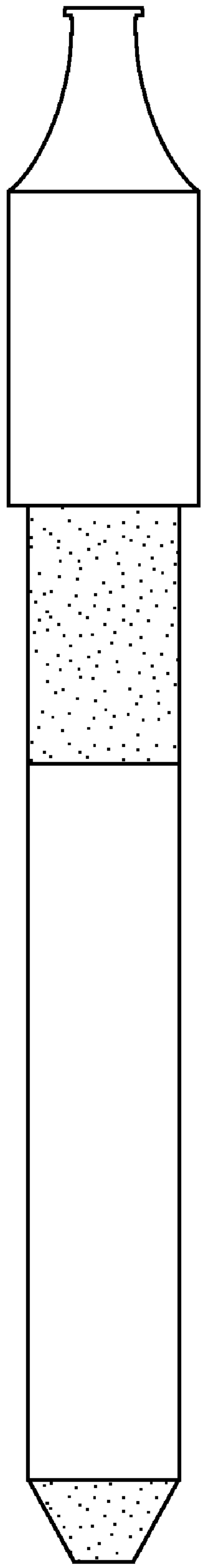

Figure 1

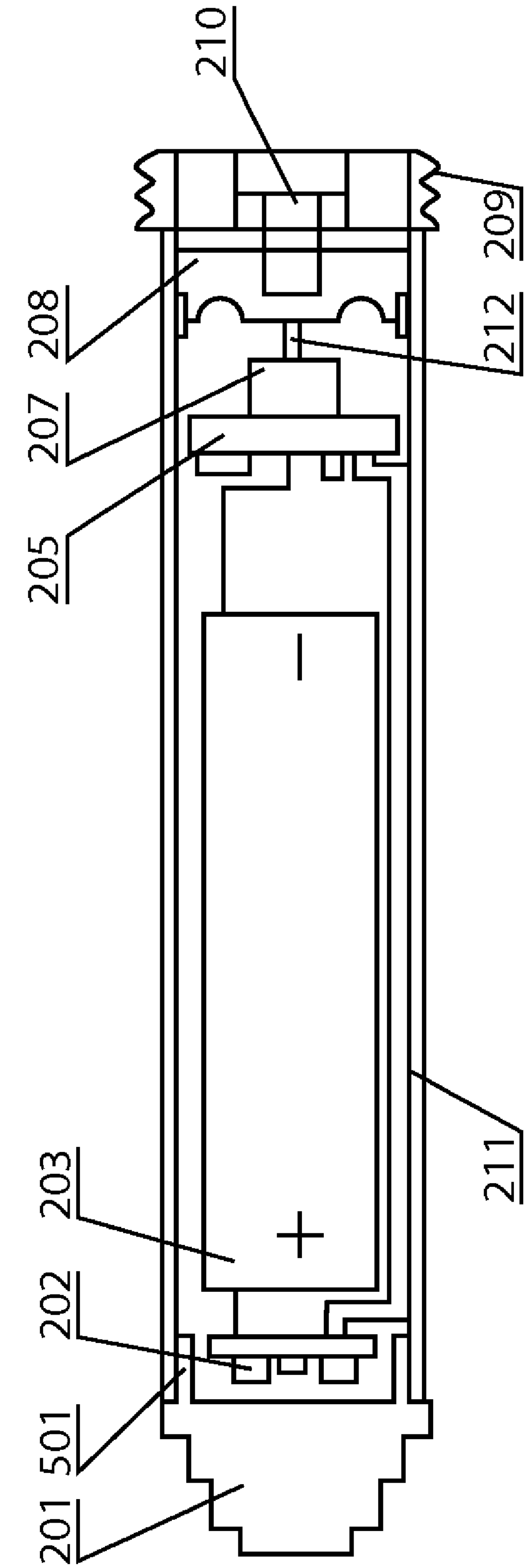

Figure 2A

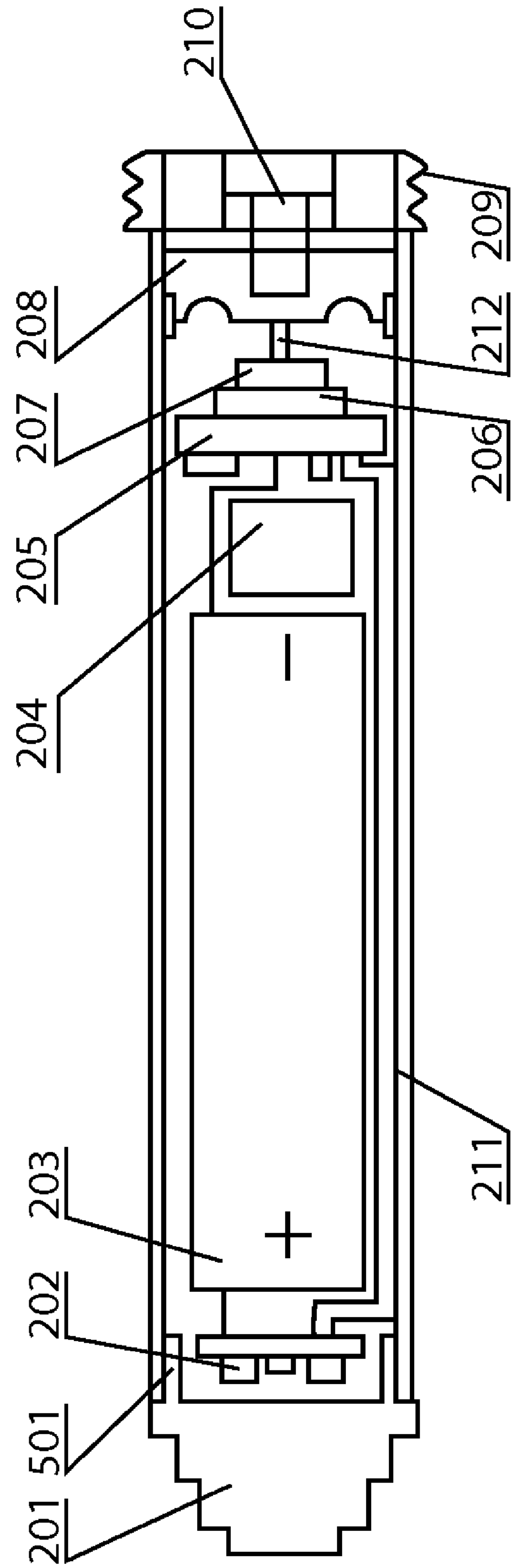

Figure 2B

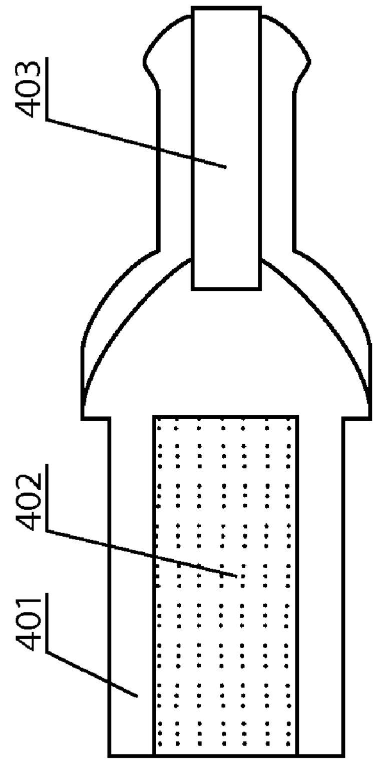

Figure 4

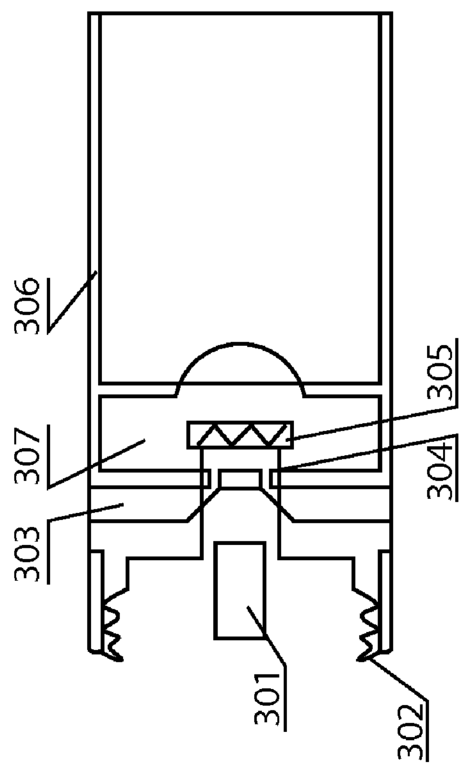

Figure 3

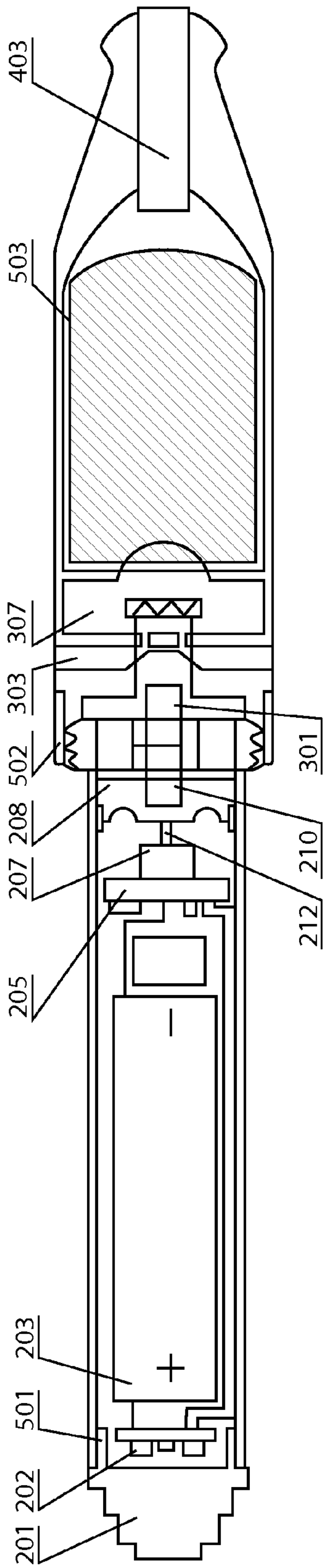

Figure 5A

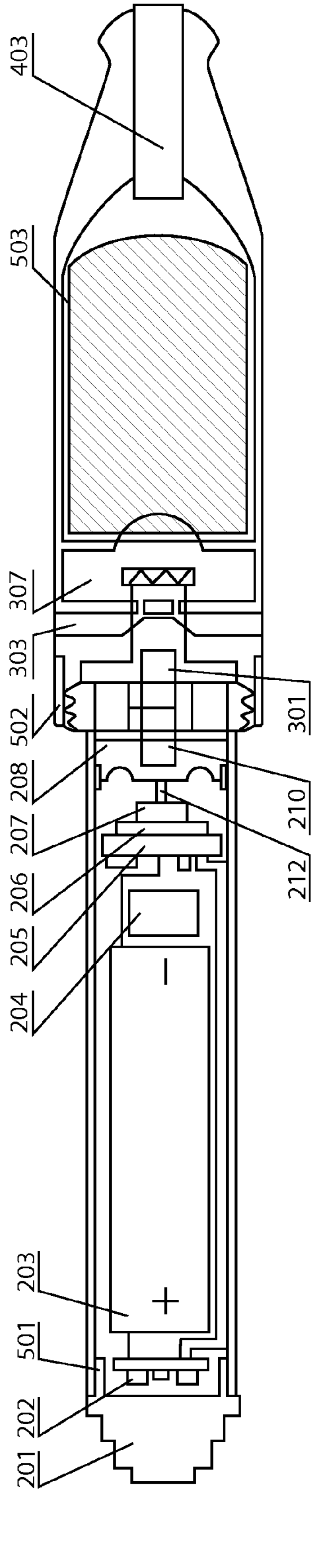
403
503
307
303
502
208
207
206
205
204
203
501
202
201
301
210
212
−
+

Figure 5B

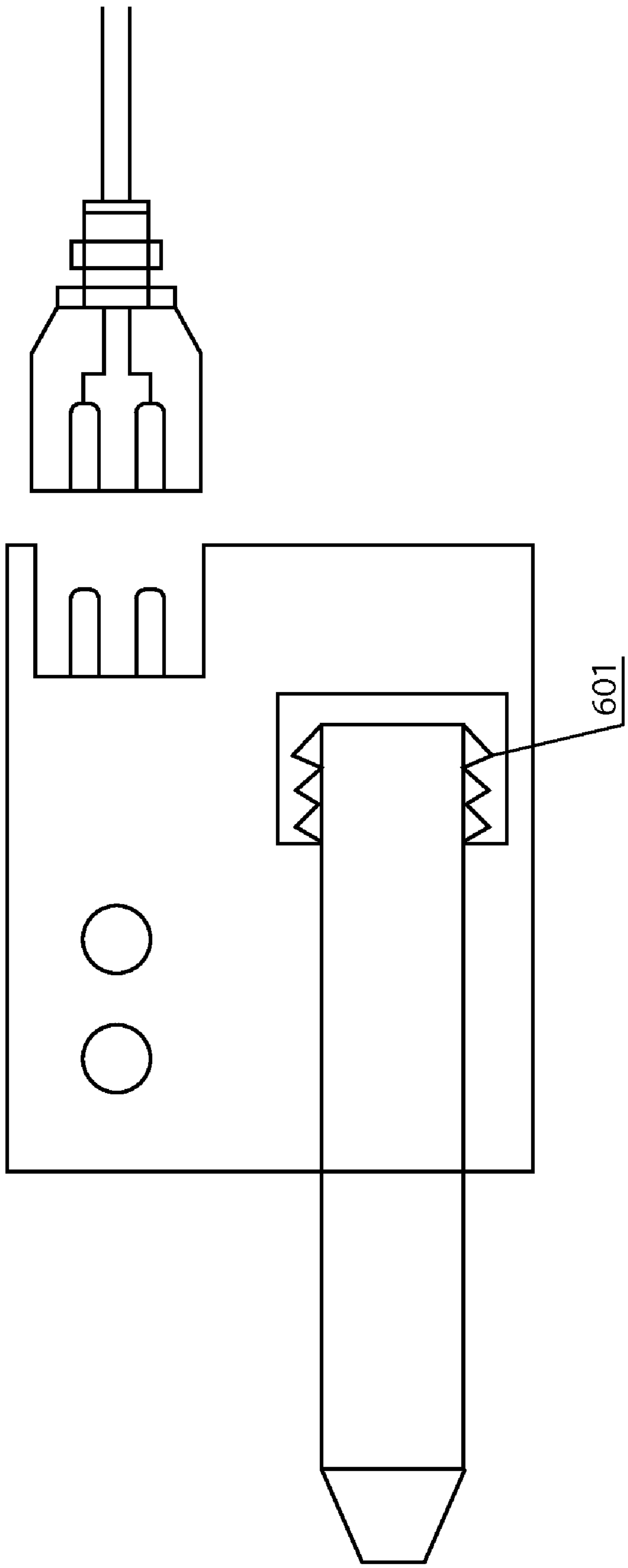

Figure 6

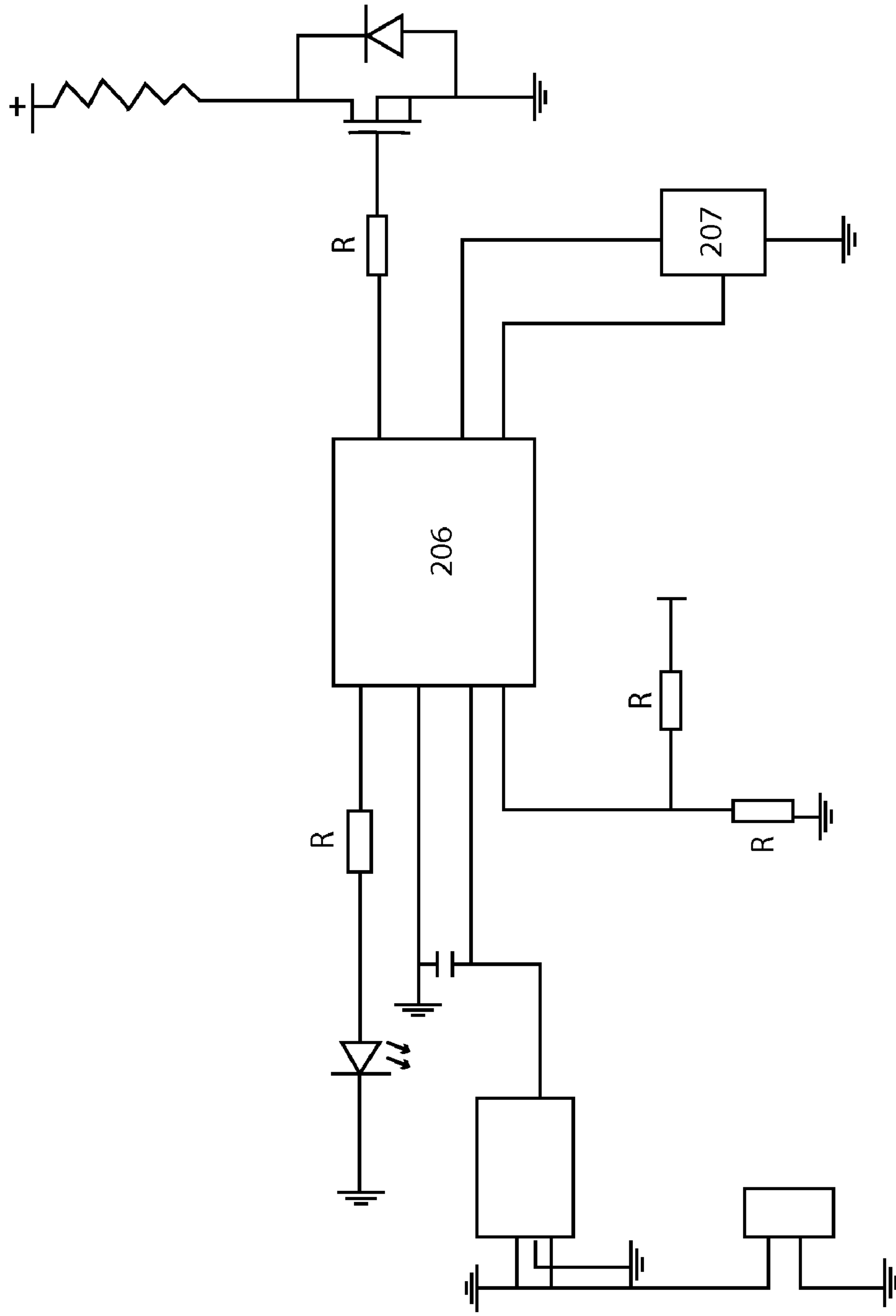

Figure 7

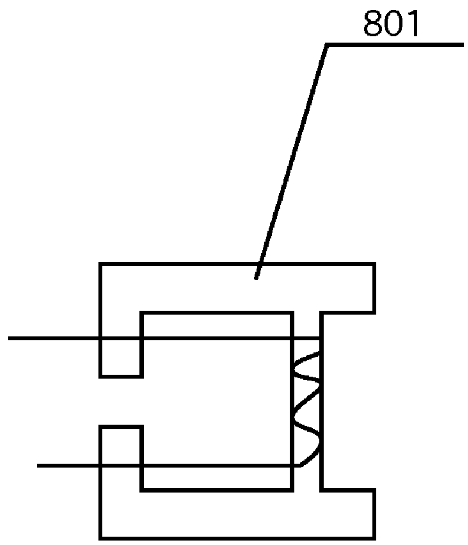

Figure 8

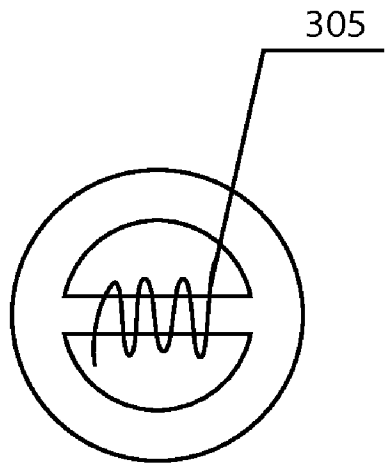

Figure 9

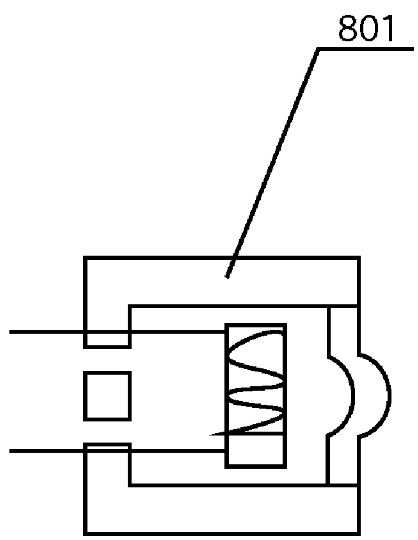

Figure 10

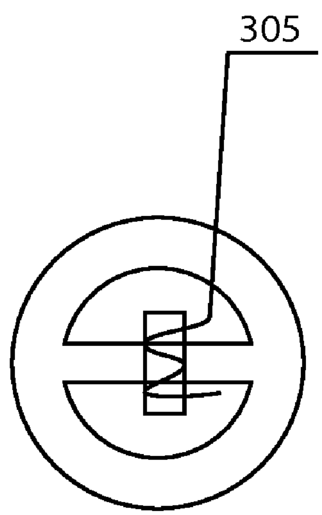

Figure 11

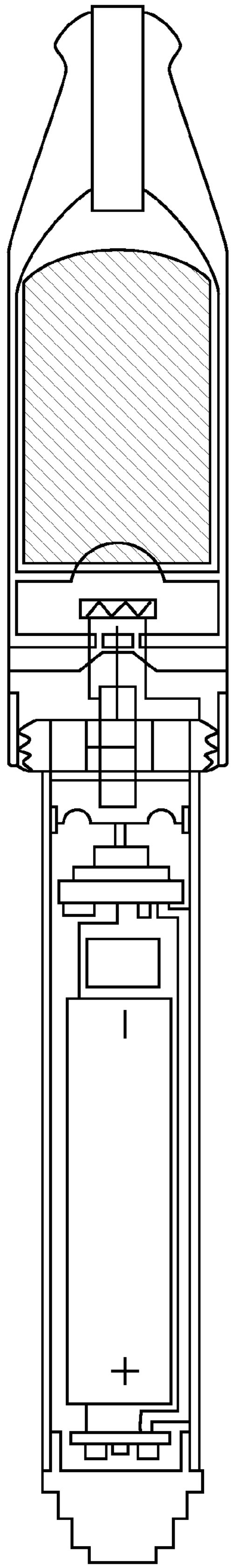

Figure 12

ELECTRONIC CIGARETTE

TECHNICAL FIELD

The invention relates to an electronic cigarette containing nicotine but not tar.

BACKGROUND ART

Today when it is known that "smoking is harmful to your health", there are still one billion people smoking cigarettes, and this figure is increasing every year. Although smoking causes serious respiratory system diseases and cancers, it is still difficult for smokers to completely quit smoking.

Nicotine is the active ingredient of a cigarette. During smoking, nicotine produces a lot of tar mist as the cigarette burns. The tar mist accesses the smoker's pulmonary alveolus and is quickly absorbed into the blood. Nicotine thus acts on the receptors of the smoker's central nervous system.

Nicotine is a micromolecular alkaloid, which is basically harmless to human bodies within a small dosage. Plus, the half life period of nicotine is extremely short in blood. Tar, on the other hand, is the major harmful substance in tobacco. Tobacco tar may include several thousands of ingredients, dozens of which are carcinogenic substances. Furthermore, it has been shown that second hand smoking is even more harmful to non-smokers.

Some cigarette substitutes do not contain harmful tar but do contain relatively pure nicotine. Such products include the "Cigarette Patch", "Nicotine Gargle", "Aerosol Packed in the High Pressure Tank with Propellant", "Nicotine Chewing Gum". These products are not as harmful as tar, but they are absorbed very slowly. As a result, the peak concentration of nicotine cannot be effectively established in blood, and the smokers are not satisfied in full. In addition, the substitutes do not satisfy the smokers "smoking" habit of repetitively inhaling and exhaling. Therefore, the substitute products are not effective as cigarette substitutes to quit smoking.

THE SUMMARY OF THE INVENTION

The purpose of this invention is to provide an electronic cigarette that substitutes for real cigarettes and helps smokers to quit smoking. For this invention, the aerosol may be regarded as liquid drops suspended in the air.

The present invention includes a battery assembly, an atomizer assembly and a cigarette bottle assembly. The battery assembly connects with one end of the atomizer assembly, and the cigarette bottle assembly is inserted into the other end of the atomizer assembly, thus forming one cigarette type or cigar type body.

The atomizer may be a capillary impregnation atomizer or spray atomizer, inside which there is a heating body. The said spray atomizer has a spray hole on it. The said spray hole is made of foamed ceramics, micro-porous ceramics, foamed metal, stainless steel fiber felt, or chemical fiber molding, which are drilled for holes. The said heating body is made of the micro-porous ceramics on which nickel-chromium alloy wire, iron-chromium alloy wire, platinum wire, or other electrothermal materials are wound. Alternatively, it may be a porous component made of electrically conductive ceramics or PTC ceramics and associated with a sintered electrode. The surface of the heating body is sintered into high-temperature glaze to fix the zeolite grains, which are made of natural zeolite, artificial non-organic micro-porous ceramics or aluminum oxide grains. The said cigarette bottle assembly includes the cigarette liquid bottle, fiber and suction nozzle.

The fiber containing cigarette liquid is located on one end of the cigarette liquid bottle, and this end is inserted into the secondary shell and lies against the atomizer. The suction nozzle is located on the other end of the cigarette liquid bottle. Between the fiber and interior wall of the cigarette liquid bottle is an air intake hole. The said cigarette liquid bottle and suction nozzle are made of non-toxic plastic. The said fiber is made of polypropylene or nylon. The cigarette liquid in the said fiber for atomization contains 0.1-3.5% nicotine, 0.05-5% tobacco flavor, 0.1-3% organic acid, 0.1-0.5% stabilizer, and propanediol for the remaining. The said sucker and its connecting structure may be loaded with conventional drugs for delivery to the lung.

This invention will bring the following benefits and active effects: For this invention, smoking doesn't bring any cigarette tar, considerably reducing the carcinogenic risks. At the same time, the smokers can still enjoy the feel and excitement of smoking, and there is no fire hazard since there is no need for igniting. In addition, the unit and its connecting structure of this invention may also be loaded with conventional drugs for delivery to the lung.

DESCRIPTION OF DRAWINGS

FIG. **1** is the visual appearance of the cigarette type of this invention.

FIG. **2**A is the diagram of one structure of the battery assembly of this invention.

FIG. **2**B is the diagram of another structure of the battery assembly of this invention.

FIG. **3** is the diagram of the diagram of the atomizer assembly of this invention.

FIG. **4** is the diagram of the cigarette bottle assembly of this invention.

FIG. **5**A is the diagram of one internal structure of this invention.

FIG. **5**B is the diagram of another internal structure of this invention.

FIG. **6** is the diagram of the structure of the charger of this invention.

FIG. **7** is the electric circuit diagram of MCU and MOSFET of this invention.

FIG. **8** is the diagram of the structure of the capillary impregnation atomizer of this invention.

FIG. **9** is the left view of FIG. **8**.

FIG. **10** is the diagram of the structure of the spray atomizer of this invention.

FIG. **11** is the left view of FIG. **10**.

FIG. **12** is the diagram of the structure of the cigar type of this invention.

SPECIFIC MODE FOR CARRYING OUT THE INVENTION

This invention is further described as follows on the basis of the drawings.

Example 1

As shown in FIG. **1**, the visual appearance of this invention is similar to a cigarette inserted into the cigarette holder, and includes a battery assembly, an atomizer assembly and a cigarette bottle assembly. An external thread electrode (**209**) is located in one end of the battery assembly, and an internal thread electrode (**302**) is located in one end of the atomizer assembly. The battery assembly and atomizer assembly are connected through the screwthread electrode into an emulation cigarette. The cigarette bottle assembly is inserted into the other end of atomizer assembly, to form one cigarette type emulation aerosol sucker.

As shown in FIG. **2**A, the battery assembly includes the indicator (**202**), lithium ion battery (**203**), MOSFET electric circuit board (**205**), sensor (**207**), silica gel corrugated membrane (**208**), primary screwthread electrode (**209**), primary negative pressure cavity (**210**), and primary shell (**211**). On one end of the primary shell (**211**) is an external thread electrode (**209**), while on the other end is an indicator (**202**), where there is an indicator cap (**201**) on one side, in which there is a fine hole (**501**). On the other side, the lithium ion battery (**203**) and MOSFET electric circuit board (**205**) are connected successively. The sensor (**207**) is located on MOSFET electric circuit board (**205**). Between the primary screwthread electrode (**209**) and sensor (**207**) is a silica gel corrugated membrane (**208**), on which there is the primary negative pressure cavity (**210**). The sensor (**207**) is connected with the silica gel corrugated membrane (**208**) through the switch spring (**212**).

Therein, the sensor (**207**) may be switch sensor made of elastic alloy slice, Hall element of linear output, semiconductor force-sensitive chip, semiconductor matrix thermoelectric bridge chip, capacitance or inductance sensor. The indicators (**202**) include two red LEDs. The lithium ion battery (**203**) may be either a rechargeable polymer lithium ion battery or a rechargeable lithium ion battery. The external thread electrode (**209**) is a gold-coated stainless steel or brass part with a hole drilled in the center. The silica gel corrugated membrane (**208**) may alternatively be made of fluorinated rubber, butyronitrile rubber, or elastic alloy film.

As shown in FIG. **3**, the atomizer assembly includes the internal thread electrode (**302**), air-liquid separator (**303**), atomizer (**307**) and the secondary shell (**306**). One end of the secondary shell (**306**) is inserted into the cigarette bottle assembly for connection, while the other end has an internal thread electrode (**302**), in which there is the secondary negative pressure cavity (**301**). The air-liquid separator (**303**) and the atomizer (**307**) are connected with the internal thread electrode (**302**) successively. On the secondary shell (**306**), there is an air intake hole (**502**). The air-liquid separator (**303**) is made of stainless steel or plastic with a hole drilled. The internal thread electrode (**302**) is a gold-coated stainless steel or brass part with a hole drilled in the center.

The atomizer (**307**) may be a capillary impregnation atomizer as FIGS. **8** and **9** show, or a spray atomizer as FIGS. **10** and **11** show. For this embodiment, it is a spray atomizer.

As shown in FIG. **4**, the cigarette bottle assembly includes the cigarette liquid bottle (**401**), fiber (**402**) and suction nozzle (**403**). The fiber (**402**) containing cigarette liquid is located on one end of the cigarette liquid bottle (**401**), and this end is inserted into the secondary shell (**306**) and lies against the atomizer (**307**). The suction nozzle (**403**) is located on the other end of the cigarette liquid bottle (**401**). Between the fiber (**402**) and interior wall of the cigarette liquid bottle (**401**) is an air intake hole (**503**).

As shown in FIG. **5**A, the standby state of this invention has the fully charged battery assembly shown on FIG. **2**A fastened onto the atomizer assembly shown on FIG. **3**, which is then inserted into the cigarette bottle assembly shown on FIG. **4**. When the user slightly sucks the suction nozzle (**403**), the negative pressure forms on the silica gel corrugated membrane (**208**) through the air intake hole (**503**) and the primary and secondary negative pressure cavities (**210**, **301**), and the silica gel corrugated membrane (**208**), under the action of suction pressure difference, distorts to drive the switch spring (**212**) and sensor (**207**), thus invoking MOSFET electric circuit board (**205**). At this moment, the indicators (**202**) are lit gradually; the lithium ion battery (**203**) electrifies the heating body (**305**) inside the atomizer (**307**) through MOSFET electric circuit board (**205**) as well as the internal and external thread electrodes (**302**, **209**), so that the heating body (**305**) inside the atomizer (**307**) produces heat. The fiber (**402**) inside the cigarette liquid bottle (**401**) contains cigarette liquid, which soaks the micro-porous ceramics (**801**) inside the atomizer through the fiber (**402**). The air enters through the air intake hole (**502**), passes through the run-through hole on the air-liquid separator (**303**), and helps to form air-liquid mixture in the spray nozzle (**304**) of the atomizer (**307**). The air-liquid mixture sprays onto the heating body (**305**), gets vaporized, and is quickly absorbed into the airflow and condensed into aerosol, which passes through the air intake hole (**503**) and suction nozzle (**403**) to form white mist type aerosol.

When suction stops, the switch spring (**212**) and sensor (**207**) are reset; the atomizer (**307**) stops working; the indicators (**202**) gradually die down. When the operation times reaches the pre-set value, the atomizer (**307**) provides a work delay of 5-20 seconds per time, so as to remove the micro-dirt accumulated on the heating body (**305**).

Besides the micro-porous ceramics, the liquid supply material of the atomizer (**307**) may also be foamed ceramics, micro-porous glass, foamed metal, stainless steel fiber felt, terylene fiber, nylon fiber, nitrile fiber, aramid fiber or hard porous plastics. The heating body (**305**) is made of the micro-porous ceramics on which nickel-chromium alloy wire, iron-chromium alloy wire, platinum wire, or other electrothermal materials are wound. Alternatively, it may be a porous component directly made of electrically conductive ceramics or PTC (Positive Temperature Coefficient) ceramics and associated with a sintered electrode. The surface of the heating body (**305**) is sintered into high-temperature glaze to fix the zeolite grains, which are made of natural zeolite, artificial non-organic micro-porous ceramics or aluminum oxide grains. The cigarette liquid bottle (**401**) and suction nozzle (**403**) in the cigarette bottle assembly are made of non-toxic plastic, and inside them is the fiber (**402**) made of polypropylene fiber or nylon fiber to absorb cigarette liquid. In the battery assembly, there is a fine hole (**501**) on the indicator cap (**201**) for balancing the pressure difference on both sides of the silica gel corrugated membrane (**208**).

The cigarette liquid contains 0.1-3.5% nicotine, 0.05-5% tobacco flavor, 0.1-3% organic acid, 0.1-0.5% stabilizer, and propanediol for the remaining.

The primary and secondary shell (**211**, **306**) of this invention are made of stainless steel tube or copper alloy tube with baked-enamel coating of real cigarette color.

As shown in FIG. **12**, this invention may have the diameter of the battery assembly increased in proportion, so that it is consistent with the diameter of the atomizer assembly. Its shell may be decorated with the leaf veins and sub-gloss brown-yellow baked-enamel coating, to create a cigar type emulation aerosol sucker.

For charging of the lithium ion battery (**203**) of this invention, the screwthread electrode (**601**) that matches the external thread electrode (**209**) on the battery assembly may be used as the charging interface.

Example 2

As shown in FIG. **2**B, the differences of this example from example 1 are as follows: MCU (**206**) is added between MOSFET electric circuit board (**205**) and sensor (**207**). On the surface of the primary shell (**211**), there is a screen (**204**) for display of the power of the lithium ion battery (**203**) and the sucking times.

As shown in FIG. **5**B, the standby state of this invention has the fully charged battery assembly shown on FIG. **2**B fastened onto the atomizer assembly, which is then inserted into the cigarette bottle assembly shown on FIG. **4**. When the user slightly sucks the suction nozzle (**403**), the negative pressure forms on the silica gel corrugated membrane (**208**) through the air intake hole (**503**) and the primary and secondary negative pressure cavities (**210**, **301**), and the silica gel corrugated membrane (**208**), under the action of suction pressure difference, distorts to drive the switch spring (**212**) and sensor (**207**), thus invoking MCU (**206**) and MOSFET electric circuit board (**205**). At this moment, the indicators (**202**) are lit gradually; the lithium ion battery (**203**) electrifies the heating body (**305**) inside the atomizer (**307**) through MOSFET electric circuit board (**205**) as well as the internal and external thread electrodes (**302**, **209**), so that the heating body (**305**) inside the atomizer (**307**) produces heat. The fiber (**402**) inside the cigarette liquid bottle (**401**) contains cigarette liquid, which soaks the micro-porous ceramics (**801**) inside the atomizer through the fiber (**402**). The air enters through the air intake hole (**502**), passes through the run-through hole on the air-liquid separator (**303**), and helps to form air-liquid mixture in the spray nozzle (**304**) of the atomizer (**307**). The air-liquid mixture sprays onto the heating body (**305**), gets vaporized, and is quickly absorbed into the airflow and condensed into aerosol, which passes through the air intake hole (**503**) and suction nozzle (**403**) to form white mist type aerosol.

As shown in FIG. **7**, when the action of suction evokes the sensor, MCU (**206**) scans the sensor (**207**) in the power-saving mode of pulse, and according to the signal parameters of the sensor (**207**), restricts the atomizing capacity with the integral function of frequency to single operation time. Also, the MCU (**206**) accomplishes the pulse width modulation and over discharging protection for the constant power output, automatic cleansing for thousands of times per operation, step lighting/dying down control of the indicator, display of the operation times and battery capacity, automatic recovery after sensor malfunction shutdown, etc.

The unit and its connecting structure of this invention may also be loaded with drugs for delivery to the lung.

Above are just specifications of a concrete example and applied example of this invention. This doesn't necessarily restrict the scope of protection of this invention. Any equivalent modification or decoration made on the basis of the design spirit of this invention shall fall into the scope of protection of this invention.

The invention claimed is:

1. An electronic cigarette or cigar comprising:

a battery assembly comprising a battery assembly housing having a first end and a second end, with a battery, a micro-controller unit (MCU) and a sensor electrically connected to a circuit board within the battery assembly housing;

a primary screwthread electrode located on the first end of the battery assembly housing and having a hole through its center;

an atomizer assembly comprising:

an atomizer assembly housing having a first end and a second end;

an atomizer, and a solution storage area in the atomizer assembly housing;

a secondary screwthread electrode located on the second end of the atomizer assembly housing and having a hole through its center, the battery assembly and the atomizer assembly connected through the primary and secondary screwthread electrodes; and

with the atomizer including a heater coil wound around a porous component.

2. The electronic cigarette or cigar of claim **1**, with the solution storage area in the solution assembly having a first end and a second end, and the second end of the solution assembly is inserted into the first end of the atomizer assembly housing.

3. The electronic cigarette or cigar of claim **1**, wherein the primary screwthread electrode is an external screwthread electrode and the secondary screwthread electrode is an internal screwthread electrode.

4. The electronic cigarette or cigar of claim **1**, wherein the battery assembly further comprises a membrane located between the primary screwthread electrode and the sensor.

5. The electronic cigarette or cigar of claim **1**, further comprising a screen located on a surface of the battery assembly housing.

6. The electronic cigarette or cigar of claim **1**, wherein the sensor comprises a switch sensor, a Hall element, a semiconductor force-sensitive chip, a semiconductor matrix thermoelectric bridge chip, a capacitance sensor or an inductance sensor.

7. The electronic cigarette or cigar of claim **1**, wherein the atomizer assembly has an air intake hole at the secondary screwthread electrode.

8. The electronic cigarette or cigar of claim **1** further comprising a fiber material within the solution storage area.

9. The electronic cigarette or cigar of claim **1** with the porous component that the heater coil is wound around comprising a fiber material.

10. An electronic cigarette or cigar comprising:

a battery assembly housing having a first end and second end;

a battery connected to a circuit board within the battery assembly housing;

a primary screwthread electrode located on the first end of the battery assembly housing;

an atomizer assembly comprising:

an atomizer assembly housing having a first end and a second end;

a secondary screwthread electrode located on the second end of the atomizer assembly housing with the battery assembly and the atomizer assembly connected through the primary and secondary screwthread electrodes;

an atomizer in the atomizer assembly housing, with atomizer including a heater coil wound around a porous component; and

a solution assembly, which comprises, a suction nozzle at a first end of the solution assembly, and a solution storage area with a liquid containing fiber material in the solution storage area.

11. The electronic cigarette or cigar of claim **10** with the porous component that the heater coil is wound around comprising a fiber material.

12. The electronic cigarette or cigar of claim **10**, wherein the second end of the solution assembly is inserted into the first end of the atomizer assembly, thus forming a cigarette or cigar body.

13. The electronic cigarette or cigar of claim **10**, wherein the circuit board is a Metallic Oxide Semiconductor Field Effect Transistor (MOSFET) circuit board.

14. The electronic cigarette or cigar of claim **10**, wherein the primary screwthread electrode is an external screwthread electrode and the secondary screwthread electrode is an internal screwthread electrode.

15. The electronic cigarette or cigar of claim **10**, wherein the battery assembly further comprises a membrane located between the primary screwthread electrode and the sensor.

16. The electronic cigarette or cigar of claim **10**, wherein the battery assembly further comprises a micro controller unit (MCU) electrically connected to the circuit board.

17. The electronic cigarette or cigar of claim **10**, wherein the atomizer assembly has an air intake hole.

18. The electronic cigarette or cigar of claim **17**, wherein the air intake hole is at the secondary screwthread.

19. The electronic cigarette or cigar of claim **10** wherein the coil comprises nickel-chromium alloy wire, iron-chromium alloy wire, platinum wire or another electrothermal material.

20. The electronic cigarette or cigar of claim **10** wherein the heating element comprises a plurality of zeolite grains.

21. The electronic cigarette or cigar of claim **10**, wherein the primary screwthread electrode connects to a charger.

22. The electronic cigarette or cigar of claim **10** with at least one of the primary and the secondary screwthread electrodes having a hole through its center.

23. An electronic cigarette comprising:

battery assembly including a battery assembly housing having a front end and a back end, with a battery, a micro-controller unit (MCU) and a sensor electrically connected to a circuit board within the battery assembly housing;

a first screwthread electrode located on the back end of the battery assembly housing;

an atomizer assembly comprising:

an atomizer assembly housing having a front end and a back end;

an atomizer, and a solution storage area in the atomizer assembly housing;

a second screwthread electrode located on the front end of the atomizer assembly housing, the battery assembly and the atomizer assembly connected through the first and second screwthread electrodes; and

with the atomizer including a heater coil wound around a porous component.

24. The electronic cigarette of claim **23** with the solution storage area within a solution assembly, and with a front end of the solution assembly inserted into the back end of the atomizer assembly.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,375,957 B2
APPLICATION NO. : 12/226819
DATED : February 19, 2013
INVENTOR(S) : Lik Hon

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

On the Title page of the patent, between (65) and (51), insert
-- (30) Foreign Application Priority Data
May 16, 2006 (CN) .... 200620090805 U --.

In the Claims:

In column 6, line 37, in claim 10, before "second" insert -- a --.

In column 8, line 2, in claim 23, before "battery assembly including" insert -- a --.

Signed and Sealed this
Second Day of July, 2013

Teresa Stanek Rea
Acting Director of the United States Patent and Trademark Office

US 20030033055A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0033055 A1**

McRae et al. (43) **Pub. Date: Feb. 13, 2003**

(54) **METHOD AND APPARATUS FOR GENERATING A VOLATILIZED LIQUID**

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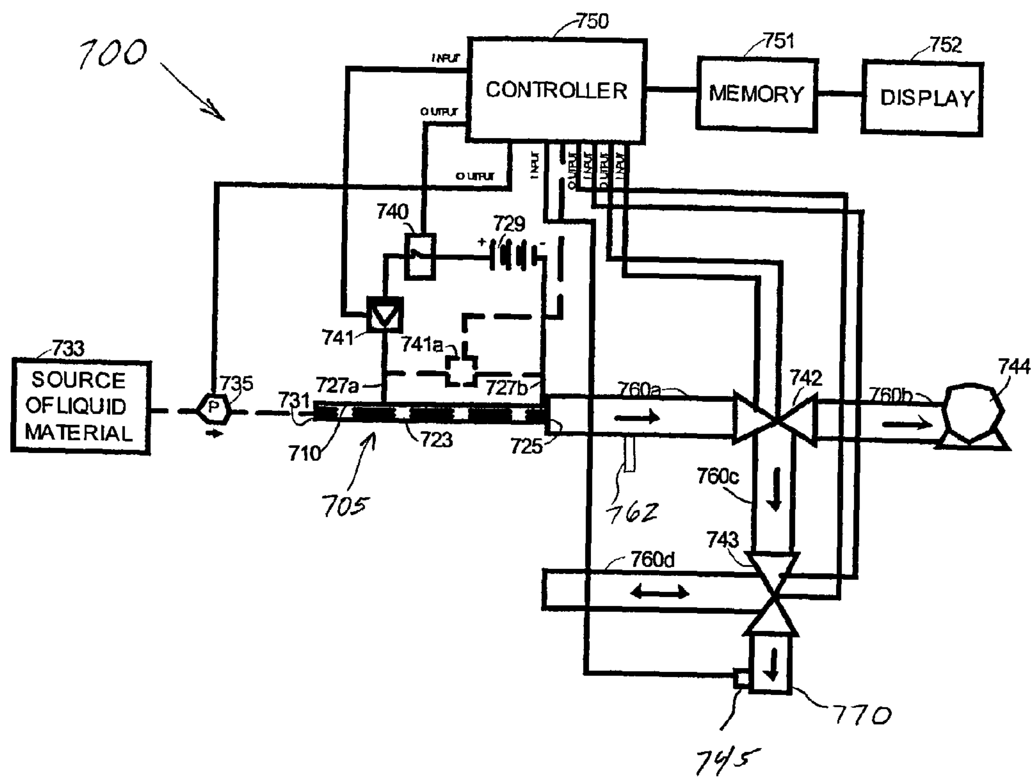
(57) **ABSTRACT**

A programmable aerosol generator forms a volatilized liquid by supplying a material in liquid form to a flow passage and heating the flow passage, such that the material volatilizes and expands out of an outlet of the channel. The volatilized material, if desired, mixes with ambient air such that volatilized material condenses to form the aerosol. An apparatus and method for generating such a volatilized liquid, as well as the control and methods of heating, are disclosed as an analytical tool useful for experimental use, a tool useful for production of commercial products or an inhaler device.



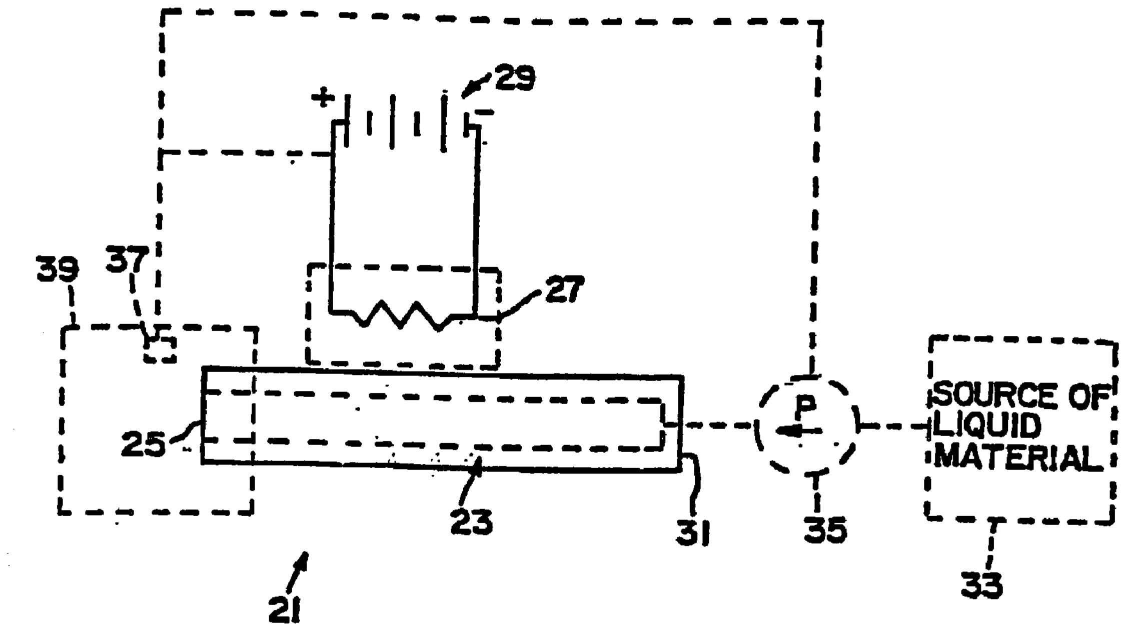


FIG. 1

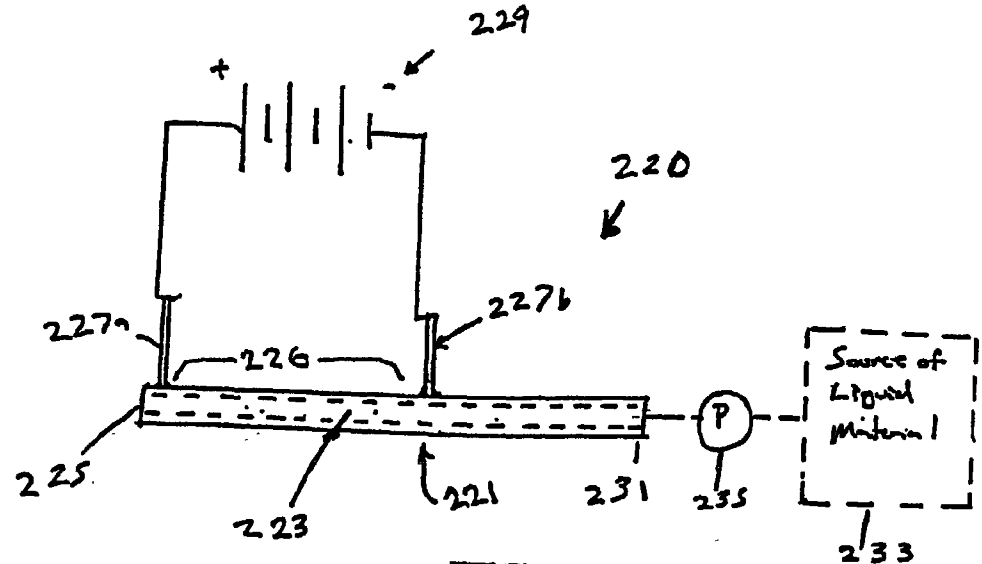

229
+
-
220
227a
227b
226
Source of Liquid Material
P
225
223
221
231
235
233

FIG. 2

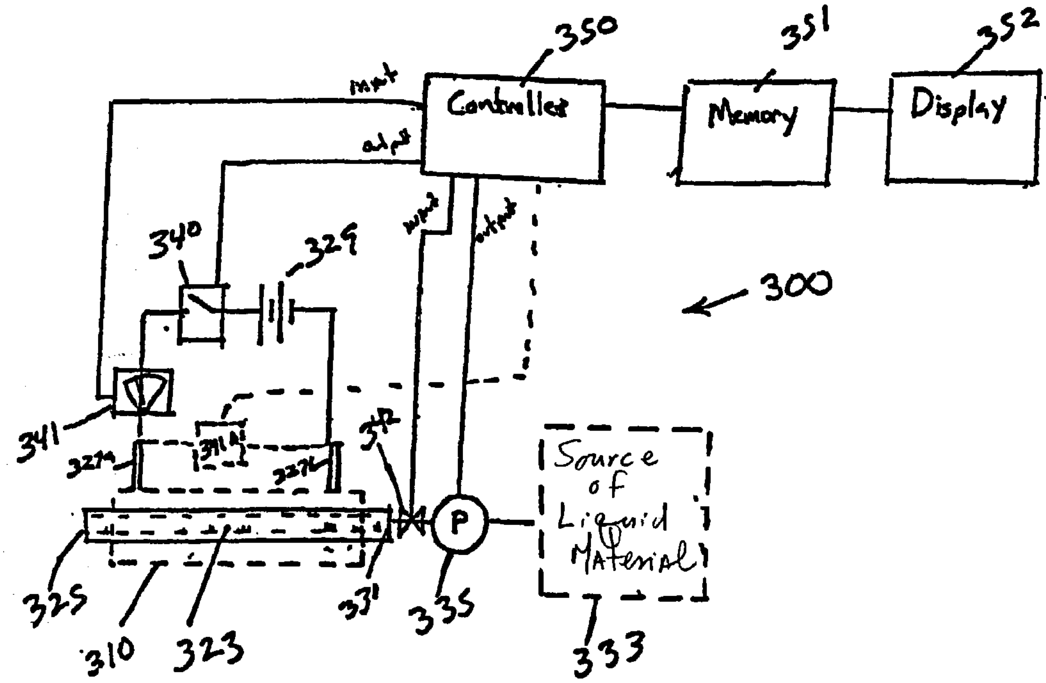
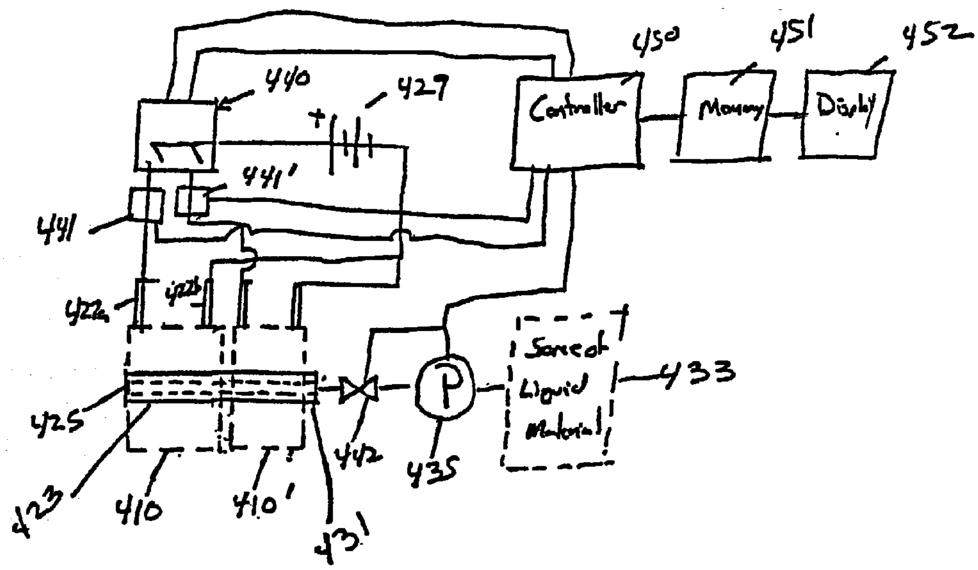
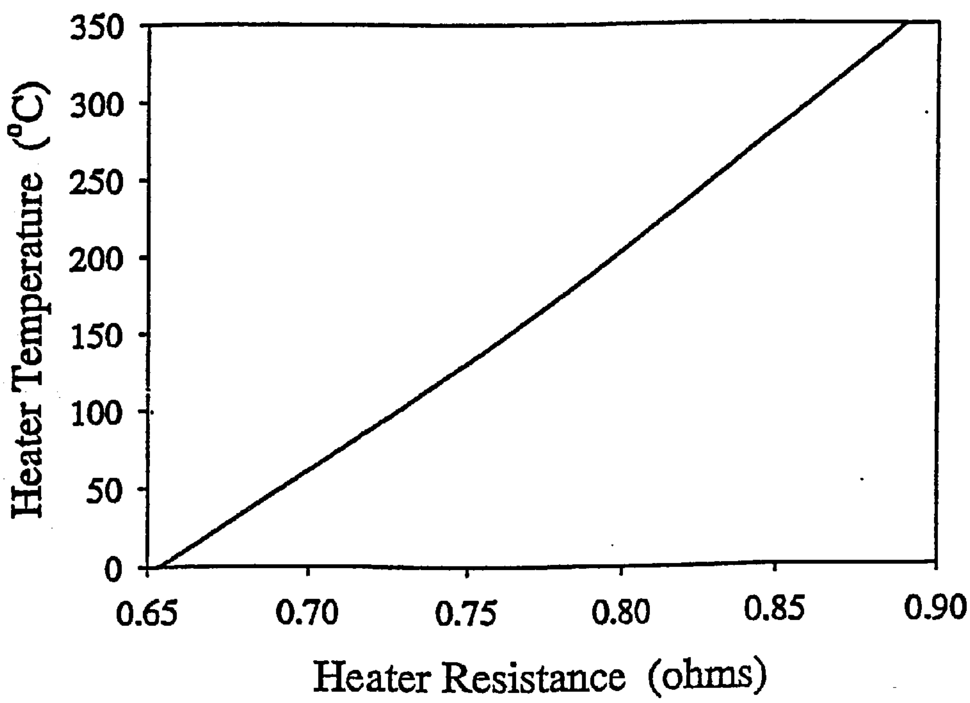

350
351
352
Controller
Memory
Display
input
output
340
329
300
341
327a
327b
325
310
323
331
335
333
P
Source of Liquid Material

FIG. 3



450
451
452
440
427
Controller
Memory
Display
441'
441
422a
422b
Source of Liquid Material
433
425
423
410
410'
431
442
435

FIG. 4



350
300
250
200
150
100
50
0
Heater Temperature (^{o}C)
0.65
0.70
0.75
0.80
0.85
0.90
Heater Resistance (ohms)

FIG. 5

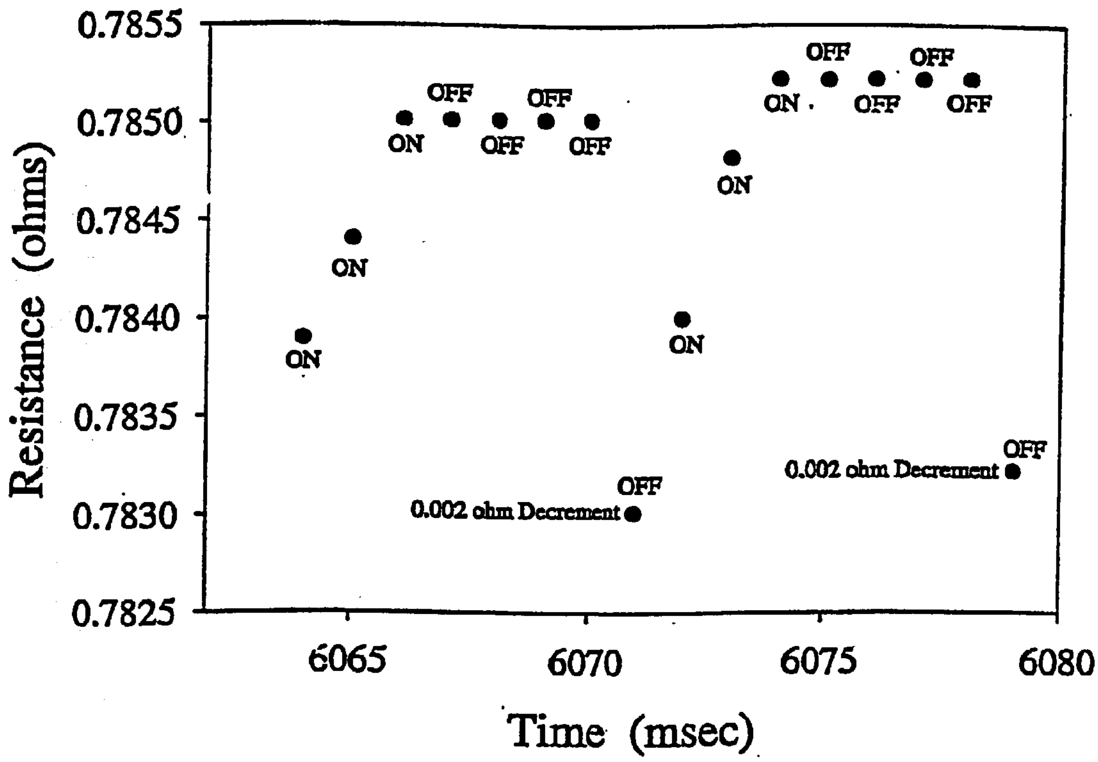

0.7855
0.7850
0.7845
0.7840
0.7835
0.7830
0.7825
Resistance (ohms)
6065
6070
6075
6080
Time (msec)
ON
OFF
0.002 ohm Decrement

FIG. 6

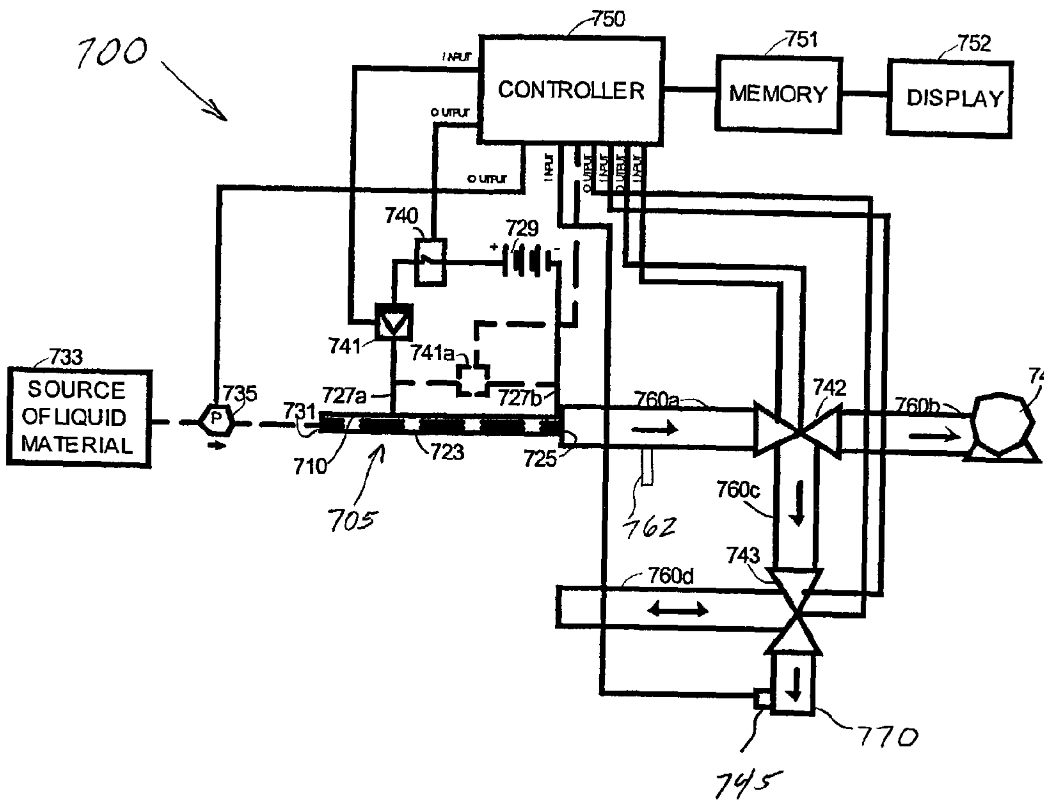

700
750
CONTROLLER
751
MEMORY
752
DISPLAY
INPUT
OUTPUT
OUTPUT
INPUT
OUTPUT
INPUT
OUTPUT
INPUT
740
729
741
741a
733
SOURCE OF LIQUID MATERIAL
735
P
731
727a
727b
760a
742
760b
744
710
723
725
705
762
760c
743
760d
770
745

FIG. 7

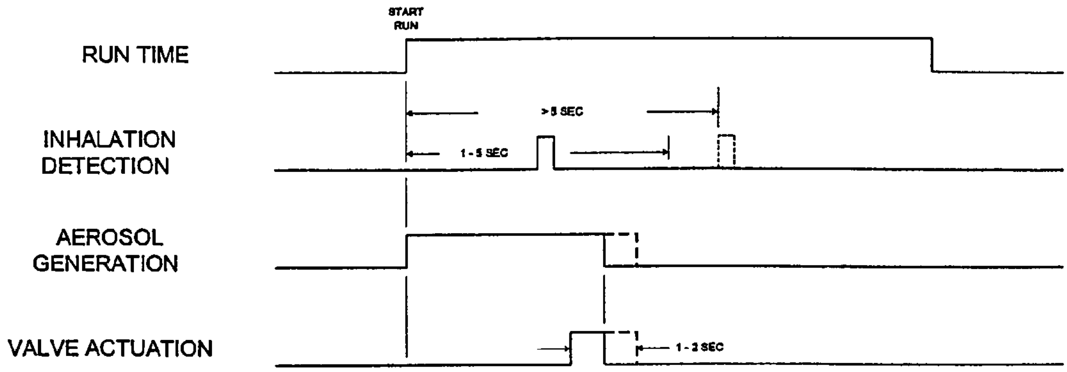

START RUN
RUN TIME
>5 SEC
INHALATION DETECTION
1 - 5 SEC
AEROSOL GENERATION
VALVE ACTUATION
1 - 2 SEC

FIG. 8

METHOD AND APPARATUS FOR GENERATING A VOLATILIZED LIQUID

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates generally to a flexible platform that generates aerosols and vapors through the volatilization of a liquid for laboratory testing and development of applications for volatilized liquids.

[0003] 2. Description of Related Art

[0004] U.S. Pat. No. 5,743,251, which is incorporated herein by reference, discloses an aerosol generator that includes a tube having a first open end. The aerosol generator further includes a heater for heating the tube to a temperature sufficient to volatilize material in a liquid form in the tube such that the volatilized material expands out of the open end of the tube and mixes with ambient air to form an aerosol.

[0005] An aerosol generator **21** according to U.S. Pat. No. 5,743,251 is schematically shown with reference to **FIG. 1**. The aerosol generator **21** includes a tube **23** having an open end **25**. A heater **27** is positioned adjacent to at least a portion of the tube **23**, but preferably in a way that provides a heated zone around the tube that maximizes heat transfer evenly throughout the heated zone. The heater **27** is connected to a power supply **29**, preferably a DC power supply, such as a battery.

[0006] In operation, a material (not shown) in liquid form is introduced to the tube **23**. The heater **27** heats the portion of the tube **23** to a sufficient temperature to volatilize the liquid material. In the case of an organic liquid material, the heater preferably heats the liquid material just to the boiling point of the liquid material, and preferably maintains the surface temperature of the tube **23** below 400 ° C., as most organic materials are not stable when they are exposed to temperatures above that temperature for periods of time. The volatilized material expands out of the open end **25** of the tube **23**. The volatilized material mixes with ambient air outside of the tube and condenses to form particles, thereby forming an aerosol.

[0007] The tube **23** is a capillary tube or a portion thereof having an inside diameter of between 0.05 and 0.53 millimeter and the inside diameter of the tube can be approximately 0.1 millimeter. The tube **23** can be a portion of a fused silica capillary column, an aluminum silicate ceramic tube, or other substantially non-reactive materials capable of withstanding repeated heating cycles and generated pressures and having suitable heat conduction properties. If desired or necessary, an inside wall of the tube **23** may be provided with a coating for reducing the tendency of material to stick to the wall of the tube, which may result in clogging.

[0008] The tube **23** may be closed at a second end **31** and material in liquid form may be introduced into the tube **23** through the open end **25** when it is desired to form an aerosol. Thus, when the liquid material is heated by the heater **27**, the volatilized material is only able to expand by exiting the tube **23** through the open end **25**. However, the second end **31** of the tube is connected to a source **33** (shown by dotted lines in **FIG. 1**) of liquid material. The liquid material in the portion of the tube **23** volatilized by the heater **27** is prevented from expanding in the direction of the second end **31** of the tube, and is forced out of the open end **25** of the tube, as a result of back pressure of liquid from the source **33** of liquid material. The back pressure of the liquid is between about 20 to 30 psi.

[0009] It is contemplated that a variety of uses can be developed for the aerosol generator described above. In order to investigate such uses, it would be desirable to have an instrument capable of generating vapors and aerosols to be evaluated.

SUMMARY OF THE INVENTION

[0010] The invention provides a programmable instrument for volatilizing liquid material, thus facilitating investigational use of the vaporized liquid for various applications.

[0011] A material in liquid form is supplied to a flow passage and the liquid material is heated to a temperature sufficient to volatilize the material such that the material expands out of the flow passage, which results in a vapor of the volatilized material, the volatilized material, then if desired, condensing upon mixing with air to form an aerosol. A programmable controller is used to control delivery of liquid material to the flow passage and/or control heating of a heater arrangement for volatilizing the liquid.

[0012] An embodiment is directed towards an instrument and method for generating an aerosol with a flow passage defined by a metal tube capable of conducting electricity. The tube has a first open end and a power supply for supplying power to a heater comprises a section of the metal tube such that the tube heats to a temperature sufficient to volatilize the liquid material in the flow passage. The volatilized material expands out of the open end of the flow passage and then may mix with ambient air to form an aerosol.

[0013] Another embodiment is directed towards an instrument and method for generating a volatilized liquid comprising a flow passage having a first open end and a heater which heats the flow passage to a temperature sufficient to volatilize material in liquid form such that the volatilized material expands out of the open end of the flow passage. The volatilized material may then mix with ambient air to form an aerosol. A controller is operable to maintain the temperature of the flow passage and regulate the flow of material. The controller is preferably capable of accepting manually entered commands or programs associated with operating parameters of the instrument. In addition, the controller is configured to be programmed for different parameters associated with the generation of the aerosol and/or precursor vapor, such that the controller can be used for developmental testing.

[0014] A further embodiment is directed to an instrument and method for generating a volatilized liquid including a flow passage with a first open end and a plurality of heaters for heating the flow passage to a temperature sufficient to volatilize material in liquid form in the flow passage such that the volatilized material expands out of the open end and may mix with ambient air to form an aerosol.

[0015] A method for generating an aerosol or vapor comprises steps of setting a target parameter, such as resistance of a heater arrangement, such as a resistance heater, corresponding to a temperature sufficient to volatilize a liquid material within a flow passage heated by the heater; supplying a liquid material to the flow passage; periodically determining the parameter of the heater; comparing the parameter to the target parameter; and energizing the heater when the parameter is less than the target parameter. In other embodiments, the method comprises setting a series or range of target parameters (i.e., multiple or variable target parameters), such as a series or range of resistance values of a heater.

[0016] Another embodiment is directed to an instrument for generation of volatilized material, which comprises at least one flow passage having an open end; a liquid supply operable to supply liquid material to the flow passage; at least one heater adapted to heat the flow passage to a temperature sufficient to volatilize material in liquid form in the flow passage such that the volatilized material expands out of the open end of the flow passage, the volatilized material optionally being admixed with air to form an aerosol; a first flow path in fluid communication with the open end of the flow passage; a second flow path in fluid communication with the open end of the flow passage, the second flow path being different from the first flow path; a first valve in fluid communication with the open end of the flow passage; and a controller operable to monitor a condition of the heater and to control operation of the first valve such that the volatilized material or aerosol (i) flows through the first flow path when the heater is in a non-conforming condition and (ii) flows through the second flow path when the heater is in a confirming condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The features and advantages of the invention are well understood by reading the following detailed description in conjunction with the drawings in which:

[0018] **FIG. 1** is a schematic view of an aerosol generator according to the prior art.

[0019] **FIG. 2** shows an embodiment of an instrument wherein a section of a metal tube is used as a heater.

[0020] **FIG. 3** shows an embodiment of an instrument wherein a controller operates a fluid supply and heater arrangement.

[0021] **FIG. 4** shows an embodiment of an instrument wherein multiple heating zones heat the liquid.

[0022] **FIG. 5** is a plot of temperature versus resistance of a resistance heater.

[0023] **FIG. 6** is a plot of resistance of a resistance heating element versus time, the plotted points indicating when the heating element is supplied power and when the heating element is not supplied power.

[0024] **FIG. 7** shows another embodiment of an instrument wherein a controller operates a fluid supply and heater arrangement.

[0025] **FIG. 8** illustrates an exemplary timing diagram for operation of the instrument shown in **FIG. 7**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] The invention provides an instrument, which incorporates control and measurement capabilities during generation of vaporized liquid, which may be condensed in ambient air to form an aerosol. The instrument can be used for medical, agricultural, industrial and scientific purposes. The instrument incorporates a heater arrangement which is used to volatilize liquid material. The instrument permits the precise application of energy to the heater arrangement under various control schemes to thereby generate solid and liquid aerosols. The aerosols can be produced from a single flow passage or a multiple flow passage arrangement.

[0027] Aerosols are useful in a wide variety of applications. For example, it is often desirable to treat respiratory ailments with, or deliver drugs by means of, aerosol sprays of finely divided particles of liquid and/or solid, e.g., powder, medicaments, etc., which are inhaled into a patient's lungs. Aerosols are also used for purposes such as providing desired scents to rooms, applying scents on the skin, and delivering paint and lubricant. Aerosols have also been considered for fuel delivery systems for high performance engines and turbines where the small particle size influences ignition rates, combustion efficiencies and flame speed. Aerosol generation in areas of combustion initially result in the formation of aerosols, but may after ignition result in only producing vapor, due to the temperature experienced at combustion.

[0028] Aerosols and the precursor vapor may also have applications in creating nano particles and other powders. The volatilization of liquid metals brings the possibility of producing micro ball bearings, foam metal and metal plating in a precise and cost effective manner. The uses of aerosols and the precursor vapor also have applications in the area of lubrication, where disbursement of the lubricant can be facilitated with the introduction of a concentration of particles of lubricant.

[0029] Development of such applications can be investigated using a versatile platform capable of producing an aerosol precursor vapor with a variety of user control elements, programmable functions and recording systems not presently available. The instrument can be used for such investigational purposes or used for commercial production of products formed as a result of, or in conjunction with, aerosol or volatilization of one or more materials.

[0030] The instrument incorporates a programmable vapor generator as described above. Embodiments of the instrument can incorporate various electronic hardware and software designed to achieve desired objectives. For instance, the instrument can be used to control and measure the energy applied to generate the vapor on time scales of one hundred milliseconds or less. The instrument can be programmed to control vapor generation by a variety of control strategies and using a variety of different vapor generator designs. Some of the control strategies include: constant and variable power profiles, constant and variable energy profiles, constant and variable heater resistance (temperature) profiles, constant and variable fluid flow profiles, constant and variable fluid pressure profiles, fluid valving control to the vapor generator, hot fluid heat transfer control, active energy control, inductive heating, different heater designs, multiple zone heaters, multiple heaters, and the like. Further control strategies can include variable, stepped heater resistance profiles, such as by varying the resistance parameter over time using one or more predetermined functions and/or equations. Other control strategies that can be used include constant and variable duty cycle profiles. It is contemplated that the instrument can be used for characterization of aerosols for the delivery of medication to the lungs, characterization of aerosols for laboratory experiments, characterization of aerosols for inhalation studies, characterization of aerosols for the application of pesticides, characterization of vapors used in combustion applications, and the like. However, the instrument can be used for commercial production of products if so desired.

[**0031**] The liquid can be delivered to the heater arrangement by various techniques. For instance, a syringe pump can be used to deliver liquid to the heater arrangement in which case the liquid can be delivered at a constant rate for a predetermined time. However, if desired, the syringe pump can be used to deliver liquid to the heater arrangement at a variable rate. A programmed controller can execute the instructions for operating the syringe pump to deliver a desired amount of liquid to the heater arrangement. Another possibility is the use of a liquid pump, which withdraws liquid from a container and delivers the liquid at a constant rate to the heater arrangement. However, if desired, the liquid pump can deliver the liquid at a variable rate to the heater arrangement. With such an arrangement, the pump would continuously circulate the liquid and a valve would be used to divert the liquid to the heater arrangement as instructed by the controller. A further possibility is the use of a pressurized fluid arrangement wherein a valve is used to deliver the pressurized liquid to the heater arrangement as instructed by the controller.

[**0032**] The heater arrangement can be designed as a replaceable unit. For instance, the instrument can be designed to accommodate interchangeable heater arrangements wherein the size of the flow passage can be varied with respect to length and/or width thereof. Likewise, the heater used to volatilize liquid in the flow passage can take various forms such as a single heater or multiple heater arrangement.

[**0033**] Preferably, the flow passage is a capillary sized flow passage with transverse dimensions of 0.01 to 10 mm, preferably 0.05 to 1 mm, and more preferably about 0.1 to 0.5 mm. Alternatively, the capillary passage can be defined by transverse cross sectional area of the passage, which can be 8×10^{-5} to 80 mm^2, preferably 2×10^{-3} to 8×10^{-1} mm^2 and more preferably 8×10^{-3} to 2×10^{-1} mm^2. As an example, the heater arrangement can comprise a stainless steel tube having electrical leads attached thereto for passage of DC current through the tube. The stainless steel tube can have any desired diameter. For investigating the behavior of aerosolized fluids including medication for inhalation, the tube can comprise various hypodermic needle gauges. A 32 gauge needle has an internal diameter of 0.11 mm (0.004 inch) and a 26 gauge needle has an internal diameter of 0.26 mm (0.01 inch). Thus, if a higher flow rate of liquid is desired, a larger sized flow passage can be used to volatilize the liquid. Although a stainless steel tube can be used as a combination heater/flow passage, other arrangements can be used for the flow passage/heater arrangement. For instance, a ceramic layer can be etched to provide a groove, which defines the flow passage and the ceramic layer can be overlaid with another ceramic layer, which incorporates a heater, such as a platinum heater, arranged to heat liquid in the groove. Like the stainless steel tube, the resistance heater can be heated by passing DC current therethrough.

[**0034**] The instrument can be programmed to achieve various control schemes. For instance, a resistance control scheme can be used to minimize overheating and under heating of the heater arrangement. In particular, a program can be used to send power to the heater until a target resistance value is reached. Under a power control scheme, a certain amount of power is supplied to the heater arrangement and the power is monitored and adjusted to maintain the heater arrangement at a desired temperature. In a voltage control scheme, a certain voltage (e.g., 4 volts) can be continuously supplied to the heater arrangement and a program (e.g., algorithm) is used to monitor and maintain the voltage at a target value. As an example, the controller can be programmed to control delivery of a pulse of power (e.g., duty cycle of 25% to 100% using a fixed pulse and pulse width of 1 to 10 msec) to the heater, measure the voltage drop across the heater, calculate the temperature dependent resistance of the heater and control the on/off supply of energy to the heater arrangement to maintain a target resistance value of the heater arrangement. In a preferred arrangement, the on time of the duty cycle is 2 to 4 milliseconds and the off time is varied between 2 and 16 milliseconds.

[**0035**] The instrument can be operated in conjunction with various detectors for analyzing the volatilized fluid. For instance, a filter can be used to collect aerosol and the collected aerosol can be weighed or submitted to gas or liquid chromatography for further evaluation. In order to determine particle sizing and distribution, a collection device can be located close to the jet of atomized liquid produced by the heater arrangement, or a manifold can be used to confine the aerosol and direct the aerosol to the collection device. Another possibility is to use a device which passes light through the aerosol to measure how thick the aerosol is and thus measure concentration of the particles in the aerosol. The instrument can be used to study the effects of vaporizing various hydrocarbon fuels such as jet fuel, gasoline, diesel, kerosene or the like. Another possibility is to use the instrument for studying pesticide application, e.g., the heater arrangement can be used to produce a fine fog or coarse spray for fumigating plants. The instrument can be used for toxicology studies wherein laboratory animals such as rats can be used to observe the effects of inhaled material.

[**0036**] The controller can be programmed to plot or store values of interest during operation of the heater arrangement. For instance, a memory can be used to store time and other parameters, which vary over time, such as resistance of the heater, total energy sent to the heater, power, voltage and/or current. The memory can also be used to store duty cycle and/or time to reach steady state. Further, such parameters can be plotted on a screen or printed out during operation of the heater arrangement or at a later time.

[**0037**] The instrument can be designed to produce a plurality of vaporized liquids. For instance, a conduit or manifold can be arranged to receive the aerosolized output of multiple heater arrangements. For example, two or more heater arrangements can be arranged along the axial length of a tube and the flow passages of the heater arrangements can be oriented to deliver the vaporized fluid in a direction perpendicular to the axis of the tube, or the directions of the vaporized liquid can be non-perpendicular to the tube axis. The multiple heater arrangements can be spaced apart axially along the length of the tube, or spaced apart circumferentially around the outer diameter of the tube.

[0038] The controller can be operated by a user interface, which allows selection of various programmable variables to be input into memory for operation of the instrument. The controller can be programmed to utilize an algorithm which performs calculations based on the following variables. Any suitable algorithm can be used to achieve the desired control scheme, e.g., algorithms provided with commercial diagnostic equipment available from Agilent Technologies, Inc., Palo Alto, Calif. See, for example, U.S. Pat. Nos. 6,269,267; 6,173,207; 6,246,613 and 6,205,362. An "event" variable switches the program between waiting to run (event=0) and running the heater (event=1). An event "trigger" variable activates a counter for sensing a trigger signal. A "pulse" variable corresponds to the output state for sending power to the heater (pulse=1). In a preferred embodiment, a "pulse count" variable activates a counter for an 8 millisecond heater cycle. An "event count" variable corresponds to the cumulative time in milliseconds during a run. A "resist target" variable corresponds to the target resistance for the heater during operation. An "energy" variable is the cumulative energy sent to the heater. A "resistance" variable is the measured resistance of the heater. An "energy COEF" variable corresponds to the calibration coefficiency for energy. A "resist COEF" variable is the calibration coefficient for resistance. An "armed" variable indicates which kind of trigger will be used to start the run. A "time" variable is the length of time for a run defined as the time the heater is powered and expressed in milliseconds. A "vd count" variable actuates a counter for timing the valve or energy delay. A "valve delay" variable can be used to open the valve after the heater is activated, the valve delay being the time lag in milliseconds between applying power to the heater and opening the valve. A "heater delay" variable can be used to open the valve before the heater is activated, the heater delay being the time lag in milliseconds between opening the valve and applying power to the heater.

[0039] **FIG. 2** shows an embodiment of volatilized liquid generator **220**. The volatilized liquid generator includes a member **221** defining a flow passage or channel **223** capable of conducting a fluid or vapor to a first open end **225** and a power supply **229** for applying a voltage to the member **221** such that a current in the member heats the channel to a temperature sufficient to volatilize a liquid material in the flow passage **223**, such that the volatilized material expands out of the open end **225** of the flow passage **223** and, if desired, mixes with the ambient air to form an aerosol. Liquid can be supplied from a source of material by a pump **235** or other suitable mechanism.

[0040] The flow passage **223** in this embodiment is preferably **304** stainless steel. However, any electrically conductive material capable of being resistively heated, retaining the necessary structural integrity at the operating temperature experienced by the flow passage **223**, and sufficiently non-reactive with the liquid material, could be used. Such materials include, but are not limited to copper, aluminum, metal composites, or other metals and alloys. The flow passage **223** has an open end **225** that allows the heated material to escape and an end **231** that allows the liquid material to be supplied.

[0041] The power supply for applying a voltage in this embodiment includes a voltage source **229** and two terminals **227***a* and **227***b*. The voltage source **229** can be a direct current battery. However, the use of alternating current could also be effective. The terminals **227***a* and **227***b* are preferably in contact with at least a portion of the perimeter of the member **221**. The contact terminals **227***a* and 227*b* are preferably made of a material with a low resistance compared to the member **221** and have a coefficient of thermal expansion that avoids separation from the member **221**.

[0042] The member **221** is preferably heated by resistance heating. The energy transferred to the member **221** from the voltage source **229** is governed by Ohm's Law.

$$V\text{ (voltage)}=I\text{ (current)}\cdot R\text{ (resistance)} \tag{1}$$

$$\text{Power}=V\cdot I=V^2/R \tag{2}$$

[0043] In an example, for a 0.001 to 0.020 inch internal diameter/0.018 to 0.030 inch outside diameter tube of 304 stainless steel with an average internal resistance of about 3.12 ohms (for this example assuming the resistance remains constant for all temperatures) and the voltage source supplying 2.5 volts DC, the rate of energy transfer to the flow passage **223** is as follows:

$$\text{Power}=(2.5\text{ V})^2/(3.12\text{ ohm})=19.5\text{ joules/sec} \tag{3}$$

[0044] Thus, the heat generated in the tube is a function of V (voltage drop across the flow passage) and the average resistance R of the tube.

[0045] A volatilized liquid generator, consistent with the foregoing example has been found to operate successfully in generating a vapor from liquid propylene glycol, when operated continuously at approximately 2.5 Volts and 0.8 Amps. The power supplied by the voltage source operating at this level is close to the minimal power requirements for volatilizing propylene glycol at a rate of 1.5 milligrams per second at atmospheric pressure, illustrating that the volatilized liquid generator **220** may be operated efficiently.

[0046] The volatilized liquid generator **220** may be operated intermittently, e.g., on demand, as discussed further below, continuously, or according to a predetermined profile. When it is desired to generate an intermittent volatilized liquid, the material in liquid form may be supplied intermittently to the heating zone **226** located between terminals **227***a,* **227***b* each time that it is desired to generate the precursor vapor or aerosol. Additionally, in intermittent operation the heater could be turned off to prevent liquid in the flow passage from volatilizing. Preferably, the material in liquid form flows from the source **233** of material to the heating zone **226**, via a pump **235**, pressurized source or other suitable supply arrangement.

[0047] One or more valves may be provided in a flow line between the source **233** of material and the heating zone **226** to interrupt flow of liquid. Preferably, the material in liquid form is pumped by a pump **235** in metered amounts (e.g., predetermined volume, mass, flow rate, etc.) to the heating zone **226**. The remaining material in the flow line between the source **233** of material and the heating zone **226** provides a barrier to prevent expansion of the volatilized material in the direction of the upstream end **231** of the flow passage **223**. The pump can be operated by a stepping motor to achieve precise metering of the liquid material. However, other arrangements can be used to deliver liquid to the flow passage **223**, e.g., a syringe pump, which holds a quantity of liquid and delivers precise quantities of liquid or delivers liquid at a constant flow rate; a single shot delivery mechanism, which delivers a precise volume of liquid; a pressurized liquid container arrangement, which delivers liquid to a solenoid valve, which controls delivery of the liquid to the flow passage **223**, etc.

[**0048**] **FIG. 3** illustrates an embodiment of an instrument **300** for controlled vaporization of liquid material. The instrument includes a flow passage **323** with a downstream first open end **325**, heater **310** for heating the flow passage **323** to a temperature sufficient to volatilize liquid material in the flow passage **323**, such that the volatilized material expands out of the open end **325** of the flow passage and, if desired, mixes with ambient air to form an aerosol.

[**0049**] The instrument **300** includes a controller **350** for operating the heater **310** and delivery of liquid from liquid source **333** to the flow passage via operation of a valve **342** and pump **335**. The controller **350** also directs the storage of parameters associated with generating the volatilized liquid in a memory **351**. The controller **350** also operates a switching arrangement or switch **340** for applying power to the heater **310**. The memory **351** is provided for recording parameters such as liquid material flow rate and energy transfer, as well as storing operational programs. The maintaining and/or recording of associated parameters with respect to operation of the volatilized liquid generator may be desired when conducting experiments or monitoring quality of the precursor vapor and the aerosol. Also associated with the controller **350** is a display **352** to assist a user in visually monitoring the generator while in operation and also for displaying the user settings and the contents of the memory **351**.

[**0050**] The heater **310** can be activated by application of a voltage across an electrically conducting portion thereof or other suitable arrangement. For instance, a heating element can be comprised of a coil of wire or a layer of conductive material along the flow passage **323**. The use of a heat exchanger or exposure to combusted gases could also be used to heat the flow passage. Lasers, and electromagnetic waves, as well as chemical and mechanical methods of vaporizing liquid in the passage, are also possible. The resistance heating arrangement heats the liquid material inside the flow passage, in the particular embodiment by converting electrical energy into heat energy as a result of the electrical resistance of the tube or heating element and the voltage and induced current supplied across it. The voltage is applied by a power source **329** across the terminals of the heating element **327***a* and **327***b*. The application of voltage to the heater **310** is regulated, by the controller **350**, through manual inputs or an operating program, through a switch **340**. In this embodiment, the switch **340** is a field effect transistor which allows rapid switching through cycles less than 10 milliseconds, preferably less than 1 millisecond.

[**0051**] The controller **350** receives input relating to the temperature of the flow passage **323**, through a measuring device **341** and input relating to the flow rate of the liquid material into the flow passage **323** from a measuring device **342**. Venturi channels, positive displacement pumps and other equipment capable of such measurements can be used as the measuring device **342**. The temperature of the liquid in the flow passage **323** is calculated based on the measured or calculated resistance of the heating element. In a preferred embodiment, the heater **310** is a portion of a metal tube, or the heater can be a strip or coil of resistance heating material. The controller **350** regulates the temperature of the flow passage **323** by monitoring the resistance of the heater.

[**0052**] Resistance control can be based on a simple principle that the resistance of the heater **310** increases as its temperature increases. As power is applied, via switch **340**, to the heating element **310**, its temperature increases because of resistive heating and the actual resistance of the heater also increases. When the power is turned off, the temperature of the heater **310** decreases and correspondingly its resistance decreases. Thus, by monitoring a parameter of the heater (e.g., voltage across the heater using known current to calculate resistance) and controlling application of power, the controller **350** can maintain the heater **310** at a temperature that corresponds to a specified resistance target. The use of one or more resistive elements could also be used to monitor temperature of the heated liquid in cases where a resistance heater is not used to heat the liquid in the flow passage.

[**0053**] The resistance target is selected to correspond to a temperature that is sufficient to induce a heat transfer to the liquid material such that liquid is volatilized and expands out the first open end **325** of the flow passage **323**. The controller **350** effects closing of the switch **340**, which activates the heating thereby applying for a duration of time, energy to the heater **310** and, after and/or during such duration, determines the real time resistance of the heater, using input from the measuring device **341**. In the preferred embodiment, the resistance of the heater is calculated by measuring the voltage across a shunt resistor (not shown) in series with the heater **310** (to thereby determine current flowing to the heater) and measuring the voltage drop across the heater (to thereby determine resistance based on the measured voltage and current flowing through the shunt resistor). To obtain continuous measurement, a small amount of current can be continually passed through the shunt resistor and heater for purposes of making the resistance calculation, and pulses of higher current can be used to effect heating of the heater to the desired temperature.

[**0054**] If desired, the heater resistance can be derived from a measurement of current passing through the heater, or other techniques can be used to obtain the same information. The controller **350** then makes decisions as to whether or not to send an additional duration of energy based on the difference between the desired resistance target for the heater **310** and the actual resistance as determined by the controller **350**.

[**0055**] In a developmental model, the duration of power supplied to the heater was set at 1 millisecond. If the monitored resistance of the heater **310** minus an adjustment value is less than the resistance target, the controller **350** is programmed to supply another duration of energy by leaving the switch **340** in the closed ("on") position. The adjustment value takes into account factors such as heat loss of the heater when not activated, the error of the measuring device and a cyclic period of the controller and switching device, among other possibilities. In effect, because the resistance of the heater varies as a function of its temperature, resistance control can be used to achieve temperature control.

[**0056**] The equation for the temperature coefficient of resistivity for type **304** stainless steel is:

$$\rho(\text{ohm-cm})=4.474\times10^{-5}+1.0\times10^{-7}T-3.091\times10^{-11}T^2 \qquad (4)$$

[0057] where T is the temperature in degrees Kelvin. A plot of the average temperature of a heater comprising a 28 gauge, 44-mm long capillary tube with a cold resistance (room temperature, 24° C.) of 0.669 ohms as a function of its resistance is shown in **FIG. 5**. The values shown in **FIG. 5** represent the average temperature of the heater, i.e., the actual temperature along the length of the heater can vary due to factors such as heat losses from the electrical leads and the vaporization of the fluid, and the temperature of the heater proximate the end **331** and the open end **325** of the flow passage **323** will tend to be lower than in the middle of the heater.

[0058] The controller **350** can be programmed to determine the resistance of the heater **310** by processing data representative of the voltage drop across a shunt resistor and voltage drop across the heater. The power being sent to the heater, the cumulative energy sent and the real time resistance of the heater are calculated by the following equations:

$$\text{Energy}=(\text{Input 1}\cdot\text{Input 2}\cdot 0.100\cdot\text{Energy Coef})+\text{Energy} \tag{5}$$

$$\text{Resistance}=(\text{Input 1}/(\text{Input 2}\cdot 100))\cdot\text{Resist Coef.} \tag{6}$$

[0059] These equations are based on Ohm's Law. Input 1 is a multifunction measurement and control unit that measures the voltage drop across the heater, and Input 2 is the input terminal that measures the voltage drop across the shunt resistor. The shunt resistor can have a resistance of 0.010 ohms. Thus, energy in joules is:

$$\text{Energy}=\text{Power}\times\text{Time}=V_{\text{heater}}\cdot I\cdot t. \tag{7}$$

[0060] where V_{heater} is the voltage drop across the heater (Input 1), I is the current through the system, and t is the duration time (e.g., 1 millisecond) of power applied to the heater. The current through the system can be calculated from the voltage drop across the shunt resistor and its known resistance as follows:

$$I=V_{\text{shunt}}/R_{\text{shunt}} \tag{8}$$

[0061]

$$\text{Energy} = \text{Input 1}\cdot\frac{\text{Input 2}}{0.01\text{ (ohm)}}\cdot 0.001\text{ (sec)} = \text{Input 1}\cdot\text{Input 2}\cdot 0.100. \tag{9}$$

[0062] where V_{shunt} is the voltage drop across the shunt resistor (Input 1) and R_{shunt} is the resistance value of the shunt resistor (0.010 ohm).

[0063] The energy per duration value can be corrected for instrumental variations with a calibration factor, ECF. The duration energy is added to the previous energy value stored in the memory **351** so that the instrument keeps track of the cumulative energy sent to the heater **310**. Likewise for the resistance value of the heater:

$$\text{Resistance} = \frac{V_{heater}}{I} = \left(\frac{V_{heater}}{V_{shunt}/R_{shunt}}\right) = \frac{\text{Input 1}}{\text{Input 2}\cdot 100} \tag{10}$$

[0064] The resistance value is then corrected by a calibration factor, RCF.

[0065] Control of resistance by the controller **350** offers several advantages for controlling the heater. First, when the heater **310** is initially started, the controller **350** can send energy continuously to the heater **310** until it reaches its operating resistance target or a lower value to prevent initial overheating the heater after which the heater can be heated gradually to the desired temperature. This provides the fastest start up of the heater. Second, the controller can automatically adjust the energy being sent to the heater to match the requirements for maintaining the resistance target without regard to the delivery rate of the liquid material, at least to the upper limit of the power source **329**. As long as the resistance target and corresponding temperature is set within the material limits of the heater **310**, the heater cannot be overheated due to a failure in the fluid supply system. An example of a heating cycle is depicted in **FIG. 6**, which illustrates the timing cycle for the resistance control algorithm, the resistance target in this example being 0.785 ohms. This also protects against over heating due to the power supply voltage being set too high. In addition, this system was found to respond much faster than an actual temperature control system based on thermocouple measurements.

[0066] If the measured resistance of the heater minus the predetermined adjustment value is greater than the target resistance at the end of a pulse duration, the controller **350** turns the switch **340** off, thereby withholding energy from the heater **310**. After another predetermined duration, the controller turns the switch **340** on and repeats the process. For example, the second predetermined duration can be set at 8 msec (e.g., 2 milliseconds on and 6 milliseconds off or 4 milliseconds on and 4 milliseconds off, etc.) from the previous occasion when the switch **340** was turned on.

[0067] **FIG. 4** shows details of an additional embodiment of an instrument for generating a volatilized liquid in which a plurality of separate heaters are used to heat the flow passage and the liquid material passing therethrough such that the material is volatilized and expands out the open end of the channel. As in the previous embodiments, a flow passage **423** with a first open end **425** has a liquid material supplied to it through an end **431**, a valve **442** controls the introduction of the liquid, which is supplied from a source of liquid material **433** by a pump **435**. In this particular embodiment, two separate heaters **410** and **410**' are used to heat the flow passage and the liquid. The heating can be accomplished through resistant heating. However, as discussed earlier, the heating is not limited to this method.

[0068] Power is supplied to each of the heaters through terminals **427***a* and **427***b* for heater **410** and terminals **427***a*' and **427***b*' for heater **410**'. The application of power to the heaters is controlled by controller **450** with an associated memory **451** and a display **452**. The controller **450** controls the application of power through a switching circuit **440** or other suitable arrangement for power control. The switching circuit is capable of applying power independently to each of the heaters. The power is supplied by voltage source **429**. The controller controls the application of power to the heaters separately using information from measuring devices **441** and **441**' as well as input from the valve **442**. The controller is capable of being programmed to function autonomously or in response to a user interaction.

[0069] Measuring devices 441 and 441' in this particular embodiment measure the current through a shunt resistor and are combined with voltage drop across the respective heaters to determine the resistance of the heaters, which facilitates control by the controller 450 as described previously. As discussed above, the temperature across the flow passage 423 can vary from the end 431 where liquid material is supplied to the open end 425 where the material exits as a vapor. As such, the use of a plurality of separate heaters to control the temperature of the flow passage and the liquid therein is advantageous because of different heat transfer characteristics across portions of the flow passage. To further regulate heat transfer of the flow passage to the liquid, additional heaters can be added and controlled as desired.

[0070] Similarly to FIG. 3, heat transfer to the liquid material from the heaters can actually be accomplished using a single heater with different heating zones. For example, a single heater having different zones can apply more heat at a desired location along the flow passage, e.g., more heat at one end of the flow passage 423 and lesser heat in the middle as desired. Although dynamic control of the different heating zones would be more difficult, a more desirable heat profile could be obtained using only the single heater. Multiple zone heating could be achieved with a heater having multiple coils with a high resistance value placed on the end of the flow passage, whereas in the middle the resistance value of the heating element could be reduced and therefore reduce heat transfer to that section. In addition, a pre-heater could be used to heat the material prior to entry to the flow passage to a temperature just below the point at which the liquid material would volatilize.

[0071] Embodiments of the instrument can be designed to deliver a desired, specific quantity of vaporized liquids by controlled output of the heater arrangement. For example, the heater arrangement can be connected to multiple fluid flow paths, such as conduits or tubing. The aerosolized output may be conducted through different paths by manipulation of valves. Valve control permits the aerosolized output to be directed to different exits, for a predetermined time interval. For example, the vapor/aerosol can be directed through a first flow path when the heater is in a non-conforming condition (e.g., non-steady state condition), and a valve arrangement can direct the vapor/aerosol through a second flow path when the heater is in a conforming condition (e.g., steady state condition). Embodiments of the instrument can be used for clinical studies in which a constant, repeatable dose is desired to be administered to human volunteers.

[0072] FIG. 7 illustrates an embodiment of an instrument 700 for controlled vaporization of liquid material, and selective delivery of aerosol. The instrument 700 includes a member 705 defining a flow passage or channel 723 capable of conducting a fluid or vapor to a first open end 725, and a power source 729 for applying a voltage to the member 705 such that a current in the member heats the flow passage to a temperature sufficient to volatilize a liquid material in the flow passage 723, the volatilized material expands out of the open end 725 of the flow passage 723 and, if desired, mixes with the ambient air to form an aerosol. Liquid can be supplied from a source 733 of liquid material by a pump 735 or other suitable mechanism.

[0073] The flow passage 723 in this embodiment is preferably 304 stainless steel. However, any electrically conducting material capable of being resistively heated, retaining the necessary structural integrity at the operating temperature experienced by the flow passage 723, and sufficiently non-reactive with the liquid could be used. Such materials include, but are not limited to, copper, aluminum, metal composites, or other metals or alloys. The flow passage 723 has an outlet 725 that allows the heated material to escape and an inlet 731 that allows the liquid material to be supplied.

[0074] The instrument 700 also includes valves 742 and 743. Valves 742 and 743 are actuated by the controller 750. The valve 742 is in fluid communication with the heater via a flow passage 760*a* and directs vaporized material or aerosol from the heater 710 to the valve 742. Aerosol can be formed, if desired, by mixing vaporized material generated by the heater 710 with air present in and/or supplied to the flow passage 760*a*. For example, an optional air inlet 762 may be arranged to introduce air into the flow passage 760*a*, or air may be entrained around the heater 710 and drawn into the flow passage 760*a*. The valve 742 is in fluid communication with an exhaust vacuum pump 744 via a flow passage 760*b*, and is in fluid communication with valve 743 via a flow passage 760*c*. Valve 743 is in fluid communication with a flow passage 760*d*. The pump 744 includes a filter, preferably a high efficiency particulate air (HEPA) filter, to remove material from the aerosol or vapor before the air is exhausted to the atmosphere. Flow passages 760*a*, 760*b*, 760*c* and 760*d* are preferably made of medical grade respiratory tubing. Valve 743 is in fluid communication with a mouthpiece 770, through which a user can inhale aerosol. However, the mouthpiece 770 can be omitted or replaced with any suitable equipment, such as analytical equipment, collection devices, etc.

[0075] In the case of an inhaler, the instrument preferably includes a pressure sensor 745 electrically connected to the controller 750 and in fluid communication with the mouthpiece 770. The pressure sensor 745 is activated by a user inhaling on the mouthpiece 770. The inhalation causes a pressure drop in the mouthpiece 770, which is sensed by the pressure sensor 745. The pressure sensor 745 can be extremely sensitive. For example, the pressure sensor 745 can be triggered at a selected pressure drop and/or threshold value of air flow, for example, as low as about 3 liters/min, which is about 1/10 of the typical human inhalation rate. Accordingly, the pressure sensor 745 can be triggered by a user without wasting appreciable lung volume.

[0076] Valves 742 and 743 preferably operate in the following manner. When valve 742 is in its default position, the aerosol can flow along a first flow path. Namely, flow passage 760*a* carries aerosol from the heater 710 to the valve 742, and the flow passage 760*b* carries aerosol from valve 742 to the pump 744. The aerosol is filtered by the filter provided in the pump 744 and exhausted to the environment. When valve 742 is in its default position, the flow passage 760*c* is empty (i.e., there is no aerosol moving through it). Accordingly, no aerosol flow is permitted to the mouthpiece 770.

[0077] When valve 742 is in its default position, valve 743 is also in its default position. When valve 743 is in its default position, flow passage 760*d* directs ambient air through valve 743 to mouthpiece 770.

[0078] In preferred embodiments, the aerosol generated by the heater 710 is exhausted to the pump 744, and aerosol flow is not supplied to the mouthpiece **770**, until the heater **710** reaches a conforming condition. For example, a monitored condition of the heater **710** can be resistance, and the conforming condition can be when the measured resistance reaches a steady state condition, e.g., nearly constant at the resistance target. In the steady state condition, the aerosol that is generated is thus optimal for human inhalation. The conforming condition may alternatively be, for example, a selected temperature range of the flow passage **723**. Once a desired condition of the heater **710** is achieved, aerosol can be delivered to the mouthpiece **770** via a second flow path.

[**0079**] The instrument **700** can operate such that the valves **742** and **743** remain in their non-default positions for a selected period of time, during which aerosol is delivered to the mouthpiece. The selected period of time is not limited and can be, for example, ⅔ second, 1 second or 2 second. Once the selected period has expired, under control of the controller **750**, the valves **742** and **743** are moved to their default positions, and aerosol delivery to the flow passage **760***c* and mouthpiece **770** is terminated.

[**0080**] The instrument **700** can also operate such that vapor generation is terminated unless a user inhales on the mouthpiece **770** within a predetermined period of time after the user has been instructed to inhale. For example, the instrument may include a displayed message or light, which informs the user that the instrument is ready to deliver a dose of medicated aerosol. Alternatively, the pressure sensor **745** can indicate that the user is attempting to receive a dose of aerosol, but if the user stops inhaling for a predetermined period of time, the instrument will shut off the heater **710** and maintain the values in the default condition. Thus, if within the predetermined time period the controller **750** stops receiving signals from the pressure sensor **745** that indicate a user is inhaling on the mouthpiece **770**, the controller **750** terminates generation of the volatilized material by the heater **710**. For example, the time period can be 5 seconds. If, within the selected time period, the controller **750** receives a signal from the pressure sensor **745** indicating that it has been triggered by a user inhaling on the mouthpiece **770**, the controller **750** moves the valves **742** and **743** to their non-default positions so that volatilized material or aerosol flows through the flow passage **760***c* and to the mouthpiece. **FIG. 8** illustrates an exemplary embodiment of a timing diagram for the operation of the instrument **700** for a selected time period of 5 seconds, indicating instrument run time, inhalation detection (by the pressure sensor **745**), aerosol generation and valve actuation cycles.

[**0081**] In other embodiments of the instrument **700**, the mouthpiece **770**, pressure sensor **745** and flow passage **760***d* can be omitted. The valve **743** can optionally be included, if desired. An optional flow passage (not shown) can be provided in place of the mouthpiece. In such embodiments, operation of valve **742** by the controller **750** can direct the volatilized material or aerosol via the flow passage **760***c* to a detector for analysis. The volatilized material or aerosol can alternatively be used for other purposes, for example, applying coatings, making powders, chemical interactions with other substances, etc.

[**0082**] The controller **750** is operable to control operation of the heater **710** and delivery of liquid from the liquid source **733** to the flow channel **723** via operation of the pump **735**. As explained above, the controller **750** receives signals from the pressure sensor **745**, and operates valves **742** and **743** and pump **744** to control the flow of aerosol from the heater **710** to the mouthpiece **770**. The controller **750** directs the storage of parameters associated with generating the volatilized liquid in a memory **751**. The memory **751** can record such parameters with respect to operation of the volatilized liquid generator, which may be desired when conducting experiments, or monitoring quality of the precursor vapor and the aerosol. The controller **750** also operates a switching circuit **740** for applying power to the heater **710**. Also associated with the controller **750** is a display **752** to assist a user in visually monitoring the generator while in operation, and also for displaying user settings and the contents of the memory **751**.

[**0083**] The power supply for applying a voltage in this embodiment includes the power source **729** and two terminals **727***a* and **727***b*. The power source **729** can be a direct current (DC) battery or a direct current power supply. The application of voltage to the heater **710** is regulated, by the controller **750**, through manual inputs or operating program, through a switch **740**. In this embodiment, the switch **740** is a field effect transistor, which allows rapid switching through cycles less than 10 milliseconds, preferably less than 1 millisecond.

[**0084**] The controller **750** receives input relating to the temperature of the flow passage **723**, through a measuring device **741**. The temperature of the liquid in the flow passage **723** is calculated based on the measured or calculated resistance of the heating element. In a preferred embodiment, the heater **710** is a metal tube. The controller **750** regulates the temperature of the flow passage **723** by monitoring the resistance of the heater.

[**0085**] As described above, resistance control can be based on the principle that the resistance of the heater **710** increases as its temperature increases. As power is applied, via switch **740**, to the heater **710**, its temperature increases because of resistive heating, and the actual resistance of the heater **710** also increases. When the power is turned off, the temperature of the heater **710** decreases and correspondingly its resistance decreases. Thus, by monitoring a parameter of the heater (e.g., voltage across the heater using known current to calculate resistance) and controlling application of power, the controller **750** can maintain the heater **710** at a temperature that corresponds to a specified resistance target. The use of one or more resistive elements could also be used to monitor temperature of the heated liquid in embodiments where a resistance heater is not used to heat the liquid in the flow passage.

[**0086**] The resistance target is selected to correspond to a temperature that is sufficient to induce a heat transfer to the liquid material such that liquid is volatilized and expands through outlet **725**. The controller **750** effects closing of the switch **740**, which activates heating, thereby applying for a duration of time, energy to the heater **710** and after and/or during such duration, determines the real time resistance of the heater using input from the measuring device **741**. In a preferred embodiment, the resistance of the heater is calculated by measuring the voltage across a shunt resistor (not shown) in series with the heater **710** (to thereby determine current flowing to the heater), and measuring the voltage drop across the heater (to thereby determine resistance based on the measured voltage and current flowing through the shunt resistor). To obtain continuous measurement, a small amount of current can be continually passed through the shunt resistor and heater to make the resistance calculation, and pulses of higher current can be used to effect heating of the heater to the desired temperature.

[0087] If desired, the heater resistance can be derived from a measurement of current passing through the heater, or other techniques can be used to obtain the same information. The controller **750** then makes decisions as to whether or not to send an additional duration of energy based on the difference between a desired resistance target for the heater **710** and the actual resistance as determined by the controller **750**.

[0088] In a developmental model, the duration of power supplied to the heater was set at 1 millisecond. If the monitored resistance of the heater **710** minus an adjustment value is less than the resistance target, the controller **750** is programmed to supply another duration of energy by leaving the switch **740** in the closed ("on") position. The adjustment value takes into account factors, such as heat loss of the heater when not activated, the error of the measuring device, and cyclic period of the controller and switching device, among other possibilities. In effect, because the resistance of the heater **710** varies as a function of its temperature, resistance control can be used to achieve temperature control.

[0089] The controller **750** can be programmed to determine the resistance of the heater **710** by processing data representative of the voltage drop across a shunt resistor and voltage drop across the heater. The power being sent to the heater, the cumulative energy sent, and the real time resistance of the heater are calculated by equations (5) and (6) described above. The shunt resistor can have a resistance of 0.010 ohms. Thus, energy in joules is given by equation (7) described above.

[0090] The current through the system can be calculated from the voltage drop across the shunt resistor and its known resistance by equation (8) described above.

[0091] The energy per duration value can be corrected for instrumental variations with a calibration factor, ECF. The duration energy is added to the previous energy value stored in the memory **751** so that the instrument keeps track of the cumulative energy sent to the heater **710**. Likewise, for the resistance value of the heater, equation (10) described above is used. The resistance value is then corrected by a calibration factor, RCF.

[0092] Control of resistance by the controller **750** offers several advantages for controlling the heater. First, when the heater **710** is initially started, the controller **750** can send energy continuously to the heater **710** until it reaches its operating resistance target or a lower value to prevent initial overheating of the heater after which the heater can be heated gradually to the desired temperature. This provides the fastest start up of the heater.

[0093] Second, the controller **750** can automatically adjust the energy being sent to the heater to match the requirements for maintaining the resistance target without regard to the delivery rate of the liquid material, at least to the upper limit of the power source **729**. As long as the resistance target and corresponding temperature is set within the material limits of the heater **710**, the heater **710** can be protected from overheating due to a failure in the fluid supply system. An example of a heating cycle is depicted in **FIG. 6** described above. This also protects against overheating due to the power supply voltage being set too high. In addition, this system was found to respond much faster than an actual temperature control system based on thermocouple measurements.

[0094] If the measured resistance of the heater **710** minus the predetermined adjustment value is greater than the target resistance at the end of a pulse duration, the controller **750** turns the switch **740** off, thereby withholding energy from the heater **710**. After another predetermined duration, the controller turns the switch **740** on and repeats the process. For example, the second predetermined duration can be set at 8 milliseconds (e.g., 2 milliseconds on and 6 milliseconds off or 4 milliseconds on and 4 milliseconds off, etc.) from the previous occasion when the switch **740** was turned on.

[0095] If desired, the instrument can be provided with multiple vapor generators. For example, two or more flow passages with heaters as described above could be arranged to deliver vaporized liquid to a conduit through which air or other medium is passed. Analytical devices could be located along and/or downstream of the conduit to measure various characteristics of the vaporized liquid, e.g., devices to measure aerosol size and/or particle size distribution, determine effects of chemical interactions of the vaporized liquid, etc. The vapor generators can be arranged to deliver the vaporized liquid as intersecting or non-intersecting gas streams. For example, the flow passages can be arranged to direct the vaporized fluid into the conduit as adjacent parallel gas streams, radially directed, circumferentially spaced apart gas streams or radially directed, axially spaced apart gas streams, etc. The parallel generator arrangement facilitates forming a combination aerosol or precursor vapor formed by mixing together two or more separately generated volatilized liquids. The parallel volatilized liquid generator arrangement is particularly useful where it is desired to form an aerosol comprising two or more materials, which do not mix well in liquid form.

[0096] The instrument can be used to study various aspects of aerosol generation, which vary as functions of parameters of the aerosol generator and the liquid material supplied to the aerosol generator. For example, for aerosols intended for human inhalation, an aerosol can be produced with a mass median particle diameter of particles of the aerosol less than 2 microns, preferably between 0.2 and 2 microns, and more preferably between 0.5 and 1 micron.

[0097] It has been observed that liquid materials, such as propylene glycol and glycerol, can be formed into aerosols having mass median particle diameters and temperatures in desirable ranges. While not wishing to be bound by theory, it is believed that the extremely small mass median particle diameters of the aerosol are achieved, at least in part, as a result of the rapid cooling and condensation of the volatilized material that exits the heated flow passage. Manipulation of parameters of the volatilized liquid generator, such as the internal diameter of the flow passage, heat transfer characteristics of the material defining the flow passage, heating capacity of the heater, and/or the rate at which material in liquid form is supplied to the flow passage, can be performed to affect aerosol temperature and mass median particle diameter. The instrument can be used to investigate aerosol formation using propylene glycol and glycerol as liquid carriers for drugs such as budesonide. The instrument can also be used to investigate aerosol formation and/or vaporized fluid properties of liquid materials, such as jet fuel, pesticides, herbicides, paint and other types of materials.

[0098] It will be appreciated that the instrument may be fairly large, such as a table-top mounted item, but the principles of the instrument may be implemented in other forms, such as a miniaturized device. The ability of the generator to be miniaturized is, in large part, due to the highly efficient heat transfer between the heater and the flow passage, which facilitates battery operation of the volatilized liquid generator with low power requirements.

[0099] The instrument can be implemented as a laboratory unit designed to include programmable operation of an aerosol generator, wherein liquid is vaporized by a heater arrangement. The instrument can be modular in construction so that the various components can be exchanged. Aerosol mass median particle diameter can be measured using a cascade impactor in accordance with the methods specified in the Recommendations of the U.S.P. Advisory Panel on Aerosols on the General Chapters on Aerosols (601) and Uniformity of Dosage Units (905), *Pharmacopeial Forum.,* Vol. 20, No. 3, pp. 7477 et. seq. (May-June 1994), and mass can be measured gravimetrically as collected from the impactor.

[0100] The basic resistance control program used by the instrument can be adapted for various applications. For example, the liquid can be supplied by a syringe pump and the apparatus can be programmed to generate an aerosol for very long run times. For example, in toxicological studies it may be desired to generate an aerosol for several hours. In such case, it may be desirable to run four heaters simultaneously for an extended period of time, such as 4 hours. In contrast, if the instrument is used to mimic the operation of hand-held inhaler, the run times would be more on the order of 10 to 15 seconds. During extended runs, the operator of the instrument can be kept informed of the operation of the instrument by outputting data to be monitored periodically, such as every 10 seconds.

[0101] The optimal resistance target for a heater can be determined experimentally using a standard operating procedure. As the resistance target entered in the instrument control program is lowered from its optimal value, the aerosol quality soon decreases. In particular, more liquid will be ejected from the heater as large droplets and excess fluid will drip from the end of the heater. As the resistance target is increased over its optimal value, aerosol quality will also degrade eventually. For instance, the generator will use more energy needed to produce the aerosol and, at higher resistance target values, significant thermal degradation of the aerosol fluid may occur. In an extreme limit, the heater may begin to glow red and could become damaged.

[0102] The voltage chosen to drive the heater determines the amount of energy that will be sent to the heater in each pulse. For 1 millisecond pulses, the energy per pulse in joules is given by the equation: energy=$V^2 \cdot t/R$, where V is the voltage across the heater, R is the heater resistance, and t is 1 millisecond. The voltage across the heater is directly related to the voltage of the power supply, but is slightly lower because of losses in the wiring. In general, the lowest voltage that can be used with a preferred embodiment of the instrument is 4 volts. This lower limit is set by the minimum voltage required to operate the FET.

[0103] The instrument is preferably wired such that the power supply providing the power to the heater also provides the switching voltage for the FET. The resistance of the heater at steady state can be assumed to be nearly constant at the resistance target. Thus, changing the voltage can make a large difference in the energy sent in each pulse. The effects of voltage appear mainly in the steady state operation of the heater. If the voltage is too low, the heater may have trouble reaching the resistance target and the aerosol quality can be degraded. If the setting for the voltage is too high in the case where the algorithm uses an 8 millisecond cycle to control the heater, if too much energy is sent in a single pulse the heater may exceed the resistance target by more than 0.002 ohms. In such case, it may take several cycles for the heater to come back on, but by this time the heater may have cooled substantially because of the fluid flow passing through it. Accordingly, the voltage setting can be optimized for a particular flow rate and particular liquid material.

[0104] The power required by the heater to produce an aerosol is directly proportional to the fluid flow rate passing therethrough. If the flow rate is very low, e.g., less than 0.1 ml/min, the heater may act as if the voltage is too high. On the other hand, if the flow rate is too high, the heater may act as if the voltage is too low. Raising the voltage may be required to compensate for high flow rates. The length of the timing (duty) cycle is preferably set such that the heater will turn back on before it cools significantly. Experiments with a 32 gauge stainless steel tube as the heater at a flow rate of 0.1 ml/min indicate that timing cycles between 4 and 10 milliseconds have little effect on the aerosol. However, the timing cycle can be changed to compensate for behavior of the heater and/or properties of the aerosol. The goal of resistance control is to keep the operating resistance of the heater very close to the resistance target. As an example, the voltage can be set such that the resistance increase for a single pulse of energy is relatively small. For example, the controller can be programmed to monitor the resistance of the heater and ensure that the resistance target is not exceeded by more than 0.002 ohms when the algorithm turns the heater off. Thus, a 0.002 ohm decrement can be used to trigger supply of power to the heater. In principle, the instrument can be designed to effect operation of the heater with an desired change in the resistance target other than the 0.002 ohm decrement described above.

[0105] While the invention has been described with reference to the foregoing embodiments, it will be apparent that various changes can be made to the instrument and/or method of use thereof. While the instrument has been described as useful for characterizing aerosols for inhalation or other uses such as toxicology studies, the instrument could be used for additional purposes such as applying coatings such as optical coatings to a substrate, making powders such as nanosize powders, delivering vaporized fuel to devices such as a microcombustor, delivering multiple feeds of volatilized fluids for chemical interaction thereof or other purpose, and the like.

What is claimed is:

1. An instrument for programmable generation of volatilized material, comprising:

at least one flow passage having a first open end;

a liquid supply operable to supply liquid material to the flow passage;

at least one heater arrangement adapted to heat the flow passage to a temperature sufficient to volatilize material in liquid form in the flow passage such that the volatilized material expands out of the open end of the flow passage;

a controller operable to control operation of the heater and control operation of the liquid supply;

a monitoring arrangement operable to supply heater performance data to the controller, the data being used by the controller to supply power to the heater arrangement or to cut off power to the heater arrangement to maintain the heater arrangement at a desired temperature range; and

a memory operable to store parameters associated with the instrument.

2. The instrument according to claim 1, wherein the monitoring arrangement includes a switching device which controls supply of power to the heater arrangement.

3. The instrument according to claim 2, wherein the heater arrangement includes at least one resistance heater optionally comprising a section of a metal tube defining the flow passage.

4. The instrument according to claim 3, wherein the flow passage comprises a capillary sized passage such as the interior of a capillary tube.

5. The instrument according to claim 3, wherein the monitoring arrangement outputs data representative of a temperature dependent resistance of the resistance heater and the controller calculates monitored resistance of the resistance heater based on the data received from the monitoring arrangement, the controller operates the switching device to supply pulses of power to the resistance heater at least when the monitored resistance falls below a target resistance.

6. The instrument according to claim 1, wherein the at least one heater arrangement comprises a plurality of resistance heaters.

7. The instrument according to claim 1, wherein the liquid supply includes a valve arrangement operable to supply the liquid for a predetermined period of time, the predetermined period of time being determined by input of an instruction command to the controller.

8. The instrument according to claim 7, wherein the controller operates the valve arrangement prior to operating the heater arrangement to heat the liquid material supplied by the liquid supply.

9. The instrument according to claim 1, further comprising a display displaying settings of the instrument.

10. The instrument according to claim 1, further comprising a measuring device which monitors the amount of liquid material supplied to the flow passage.

11. The instrument according to claim 1, wherein the heater arrangement forms an aerosol having a mass median particle diameter of less than 2 microns.

12. The instrument according to claim 11, wherein the aerosol has a mass median particle diameter of between 0.2 and 2 microns.

13. The instrument according to claim 11, wherein solid particles are suspended in solution in the liquid material, the solid particles being forced out of the open end of the flow passage as the volatilized material expands such that the aerosol includes condensed particles of the liquid material and the solid particles.

14. The instrument according to claim 1, wherein the flow passage is defined by an internal diameter of a stainless steel tube, the heater arrangement comprises a pair of electrical leads attached to axially spaced apart locations on the tube, a DC power supply is electrically connected to the pair of leads, and a switching arrangement is operable to interrupt flow of DC current from the power supply to the tube, the controller being operably connected to the switching arrangement to effect supply of pulsed power to the tube when liquid material is supplied to the tube.

15. The instrument according to claim 1, wherein the flow passage is defined by a passage in a ceramic laminate, the heater arrangement comprises a resistance heater located along the flow passage, a DC power supply is electrically connected via a pair of leads to the heater, and a switching arrangement is operable to interrupt flow of DC current from the power supply to the heater, the controller being operably connected to the switching to effect supply of power to the heater when liquid material is supplied to the heater.

16. The instrument according to claim 1, wherein the at least one flow passage comprises a plurality of flow passages and the at least one heater arrangement comprises a plurality of heater arrangements, each of the flow passages being associated with one of the heater arrangements and the heater arrangements being selectively operable by the controller, each of the flow passages being supplied the same or different liquid material and outlets of the flow passages being directed into a manifold arrangement.

17. A method of operating the instrument according to claim 1, comprising the steps of:

selecting a target parameter corresponding to a temperature sufficient to volatilize a liquid material within the flow passage;

supplying the liquid material to the flow passage;

energizing the heater arrangement;

periodically determining a monitored parameter of a resistance heating element of the heater arrangement;

comparing the monitored parameter to the target parameter; and

supplying power to the resistance heating element when the monitored parameter is less than the target parameter.

18. The method according to claim 17, wherein the step of periodically determining the monitored resistance comprises measuring voltage drop across a shunt resistor, and measuring voltage drop across the resistance heating element.

19. The method according to claim 17, wherein the resistance heating element is supplied power in pulses having a duty cycle of 1 to 100 milliseconds.

20. The method according to claim 17, wherein the target parameter is target resistance and the monitored parameter is monitored resistance.

21. The method according to claim 17, wherein the controller is operable to control a duration of supply of the liquid material to the flow passage.

22. The method according to claim 17, wherein the flow passage is defined by an internal diameter of a stainless steel tube, the heater arrangement comprises a pair of electrical leads attached to axially spaced apart locations on the tube, a DC power supply is electrically connected to the pair of leads, and a switching arrangement is operable to interrupt flow of DC current from the power supply to the tube, the controller operates the switching arrangement to supply power to the tube when liquid material is supplied to the tube.

23. The method according to claim 17, wherein the flow passage is defined by a passage in a ceramic laminate, the heater arrangement comprises a resistance heater located along the flow passage, a DC power supply is electrically connected via a pair of leads to the heater, and a switching arrangement is operable to interrupt flow of DC current from the power supply to the heater, the controller operates the switching arrangement to supply power to the heater when liquid material is supplied to the heater.

24. The method according to claim 17, wherein the at least one flow passage comprises a plurality of flow passages and the at least one heater arrangement comprises a plurality of heater arrangements, each of the flow passages being associated with one of the heater arrangements and the heater arrangements being selectively operable by the controller, each of the flow passages being supplied the same or different liquid material and outlets of the flow passages being directed into a manifold arrangement.

25. An instrument for generation of volatilized material, comprising:

at least one flow passage having an outlet;

a liquid supply operable to supply liquid material to the flow passage;

at least one heater adapted to heat the flow passage to a temperature sufficient to volatilize material in liquid form in the flow passage such that the volatilized material expands out of the outlet of the flow passage, the volatilized material optionally being admixed with air to form an aerosol;

a first flow path in fluid communication with the outlet of the flow passage;

a second flow path in fluid communication with the outlet of the flow passage, the second flow path being different from the first flow path;

a first valve in fluid communication with the outlet of the flow passage; and

a controller operable to control operation of the first valve such that the volatilized material or aerosol (i) flows through the first flow path when the heater is in a non-conforming condition and (ii) flows through the second flow path when the heater is in a confirming condition.

26. The instrument according to claim 25, further comprising a pump in fluid communication with the first flow path, the volatilized material or aerosol being directed to the pump by the first valve when the heater is in a non-conforming condition.

27. The instrument according to claim 26, wherein the pump comprises a filter which filters the volatilized material or aerosol and the pump exhausts filtered air to the environment.

28. The instrument according to claim 25, further comprising:

a mouthpiece having an outlet, the mouthpiece being in fluid communication with the second flow path; and

a pressure sensor in fluid communication with the mouthpiece;

wherein the pressure sensor outputs at least one signal to the controller when a user inhales on the outlet of the mouthpiece.

29. The instrument according to claim 28, wherein the controller is operable to control operation of the first valve such that the volatilized material or aerosol flows through the second flow path and into the mouthpiece when the pressure sensor detects a threshold pressure drop in the mouthpiece.

30. The instrument according to claim 29, wherein the controller is operable to control operation of the first valve such that the volatilized material or aerosol flows through the second flow path and into the mouthpiece for a selected period of time.

31. The instrument according to claim 29, wherein the controller is programmed to terminate formation of volatilized material by the heater when the controller does not receive a signal from the pressure sensor indicating that the threshold pressure drop has been detected after a predetermined time interval.

32. The instrument according to claim 29, wherein the controller is operable to continue formation of volatilized material by the heater if, within a predetermined time interval, the controller receives a signal from the pressure sensor indicating that the threshold pressure drop has been detected.

33. The instrument according to claim 28, further comprising a second valve in fluid communication with the mouthpiece, the controller being operable to control operation of the second valve to direct flow of air into the mouthpiece.

34. The instrument according to claim 25, wherein:

the controller is programmed to control operation of the heater and the liquid supply; and

the instrument further comprises:

- a monitoring arrangement operable to supply heater performance data to the controller, the data being used by the controller to supply power to the heater or to cut off power to the heater to maintain the heater at a desired temperature range; and
- a memory operable to store parameters associated with the instrument.

35. The instrument according to claim 25, wherein the heater is at least one resistance heater.

36. The instrument according to claim 35, wherein the conforming condition of the heater is a steady state resistance value.

37. The instrument according to claim 25, wherein the conforming condition of the heater is a selected temperature range of the flow passage.

38. The instrument according to claim 25, wherein the instrument includes an air supply arranged such that the volatilized material is admixed with air to form the aerosol.

39. A method of operating the instrument according to claim 25, comprising:

supplying liquid material to the flow passage;

heating the liquid material in the flow passage with the heater such that the volatilized material expands out of the outlet of the flow passage;

optionally admixing the volatilized material with air to form an aerosol;

monitoring the heater; and

controlling operation of the first valve such that the volatilized material or aerosol (i) flows through the first flow path when the heater is in a non-conforming condition and (ii) flows through the second flow path when the heater is in the conforming condition.

40. The method according to claim 39, wherein the conforming condition of the heater is a steady state resistance value.

41. The method according to claim 39, wherein the conforming condition of the heater is a selected temperature range of the flow passage.

42. The method according to claim 39, further comprising filtering the volatilized material or aerosol that flows through the first flow path and exhausting air to the environment.

43. The method according to claim 39, wherein the instrument further comprises:

a mouthpiece in fluid communication with the second flow path; and

a pressure sensor in fluid communication with the mouthpiece;

the method further comprises detecting a pressure drop in the mouthpiece with the pressure sensor when a user inhales on the mouthpiece.

44. The method according to claim 43, further comprising controlling operation of the first valve using the controller such that the volatilized material flows through the second flow path and into the mouthpiece when the pressure sensor detects a threshold pressure drop in the mouthpiece.

45. The method according to claim 43, further comprising controlling operation of the first valve using the controller such that the volatilized material or aerosol flows through the second flow path and into the mouthpiece for a selected period of time.

46. The method according to claim 44, further comprising terminating formation of volatilized material by the heater if, after a predetermined time interval, the controller does not receive a signal from the pressure sensor indicating that the threshold pressure drop has been detected.

47. The method according to claim 44, further comprising continuing formation of volatilized material by the heater if, within a predetermined time interval, the controller receives a signal from the pressure sensor indicating that the threshold pressure drop has been detected.

48. The instrument according to claim 39, further comprising admixing the volatilized material with air to form the aerosol.

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(54) ELECTRONIC EVAPORABLE SUBSTANCE DELIVERY DEVICE AND METHOD

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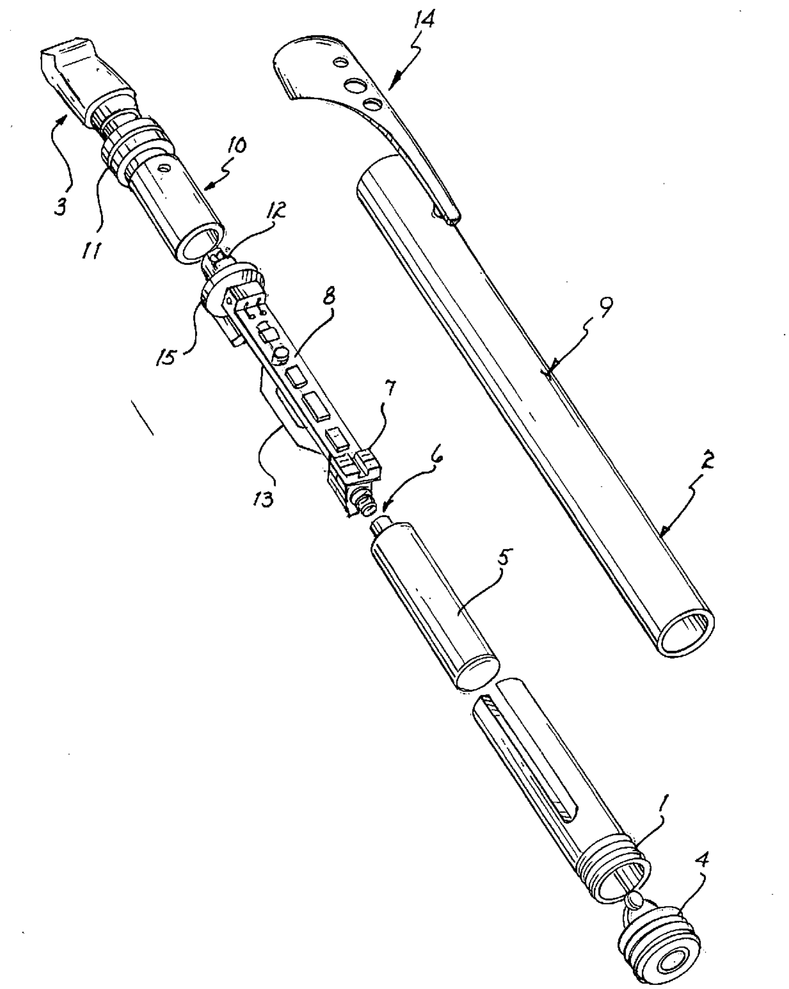
(57) **ABSTRACT**

An improved electronic evaporable substance delivery device delivers nicotine-containing vapor to a user from a smoking device. The smoking device comprises a case having therein a power source, microprocessor, heating element and nicotine-containing cartridge. Microprocessor-controlled heating of the heating element causes air passing thereover to be heated. Passage of the heated air in proximity of the cartridge causes boiling of cartridge contents, and the release of a nicotine-containing vapor. A user may ingest the nicotine-containing vapor via a mouthpiece located at a first end of the case.



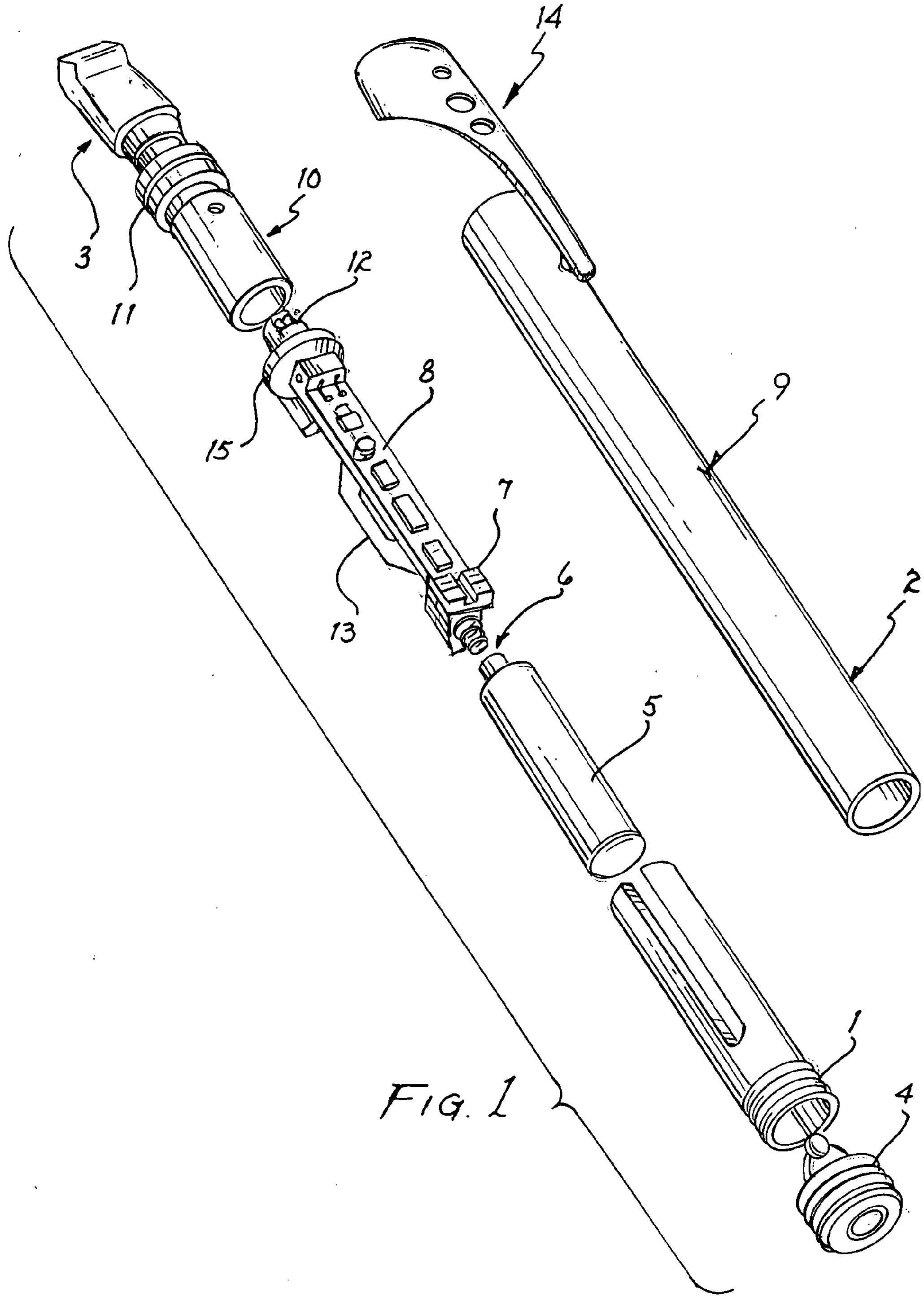


FIG. 1

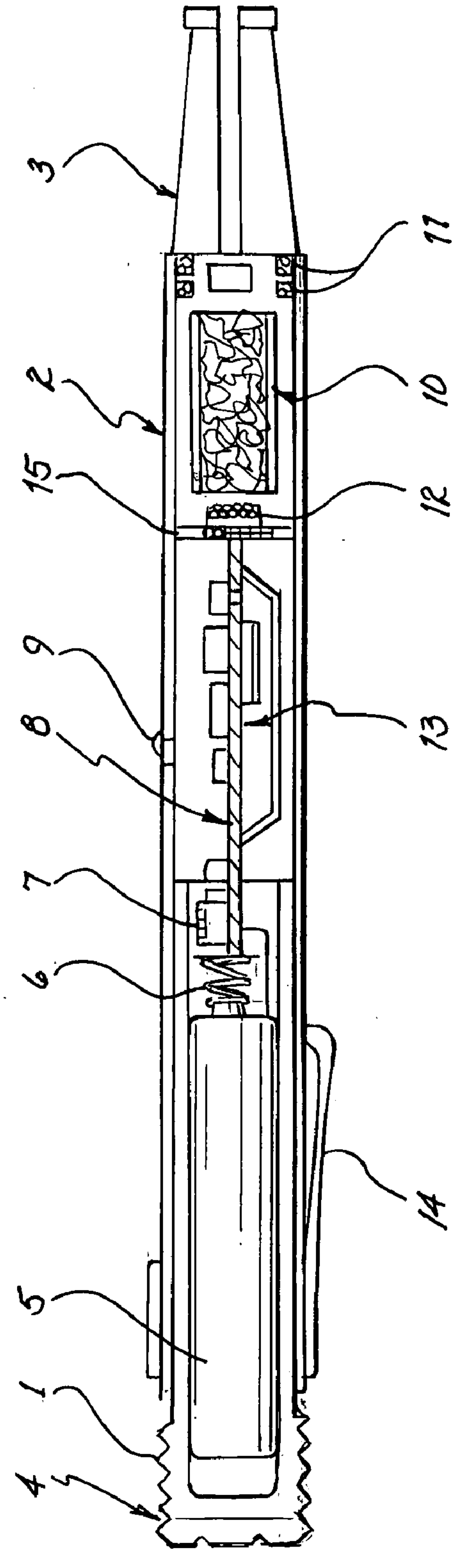


FIG. 2

ELECTRONIC EVAPORABLE SUBSTANCE DELIVERY DEVICE AND METHOD

FIELD OF THE INVENTION

[0001] The present invention relates to electronic substance delivery devices and, more particularly, to an electronic cigarette-like evaporable substance delivery device.

BACKGROUND OF THE INVENTION

[0002] The smoking of cigarettes and, to a lesser extent, cigars and pipes, remains very popular throughout the world. Increasingly, however, there is an awareness of the health-risks associated with tobacco smoke. In the West in particular, there has been in recent years a flurry of legislation aimed at reducing smoking in public places so as to reduce exposure of non-smokers to second-hand smoke. This has made it substantially more difficult for smokers to engage in smoking activity.

[0003] While the health-risks associated with tobacco smoke are well known, recent research points to the many health benefits associated with nicotine itself. Nicotine has been shown to improve attention, memory and overall mood. Most studies nevertheless conclude that the health benefits of nicotine are far outweighed by the carcinogenic effects of tobacco smoke. Nicotine gum and nicotine patches have been developed as non-carcinogenic delivery systems for nicotine. However, while these methods of nicotine intake can be effective in delivering nicotine into the body, studies have shown that many smokers have a psychological addiction to the use of cigarettes themselves. Many smokers have grown accustomed to the oral fixation and manual manipulation that is associated with cigarette smoking. A need therefore exists for a device capable of delivering nicotine while mimicking the smoking experience, but without the carcinogenic effects associated with tobacco smoke.

[0004] Various versions of an electronic cigarette have been disclosed. See PCT applications entitled "A Flameless Electronic Atomizing Cigarette" (WO 2004/095955); "A Flameless Electronic Atomizing Cigarette" (WO/2004/080216); and "An Aerosol Electronic Cigarette" (WO/2005/099494). These devices rely on an atomizer high frequency vibrator and aerosol, respectively, to convert a nicotine solution into gas form for inhalation. These devices do not provide for a means for monitoring the amount and controlling the delivery of nicotine. In addition, these devices do not contemplate the delivery of other therapeutic substances other than nicotine. Finally, these devices do not disclose or suggest alternative mechanisms (besides high frequency vibration and aerosol technology) for the dispersion of nicotine or other therapeutic substances in gas form. Therefore, a need remains for an improved electronic substance delivery device.

SUMMARY OF THE INVENTION

[0005] In accordance with an embodiment of the present invention, an electronic evaporable substance delivery device is provided. The device comprises, in combination: a case; a power source located in an interior of the case; a printed circuit board located in the interior of the case; a microprocessor located on the printed circuit board and in communication with the power source; a heating element in communication with the microprocessor; a cartridge containing an evaporable substance proximate the heating element; an air path opening located in the case; a mouthpiece located at a first end of the case wherein the mouthpiece has a channel therein and is in communication with the air path opening so that air entering the case through the air path opening may be sucked though the mouthpiece; and a switch configured to activate the microprocessor upon a sucking of air through the interior of the case by a user.

[0006] In accordance with a further embodiment of the present invention, an electronic nicotine delivery device is provided. The device comprises, in combination: a case; a power source located in an interior of the case; a printed circuit board located in the interior of the case; a microprocessor located on the printed circuit board and in communication with the power source; a heating element in communication with the microprocessor; a nicotine-containing cartridge proximate the heating element; an air path opening located in the case; a mouthpiece located at a first end of the case wherein the mouthpiece has a channel therein and is in communication with the air path opening so that air entering the case through the air path opening may be sucked though the mouthpiece; a display device in communication with the microprocessor, the display device configured to display data of at least one of a substance intake and battery power levels; a switch configured to activate the microprocessor upon a sucking of air through the interior of the case by a user; and a light located at a second end of the case, the light configured to indicate at least one of a nicotine intake level and battery power levels.

[0007] In accordance with an additional embodiment of the present invention, a method for delivering an evaporable substance is disclosed. The method comprises: providing an electronic evaporable substance delivery device comprising, in combination: a case; a power source located in an interior of the case; a printed circuit board located in the interior of the case; a microprocessor located on the printed circuit board and in communication with the power source; a heating element in communication with the microprocessor; a cartridge containing an evaporable substance proximate the heating element; an air path opening located in the case; a mouthpiece located at a first end of the case wherein the mouthpiece has a channel therein and is in communication with the air path opening so that air entering the case through the air path opening may be sucked though the mouthpiece; and a switch configured to activate the microprocessor upon a sucking of air through the interior of the case by a user; providing power from the power source to the microprocessor; the microprocessor causing the heating element to heat; air entering the case being heated by the heating element; the heated air coming into proximity with the evaporable substance in the cartridge; at least a portion of the evaporable substance boiling and producing a vapor; and the vapor exiting the case via the mouthpiece.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0008] FIG. **1** is a perspective, exploded view of an electronic evaporable substance delivery device consistent with an embodiment of the present invention.

[0009] FIG. **2** is a side, cross-sectional view of the electronic evaporable substance delivery device of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] Referring first to FIG. **1**, an electronic evaporable substance delivery device consistent with an embodiment of the present invention is shown. Initially, it should be noted that the device is adapted to permit a user to inhale a vapor containing preferably nicotine and perhaps other additives, and to exhale that vapor. The device is electronically powered, generally re-useable, does not require "lighting" in the conventional manner that a cigarette is commonly lit, and does not produce second-hand smoke of the type associated with cigarettes. It should be clearly understood that while in the preferred embodiment, the evaporable substance is comprised primarily of nicotine, substantial benefit could be derived from alternative embodiments of the present invention in which other substances having a therapeutic effect (such as medications, herbs, or vitamin compounds) are evaporated for a user to inhale.

[0011] The user may insert the mouthpiece **3** into his or her mouth. The mouthpiece **3** may comprise a hard plastic, rubber, or other desired material. It should be noted that some users enjoy chewing on the end of a cigar or cigarette, and it may be desired to provide a mouthpiece **3** comprising a deformable material, to facilitate such activity.

[0012] As shown in FIG. **2**, the mouthpiece **3** contains a channel therethrough which opens into an interior of the device. Air path hole **9** permits the entry of outside air into the device interior. The user may inhale, causing a sucking action that is communicated via that channel and drawing in ambient air via air path hole **9**. That sucking action may cause reed switch **13** to move, sending a signal to a microprocessor located on printed circuit board **8** that "smoking" has been initiated. The microprocessor may then send a signal, activating heating member **12**. The heating member **12** may be a heating coil, light emitting diode, an infra-red device, a laser, vibration chamber, pressure chamber, butane or other flame, or other device capable of bringing nicotine (or another substance) to its boiling point.

[0013] Where the heating member **12** is a heating coil, it is noted that the passage of current therethrough causes warming, at a level dependent upon the amount of current. which can be controlled. Air entering via air path hole **9** passes through the heating coil and is heated, causing hot air to hit the cartridge **10**, boiling and vaporizing its contents.

[0014] Where the heating element **12** is a laser, a beam is focused at a heat collector. Where the heating element **12** is infrared, an infra-red LED heats a heat collector. In both examples, air entering via air path hole **9** passes directly through the heat collector, causing hot air to hit the cartridge **10**, boiling and vaporizing its contents.

[0015] The heating member **12** is located proximate cartridge **10**, which may contain therein nicotine mixed with a low boiling point substance (e.g., propylene glycol) and, optionally, flavors and/or other additives. For example, flavored nicotine, or other flavored evaporable substances could be provided in cartridges **10**, allowing users different the experience of inhaling and tasting different flavors. Activation of the heating member **12** causes the contents of the cartridge **10** to reach their boiling point, producing a vapor. The vapor is inhaled by the user via the channel located in mouthpiece **3**. Cartridge **10** may be replaced when emptied by removal from the device of the mouthpiece **3**. Heat shield **15** may be interposed between the heating member **12** and the printed circuit board **8**, to protect components thereon.

[0016] The microprocessor may maintain the heating member **12** at a constant temperature, where desired, using a smart monitoring circuit located on the printed circuit board **8**, so as to limit power consumption and/or optimize performance. The microprocessor may utilize an algorithm software program that calculates nicotine consumption by the user and may store the amount of consumption in onboard flash memory integrated into the microprocessor. The printed circuit board **8** may further comprise at least one display device **7**, in communication with the microprocessor, to relay data to the user regarding, for example, nicotine intake and/or battery power levels. The display device **7** may be one or more light emitting diode (in one embodiment, nicotine intake quantity may be communicated by a blinking of the display device, with each blink corresponding to the nicotine associated with a single cigarette), a liquid crystal display, or other display. In one embodiment, the display device **7** may be a radio frequency transmitter, adapted to relay data (including data saved in memory) to the user via a remote radio frequency receiver (not shown). In this manner, a user may monitor and/or track nicotine consumption.

[0017] The device, including the heating member **12** and microprocessor **8**, is powered by power source **5**. Power source **5** may be a replaceable or rechargeable battery, inserted against battery spring **6**. Where rechargeable, the battery may be removed for recharging or, optionally, be recharged while remaining in the device by placement of the device in contact or proximity to a docking device (not shown). The microprocessor can also be used to monitor the battery when charging. The docking station itself may be battery-operated, so that it can recharge the device a number of times when away from an AC outlet. This docking station may be the size of a pack of cigarettes and have a collapsible plug so that it plugs directly into the wall. It may also be provided with a storage compartment, for use in carrying replacement cartridges **10**.

[0018] At least the power source **5**, printed circuit board **8**, heating element **12** and cartridge **10** may be retained within a case **2**. In the preferred embodiment, the case **2** and the mouthpiece **3** together approximate a tobacco cigarette in size and form factor, although it should be clearly understood that substantial benefit could be deprived from an alternative embodiment of the present invention in which the case **2** with or without a mouthpiece **3** together approximate a tobacco cigar in size and form factor.

[0019] In one embodiment, a lighted tip **4** may be provided at an end of the case **2**. The lighted tip **4** may be in contact with the power source **5** and may also be activated by movement of the reed switch **13**, so as to light when "smoking action" is occurring. The lighted tip **4** may simulate the lighting of an end of a cigarette or cigar.

[0020] A pocket clip **14** may be provided on an exterior of the case **2**. The pocket clip **14** facilitates clipping of the case **2** to the interior of a shirt pocket or the like.

[0021] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. An electronic evaporable substance delivery device comprising, in combination:

a case;

a power source located in an interior of said case;

a printed circuit board located in said interior of said case;

a microprocessor located on said printed circuit board and in communication with said power source;

a heating element in communication with said microprocessor;

a cartridge containing an evaporable substance proximate said heating element;

an air path opening located in said case;

a mouthpiece located at a first end of said case wherein said mouthpiece has a channel therein and is in communication with said air path opening so that air entering said case through said air path opening may be sucked though said mouthpiece; and

a switch configured to activate said microprocessor upon a sucking of air through said interior of said case by a user.

2. The device of claim **1** wherein said evaporable substance is nicotine.

3. The device of claim **1** wherein said power source is a replaceable battery.

4. The device of claim **1** wherein said power source is a rechargeable battery.

5. The device of claim **1** further comprising a heat shield interposed between said heating element and said printed circuit board.

6. The device of claim **1** further comprising a display device in communication with said microprocessor, said display device configured to display data of at least one of a substance intake and battery power levels.

7. The device of claim **1** further comprising a light located at a second end of said case, said light configured to indicate at least one of a substance intake level and battery power levels.

8. The device of claim **1** further comprising a pocket clip coupled to an exterior of said case.

9. The device of claim **1** wherein said case and said mouthpiece substantially resemble a tobacco cigarette.

10. An electronic nicotine delivery device comprising, in combination:

a case;

a power source located in an interior of said case;

a printed circuit board located in said interior of said case;

a microprocessor located on said printed circuit board and in communication with said power source;

a heating element in communication with said microprocessor;

a nicotine-containing cartridge proximate said heating element;

an air path opening located in said case;

a mouthpiece located at a first end of said case wherein said mouthpiece has a channel therein and is in communication with said air path opening so that air entering said case through said air path opening may be sucked though said mouthpiece;

a display device in communication with said microprocessor, said display device configured to display data of at least one of a substance intake and battery power levels;

a switch configured to activate said microprocessor upon a sucking of air through said interior of said case by a user; and

a light located at a second end of said case, said light configured to indicate at least one of a nicotine intake level and battery power levels.

11. The device of claim **10** wherein said power source is a replaceable battery.

12. The device of claim **10** wherein said power source is a rechargeable battery.

13. The device of claim **10** further comprising a heat shield interposed between said heating element and said printed circuit board.

14. A method for delivering an evaporable substance comprising:

providing an electronic evaporable substance delivery device comprising, in combination:

a case;

a power source located in an interior of said case;

a printed circuit board located in said interior of said case;

a microprocessor located on said printed circuit board and in communication with said power source;

a heating element in communication with said microprocessor;

a cartridge containing an evaporable substance proximate said heating element;

an air path opening located in said case;

a mouthpiece located at a first end of said case wherein said mouthpiece has a channel therein and is in communication with said air path opening so that air entering said case through said air path opening may be sucked though said mouthpiece; and

a switch configured to activate said microprocessor upon a sucking of air through said interior of said case by a user;

providing power from said power source to said microprocessor;

said microprocessor causing said heating element to heat;

air entering said case being heated by said heating element;

said heated air coming into proximity with said evaporable substance in said cartridge;

at least a portion of said evaporable substance boiling and producing a vapor; and

said vapor exiting said case via said mouthpiece.

15. The method of claim **14** wherein said evaporable substance is nicotine.

16. The method of claim **15** further comprising the step of said microprocessor calculating an amount of nicotine exiting said case via said mouthpiece.

17. The method of claim **15** further comprising displaying said amount of nicotine exiting said case via said mouthpiece to a user.

18. The method of claim **15** wherein said step of displaying occurs on a display device located on said case.

19. The method of claim **15** wherein said amount of nicotine exiting said case via said mouthpiece to a user is communicated from said case to another device.

20. The method of claim **14** wherein said heating element comprises at least one of a heating coil, a light emitting diode, an infra-red device, a laser, a vibration chamber, a flame, and a pressure chamber.

* * * * *

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(54) **AEROSOL ELECTRONIC CIGARETTE**

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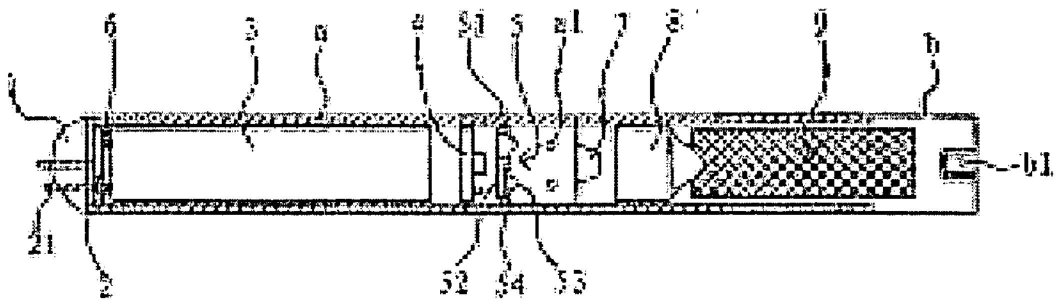
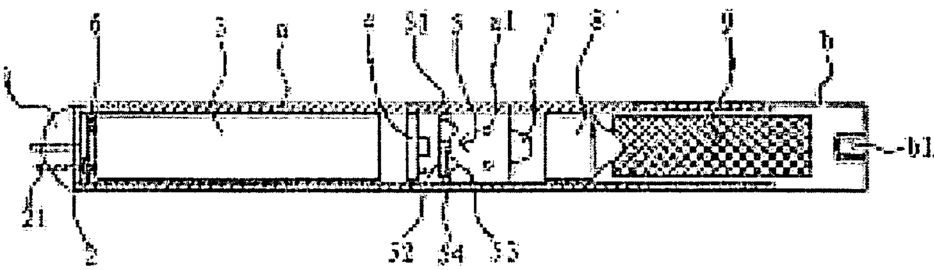
(57) **ABSTRACT**

An aerosol electronic cigarette includes a battery assembly, an atomizer assembly and a cigarette bottle assembly and also includes a shell (a) which is hollow and integrally formed. Said battery assembly connects with said atomizer assembly and both are located in said shell (a). Said cigarette bottle assembly is located in one end of the shell (a), which is detachable. Said cigarette bottle assembly fits with said atomizer assembly. Said shell (a) has through-air-inlets (a**1**).





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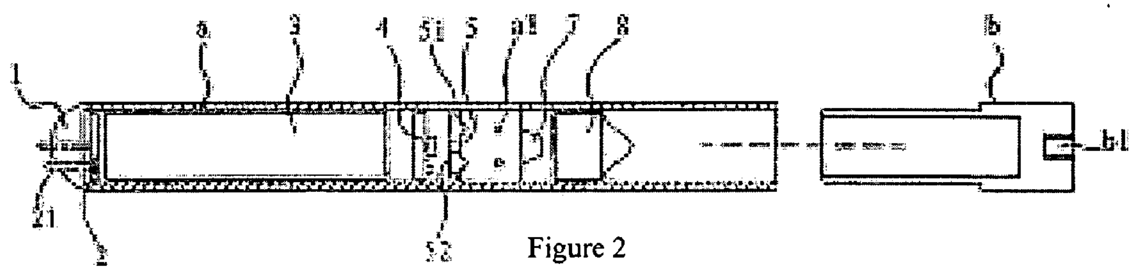

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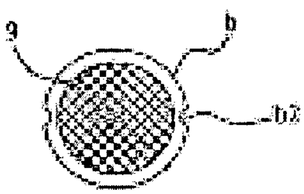

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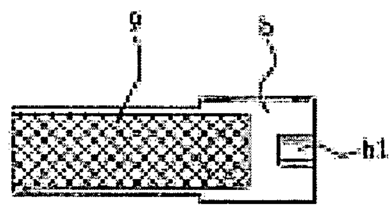

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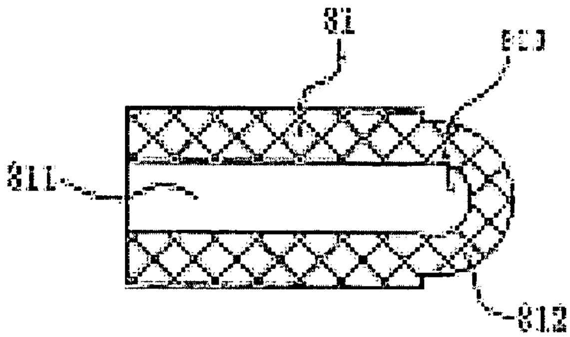

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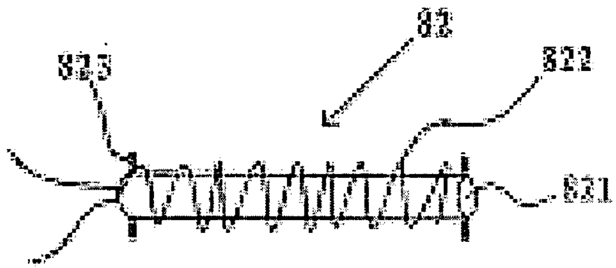

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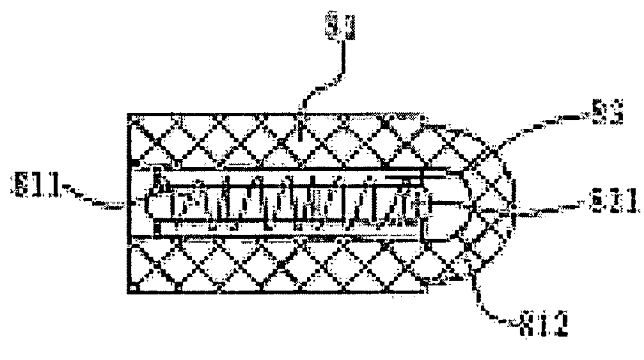

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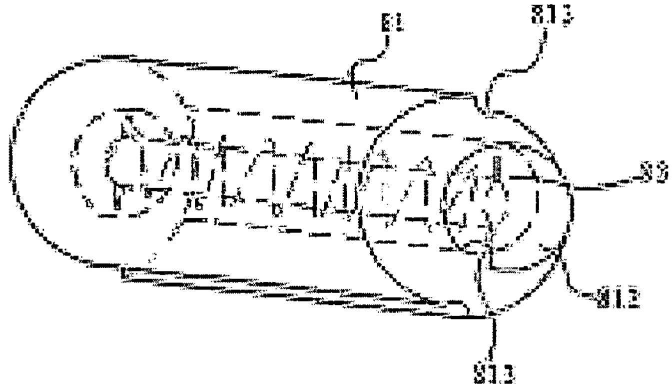

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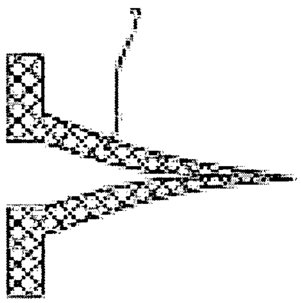

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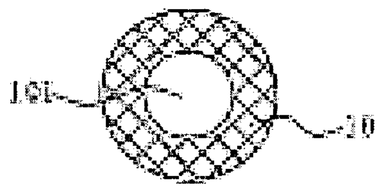

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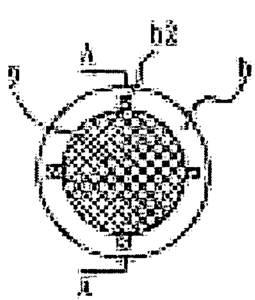

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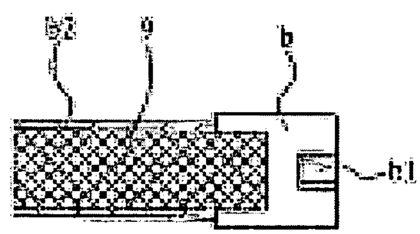

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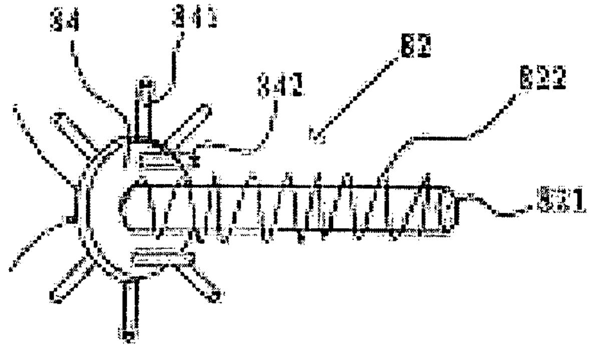

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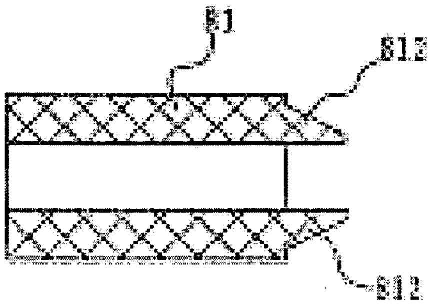

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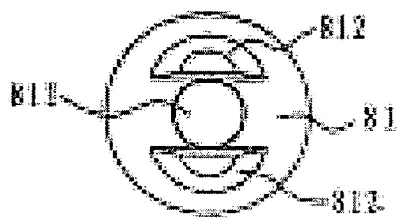

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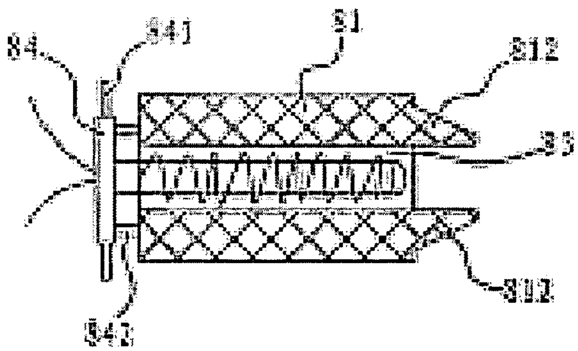

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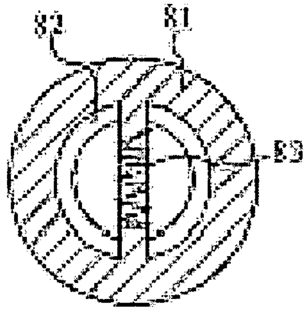

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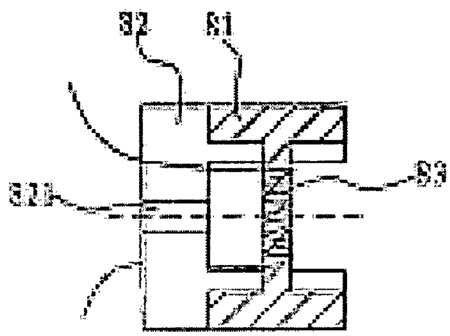

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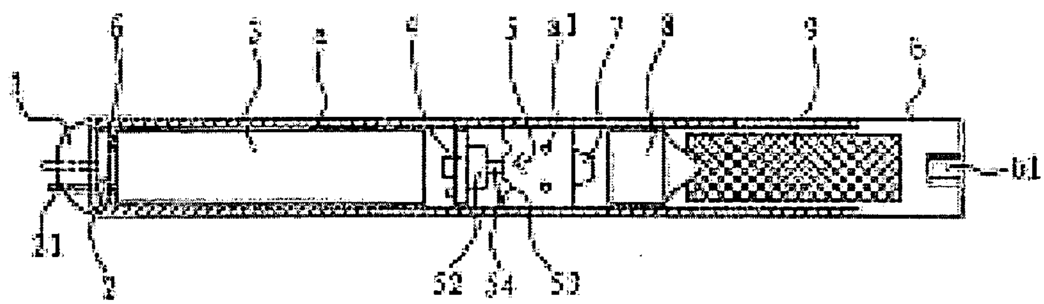

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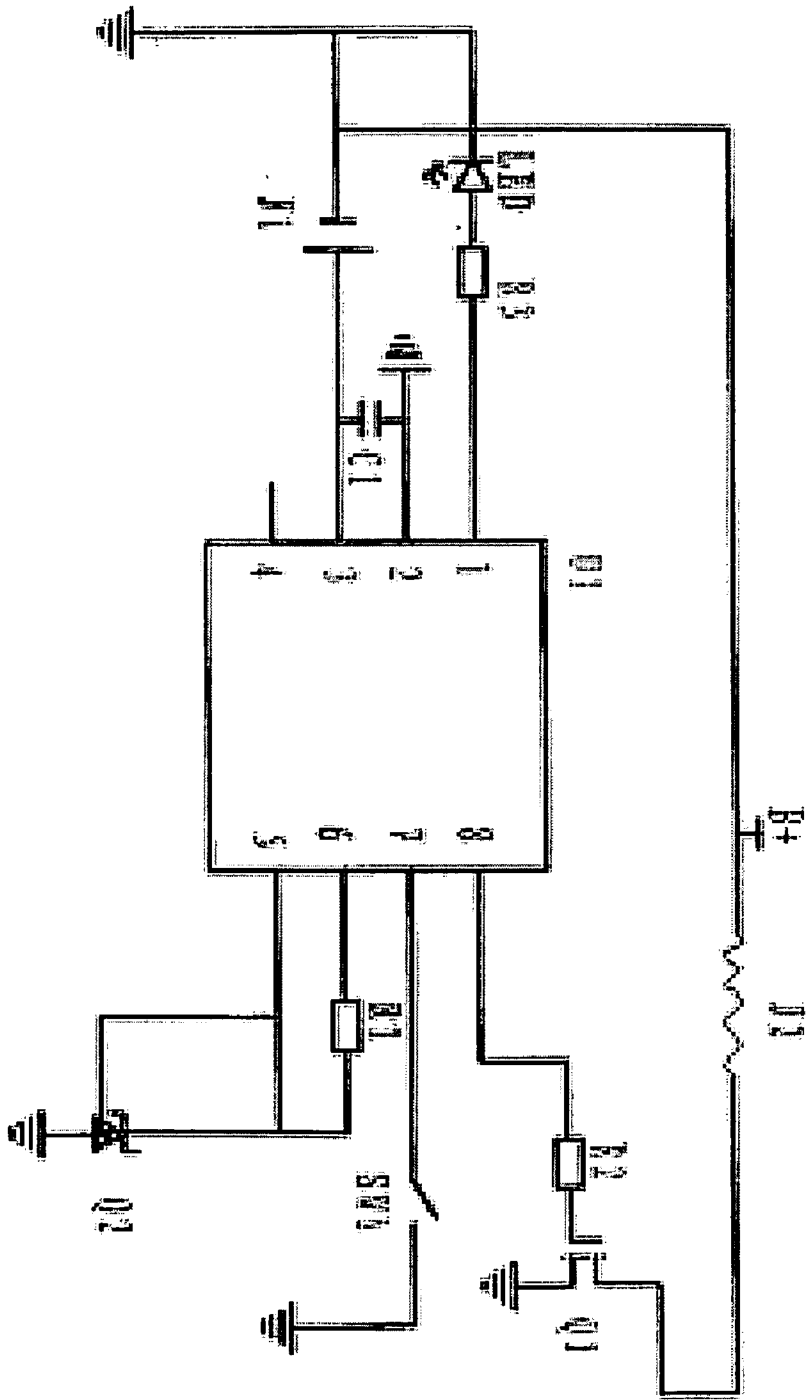

Figure 20

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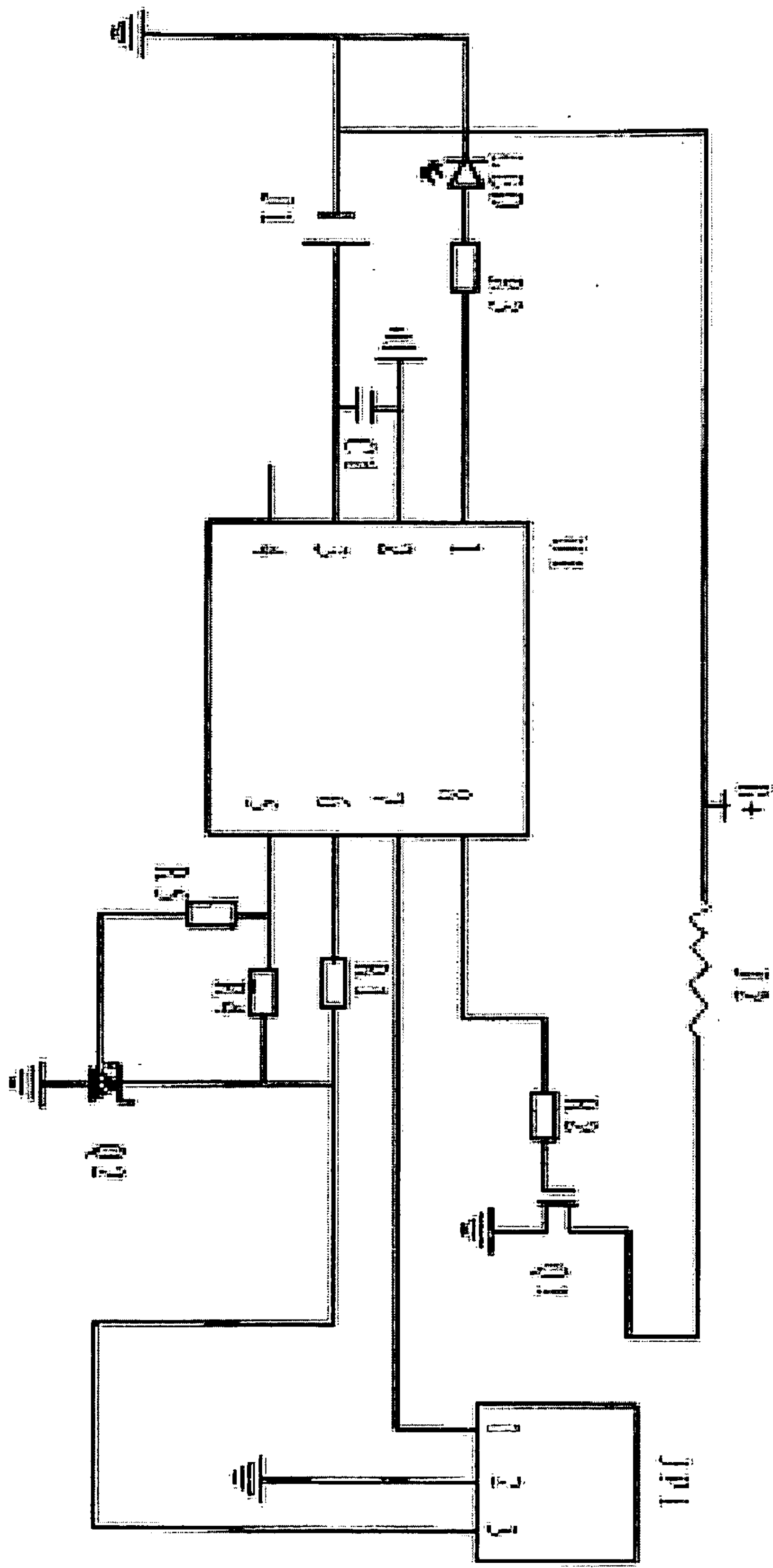

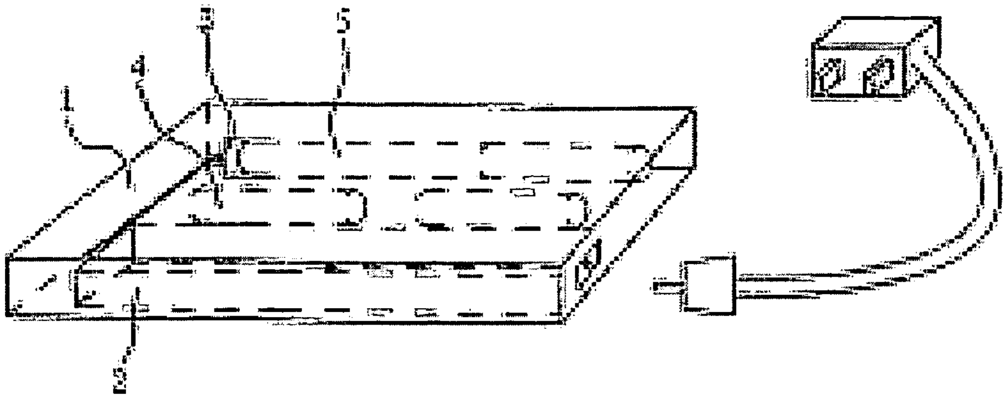

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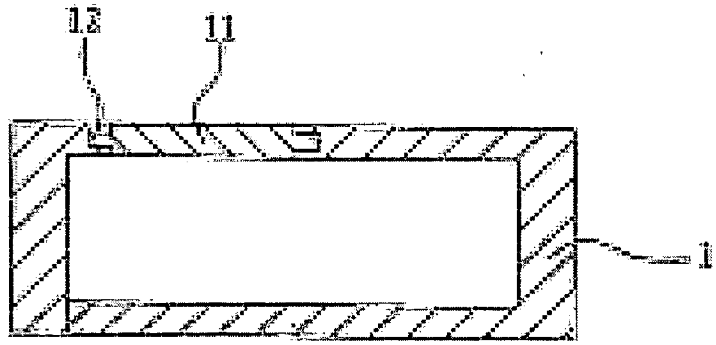

Figure 23

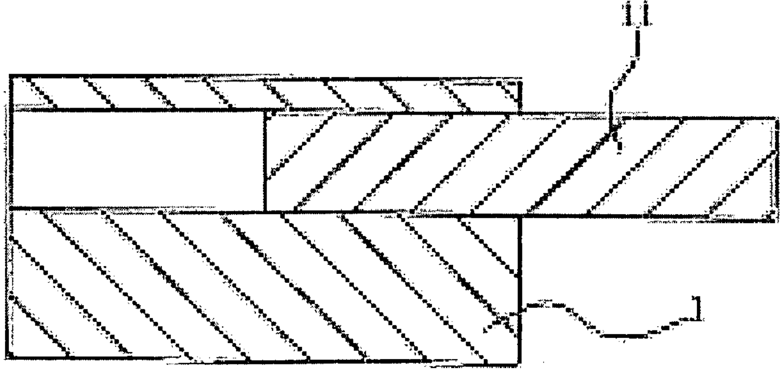

Figure 24

AEROSOL ELECTRONIC CIGARETTE

TECHNICAL FIELD

[0001] The present invention relates to an electronic cigarette, in particular, an aerosol electronic cigarette that doesn't contain tar but nicotine.

BACKGROUND ART

[0002] Today when "smoking is harmful to your health" has become a common sense, there are one billion people smoking cigarettes, and this figure is still rising. On Mar. 1, 2003, the World Health Organization (WHO) issued the first international smoking ban—Framework Convention on Tobacco Control. According to WHO's data, smoking causes 4,900,000 deaths each year. Smoking causes serious respiratory system diseases and cancers, though it is a hard job to persuade the smokers to completely quit smoking.

[0003] Nicotine is the effective ingredient of cigarette, which produces a lot of tar mist as the cigarette bums. The tar mist accesses the pulmonary alveolus and is quickly absorbed into the blood. Nicotine thus acts on the receptor of the central nervous system, bringing the euphoria like stimulant drugs to the smokers, who feel light in the head and on wings as well.

[0004] Nicotine is a micromolecular alkaloid, which is basically harmless to human bodies with a small dosage. Plus, its half life period is extremely short in blood. Tar is the major harmful substance in tobacco. Tobacco tar comprises of several thousands of ingredients, dozens of which are carcinogenic substances. It has now been proved that second hand smoking is even more harmful to those who don't smoke.

[0005] To seek the cigarette substitutes that don't contain harmful tar but nicotine, many inventors have used the relatively pure nicotine to create such products as "Cigarette Patch", "Nicotine Gargle", "Aerosol Packed in the High Pressure Tank with Propellant", "Nicotine Chewing Gum", and "Nicotine Beverage". These products are not as harmful as tar, but are absorbed very slowly. As a result, its peak concentration can't be effectively established in blood, and the smokers can't be satisfied to the full. In addition, the smokers are deprived of the "smoking" habit. Therefore, the substituting products are not real cigarette substitutes or products helping to quit smoking.

[0006] The electronic cigarettes currently available on the market may resolve the above-mentioned issue, though they are complicated in structure. Their cigarette bodies can be roughly divided into three sections, which have to be connected through via plugging or thread coupling before use. Also, their batteries have to be changed frequently, making it inconvenient for the users. What's worse, the electronic cigarettes don't provide the ideal aerosol effects, and their atomizing efficiency is not high.

CONTENTS OF INVENTION

[0007] To overcome the above-mentioned disadvantages, this invention has been designed to provide an aerosol electronic cigarette that substitutes for cigarettes and helps the smokers to quit smoking.

[0008] The purpose of this invention is fulfilled with the following technical solution: an aerosol electronic cigarette includes a battery assembly, an atomizer assembly and a cigarette bottle assembly, and also includes a shell, which is hollow and integrally formed. The said battery assembly connects with the said atomizer assembly and both are located in the said shell. The said cigarette bottle assembly is located in one end of the shell, which is detachable. The said cigarette bottle assembly fits with the said atomizer assembly. The said shell has through-air-inlets.

[0009] The additional features of this invention are as follows: the said battery assembly includes the battery, and the operating indicator, electronic circuit board, and airflow sensor, which are connected with the said battery; the signal output of the said airflow sensor is connected with the said electronic circuit board.

[0010] It also includes a check valve. The said battery is a rechargeable battery, which has a flexibly connected charging plug. The blades of the said plug come out of the other end of the said shell.

[0011] Between the said charging plug and rechargeable battery is a spring, which lies against the body of the said rechargeable battery on one end, and its free end lies against the said charging plug.

[0012] The said battery is a rechargeable battery, which has a charging slot on it. The said operating indicator is a LED.

[0013] The said airflow sensor may be alternatively a semiconductor force-sensitive chip capacitance sensor or an inductance sensor.

[0014] The said electronic circuit board includes an electronic switch circuit.

[0015] The said airflow sensor has a silica gel corrugated membrane, which connects with magnetic steel with a reed relay on one of its ends. Both ends of the said reed relay correspond to the relay electrodes.

[0016] The said airflow sensor has a silica gel corrugated membrane, which connects with magnetic steel with a Hall element or a magneto-diode or a magneto-triode on one of its ends.

[0017] The said atomizer assembly is an atomizer, which includes a porous component and a heating body.

[0018] The said atomizer also includes an electric heating rod. The body of the said porous component has a run-through atomizing chamber. The diameter of the said electric heating rod is less than the diameter of the said atomizing chamber. The said electric heating rod enters into the said atomizing chamber, and there is a clearance between the said electric heating rod and interior wall of the atomizing chamber. The said clearance forms a negative pressure cavity. One end of the said porous component fits with the said cigarette bottle assembly.

[0019] The said electric heating rod includes a cylinder. The said heating body is heating wire, which is wound on the wall of the said cylinder. The said porous component has a protuberance on one end, and the said protuberance fits with the said cigarette bottle assembly. The said protuberance is a half sphere, on the side of which there is a run-through hole connecting to the said atomizing chamber.

[0020] The said electric heating rod includes a cylinder. The said heating body is made of electrically conductive ceramic PTC material. The said heating body is set on the wall of the said cylinder. On the wall of both ends of the said cylinder, there are mandrils respectively. The said porous component has a protuberance on one end, and the said protuberance fits with the said cigarette bottle assembly. The said protuberance is a half sphere, on the side of which there is a run-through hole connecting to the said atomizing chamber.

[0021] The said heating body is heating wire. The said atomizer assembly includes a frame. The said porous component is set on the said frame. The said porous component is wound with heating wire. The said frame has a run-through hole on it. The said porous component is wound with heating wire in the part that is on the side in the axial direction of the said run-through hole. One end of the said porous component fits with the said cigarette bottle assembly.

[0022] The said porous component is made of foamed nickel, stainless steel fiber felt, macromolecular polymer foam or foamed ceramics.

[0023] The said heating wire is made of platinum wire, nickel-chromium alloy wire or iron-chromium alloy wire containing rare earth, or is flaked.

[0024] A restriction component, which is detachable, is set on one end of the said porous component. There is a restriction hole on the body of the said restriction component. The said restriction hole corresponds to the said atomizing chamber. The pore diameter of the said restriction hole is less than the inner diameter of the atomizing chamber.

[0025] The said cigarette bottle assembly includes a hollow cigarette holder shell, and a perforated component for liquid storage inside the said cigarette holder shell. One end of the said cigarette holder shell plugs into the said shell, and the outer peripheral surface of the said cigarette holder shell has an inward ventilating groove. On one end surface of the said cigarette holder shell, there is an air channel extending inward.

[0026] The said air channel is located in the center on one end surface of the said cigarette holder shell.

[0027] One end of the said porous component lies against one end surface of the said perforated component for liquid storage, and contacts the said perforated component for liquid storage.

[0028] The said perforated component for liquid storage is made of such materials as PLA fiber, terylene fiber or nylon fiber.

[0029] The said perforated component for liquid storage is plastic foam molding or column of multi-layer plates made through plastic injection with polyvinyl chloride, ploypropylene and polycarbonate.

[0030] The said electronic cigarette is held in a charging device.

[0031] The said charging device includes a case, which contains an auxiliary charging storage battery inside it, and holds the electronic cigarette and the charger for the rechargeable battery embedded in the electronic cigarette, as well as the power supply circuit. The power inputs of the said auxiliary charging storage battery and charger are connected with the power supply circuit respectively.

[0032] The said case has a spare liquid supply bottle in it.

[0033] The power output of the said auxiliary charging storage battery is connected with the power input of the said charger.

[0034] The power output of the said charger is a charging slot, which fits with the charging plug of the rechargeable battery inside the said electronic cigarette, or a charging plug, which fits with the charging slot of the rechargeable battery.

[0035] The said charger is a constant voltage & current charger.

[0036] On the body of the said shell, there is a pair of slide ways corresponding to the position of the said electronic cigarette, and on the slide ways, there is a slide cover.

[0037] This invention will bring the following benefits: (1) For this invention, the perforated component for liquid storage of the cigarette bottle assembly stores the nicotine liquid only, which doesn't contain cigarette tar, considerably reducing the carcinogenic risks of smoking. At the same time, the smokers can still enjoy the feel and excitement of smoking, and there is no fire hazard since there is no need for igniting. (2) For this invention, the battery assembly and atomizer assembly are directly installed inside the shell, and then connected with the cigarette bottle assembly. That is, there is just one connection between two parts, resulting in a very simple structure. For use or change, you just need to plug the cigarette holder into the shell, providing great convenience. When the nicotine liquid in the cigarette bottle assembly is used up or the cigarette bottle assembly is damaged and needs to be changed, the operation will be extremely easy. (3) For this invention, the rechargeable battery inside the battery assembly has a charging plug, whose blades come out of the shell. When the rechargeable battery inside the electronic cigarette runs out of power, it may be directly plugged into the charger for charging, with no need to remove the rechargeable battery, resulting in very easy use. (4) For this invention, the charging device includes the charger and the auxiliary charging storage battery. The electronic cigarette is put inside the charger when not in use, and then the charging device may be electrified to charge the electronic cigarette and the auxiliary charging storage battery as well. In the event that power supply is not available for the charging device, the auxiliary charging storage battery may be used to charge the electronic cigarette. Therefore, the electronic cigarette can be charged anywhere you go, and it is very suitable for use when you are on a business or tourist trip. Further, the charging device includes a spare liquid supply bottle, which contains nicotine liquid for spare use when you are on a business or tourist trip. (5) For this invention, on one end of the shell of the cigarette bottle assembly, there is an air channel extending inward. The electronic cigarette works to produce mist, which flows to the shell, generating some fine drips; the fine drips are condensed into bigger drips, which fall along the exterior wall of the air channel into the cavity of the shell of the cigarette bottle assembly, so that they are not inhaled by the smoker out of the air channel. (6) In addition, with a little bit modification to the liquid storage, the unit and its connecting structure of this invention may also be loaded with drugs for delivery to the lung.

DESCRIPTION OF DRAWINGS

[0038] FIG. **1** is the side section view of the electronic cigarette of this invention.

[0039] FIG. **2** is the section view of the shell (a) separated from the cigarette bottle assembly of the electronic cigarette of this invention, illustrating the structure of the cigarette bottle assembly that is detachably plug in the shell (a).

[0040] FIG. **3** is the diagram of the axial structure of the cigarette bottle assembly of this invention, illustrating the ventilating groove on the peripheral surface of the cigarette holder shell.

[0041] FIG. **4** is the side section view of the cigarette bottle assembly of this invention, illustrating the structure of the air channel.

[0042] FIG. **5** is the side section view of the porous component of the atomizer of this invention, illustrating the atomizing chamber, a protruding half sphere structure.

[0043] FIG. **6** is the diagram of the structure of the electric heating rod of the atomizer of this invention.

[0044] FIG. **7** is the side section of the atomizer of this invention, illustrating the locations of and connection relation between the electric heating rod and porous component.

[0045] FIG. **8** is the diagram of the cubic structure of the atomizer of this invention, illustrating the locations of and connection relation between the electric heating rod and porous component.

[0046] FIG. **9** is the section view of the check valve of this invention.

[0047] FIG. **10** is the front section view of the restriction component in the second preferred embodiment of this invention, illustrating the structure of the restriction component.

[0048] FIG. **11** is the diagram of the axial structure of the cigarette bottle assembly in the third preferred embodiment of this invention.

[0049] FIG. **12** is the A-A section view of FIG. **11**.

[0050] FIG. **13** is the diagram of the structure of the electric heating rod of the atomizer in the fourth preferred embodiment of this invention.

[0051] FIG. **14** is the section view of the porous component of the atomizer in the fourth preferred embodiment of this invention.

[0052] FIG. **15** is the diagram of the axial structure of FIG. **14**.

[0053] FIG. **16** is the side section view of the atomizer in the fourth preferred embodiment of this invention, illustrating the locations of and connection relation between the electric heating rod and porous component.

[0054] FIG. **17** is the diagram of the axial structure of the atomizer in the fifth preferred embodiment of this invention.

[0055] FIG. **18** is the side section view of the atomizer in the fifth preferred embodiment of this invention.

[0056] FIG. **19** is the side section view of the electronic cigarette in the sixth preferred embodiment of this invention, illustrating the diagram of the structure of the airflow sensor adopting Hall element.

[0057] FIG. **20** is the electric circuit diagram of the electronic cigarette of this invention, with the airflow sensor adopting a reed relay structure.

[0058] FIG. **21** is the electric circuit diagram of the electronic cigarette of this invention, with the airflow sensor adopting Hall element.

[0059] FIG. **22** is the diagram of the cubic structure of the charging device of this invention, illustrating the locations of and connection relation of various internal parts.

[0060] FIG. **23** is the side section view of the charging device of this invention, illustrating the structure of slide way and cover.

[0061] FIG. **24** is the diagram of the front structure of the charging device of this invention, illustrating the structure of the sliding cover.

SPECIFIC MODE FOR CARRYING OUT THE INVENTION

[0062] This invention is further described as follows on the basis of the drawings.

[0063] As shown in FIG. **1-10**, this utility model provides an aerosol electronic cigarette, which includes a battery assembly, an atomizer assembly and a cigarette bottle assembly, and also includes a shell (a), which is hollow and integrally formed. The battery assembly connects with the atomizer assembly and both are located in the shell. The cigarette bottle assembly is located in one end of the shell, which is detachable. The cigarette bottle assembly fits with the atomizer assembly. The shell has through-air-inlets (a**1**).

[0064] In this specific embodiment, the battery assembly includes the battery, and the operating indicator (**1**), electronic circuit board (**4**), and airflow sensor (**5**), which are connected with the battery. It also includes a check valve (**7**). The signal output of the airflow sensor (**5**) is connected with the said electronic circuit board (**4**). The battery is a rechargeable battery (**3**), which may be either a rechargeable polymer lithium ion battery or a rechargeable lithium ion battery. The airflow sensor (**5**) may be alternatively a semiconductor force-sensitive chip capacitance sensor or an inductance sensor. The rechargeable battery (**3**) has a flexibly connected charging plug (**2**). The blades (**21**) of the charging plug (**2**) come out of the other end of the shell (a). Between the charging plug (**2**) and rechargeable battery (**3**) is a spring (**6**), which lies against the body of the rechargeable battery (**3**) on one end, while its free end lies against the charging plug (**2**), forming a flexible structure, which buffers the charging plug (**2**) when plugged for charging, thus protecting the rechargeable battery against any damage. Of course, the rechargeable battery (**3**) in this embodiment has a charging slot on it, which replaces the structure of charging plug (**2**) to perform the charging function and protect the rechargeable battery (**3**) against any damage. The operating indicator (**1**) is a LED. In this embodiment, there are two LEDs. The electronic circuit board (**4**) includes an electronic switch circuit, which controls the electric circuit according to the input signals, so that the rechargeable battery (**3**) electrifies the electric heating rod (**82**) inside the atomizer (**8**) and the LEDs as well.

[0065] As shown in FIGS. **1** and **2**, the airflow sensor (**5**) has a silica gel corrugated membrane (**53**), which connects with magnetic steel (**54**) with a reed relay (**52**) on one of its ends. Both ends of the said reed relay (**52**) correspond to the relay electrodes (**51**) respectively.

[0066] As shown in FIG. **5-8**, the atomizer assembly is an atomizer (**8**), which includes a porous component (**81**) and a heating rod (**82**). The body of the porous component (**82**) has a run-through atomizing chamber (**811**). The diameter of the electric heating rod (**82**) is less than the diameter of the atomizing chamber (**811**). The electric heating rod (**82**) enters into the atomizing chamber (**811**), and there is a clearance between the electric heating rod (**82**) and interior wall of the atomizing chamber (**811**), which forms a negative pressure cavity (**83**). One end of the said porous component (**81**) fits with the said cigarette bottle assembly. As FIGS. **5**, **7** and **8** show, the porous component (**81**) has a protuberance (**812**) on the other end, and the protuberance (**812**) fits with the cigarette bottle assembly. The protuberance (**812**) is a protruding half sphere, on the side of which there is a run-through hole (**813**) connecting to the atomizing chamber (**811**). Of course, the protuberance (**812**) may also be a taper, rectangle or any other shape. The porous component (**81**) is made of foamed nickel, stainless steel fiber felt, macromolecular polymer foam or foamed ceramics, providing the remarkable capabilities in liquid absorption and diffusion, and the ability to absorb the liquid stored in the cigarette bottle assembly.

[0067] As shown in FIG. **6**, the electric heating rod (**82**) includes a cylinder (**821**). The heating wire (**822**) is wound on the wall of the cylinder (**821**). On the wall of both ends of the cylinder (**821**), there are mandrils (**823**) respectively, which lie against the interior wall of the atomizing chamber (**811**) of the porous component (**81**). There is a negative pressure cavity (**83**) between the electric heating rod and interior wall of the atomizing chamber.

[0068] The heating wire is made of platinum wire, nickel-chromium alloy wire or iron-chromium alloy wire containing rare earth, or is flaked. The electric heating rod (**82**) may alternatively have on its peripheral wall the heating layer made of electrically conductive ceramic PTC material, to replace the heating wire.

[0069] Of this embodiment, the battery assembly and atomizer assembly are mutually connected and then installed inside the integrally formed shell (a) to form a one-piece part. The rechargeable battery (**3**) may be charged without frequent change of battery. The user just needs to plug the cigarette bottle assembly into the open end of the shell (a), for easy use and very easy change.

[0070] As shown in **3** and **4**, the cigarette bottle assembly includes a hollow cigarette holder shell (b), and a perforated component for liquid storage (**9**) inside the shell (b). The perforated component for liquid storage (**9**) is made of such materials as PLA fiber, terylene fiber or nylon fiber, which are suitable for liquid storage. Alternatively, it may be plastic foam molding or column of multi-layer plates made through plastic injection with polyvinyl chloride, ploypropylene and polycarbonate. One end of the cigarette holder shell (b) plugs into the shell (a), and the outer peripheral surface of the cigarette holder shell (b) has an inward ventilating groove (b**2**). On one end surface of the cigarette holder shell (b), there is an air channel (b**1**) extending inward. The air channel (b**1**) is located in the center on the surface of one end of shell (b).

[0071] As shown in FIG. **1**-**9**, one end of the porous component (**81**) lies against one end surface of the said perforated component for liquid storage (**9**), and contacts the perforated component for liquid storage (**9**). It absorbs the cigarette liquid from the perforated component for liquid storage (**9**). When the smoker smokes, the cavity of the cigarette holder shell (b) is in the negative pressure state. In the shell (b), one end of the airflow sensor (**5**) forms a normal pressure cavity, while the other end forms a negative pressure cavity. The air pressure difference between the normal pressure cavity and negative pressure cavity or the high-speed airflow enables the magnetic steel (**54**) of the airflow sensor (**5**) to drive the reed relay(**52**) to contact the relay electrode (**51**). As shown in FIG. **20**, the electric circuit is electrified, and the electronic switch circuit on the electronic circuit board (**4**) is electrified. Thus, the rechargeable battery (**3**) starts to electrify the electric heating rod (**82**) inside the atomizer (**8**), and at the same time, the LEDs, which are electrified by the rechargeable battery (**3**), emit light. The air enters the normal pressure cavity through the air inlet (a**1**), passes the check valve (**7**) via the airflow passage in the airflow sensor (**5**), and flows to the negative pressure cavity (**83**) in the atomizer (**8**). Since the negative pressure cavity (**83**) provides the negative pressure compared with the outside, the air flow sprays into it, bringing the cigarette liquid from the porous component (**81**) to spray into the negative pressure cavity (**83**) in the form of fine drips. In the meantime, the electric heating rod (**82**) is electrified by the rechargeable battery (**3**) under the control of electronic circuit board (**4**), to heat the fine drips for atomization. After atomization, the big-diameter fine drips are re-absorbed by the porous component (**81**) under the action of vortex, while the small-diameter fine drips are suspended in the airflow to form gasoloid, which is discharged through the negative pressure cavity (**83**) and run-through hole (**813**), flows into the cigarette holder shell (b) of the cigarette bottle assembly, and is absorbed by the air channel (b**1**). When the gasoloid enters the cigarette holder shell (b), multiple small liquid drips are condensed into bigger ones, which fall into the clearance between the cigarette holder shell (b) and air channel (b**1**) without being absorbed by the air channel (b**1**). The perforated component for liquid storage (**9**) of the cigarette bottle assembly and the porous component (**81**) of the atomizer (**8**) contact each other to achieve the capillary impregnation for liquid supply.

[0072] The unit and its connecting structure of this invention may also be loaded with drugs for delivery to the lung.

[0073] As shown in FIGS. **22**, **23** and **24**, the electronic cigarette (**5**) is held in a charging device. The charging device includes a case (**1**), which contains an auxiliary charging storage battery (**2**) inside it, and holds the electronic cigarette (**5**) and the charger (**3**) for the rechargeable battery embedded in the electronic cigarette (**5**), as well as the power supply circuit. The power inputs of the auxiliary charging storage battery (**2**) and charger (**3**) are connected with the power supply respectively. The charger (**3**) in this embodiment is a constant voltage & current charger. It may be a GY5210 charger, or any other constant voltage & current charger. The case (**1**) has a spare liquid supply bottle (**4**) in it. The power output of the auxiliary charging storage battery (**2**) is connected with the power input of the charger (**3**). The power output of the charger (**3**) is a charging slot (**31**), which fits with the charging plug of the rechargeable battery inside the electronic cigarette, or a charging plug, which fits with the charging slot of the rechargeable battery.

[0074] As shown in FIGS. **23** and **24**, on the body of the shell (**1**), there is a pair of slide ways (**12**) corresponding to the position of the electronic cigarette, and on the slide ways, there is a slide cover (**11**).

[0075] In the second preferred embodiment of this utility model, a restriction component (**10**), which is detachable, is set on one end of the said porous component (**81**). There is a restriction hole (**101**) on the body of the restriction component (**10**). The restriction hole (**101**) corresponds to the atomizing chamber (**811**). The pore diameter of the restriction hole is less than the inner diameter of the atomizing chamber (**811**) to the extent that the size of the restriction component (**10**) installed on the porous component (**81**) varies, for the purpose of airflow capacity control. On the basis of different applications, the restriction component of different sizes and pore diameters may be used.

[0076] In the third preferred embodiment of this utility model, as shown in **11** and **12**, on the outer peripheral wall of the cigarette shell (b), there is a protruding rib (b**2**) that is evenly partitioned. The perforated component for liquid storage (**9**) enters the cigarette holder shell (b) and lies against the protruding rib (b**2**). Thus, there appears a clearance between the outer peripheral surface of the perforated component for liquid storage (**9**) and the interior wall of the shell (b). The clearance is for connection the shell (a) and cigarette holder shell (b). When the user smokes, the air channel (b**1**) absorbs the air to cause airflow inside the shell (a), thus triggering the airflow sensor (**5**) and eventually starting the electronic cigarette. Also, the atomizer (**8**) works to atomize the cigarette liquid and produce gas flow, which enters the cigarette holder shell (b).

[0077] In the fourth preferred embodiment of this utility model, as shown in FIGS. **13**, **14**, **15** and **16**, on one end of the cylinder (**821**), there is a fixed plate (**84**), whose outer peripheral wall has partitioned supports (**841**). The outer ends of the supports (**841**) lie against the interior wall of the shell (a), thus suspending the cylinder (**821**), which is connected with the fixed plate (**84**), in the cavity of the shell (a). On the surface of the fixed plate (**84**), there is a mandril (**842**), whose front end lies against one end of the porous component (**81**), so that the fixed plate (**84**) is separated from the atomizing chamber (**811**) of the porous component (**81**). As a result, the run-through hole on one end of the atomizing chamber (**811**) won't be blocked, and the mist generated in the atomizing chamber (**811**) can be dispersed. One end of the porous component (**81**) has two protuberances (**812**) at the outlet of the atomizing chamber (**811**). Between the two protuberances (**812**) is a clearance. The two protuberances (**812**) lie against the perforated component for liquid storage (**9**).

[0078] In the fifth preferred embodiment of this utility model, as shown in FIGS. **17** and **18**, the atomizer assembly is an atomizer (**8**), which includes a frame (**82**), the porous component (**81**) set on the frame (**82**), and the heating wire (**83**) wound on the porous component (**81**). The frame (**82**) has a run-through hole (**821**) on it. The porous component (**81**) is wound with heating wire (**83**) in the part that is on the side in the axial direction of the run-through hole (**821**). One end of the porous component (**81**) fits with the cigarette bottle assembly. The porous component (**81**) is made of foamed nickel, stainless steel fiber felt, macromolecular polymer foam or foamed ceramics.

[0079] In the sixth preferred embodiment of this utility model, as shown in FIG. **19**, the airflow sensor (**5**) has a silica gel corrugated membrane (**53**), which connects with magnetic steel (**54**) with a Hall element (**52**), or a magneto-diode or a magneto-triode on one of its ends. FIG. **21** shows the electric circuit of the electronic cigarette of this solution.

1. An aerosol electronic cigarette includes a battery assembly, an atomizer assembly and a cigarette bottle assembly, wherein further including a shell (a) that is hollow and integrally formed; the said battery assembly connects with the said atomizer assembly and both are located in the said shell (a); the said cigarette bottle assembly is located in one end of the shell (a), which is detachable; the said cigarette bottle assembly fits with the said atomizer assembly; the said shell (a) has through-air-inlets (a**1**).

2. The aerosol electronic cigarette of claim **1**, wherein the said battery assembly includes the battery, and the operating indicator (**1**), electronic circuit board (**4**), and airflow sensor (**5**), which are connected with the said battery; the signal output of the said airflow sensor (**5**) is connected with the said electronic circuit board (**4**).

3. The aerosol electronic cigarette of claim **2**, further including a check valve (**7**); the said battery is a rechargeable battery (**3**), which has a flexibly connected charging plug (**2**); the blades (**21**) of the said charging plug (**2**) come out of the other end of the said shell (a).

4. The aerosol electronic cigarette of claim **3**, wherein a spring (**6**) between the said charging plug (**2**) and rechargeable battery (**3**), which lies against the body of the said rechargeable battery (**3**) on one end, and its free end lies against the said charging plug (**2**).

5. The aerosol electronic cigarette of claim **2**, wherein the said battery is a rechargeable battery (**3**), which has a charging slot on it; the said operating indicator (**1**) is a LED.

6. The aerosol electronic cigarette of claim **2**, wherein the said airflow sensor (**5**) may be alternatively a semiconductor force-sensitive chip capacitance sensor or an inductance sensor.

7. The aerosol electronic cigarette of claim **2**, wherein the said electronic circuit board (**4**) includes an electronic switch circuit.

8. The aerosol electronic cigarette of claim **2**, wherein the airflow sensor (**5**) has a silica gel corrugated membrane (**53**), which connects with magnetic steel (**54**) with a reed relay (**52**) on one of its ends, both ends of the said reed relay (**52**) correspond to the relay electrodes (**51**) respectively.

9. The aerosol electronic cigarette of claim **2**, wherein the said airflow sensor (**5**) has a silica gel corrugated membrane (**53**), which connects with magnetic steel (**54**) with a Hall element (**52**) or a magneto-diode or a magneto-triode on one of its ends.

10. The aerosol electronic cigarette of claim **3**, wherein the atomizer assembly is an atomizer (**8**), which includes a porous component (**81**) and a heating body.

11. The aerosol electronic cigarette of claim **10**, wherein the said atomizer (**8**) includes an electric heating rod (**82**); the body of the said porous component (**81**) has a run-through atomizing chamber (**811**); the diameter of the said electric heating rod (**82**) is less than the diameter of the said atomizing chamber (**811**); the said electric heating rod (**82**) enters into the said atomizing chamber (**811**), and there is a clearance between the said electric heating rod (**82**) and interior wall of the atomizing chamber (**811**); the said clearance forms a negative pressure cavity (**83**); one end of the said porous component (**81**) fits with the said cigarette bottle assembly.

12. The aerosol electronic cigarette of claim **11**, wherein the said electric heating rod (**82**) includes a cylinder (**821**); the said heating body is heating wire (**822**), which is wound on the wall of the cylinder (**821**); on the wall of both ends of the cylinder (**821**), there are mandrils (**823**) respectively; the said porous component (**81**) has a protuberance (**812**) on one end, and the protuberance (**812**) fits with the cigarette bottle assembly; the said protuberance (**812**) is a protruding half sphere, on the side of which there is a run-through hole (**813**) connecting to the atomizing chamber (**811**).

13. The aerosol electronic cigarette of claim **11**, wherein the said electric heating rod (**82**) includes a cylinder (**821**); the said heating body is made of electrically conductive ceramic PTC material; the said heating body is set on the wall of the said cylinder (**821**); on the wall of both ends of the said cylinder (**821**), there are mandrils (**823**) respectively; the said porous component (**81**) has a protuberance (**812**) on one end, and the said protuberance (**812**) fits with the said cigarette bottle assembly; the said protuberance (**812**) is a protruding half sphere, on the side of which there is a run-through hole (**813**) connecting to the said atomizing chamber (**811**).

14. The aerosol electronic cigarette of claim **10**, wherein the said heating body is heating wire; the said atomizer (**8**) includes a frame (**82**); the said porous component (**81**) is set on the frame (**82**); the heating wire (**83**) is wound on the porous component (**81**); the frame (**82**) has a run-through hole (**821**) on it; the porous component (**81**) is wound with heating wire (**83**) in the part that is on the side in the axial direction of the run-through hole (**821**); one end of the porous component (**81**) fits with the cigarette bottle assembly.

15. The aerosol electronic cigarette of claim **10**, wherein the said porous component (**81**) is made of foamed nickel, stainless steel fiber felt, macromolecular polymer foam or foamed ceramics.

16. The aerosol electronic cigarette of claim **10**, wherein the said heating wire is made of platinum wire, nickel-chromium alloy wire or iron-chromium alloy wire containing rare earth, or is flaked.

17. The aerosol electronic cigarette described in claim **11** features that a restriction component, which is detachable, is set on one end of the said porous component (**81**); there is a restriction hole on the body of the said restriction component;

the said restriction hole corresponds to the said atomizing chamber (**811**); the pore diameter of the said restriction hole is less than the inner diameter of the atomizing chamber (**811**).

18. The aerosol electronic cigarette of claim **12**, wherein the said cigarette bottle assembly includes a hollow cigarette holder shell (b), and a perforated component for liquid storage (**9**) inside the shell (b); one end of the said cigarette holder shell (b) plugs into the shell (a), and the outer peripheral surface of the said cigarette holder shell (b) has an inward ventilating groove (b**2**); on one end surface of the cigarette holder shell (b), there is an air channel (b**1**) extending inward.

19. The aerosol electronic cigarette of claim **18**, wherein the said air channel (b**1**) is located in the center on one end surface of the said cigarette holder shell (b).

20. The aerosol electronic cigarette of claim **18**, wherein one end of the porous component (**81**) lies against one end surface of the said perforated component for liquid storage (**9**), and contacts the perforated component for liquid storage (**9**).

21. The aerosol electronic cigarette of claim **18**, wherein the said perforated component for liquid storage (**9**) is made of such materials as PLA fiber, terylene fiber or nylon fiber.

22. The aerosol electronic cigarette of claim **18**, wherein the said perforated component for liquid storage (**9**) is plastic foam molding or column of multi-layer plates made through plastic injection with polyvinyl chloride, ploypropylene and polycarbonate.

23. The aerosol electronic cigarette of claim **11**, wherein the said aerosol electronic cigarette (**5**) is located in a charging device.

24. The aerosol electronic cigarette of claim **23**, wherein the said charging device includes a case (**1**), which contains an auxiliary charging storage battery (**2**) inside it, and holds the electronic cigarette (**5**) and the charger (**3**) for the rechargeable battery embedded in the electronic cigarette (**5**); the power inputs of the auxiliary charging storage battery (**2**) and charger (**3**) are connected with the power supply respectively.

25. The aerosol electronic cigarette of claim **24**, wherein the said case (**1**) has a spare liquid supply bottle in it.

26. The aerosol electronic cigarette of claim **24**, wherein the said power output of the auxiliary charging storage battery (**2**) is connected with the power input of the charger (**3**).

27. The aerosol electronic cigarette of claim **24**, wherein the power output of the said charger (**3**) is a charging slot (**31**), which fits with the charging plug of the rechargeable battery inside the electronic cigarette, or a charging plug, which fits with the charging slot of the rechargeable battery.

28. The aerosol electronic cigarette of claim **26**, wherein the said charger (**3**) is a constant voltage & current charger.

29. The aerosol electronic cigarette of claim **24**, wherein, on the body of the said shell (**1**), there is a pair of slide ways (**12**) corresponding to the position of the said electronic cigarette, and on the slide ways (**12**), there is a slide cover (**11**).

30. The aerosol electronic cigarette of claim **5**, wherein the atomizer assembly is an atomizer (**8**), which includes a porous component (**81**) and a heating body.

31. The aerosol electronic cigarette of claim **14**, wherein the said cigarette bottle assembly includes a hollow cigarette holder shell (b), and a perforated component for liquid storage (**9**) inside the shell (b); one end of the said cigarette holder shell (b) plugs into the shell (a), and the outer peripheral surface of the said cigarette holder shell (b) has an inward ventilating groove (b**2**); on one end surface of the cigarette holder shell (b), there is an air channel (b**1**) extending inward.

32. The aerosol electronic cigarette of claim **14**, wherein the said aerosol electronic cigarette (**5**) is located in a charging device.

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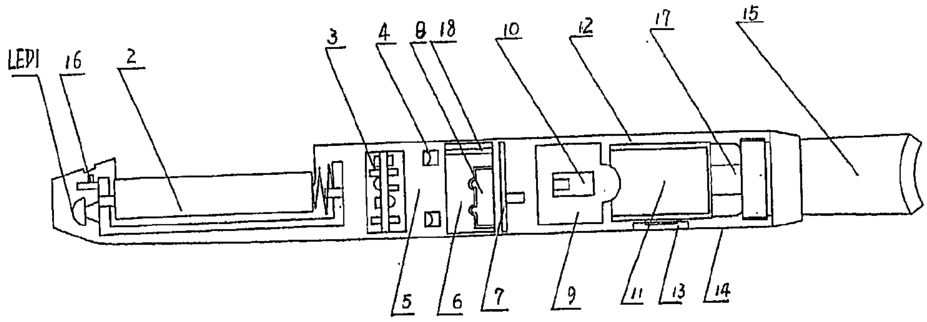

(57) **Abstract:** This invention relates to an aerosol electronic cigarette just containing nicotine without tar, which includes a shell and a suction nozzle. On the exterior wall of the shell, there is an air orifice, while there are an electronic circuit board, a constant pressure cavity, a sensor, a gasliquid separator, an atomizer, and a supplying bottle orderly located in the interior of the shell, wherein the electronic circuit board consists of an electronic switching circuit and a high-frequency generator. At one side of the sensor there is an air duct. A negative pressure cavity is located in the sensor. The atomizer connects with the supplying bottle, and there is an atomizing cavity located in the atomizer. An antiextrusion ring used to fix the supplying bottle is located between the shell and one side of the supplying bottle. At the other side of the supplying bottle there is a mirage duct. The air orifice, the constant pressure, the sensor, the gasliquid separator, the atomizer, and the mirage duct connect orderly and throughout. Without tar, this invention reduces the risk of suffering cancer, meets the requirement of the smoker, need no ignition, and has no endanger of fire.

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(57) 摘要

本发明涉及一种不含有焦油、只含烟碱（尼古丁）的雾化电子烟，包括壳体及吸嘴，壳体的外壁上开有进气孔，壳体内依次设有电子线路板、常压腔、传感器、气液分离器、雾化器、供液瓶；其中电子线路板由电子开关电路及高频发生器组成；在传感器的一侧开有传感器气流通道，传感器内设有负压腔；雾化器与供液瓶相接触，在雾化器的内部设有雾化腔；供液瓶的一侧与壳体之间设有锁定供液瓶的挡圈，供液瓶的另一侧开有雾汽通道；进气孔、常压腔、传感器、气液分离器、雾化器、雾汽通道、导气孔、吸嘴依次相连通。本发明无焦油，大大降低致癌风险，使用者仍有吸烟的感觉和兴奋，无需点燃，无火灾危害。

雾化电子烟

技术领域

本发明涉及一种电子烟，特别是一种不含有焦油、只含烟碱（尼古丁）的雾化电子烟。

背景技术

在当今“吸烟有害健康”已成为常识的情况下，全世界目前仍有10亿人吸烟，而且每年这个数字还在扩大。2003年3月1日世界卫生组织（WHO）通过的第一个国际禁烟协定《烟草控制框架公约》，据WHO提供的数字表明，吸烟每年造成490万人死亡，尽管吸烟可导致严重的呼吸系统疾病和癌症，让吸烟者完全戒烟是极其困难的事。

香烟的有效成分是烟碱（即尼古丁），吸烟时烟碱随着香烟燃烧产生的大量焦油雾滴进入肺泡后被迅速吸收，烟碱被吸收入血后作用于中枢神经系统的受体上，引起类似兴奋剂的“陶醉感”，如吸烟者所经历的头晕目眩或飘飘然的感觉。

烟碱是小分子生物碱，在小剂量下对人体基本无害，而且在血液中的半衰期极短。烟草的有害物质主要是焦油，烟草焦油是由数千种成分组成，其中有数十种成分是致癌物。目前证实被动吸烟对不吸烟者的危害更大。

为了寻找只含烟碱而不含有害焦油的香烟代用品，有许多发明是用较纯的烟碱制成诸如“戒烟贴”、“烟碱含漱水”、“包装在有抛射剂的高压气罐喷雾剂”、“烟碱口香糖”、“烟碱饮料”等产品，这些产品虽然没有焦油的危害，但因烟碱吸收缓慢，在血液中不能建立有效的高峰浓度，不能解决需求烟碱“过瘾”的感觉，同时也剥夺了吸烟者已经养成的“抽”、“吸”的习惯，因而类似的产品不能真正的作为戒烟用品或香烟代用品。

发明内容

为了克服上述不足，本发明的目的在于提供一种具有戒烟和香烟代用品作用的雾化电子烟。

本发明的目的是通过以下技术方案来实现的：

本发明包括壳体及吸嘴，壳体的外壁上开有进气孔，壳体内依次设有电子线路板、

常压腔、传感器、气液分离器、雾化器、供液瓶；其中电子线路板由电子开关电路及高频振荡器组成；在传感器的一侧开有传感器气流通道，与壳体内腔相通，传感器内设有负压腔；雾化器与供液瓶相接触，与壳体之间留有空隙，在雾化器的内部设有雾化腔；供液瓶的一侧与壳体之间设有锁定供液瓶的挡圈，供液瓶的另一侧留有雾汽通道；进气孔、常压腔、传感器、气液分离器、雾化器、雾汽通道、导气孔、吸嘴依次相连通；壳体内的前端还包括一个发光二极管和电池，共同构成一个烟嘴形、雪茄形或烟斗形的整体。

其中：在壳体的内壁上加设有显示屏，与电子线路板连接；在壳体内与传感器并联的有用于手动清洁的微动开关；传感器与其内部的负压腔之间设有波纹膜，传感器内还设有第一磁钢、第二磁钢及置于两者之间的干簧管，第二磁钢固接在波纹膜上；传感器内置有硅胶件逆止阀，阀内设有第三磁钢，阀外靠近第三磁钢的一侧设有干簧管；气液分离器上开有通孔，在气液分离器上的通孔外套有硅胶件逆止阀；雾化腔的雾化腔壁上开有溢流孔，雾化腔腔内设有加热体，在加热体的一侧开有第一气流喷射孔，多孔体包在雾化腔壁外，雾化器的一侧设有第一压电片，另一侧设有凸起；雾化器中加设第二压电片；雾化器中的多孔体可用泡沫镍、不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成；加热体可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体；雾化腔壁可用氧化铝或陶瓷制成；气液分离器可用塑料或硅橡胶制成；供液瓶内装有贮液多孔体，其可用聚丙纤维、涤纶纤维或尼龙纤维充填，或用塑料发泡成形体充填；也可用聚氯乙烯、聚丙烯、聚碳酸酯注塑成多层板的柱状物；干簧管、第一磁钢、第二磁钢、波纹膜可用有封闭膜的半导体应变片来代替，安装在传感器波纹膜位置。

本发明还公开了另一种结构的雾化电子烟，在壳体内，雾化器后置，供液瓶设在气液分离器和雾化器之间，在供液瓶的一端加设有将供液瓶压紧在雾化器上的弹片。

本发明的优点是：吸烟无焦油，大大降低致癌风险，使用者仍有吸烟的感觉和兴奋，无需点燃，无火灾危害。

本发明的装置和连接结构在贮液器稍加改动后可装入常规药物供肺内给药器械。

附图说明

图 1 为本发明的一种整体结构示意图；

图 2 为本发明的另一种整体结构示意图；

图 3 为本发明带显示屏的整体结构示意图；

图 4 为本发明传感器的结构图；

图 5 为本发明带有硅胶件逆止阀的传感器结构图；

图 6 为本发明一种雾化器的结构图；

图 7 为本发明雾化器中陶瓷件的结构图；

图 8 为本发明另一种雾化器的结构图；

图 9 为本发明一种气液分离器的结构图；

图 10 为本发明另一种气液分离器的结构图；

图 11 为本发明供液瓶及吸嘴的连接结构图；

图 12 为本发明的电路原理图。

具体实施方式

下面结合附图对本发明作进一步详述。

实施例 1

如图 1 所示，本发明可构成一个烟嘴形、雪茄形或烟斗形的整体。壳体 14 的外壁上开有进气孔 4，壳体 14 内顺序设置有发光二极管 LED1、电池 2、电子线路板 3、常压腔 5、传感器 6、气液分离器 7、雾化器 9、供液瓶 11、吸嘴 15。电子线路板 3 由电子开关电路及高频振荡器组成，在传感器 6 的一侧开有传感器气流通道 18，与壳体 14 内腔相通。如图 4 所示，传感器 6 内设有负压腔 8，由波纹膜 22 与传感器 6 隔开。传感器 6 内还设有第一磁钢 20、第二磁钢 21 及置于两者之间的干簧管 K1，第二磁钢 21 固接在波纹膜 22 上。雾化器 9 通过凸起 36 与供液瓶 11 相接触，与壳体 14 之间留有空隙，雾化器 9 内部设有雾化腔 10。如图 6、图 7 所示，雾化腔 10 的雾化腔壁 25 上开有溢流孔 29，腔内设有加热体 RL，可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体。正对加热体 RL 的一侧开有喷射孔，喷射孔可根据雾化腔壁 25 的材料而选用第一气流喷射孔 24 或第二气流喷射孔 30。第一气流喷射孔 24 可采用 0.1mm~1.3mm 狭缝结构或Φ0.2mm~1.3mm 圆孔的单孔及多孔结构；第二气流喷射孔 30 的直径在 0.3mm~1.3mm。雾化腔壁 25 外包有多孔体 27，可用泡沫镍、不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成。在雾化器 9 上还设有第一压电片 M1。雾化腔壁 25 可用氧化铝或陶瓷制成。如图 9 所示，气液分离器 7 上开有通孔，可用塑料或硅橡胶制成。如图 11 所示，供液瓶 11 的一侧与壳体

14之间设有锁定供液瓶11的挡圈13，另一侧开有雾汽通道12，瓶内装有贮液多孔体28，可用聚丙纤维、涤纶纤维或尼龙纤维充填，或用塑料发泡成形体如聚胺酯泡沫柱或聚丙泡沫柱充填，也可用聚氯乙烯、聚丙烯、聚碳酸酯注塑成多层板的柱状物。进气孔4、常压腔5、传感器6、气液分离器7、雾化器9、雾汽通道12、导气孔17、吸嘴15依次相连通。

如图12电路原理图所示，电子开关电路以场效应功率管U1为核心。K1为干簧管（位于传感器6中）、RL为加热体（位于雾化器9中）、LED1为发光二极管、U2为低电压检测片（用于对锂电池的过放电保护）、M1为第一压电片，第一电容C1、第二电容C2、第三电阻R3、第一电感L1、第三电容C3、三极管BG1、第一压电片M1构成三点式电容振荡器，即高频振荡器。其电路原理为：当干簧管K1闭合时，场效应功率管U1开启，加热体RL工作，同时三点式电容振荡器起振，第一压电片M1为雾化器9提供高频机械振动波，达到雾化效果。

当吸烟者吸烟时，吸嘴15处于负压状态，常压腔5与负压腔8之间的气压差或高速气流导致传感器6输出启动信号，与之相连接的电子线路板3工作。此时传感器6内的波纹膜22变形，带动第二磁钢21远离干簧管K1，干簧管K1在第一磁钢20的过量磁力线作用下闭合（即K1闭合），启动作为电子开关的场效应功率管U1，高频振荡器采用三点式电容振荡器，频率在550KHz至8MHz，电路中频率自动微调与环形的第一压电片M1谐振，对液体分子供能，同时发光二极管LED1在可充电电池2供电下发光。大气由进气孔4进到常压腔5内，经传感器气流通道18、再经气液分离器7上的通孔流到雾化器9内的雾化腔10，经过喷射孔的高速气流带动多孔体27中的烟液以微滴形式喷射进雾化腔10内，通过第一压电片M1的超声雾化，再在加热体RL的作用下进一步雾化，雾化后的大直径微滴在涡流的作用下附壁经溢流孔29被多孔体27重吸收，小直径微滴悬浮在气流中形成气溶胶经雾汽通道12、导气孔17、吸嘴15被吸出。供液瓶11中的贮液多孔体28与雾化器9上的凸起36接触实现毛细浸润供液。

吸嘴15上制有螺纹，当供液瓶11中的烟液用尽时，可旋转吸嘴15将其拧下，取出供液瓶11，将烟液注入供液瓶11内，重新装入壳体14内，拧紧吸嘴15。

干簧管K1、第一磁钢20、第二磁钢21、波纹膜22还可用有封闭膜的半导体应变片来代替，安装在传感器波纹膜位置。

为了简化设计，可取消雾化器9上的第一压电片M1，仅靠加热体RL将烟液雾

化。这种雾化器的尺寸可做的较小，整支雾化电子烟的连接结构与实施例一相同。此外，还可如图 8 所示，将雾化器 9 中的第一压电片 M1、加热体 RL 取消，在雾化腔内加设单层或多叠层、平板形的第二压电片 35，通过喷射孔的气流在其中心振动聚焦点雾化，达到强超声雾化的效果。

如图 10 所示，气液分离器 7 的通孔外还可套有硅胶件逆止阀 31。吸烟时，气流到达通孔，由于通孔内的气压升高，使硅胶件逆止阀 31 开启，气流通过；不吸烟时，硅胶件逆止阀 31 关闭。

如图 5 所示，传感器 6 还可设计成带有硅胶件逆止阀 31 的结构。吸烟时，气流汇聚在硅胶件逆止阀 31 内，气压升高、气体膨胀，阀内的第三磁钢 34 逐渐靠近干簧管 K1，直至干簧管 K1 闭合、开启电路，随着气压差继续增大，硅胶件逆止阀 31 的出气口开启。干簧管 K1 也可以用霍尔器件或磁敏二极管或磁敏三极管代替。

实施例 2

如图 2 所示，为了改善供液状态，在壳体 14 内，雾化器 9 后置，供液瓶 11 设在气液分离器 7 和雾化器 9 之间，在供液瓶 11 的一端加设有将供液瓶 11 压紧在雾化器 9 上的弹片 33，其他部件及工作原理与实施例 1 同。

在实施例 1、实施例 2 所述的雾化电子烟的壳体 14 的内壁上，还可加设数字显示屏 32，与电子开关电路中场效应功率管 U1 输出端相连，用来显示每天吸烟的次数、电池容量。传感器 6 为线性信号输出，与吸力的强弱成正比（即吸力越大、工作的时间越长），雾化器 9 按线性方式工作，以模拟更真实的人性化香烟。

在壳体 14 内与传感器 6 还并联有用于手动清洁的微动开关 16。在不吸烟时，按下微动开关 16，与其并联的传感器 6 工作，或将壳体 14 内的残留物及其他杂质清除干净。

用于雾化的烟液含有 0.4~3.5％的烟碱，烟用香精 0.05~2％，有机酸 0.1~3.1％，抗氧剂 0.1~0.5％，余量为 1，2-丙二醇。

权 利 要 求 书

1．一种雾化电子烟，包括壳体及吸嘴，其特征在于：所述壳体（14）的外壁上开有进气孔（4），壳体（14）内依次设有电子线路板（3）、常压腔（5）、传感器（6）、气液分离器（7）、雾化器（9）、供液瓶（11）；其中电子线路板（3）由电子开关电路及高频振荡器组成；在传感器（6）的一侧开有传感器气流通道（18），与壳体（14）内腔相通，传感器（6）内设有负压腔（8）；雾化器（9）与供液瓶（11）相接触，与壳体（14）之间留有空隙，在雾化器（9）的内部设有雾化腔（10）；供液瓶（11）的一侧与壳体（14）之间设有锁定供液瓶（11）的挡圈（13），供液瓶（11）的另一侧留有雾汽通道（12）；进气孔（4）、常压腔（5）、传感器（6）、气液分离器（7）、雾化器（9）、雾汽通道（12）、导气孔（17）、吸嘴（15）依次相连通；壳体（14）内的前端还包括一个发光二极管（LED1）和电池（2），共同构成一个烟嘴形、雪茄形或烟斗形的整体。

2．按照权利要求 1 所述的雾化电子烟，其特征在于：在壳体（14）内，雾化器（9）后置，供液瓶（11）设在气液分离器（7）和雾化器（9）之间，在供液瓶（11）的一端加设有将供液瓶（11）压紧在雾化器（9）上的弹片（33）。

3．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：在壳体（14）的内壁上加设有显示屏（32），与电子线路板（3）连接。

4．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：在壳体（14）内与传感器（6）并联的有用于手动清洁的微动开关（16）。

5．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述的传感器（6）与其内部的负压腔（8）之间设有波纹膜（22），传感器（6）内还设有第一磁钢（20）、第二磁钢（21）及置于两者之间的干簧管（K1），第二磁钢（21）固接在波纹膜（22）上。

6．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述的传感器（6）内置有硅胶件逆止阀（31），阀内设有第三磁钢（34），阀外靠近第三磁钢（34）的一侧设有干簧管（K1）。

7．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述的气液分离器（7）上开有通孔。

8．按照权利要求 7 所述的雾化电子烟，其特征在于：在气液分离器（7）上的通

孔外套有硅胶件逆止阀（31）。

9．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述雾化腔（10）的雾化腔壁（25）上开有溢流孔（29），雾化腔（10）腔内设有加热体（RL），在加热体（RL）的一侧开有第一气流喷射孔（24），多孔体（27）包在雾化腔壁（25）外，雾化器（9）的一侧设有第一压电片（M1），另一侧设有凸起（36）。

10．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述的雾化器（9）中加设第二压电片（35）。

11．按照权利要求 9 所述的雾化电子烟，其特征在于：所述的雾化器（9）中的多孔体（27）可用泡沫镍、不锈钢纤维毡、高分子多聚物发泡体及泡沫陶瓷制成；加热体（RL）可用铂丝、镍铬合金或含有稀土元素的铁铬铝合金丝制成，也可制成片状体；雾化腔壁（25）可用氧化铝或陶瓷制成。

12．按照权利要求 7 所述的雾化电子烟，其特征在于：所述的气液分离器（7）可用塑料或硅橡胶制成。

13．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：所述供液瓶（11）内装有贮液多孔体（28），其可用聚丙纤维、涤纶纤维或尼龙纤维充填，或用塑料发泡成形体充填；也可用聚氯乙烯、聚丙烯、聚碳酸酯注塑成多层板的柱状物。

14．按照权利要求 5 所述的雾化电子烟，其特征在于：干簧管（K1）、第一磁钢（20）、第二磁钢（21）、波纹膜（22）可用有封闭膜的半导体应变片来代替，安装在传感器波纹膜位置。

15．按照权利要求 1 或 2 所述的雾化电子烟，其特征在于：注入供液瓶（11）内用于雾化的烟液含有 0.4~3.5％的烟碱，烟用香精 0.05~2％，有机酸 0.1~3.1％，抗氧剂 0.1~0.5％，余量为 1，2-丙二醇。

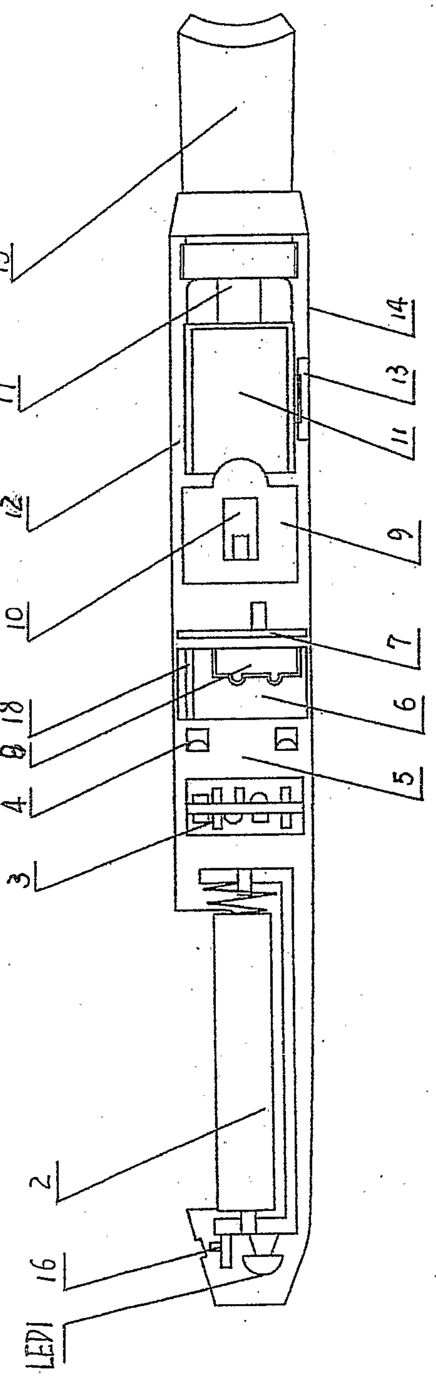

图 1

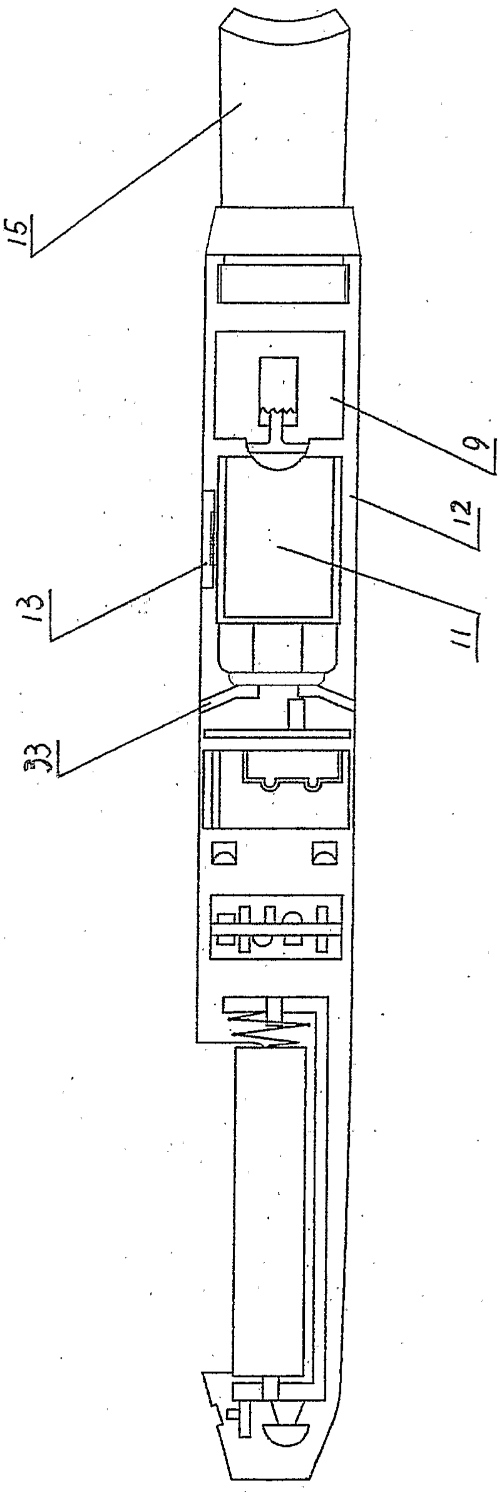

图 2

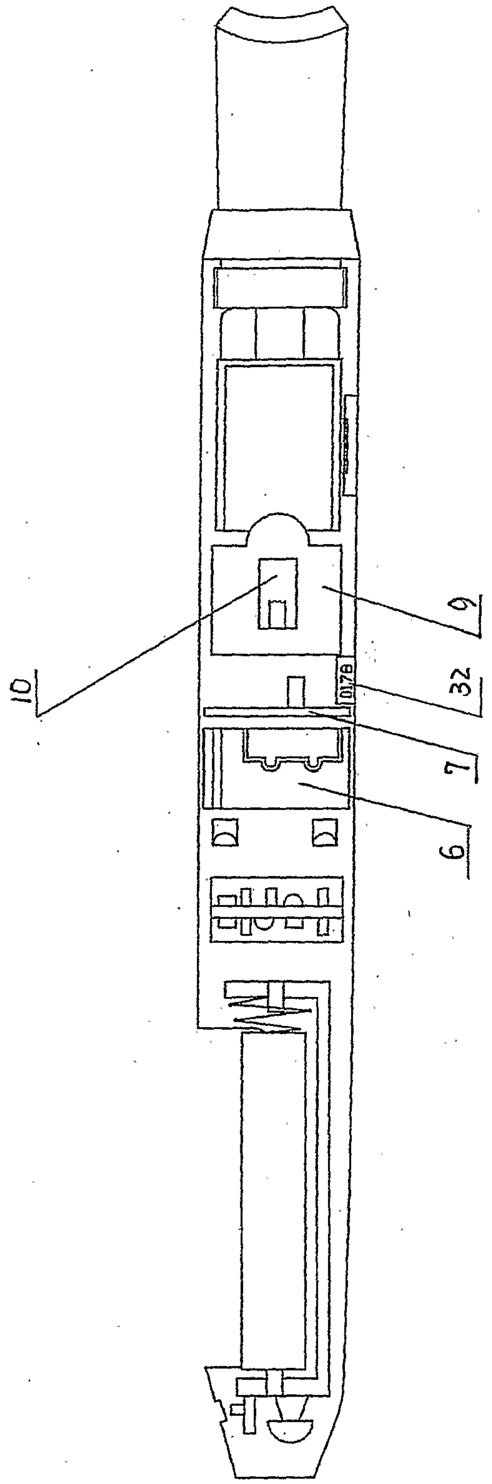

图 3

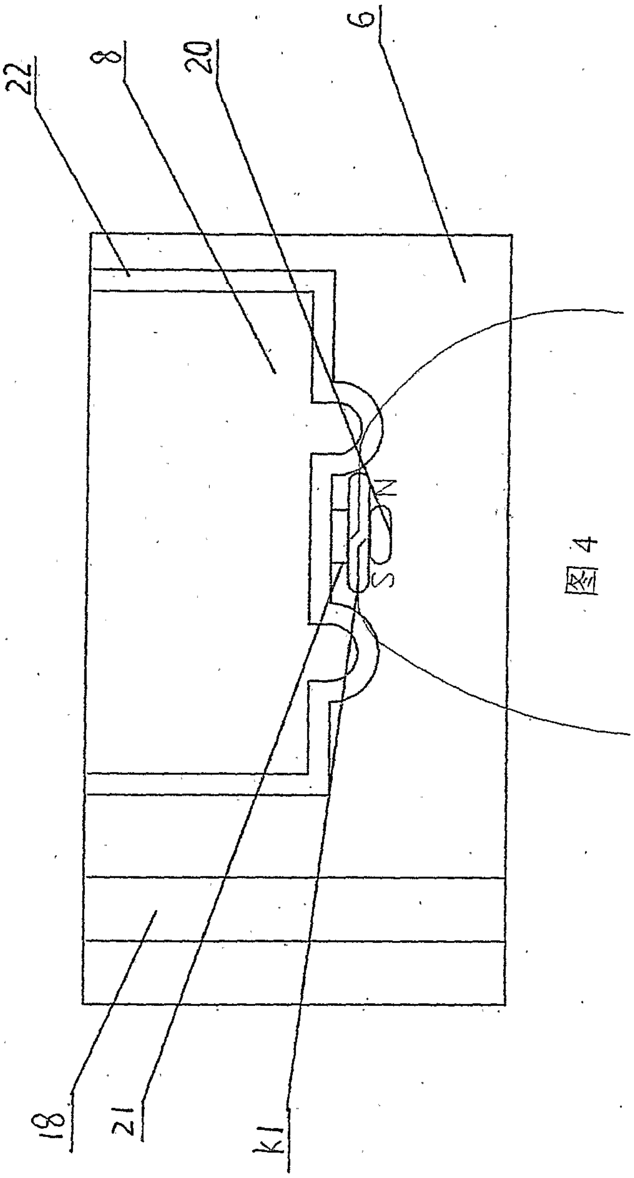

图 4

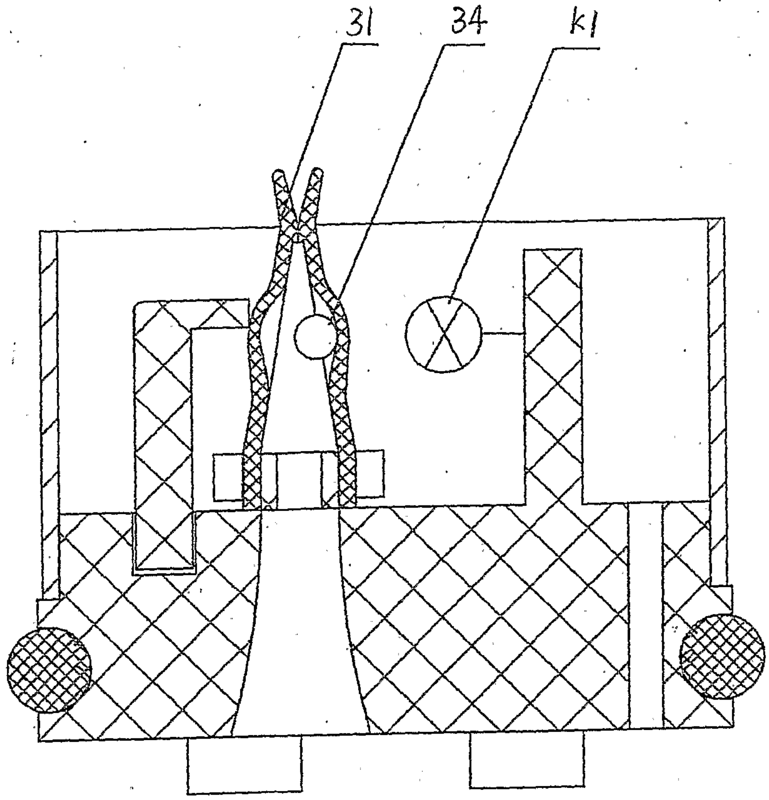

图 5

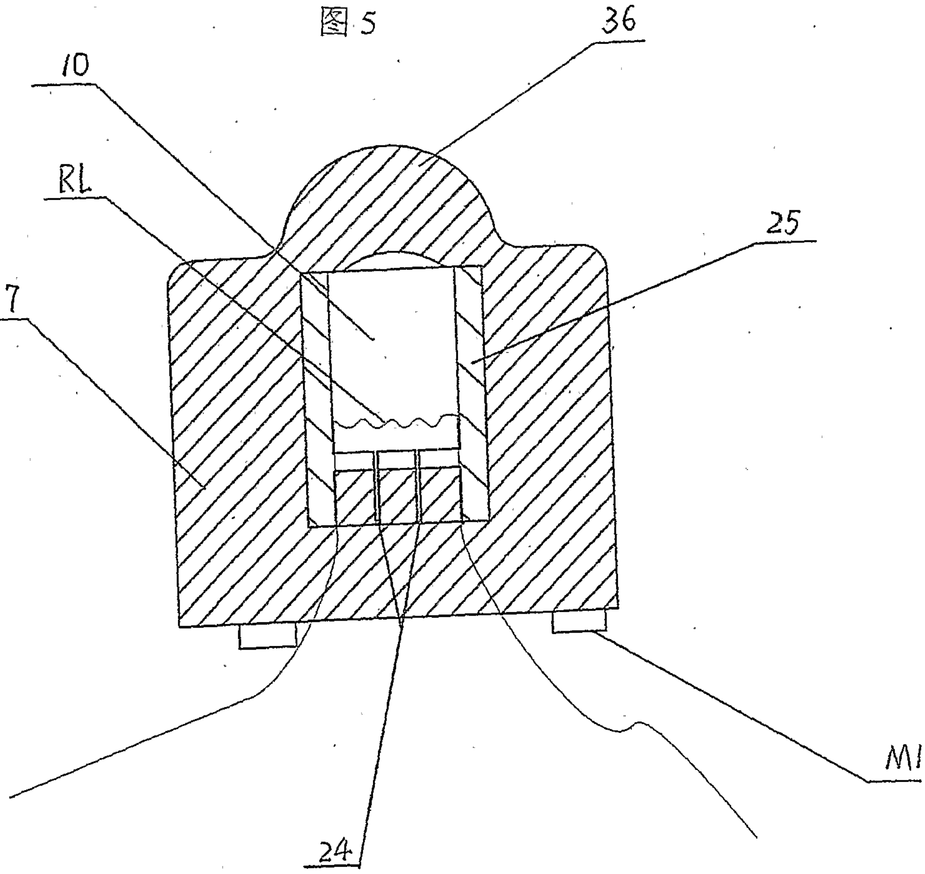

图 6

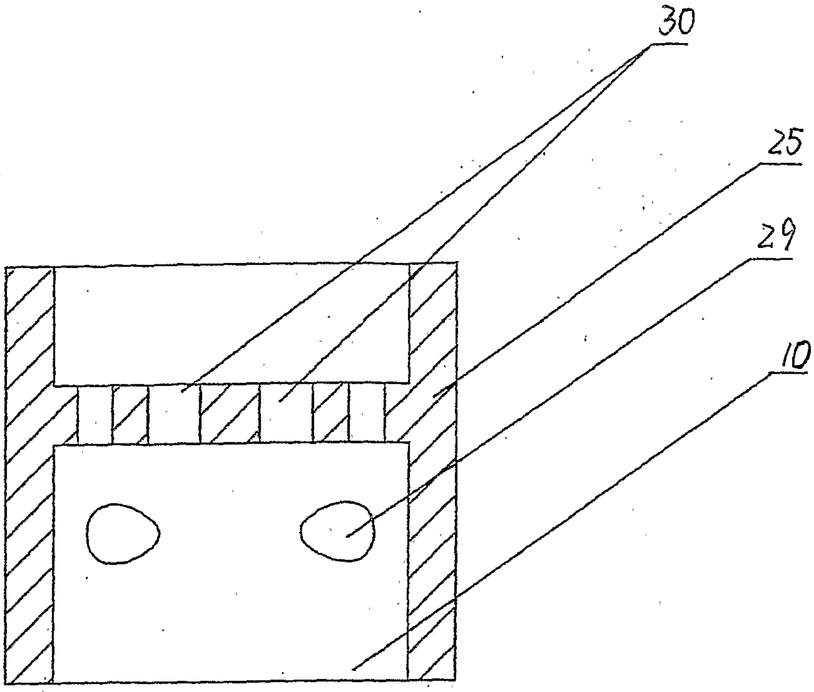

图 7

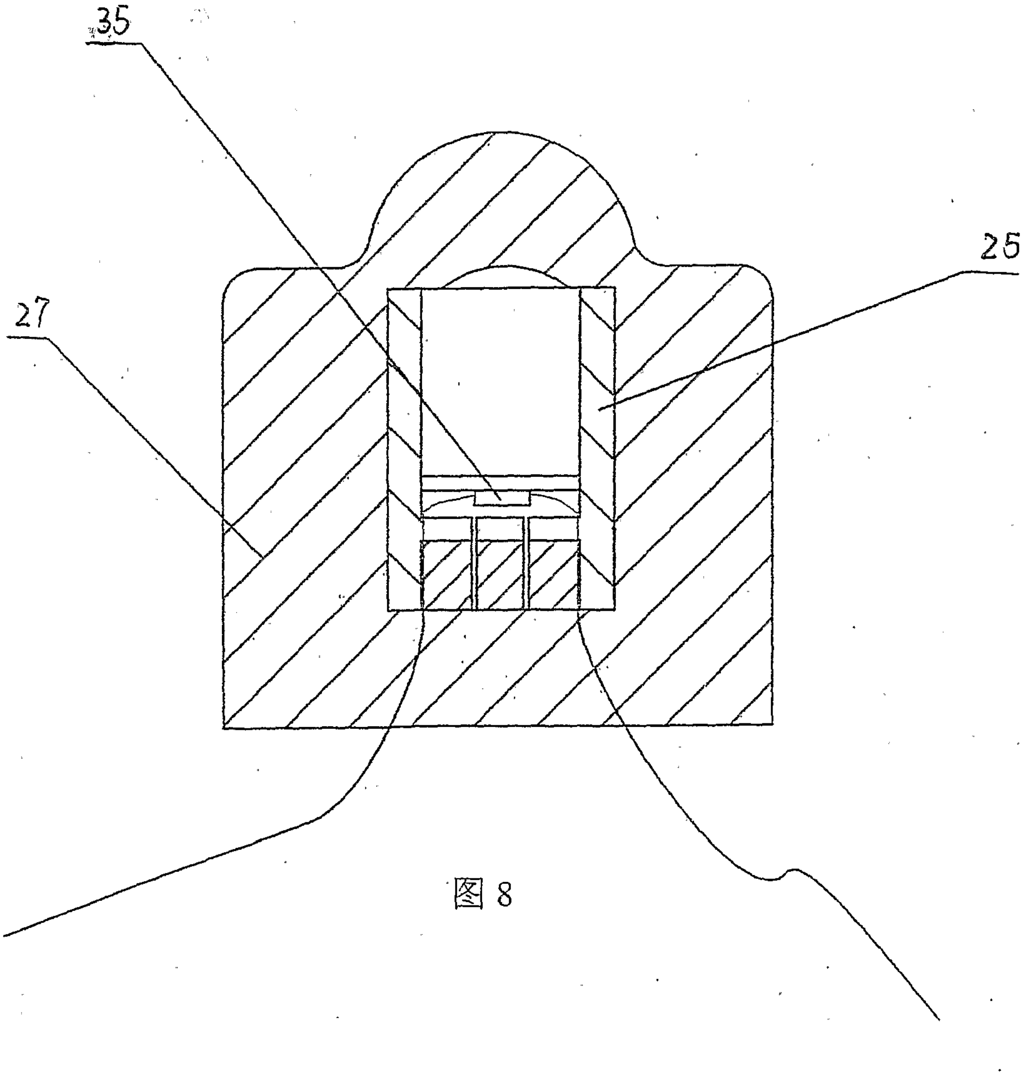

图 8

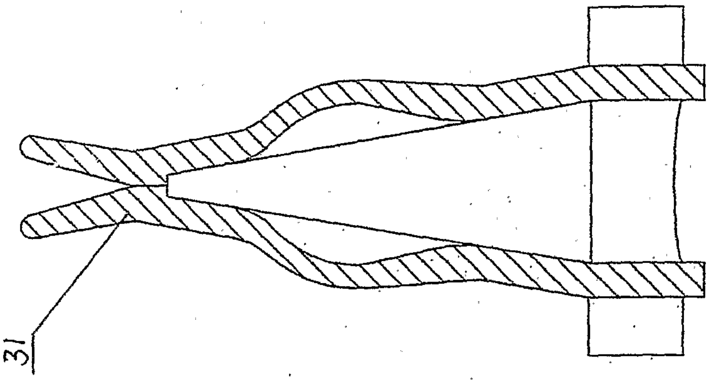

图 10

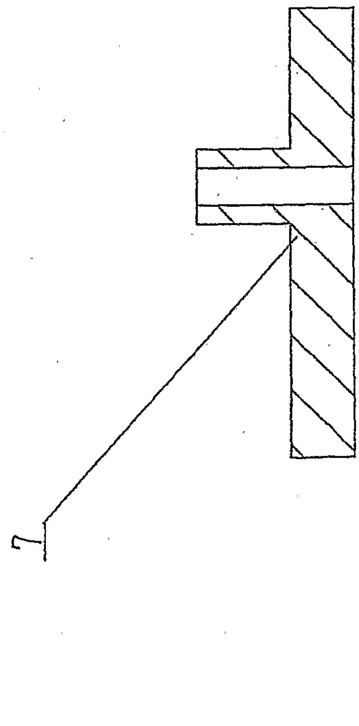

图 9

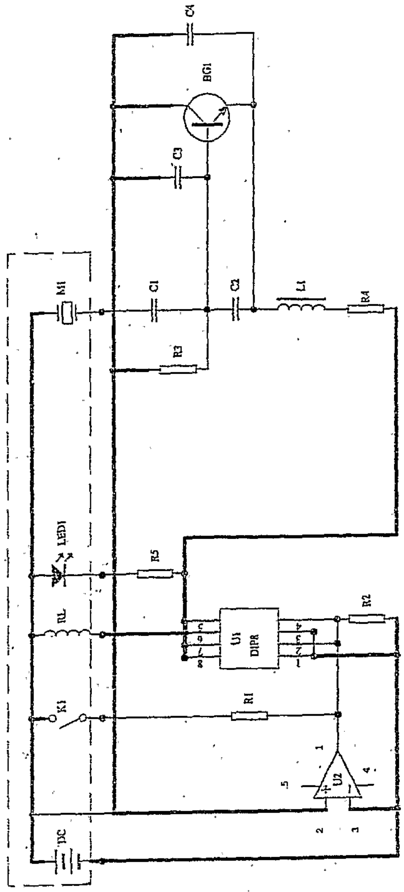

图 12

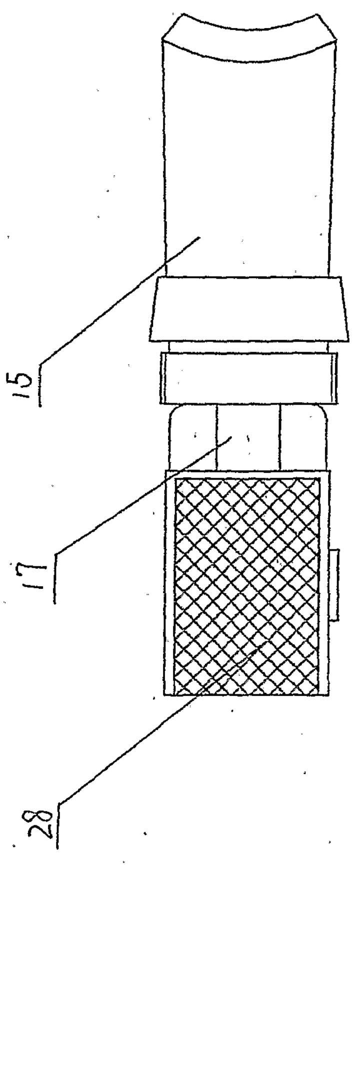

图 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2005/000337

A. CLASSIFICATION OF SUBJECT MATTER

A24F47 / 00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A24F+

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Chinese document patent:(1985-)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, EPO, WPI, PAJ: atomiz+ aerosol cigar or cigarette electronic nicotine or nicotinamide

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN1135860A(XU Du) 20.Nov.1996(20.11.1996)page 2, line 13 to page 4, line 3	1−15
A	CN1252961A (SONG Huoqiang) 17.May 2000 (17.05.2000) page 1, line 26−38	1−15
A	EP0342538A (REYNOLDS TOBACCO CO R J) 23.Nov 1989(23.11.1989)page 5, line 10 to page 12, line 38	1−15
A	EP0545186A (REYNOLDS TOBACCO CO R J) 09.Jun 1993(09.06.0993)page 5, line 43to page 24, line 57	1−15
A	US4945929 (BOC GROUP PLC & BRITISH AMERICAN TOBACCO CO LTD) 07.Aug 1990(07.08.1990) column 2, line 63 to column 4, line 6	1−15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search 16.Jun.2005(16.06.2005)	Date of mailing of the international search report 14 JUL 2005 (14・07・2005)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer 红倪 NI Xiaohong 倪 Telephone No. 86-10-62085753

Form PCT/ISA /210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2005/000337

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN1135860A	20.Nov. 1996	NONE	
CN1252961A	17.May. 2000	NONE	
EP0342538A	23.Nov. 1989	AU3468589A	16.Nov.1989
		Fi892321 A	17.Nov.1989
		FI81950B	28.Sep.1990
		FI81950C	10.Jan.1991
		DK233489A	17.Nov.1989
		NO167952B	23.Sep.1991
		NO167952C	02.Jan.1992
		PT90558A	30.Nov. 1989
		CN1038014A	20.Dec.1989
		ZA8903010A	27.Dec.1989
		MA21549A	31.Dec.1989
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		SU1812955A	30.Apr.1993
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		MX169608B	14.Jul.1993
		PH27614A	31.Aug.1993
		BG60140A	15.Nov.1993
		LV5377A	10.Mar.1994
		US5360023A	01.Nov.1994
EP0545186A	09.Jun.1993	MX9206462A	01.May.1993
		ZA9208271A	05.May.1993
		NO924577A	28.May.1993
		NO302394B	02.Mar .1998

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2005/000337

		CA2081283A	28.May.1993
		FI925319A	28.May.1993
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		FI97941C	25.Mar..1997
		BR9204581A	01.Jun..1993
		CN1072576A	02.Jun .1993
		CN1037318B	11.Feb.1998
		AU2967292A	03.Jun.1996
		SI9200348A	30.Jun.1993
		PL296752A	09.Aug.1993
		PL170199B	29.Nov.1996
		CZ9203500A	15.Sep.1993
		JP6046818A	22.Feb.1994
		JP3506722B	15.Mar.2004
		US5327917A	12.Jul.1994
		LT231A	25.Sep.1994
		LT3188B	27.Mar.1995
		RO109272B	30.Jan.1995
		US5396911A	14.Mar.19995
		HR921342A	30.Apr.1995
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		SK350092A	07.Jun.1995
		HU69944A	28.Sep.1995
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		IL103536A	16.Oct.1996
		EG19959A	31.Oct.1996
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		BG61549B	30.Dec.1997
		HU215694B	01.Feb.1999
		KR270913B	01.Nov.2000
US4945929A	07.Aug. 1990	GB2191718A	23.Dec.1987
		DE3719718A	23.Dec.1987

Form PCT/ISA /210 (extra sheet) (April 2005)

国际检索报告	国际申请号 PCT/CN2005/000337

A. 主题的分类

A24F47 / 00

按照国际专利分类表(IPC)或者同时按照国家分类和 IPC 两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

IPC7：A24F47+

包含在检索领域中的除最低限度文献以外的检索文献

中国专利文献（1985－）

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

EPO，WPI，PAJ： atomiz+ aerosol cigar or cigarette electronic nicotine or nicotinamide

CNPAT：雾化+喷雾 烟 电 尼古丁+烟碱

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
A	CN1135860A(徐度) 20.11 月.1996(20.11.1996)第 2 页第 13 行至第 4 页第 3 行	1－15
A	CN1252961A（宋国强）17.05 月 2000（17.05.2000）说明书第 1 页第 26－38 行	1－15
A	EP0342538A（REYNOLDS TOBACCO CO R J ）23.11 月 1989（23.11.1989）说明书第 5 页第 10 行至第 12 页第 38 行	1－15
A	EP0545186A（REYNOLDS TOBACCO CO R J ）09.06 月 1993（09.06.1993）说明书第 5 页第 43 行至第 24 页第 57 行	1－15
A	US4945929A（BOC GROUP PLC 和 BRITISH AMERICAN TOBACCO CO LTD ）07.8 月 1990（07.08.1990）说明书第 2 页第 63 行至第 4 栏第 6 行	1－15

☐ 其余文件在 C 栏的续页中列出。 ☒ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期 16.6 月.2005(16.06.2005)	国际检索报告邮寄日期 14 · 7月 2005 (14 · 07 · 2005)
中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路 6 号 100088 传真号： (86-10)62019451	受权官员 倪晓红 电话号码：(86-10)62085753

国际检索报告 关于同族专利的信息	国际申请号 PCT/CN2005/000337

检索报告中引用的专利文件	公布日期	同族专利	公布日期
CN1135860A	20.11 月 1996	无	
CN1252961A	17.05 月 2000	无	
EP0342538A	23.11 月 1989	AU3468589A	16.11 月 1989
		Fi892321 A	17.11 月 1989
		FI81950B	28.09 月 1990
		FI81950C	10.01 月 1991
		DK233489A	17.11 月 1989
		NO167952B	23.09 月 1991
		NO167952C	02.01 月 1992
		PT90558A	30.11 月 1989
		CN1038014A	20.12 月 1989
		ZA8903010A	27.12 月 1989
		MA21549A	31.12 月 1989
		BR8902236A	09.01 月 1990
		PL279423A	22.01 月 1990
		PL159798B	29.02 月 1993
		JP2053476A	22.02 月 1990
		HU50434A	28.02 月 1990
		YU100189A	30.06 月 1990
		AU614364B	29.02 月 1991
		HU203961B	28.11 月 1991
		DD298202A	13.02 月 1992
		US5137034A	11.08 月 1992
		IL89899A	01.12 月 1992
		SU1812955A	30.04 月 1993
		IN172374A	10.07 月 1993
		MX169608B	14.07 月 1993
		PH27614A	31.08 月 1993
		BG60140A	15.11 月 1993
		LV5377A	10.03 月 1994
		US5360023A	01.11 月 1994
EP0545186A	09.06 月 1993	MX9206462A	01.05 月 1993
		ZA9208271A	05.05 月 1993
		NO924577A	28.05 月 1993
		NO302394B	02.03 月 1998

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2005/000337

检索报告中引用的专利文件	公布日期	同族专利	公布日期
		CA2081283A	28.05 月 1993
		FI925319A	28.05 月 1993
		FI97941B	13.12 月 1996
		FI97941C	25.03 月.1997
		BR9204581A	01.06 月.1993
		CN1072576A	02.06 月 1993
		CN1037318B	11.02 月 1998
		AU2967292A	03.06 月 1996
		SI9200348A	30.06 月 1993
		PL296752A	09.08 月 1993
		PL170199B	29.11 月 1996
		CZ9203500A	15.09 月 1993
		JP6046818A	22.02 月 1994
		JP3506722B	15.03 月 2004
		US5327917A	12.07 月 1994
		LT231A	25.09 月 1994
		LT3188B	27.03 月 1995
		RO109272B	30.01 月 1995
		US5396911A	14.03 月 19995
		HR921342A	30.04 月 1995
		US5415186A	16.05 月 1995
		SK350092A	07.06 月 1995
		HU69944A	28.09 月 1995
		AU664870B	07.12 月 1995
		IL103536A	16.10 月 1996
		EG19959A	31.10 月 1996
		PH30648A	16.09 月 1997
		RU2097996C	10.12 月 1997
		BG61549B	30.12 月 1997
		HU215694B	01.02 月.1999
		KR270913B	01.11 月.2000
US4945929A	07.08 月 1990	GB2191718A	23.12 月.1987
		DE3719718A	23.12 月 1987

Patents

WO 2005/099494

An aerosol electronic cigarette

Abstract

This invention relates to an aerosol electronic cigarette just containing nicotine without tar, which includes a shell and a suction nozzle. On the exterior wall of the shell, there is an air orifice, while there are an electronic circuit board, a constant pressure cavity, a sensor, a gasliquid separator, an atomizer, and a supplying bottle orderly located in the interior of the shell, wherein the electronic circuit board consists of an electronic switching circuit and a high-frequency generator. At one side of the sensor there is an air duct. A negative pressure cavity is located in the sensor. The atomizer connects with the supplying bottle, and there is an atomizing cavity located in the atomizer. An antiextrusion ring used to fix the supplying bottle is located between the shell and one side of the supplying bottle. At the other side of the supplying bottle there is a mirage duct. The air orifice, the constant pressure, the sensor, the gasliquid separator, the atomizer, and the mirage duct connect orderly and throughout. Without tar, this invention reduces the risk of suffering cancer, meets the requirement of the smoker, need no ignition, and has no endanger of fire.

Classifications

A24F40/42 Cartridges or containers for inhalable precursors

View 28 more classifications

WO2005099494A1
WIPO (PCT)

Download PDF Find Prior Art Similar

Other languages: French, Chinese

Inventor: Lik Hon

Worldwide applications

2004 ~~CN~~ 2005 ~~CA~~ ~~BR~~ *PT* ~~KR~~ ~~JP~~ *SI* ~~CN~~ ES EP US *AT* *UA* WO DK DE *PL* ~~AU~~ ~~EA~~ *MY* 2006 ~~IL~~ 2007 ~~HK~~ 2009 *CY* 2010 US 2012 US 2013 US 2014 US 2015 US ~~US~~ 2016 US 2017 US 2018 US US 2019 US 2020 US US US US

Application PCT/CN2005/000337 events

2004-04-14	Priority to CN2004200311820U
2004-04-14	Priority to CN200420031182.0
2005-03-18	Application filed by Lik Hon
2005-10-27	Publication of WO2005099494A1
2008-12-29	First worldwide family litigation filed

Info: Patent citations (238), Non-patent citations (1), Cited by (525), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, PatentScope, Discuss

Claims

Hide Dependent

Claim

An atomized electronic cigarette, comprising a casing and a nozzle, characterized in that: an outer wall (4) is opened on an outer wall of the casing (14), and an electronic circuit is sequentially arranged in the casing (14) Plate (3), atmospheric pressure chamber (5), sensor (6), gas-liquid separator (7), atomizer (9), liquid supply bottle (11); wherein electronic circuit board (3) is controlled by electronic switch circuit And a high-frequency oscillator; on one side of the sensor (6), there is a sensor air flow channel (18), which communicates with the inner cavity of the casing (14), and a negative pressure chamber (8) is arranged in the sensor (6); The device (9) is in contact with the liquid supply bottle (11), and a gap is left between the casing (14) and the atomization chamber (10) inside the atomizer (9); the liquid supply bottle (11) A retaining ring (13) for locking the liquid supply bottle (11) is disposed between one side and the casing (14), and a mist passage (12) is left on the other side of the liquid supply bottle (11); 4), the atmospheric pressure chamber (5), the sensor (6), the gas-liquid separator (7), the atomizer (9), the mist channel (12), the air guiding hole (17), and the suction nozzle (15) are sequentially connected The front end of the housing (14) also includes a hair Diode (LEDI) and a battery (2), together constitute a mouthpiece shape, the overall shape of a pipe or cigar-shaped.

2. The atomized electronic cigarette according to claim 1, wherein: in the casing (14), the atomizer (9) is rearward, and the liquid supply bottle (11) is disposed in the gas-liquid separator (7) Between the atomizer and the atomizer (9), a spring piece (33) for pressing the liquid supply bottle (11) against the atomizer (9) is provided at one end of the liquid supply bottle (11).

The atomized electronic cigarette according to claim 1 or 2, characterized in that: a display screen (32) is attached to the inner wall of the casing (14) to be connected to the electronic circuit board (3).

4. An atomized electronic cigarette according to claim 1 or 2, characterized in that a microswitch (16) for manual cleaning is connected in parallel with the sensor (6) in the housing (14).

The atomized electronic cigarette according to claim 1 or 2, characterized in that: the sensor (6) and the internal negative pressure chamber (8) are provided with a corrugated membrane (22), and the sensor (6) There is also a first magnetic steel (20), a second magnetic steel (21) and a reed switch (KI) interposed therebetween, and the second magnetic steel (21) is fixed on the corrugated membrane (22) .

The atomized electronic cigarette according to claim 1 or 2, wherein: the sensor (6) has a silicone member check valve (31), and a third magnetic steel (34) is disposed in the valve. A reed switch (Kl) is provided on the side of the valve adjacent to the third magnetic steel (34).

The atomized electronic cigarette according to claim 1 or 2, characterized in that the gas-liquid separator (7) has a through hole.

8. The atomized electronic cigarette according to claim 7, characterized by: a pass on the gas-liquid separator (7) The hole jacket has a silicone piece check valve (31).

The atomized electronic cigarette according to claim 1 or 2, characterized in that: the atomization chamber wall (25) of the atomization chamber (10) is provided with an overflow hole (29) and an atomization chamber (10) A heating body (RL) is arranged in the cavity, and a first air flow injection hole (24) is opened on one side of the heating body (RL), and the porous body (27) is wrapped outside the atomization chamber wall (25), and is atomized. One side of the device (9) is provided with a first piezoelectric piece (M1), and the other side is provided with a protrusion (36).

The atomized electronic cigarette according to claim 1 or 2, characterized in that: the atomizer (9) is provided with a second piezoelectric piece (35).

11. The atomized electronic cigarette according to claim 9, wherein: the porous body (27) in the atomizer (9) is foamed by a foam, a stainless steel fiber felt, or a polymer polymer. Made of body and foam ceramics; heating body (RL) can be made of platinum wire, nickel-chromium alloy or iron-chromium-aluminum alloy wire containing rare earth elements, or can be made into a sheet; the atomization chamber wall (25) can be oxidized. Made of aluminum or ceramic.

12. The atomized electronic cigarette according to claim 7, wherein: the gas-liquid separator (7) is made of plastic or silicone rubber.

The atomized cigarette according to claim 1 or 2, characterized in that: the liquid supply bottle (11) is provided with a liquid storage porous body (28) which can be filled with polypropylene fiber, polyester fiber or nylon fiber. , or filled with a plastic foam molded body; it can also be injection molded into a multi-layered column by using polyvinyl chloride, polypropylene, or polycarbonate.

14. The atomized electronic cigarette according to claim 5, wherein: the reed switch (K1), the first magnet (20), the second magnet (21), and the corrugated film (22) are provided with a sealing film Instead of a semiconductor strain gauge, mount the sensor in the corrugated membrane position.

The atomized electronic cigarette according to claim 1 or 2, characterized in that: the smoke liquid injected into the liquid supply bottle (11) for atomization contains 0.4 to 3.5% of nicotine, and the tobacco flavor is 0.05 to 2 %, organic acid 0.1~3.1%, anti-oxidation 0.1-0.5%, balance is 1,2-propanediol.

Description

Atomized electronic cigarette

The present invention relates to an electronic cigarette, and more particularly to an atomized electronic cigarette which does not contain tar and contains only nicotine (nicotine). Background technique

In today's "smoking is harmful to health" has become common sense, there are still 1 billion people worldwide who smoke, and this number is still expanding every year. The first international non-smoking agreement, the Framework Convention on Tobacco Control, adopted by the World Health Organization (WHO) on March 1, 2003, according to figures provided by the WHO, shows that smoking causes 4.9 million deaths each year, although smoking can cause severe respiratory problems. Diseases and cancers make it extremely difficult for smokers to quit completely.

The active ingredient of cigarettes is nicotine (ie, nicotine). When smoking, nicotine is rapidly absorbed into the alveoli after a large amount of tar droplets generated by burning cigarettes. Nicotine is absorbed into the blood and acts on the receptors of the central nervous system. A "intoxication" that causes stimulants, such as the feeling of dizziness or swaying experienced by smokers.

Nicotine is a small molecule alkaloid that is substantially harmless to humans in small doses and has a very short half-life in the blood. The harmful substances of tobacco are mainly tar. Tobacco tar is composed of thousands of ingredients, dozens of which are carcinogens. Passive smoking has been shown to be more harmful to non-smokers.

In order to find cigarette substitutes that contain only nicotine and do not contain tar, there are many inventions made with purer nicotine such as "quit smoking sticks", "nicotine containing water", "packaging in high pressure with propellant". Gas tank sprays, "nicotine chewing gum", "nicotine beverage" and other products, although these products do not have the harm of tar, but due to the slow absorption of nicotine, can not establish an effective peak concentration in the blood, can not solve the demand for nicotine The feeling of "addictiveness" also deprives smokers of the habit of "sucking" and "sucking", so similar products cannot be used as smoking cessation supplies or cigarette substitutes. Summary of the invention

In order to overcome the above disadvantages, it is an object of the present invention to provide a misted electronic cigarette having the function of quitting smoking and cigarette substitutes.

The object of the present invention is achieved by the following technical solutions:

The invention comprises a casing and a nozzle, wherein an outer wall of the casing is provided with an air inlet hole, and an electronic circuit board is arranged in the casing, Normal pressure chamber, sensor, gas-liquid separator, atomizer, liquid supply bottle; wherein the electronic circuit board is composed of an electronic circuit and a high-frequency oscillator; a sensor air flow channel is opened on one side of the sensor, and the housing cavity In the same way, the sensor is provided with a negative pressure chamber; the atomizer is in contact with the liquid supply bottle, and a gap is left between the atomizer and the housing; an atomization chamber is arranged inside the atomizer; one side of the liquid supply bottle and the housing There is a retaining ring for locking the liquid supply bottle, and the other side of the liquid supply bottle is provided with a mist passage; the air inlet hole, the atmospheric pressure chamber, the sensor, the gas-liquid separator, the atomizer, the mist channel, the air guiding hole The nozzles are connected in sequence; the front end of the housing further includes a light emitting diode and a battery, which together form a cigarette-shaped, cigar-shaped or pipe-shaped whole.

Wherein: a display screen is arranged on the inner wall of the casing, and is connected with the electronic circuit board; a micro switch for manual cleaning is arranged in parallel with the sensor in the casing; a corrugated membrane is arranged between the sensor and the inner negative pressure chamber thereof, The sensor is further provided with a first magnetic steel, a second magnetic steel and a reed switch interposed therebetween, the second magnetic steel is fixed on the corrugated membrane; the sensor has a silicone rubber check valve built therein, and the valve is provided with a valve a third magnetic steel, a side of the valve adjacent to the third magnetic steel is provided with a reed switch; a gas-liquid separator is provided with a through hole, and a through hole on the gas-liquid separator is provided with a silicone member check valve; An overflow hole is formed in the wall of the atomization chamber of the cavity, and a heating body is arranged in the atomization cavity, and a first airflow injection hole is opened on one side of the heating body, and the porous body is wrapped outside the wall of the atomization cavity, and the atomizer One side is provided with a first piezoelectric piece, and the other side is provided with a protrusion; a second piezoelectric piece is added to the atomizer; the porous body in the atomizer can be made of foamed nickel, stainless steel fiber felt, and high polymer Made of polymer foam and foamed ceramics; the heating body can be made of platinum wire, nickel-chromium alloy or rare earth-containing material. Made of chrome-aluminum alloy wire, it can also be made into a sheet-like body; the atomization chamber wall can be made of alumina or ceramic; the gas-liquid separator can be made of plastic or silicone rubber; the liquid supply bottle is filled with a liquid storage porous body, It can be filled with polypropylene fiber, polyester fiber or nylon fiber, or filled with plastic foam molded body; it can also be injected into the column of multi-layer board by using polyvinyl chloride, polypropylene and polycarbonate; reed switch, first magnetic steel, The second magnetic steel and corrugated film may be replaced by a semiconductor strain gauge having a closed film and installed at the position of the sensor corrugated film.

The invention also discloses another structure of atomized electronic cigarette. In the casing, the atomizer is arranged behind, and the liquid supply bottle is arranged between the gas-liquid separator and the atomizer, and is provided at one end of the liquid supply bottle. Press the liquid supply bottle against the shrapnel on the nebulizer.

The advantages of the invention are: smoking without tar, greatly reducing the risk of cancer, the user still feels and excited about smoking, no need to ignite, no fire hazard.

The device and connection structure of the present invention can be loaded with conventional drugs for intrapulmonary drug delivery devices after a slight modification of the reservoir. DRAWINGS

Figure 1 is a schematic view of an overall structure of the present invention;

2 is a schematic view showing another overall structure of the present invention; 3 is a schematic view showing the overall structure of a display screen according to the present invention;

Figure 4 is a structural view of the sensor of the present invention;

Figure 5 is a structural view of a sensor with a silicone valve check valve according to the present invention;

Figure 6 is a structural view of an atomizer of the present invention;

Figure 7 is a structural view of a ceramic member in the atomizer of the present invention;

Figure 8 is a structural view of another atomizer of the present invention;

Figure 9 is a structural view of a gas-liquid separator according to the present invention;

Figure 10 is a structural view of another gas-liquid separator of the present invention;

Figure 11 is a connection diagram of the liquid supply bottle and the suction nozzle of the present invention;

Figure 12 is a circuit schematic of the present invention. detailed description

The invention will be further described in detail below with reference to the accompanying drawings.

Example 1

As shown in Fig. 1, the present invention can constitute a cigarette-shaped, cigar-shaped or pipe-shaped whole. The outer wall of the casing 14 is provided with an air inlet hole 4, and the casing 14 is sequentially provided with a light emitting diode LED1, a battery 2, an electronic circuit board 3, an atmospheric pressure chamber 5, a sensor 6, a gas-liquid separator 7, and an atomizer 9. , liquid supply bottle 11, suction nozzle 15. The electronic circuit board 3 is composed of an electronic switch circuit and a high frequency oscillator. On one side of the sensor 6, a sensor air flow path 18 is connected to communicate with the inner cavity of the casing 14. As shown in Fig. 4, a negative pressure chamber 8 is provided in the sensor 6, and is separated from the sensor 6 by a corrugated membrane 22. The sensor 6 is further provided with a first magnetic steel 20, a second magnetic steel 21 and a reed switch K1 interposed therebetween, and the second magnetic steel 21 is fixed to the corrugated membrane 22. The atomizer 9 is in contact with the liquid supply bottle 11 through the projection 36, leaving a gap with the housing 14, and the atomizer 9 is provided inside the atomizer 9. As shown in FIG. 6 and FIG. 7, the atomization chamber wall 25 of the atomization chamber 10 is provided with an overflow hole 29, and a heating body RL is disposed in the chamber, and a platinum wire, a nickel-chromium alloy or an iron-chromium-aluminum containing a rare earth element may be used. Made of alloy wire, it can also be made into a sheet. An injection hole is formed on one side of the heating body RL, and the first air flow injection hole 24 or the second air flow injection hole 30 may be selected according to the material of the atomization chamber wall 25. The first air flow injection hole 24 can be used with a 0.1 mm to 1.3 mm slit structure or a single hole and a porous structure of a circular hole of D0.2 mm to 1.3 mm; the diameter of the second air flow injection hole 30 is 0.3 mm to 1.3 mm. The cavity wall 25 is surrounded by a porous body 27, and can be made of foamed nickel, stainless steel fiber felt, polymer polymer foam, and foamed ceramic. The first piezoelectric piece M1 is further provided on the atomizer 9. The chamber wall 25 may be made of alumina or ceramic. As shown in Fig. 9, the gas-liquid separator 7 is provided with a through hole, which may be made of plastic or silicone rubber. As shown in Fig. 11, one side of the liquid supply bottle 11 And housing 14 is provided with a retaining ring 13 for locking the liquid supply bottle 11, and the other side is provided with a mist passage 12, which is filled with a liquid storage body 28, which can be filled with polypropylene fiber, polyester fiber or nylon fiber, or foamed with plastic. The shaped body is filled with a polyurethane foam column or a polypropylene foam column, and can also be injection molded into a multi-layered column by using polyvinyl chloride, polypropylene, or polycarbonate. The intake port 4, the atmospheric pressure chamber 5, the sensor 6, the gas-liquid separator 7, the atomizer 9, the mist passage 12, the air passage 17, and the suction nozzle 15 are sequentially connected.

As shown in the circuit schematic of Figure 12, the electronic switching circuit is centered on the field effect power transistor U1. K1 is a reed switch (located in sensor 6), RL is a heating body (located in atomizer 9), LED1 is a light-emitting diode, U2 is a low-voltage detection piece (for over-discharge protection of lithium batteries), Ml is The first piezoelectric piece, the first capacitor C1, the second capacitor C2, the third resistor R3, the first inductor L1, the third capacitor C3, the transistor BG1, and the first piezoelectric piece M1 constitute a three-point capacitor oscillator, that is, high frequency oscillation Device. The circuit principle is as follows: When the reed switch K1 is closed, the field effect power tube U1 is turned on, the heating body RL is working, and the three-point capacitor oscillator is started, and the first piezoelectric piece M1 provides the high frequency mechanical vibration wave for the atomizer 9. , to achieve the atomization effect.

When the smoker smokes, the nozzle 15 is in a negative pressure state, and the air pressure difference between the atmospheric pressure chamber 5 and the negative pressure chamber 8 or the high-speed air flow causes the sensor 6 to output an activation signal, and the electronic circuit board 3 connected thereto operates. At this time, the corrugated membrane 22 in the sensor 6 is deformed, and the second magnetic steel 21 is driven away from the reed switch K1. The reed switch K1 is closed under the action of excess magnetic lines of the first magnetic steel 20 (ie, K1 is closed), and is activated as an electronic switch. The field effect power tube U1, the high frequency oscillator uses a three-point capacitor oscillator, the frequency is from 550KHZ to 8MHz, the frequency in the circuit is automatically fine-tuned to resonate with the ring-shaped first piezoelectric piece M1, and the liquid molecules are energized, and the LED 1 is The rechargeable battery 2 emits light when it is powered. The atmosphere enters the atmospheric pressure chamber 5 from the air inlet hole 4, passes through the sensor air flow passage 18, and then flows through the through hole in the gas-liquid separator 7 to the atomization chamber 10 in the atomizer 9, and the high-speed airflow through the injection hole The smoke liquid in the porous body 27 is sprayed into the atomization chamber 10 in the form of droplets, ultrasonically atomized by the first piezoelectric sheet M1, and further atomized by the heating body RL, and the large diameter after atomization The droplets are reabsorbed by the porous body 27 through the overflow hole 29 under the action of the eddy current, and the small-diameter droplets are suspended in the gas stream to form an aerosol which is sucked out through the mist passage 12, the air guiding hole 17, and the suction nozzle 15. The liquid storage porous body 28 in the liquid supply bottle 11 is brought into contact with the projection 36 on the atomizer 9 to effect capillary infiltration. \

The nozzle 15 is threaded. When the liquid in the liquid supply bottle 11 is used up, the nozzle 15 can be unscrewed, the liquid supply bottle 11 is taken out, the liquid is injected into the liquid supply bottle 11, and refilled. Inside the housing 14, the nozzle 15 is tightened.

The reed switch K1, the first magnet 20, the second magnet 21, and the corrugated film 22 may be replaced by a semiconductor strainer having a closed film, which is installed at the position of the sensor corrugated film.

In order to simplify the design, the first piezoelectric piece M1 on the atomizer 9 can be eliminated, and the smoke liquid mist is only used by the heating body RL. Chemical. The size of the atomizer can be made smaller, and the connection structure of the entire atomized electronic cigarette is the same as that of the first embodiment. Further, as shown in FIG. 8, the first piezoelectric sheet M1 and the heating body RL in the atomizer 9 are eliminated, and a single layer or a plurality of layers and a second plate shape are added in the atomization chamber. The piezoelectric sheet 35, the airflow passing through the ejection holes is atomized at the center vibration focus point, and the effect of strong ultrasonic atomization is achieved.

As shown in Fig. 10, a silicone member check valve 31 may be disposed outside the through hole of the gas-liquid separator 7. When smoking, the airflow reaches the through hole. As the air pressure in the through hole rises, the silicone valve check valve 31 is opened and the airflow passes; when not smoking, the silicone member check valve 31 is closed.

As shown in Fig. 5, the sensor 6 can also be designed as a structure with a silicone member check valve 31. When smoking, the airflow converges in the silicone check valve 31, the air pressure rises, the gas expands, and the third magnetic steel 34 in the valve gradually approaches the reed switch K1 until the reed switch K1 is closed and the circuit is opened, with the pressure difference Continuing to increase, the air outlet of the silicone member check valve 31 is opened. The xenon tube K1 can also be replaced by a Hall device or a magneto-sensitive diode or a magneto-transistor.

Example 2

As shown in FIG. 2, in order to improve the liquid supply state, in the casing 14, the atomizer 9 is disposed rearward, and the liquid supply bottle 11 is disposed between the gas-liquid separator 7 and the atomizer 9, in the liquid supply bottle 11 The elastic piece 33 for pressing the liquid supply bottle 11 against the atomizer 9 is provided at one end, and the other components and working principle are the same as those of the first embodiment.

In the inner wall of the casing 14 of the atomized electronic cigarette described in the first embodiment and the second embodiment, a digital display screen 32 may be further connected to the output end of the field effect power tube U1 in the electronic switch circuit for displaying the daily The number of cigarettes smoked and the battery capacity. Sensor 6 is a linear signal output that is proportional to the strength of the suction (i.e., the greater the suction and the longer the working time), the nebulizer 9 operates in a linear fashion to simulate a more realistic humanized cigarette.

A microswitch 16 for manual cleaning is also connected in parallel with the sensor 6 in the housing 14. When not smoking, press the microswitch 16 to operate the sensor 6 in parallel with it, or remove the residue and other impurities in the housing 14.

The smoke liquid used for atomization contains 0.4~3.5% nicotine, the tobacco flavor is 0.05~2%, the organic acid is 0.1~3.1%, the antioxidant is 0.1~0.5%, and the balance is 1,2-propanediol.

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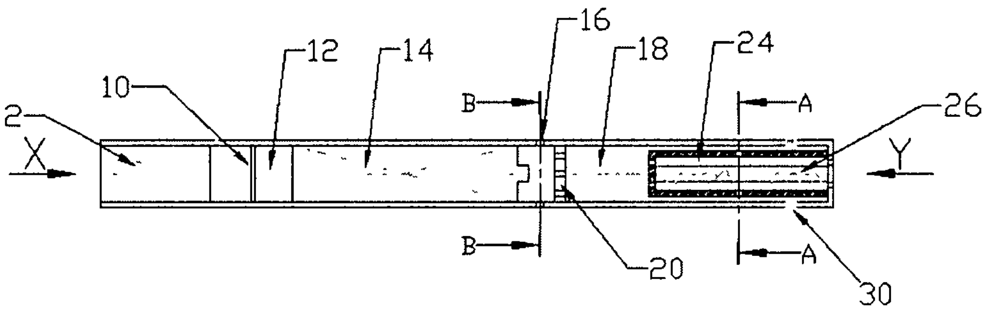
(54) **Title: NO-TAR ELECTRONIC SMOKING UTENSILS**



(57) Abstract: No-tar electronic smoking utensils includes a container (18) formed of a porous material for storing a liquid mixture. The container communicates with a heater vapouriser (24) via a series of small apertures (28). The heater is in the form of a spirally wound electrical heater (26) mounted on an electrical insulating support. Battery supply means are provided for the heater. The heater vapouriser communicates with a mouthpiece. In use, suction on the mouthpiece by the user causes air to be drawn through the porous container for liquid, over the heated vapouriser, into the mouthpiece and into the mouth of the user.

WO 2007/078273 A1

NO-TAR ELECTRONIC SMOKING UTENSILS

TECHNICAL FIELD

The present invention relates to no-tar electronic smoking utensils such as, for example, cigarettes, cigars and cigarette holders.

BACKGROUND

Cigarettes are well known in which one end of a tobacco filled cigarette is held in the mouth of the user and the other end of the cigarette is ignited by a match or a lighter and the user draws on one end of the cigarette to draw the tobacco smoke through the cigarette into the mouth/lungs of the user. The health dangers of tobacco smoking are well documented and many products have appeared on the market in an attempt to assist smokers to cease smoking tobacco products or to provide a more healthy tobacco substitute.

One such product is a "flameless electronic atomising cigarette" described in Malaysian patent application 031 11582.9. The product is a non-combustible simulated cigarette and the user draws on one end of the "cigarette" to draw a nicotine vapour through the cigarette via a solution having a controlled amount of nicotine. The lack of a flame avoids inhaling tar and other unhealthy tobacco products, and the user can also control the amount of nicotine inhaled. The nicotine mixture of the prior art electronic cigarette is pumped through the device and is atomised by the use of a high frequency generator, a piezoelectric ultrasonic atomiser and a high-temperature gasification jet tube. The resulting vapour, lacking the conventional tar and unhealthy by- products, but including a controlled amount of nicotine, is inhaled by the user.

SUMMARY OF INVENTION

It is an object of the present invention to provide a no-tar electronic smoking utensils which is a suitable alternative to known products and/or is of a simpler construction in comparison to known products.

In accordance with one aspect of the invention, there is provided a no-tar electronic smoking utensils including:
a container for a liquid,
a vapouriser including heater means adapted to vapourise the liquid,
wherein air can be drawn by the suction of the user over the container and vapouriser to form a simulated smoke vapour.

Preferably, in contrast to the above prior art device the vapourisation is effected solely or principally by the air distribution through the container in combination with the heat from the heating means.

Preferably, in contrast to the above prior art device the flow of fluids through the cigarette is caused solely or principally by the suction of the user.

Thus, the simulated cigarette of the present invention is of a simpler construction, easier to manufacture and more cost effective than the above prior art device.

Preferably, at least a portion of the container is formed of a porous material to facilitate distribution of the liquid through the container, prior to being fed to the heater means. Suitable materials include, for example, foamed metal, foamed ceramic or special fibre.

In a preferred arrangement the heater means includes an electrical heater mounted on an electrical insulating support, for example a spirally wound heater wire.

The liquid mixture may be formed from any suitable materials/chemicals. The mixture could include a controlled amount of nicotine, however the mixture need not include a nicotine content.

Indicating/monitoring means may be included for the purpose of indicating a range of activities such as when a pre-set level of nicotine has been reached, when the unit is switched on or when the liquid in the container is low.

In a preferred arrangement simulated tobacco is provided in the tip end of the smoking article to give the article the appearance of a conventional smoking article.

The no-tar electronic smoking utensils preferably includes electrical supply means, such as a battery, to supply power to the heater and/or the indicator means. In a preferred arrangement power supply switch means are located adjacent the mouthpiece end of the cigarette, the power supply switch means being adapted to be activated by the lips of the user.

In accordance with another aspect of the invention, there is provided a simulated cigarette including a container formed of a porous material for storing a liquid mixture, the container communicating with a heater vapouriser via a series of apertures, said vapouriser including a spirally wound electrical heater mounted on an electrical insulating support, battery supply means for the heater, said heater vapouriser communicating with a mouthpiece, whereby in use, suction on the mouthpiece by the user causes air to be drawn through the porous container for liquid, over the heated vapouriser, into the mouthpiece and into the mouth of the user.

SPECIFIC EXAMPLE OF THE INVENTION

In order to better understand the invention, an example will now be described with reference to the following drawings, in which:

FIG 1 is an enlarged side view of a simulated cigarette constructed in accordance with the invention,

FIG 2 is a cross- sectional side view of the simulated cigarette of FIG 1,

FIG 3 is a tip end view of the simulated cigarette of FIG 1 looking in the direction of arrow X,

FIG 4 is a mouthpiece end view of the simulated cigarette of FIG 1 looking in the direction of arrow Y,

FIG 5 is a cross-sectional end view taken along the lines AA of FIG 2,

FIG 6 is a cross-sectional end view taken along the lines BB of FIG 2, and

FIG 7 is a schematic diagram of the electrical components of the example shown in FIG 1.

Referring to FIG 1 of the example, the simulated cigarette is of the general size and shape of a conventional elongated cylindrical cigarette, having a tip end 2 and a mouthpiece end 4.

In broad terms, the simulated cigarette of the example is provided with a container for a liquid mixture, a heater for vapourising the liquid, apertures for passage of air/mixture vapour through the cigarette into the mouth of the user, and a battery for supplying power to the heater.

Referring to FIGS 1 and 2, the simulated cigarette is provided with an outer casing 6. The tip end 2 of the casing 6 is provided with simulated tobacco to give the simulated cigarette the appearance of a conventional cigarette. Modifications, such as choice and feel of materials, obvious to those skilled in the art, could also be made to give the simulated cigarette the look and feel of a conventional cigarette.

Adjacent and inner the tip end 2 of the cigarette and mounted on the cigarette casing 6 is a light emitting diode (LED) 8. The LED is for the purpose of monitoring/indicating, amongst other things, the level of liquid in the container and when a pre-set level of nicotine has been reached.
Located inner and adjacent of the simulated tobacco is a printed circuit board (PCB) control unit 10 for controlling the electrics of the cigarette.

Adjacent and inner of the PCB 10, is a cylindrical battery chamber 12 for housing a battery 14. The cigarette outer casing 6, adjacent the battery chamber 12 is provided with a plurality of apertures 16 to permit entry of air into the battery chamber. Adjacent and inner of the battery chamber 12 is a cylindrical liquid container 18 separated from the battery chamber by a dividing wall 20. The dividing wall 20 is provided with a plurality of apertures 22 to permit entry of air from the battery chamber into the liquid container.

The container liquid mixture can be fed into the container 18 via a one-way valve (not shown) mounted through the wall of the cigarette casing 6. The liquid container 18 is formed of porous inorganic material. The porous material of the liquid container facilitates the distribution and the mixing of the air and liquid mixture.

A cylindrical vapouriser heater assembly housing 24 is mounted within a central bore provided in the mouthpiece end of the liquid container 18. The vapouriser heater assembly housing houses a heater wire 26 spirally wound on a central ceramic insulating rod. The walls of the heater housing 24 are provided with a plurality of apertures 28 to permit entry of the liquid/air from the liquid container 18 into the heater housing 24.

Adjacent the mouthpiece end 4 of the cigarette and mounted on the cigarette outer casing 6 is a switch 30 activated, in use, by the mouth of the user for the purpose of switching on the battery power supply.

As indicated above, the liquid of the container may contain any suitable chemicals, and may be provided with or without nicotine.

The approximate percentages of ingredients for a mixture containing nicotine are as follows:

1,2 propylene glycol 81%, nicotine 7%, distilled water 6%, glycerol triacetin 5%, formic acid, acetic acid, acetol and fragrance etc. 1%.

The approximate percentages of ingredients for a mixture without nicotine are as follows:

1,2 propylene glycol 88%, distilled water 6%, glycerol triacetin 5%, formic acid, acetic acid, acetol and fragrance etc. 1%.

In operation, the switch 30 is activated by the lips of the user touching the switch 30 thus switching on the battery power supply. As best seen in the electrical schematic diagram of FIG 7, battery power is supplied to the PCB control unit 10, the LED 8 and the vapouriser heater 26.

As the user draws on the cigarette mouthpiece, air is drawn into the battery chamber, into the liquid container to mix with the liquid mixture, and into the heater assembly. The resulting vapour is drawn into the mouth of the user.

CLAIMS:

1. A no-tar electronic smoking utensils including:
a container for a liquid,
a vapouriser including heater means adapted to vapourise the liquid,
wherein air can be drawn by the suction of the user over the container and vapouriser to form a simulated smoke vapour.

2. A no-tar electronic smoking utensils according to Claim 1 wherein the vapourisation is effected solely or principally by the air distribution through the container in combination with the heat from the heating means.

3. A no-tar electronic smoking utensils according to Claim 1 or Claim 2 wherein the flow of fluids through the cigarette is caused solely or principally by the suction of the user.

4. A no-tar electronic smoking utensils according to any preceding claim wherein at least a portion of the container is formed of a porous material to facilitate distribution of the liquid through the container, prior to being fed to the heater means.

5. A no-tar electronic smoking utensils according to any preceding claim wherein the heater means includes an electrical heater mounted on an electrical insulating support.

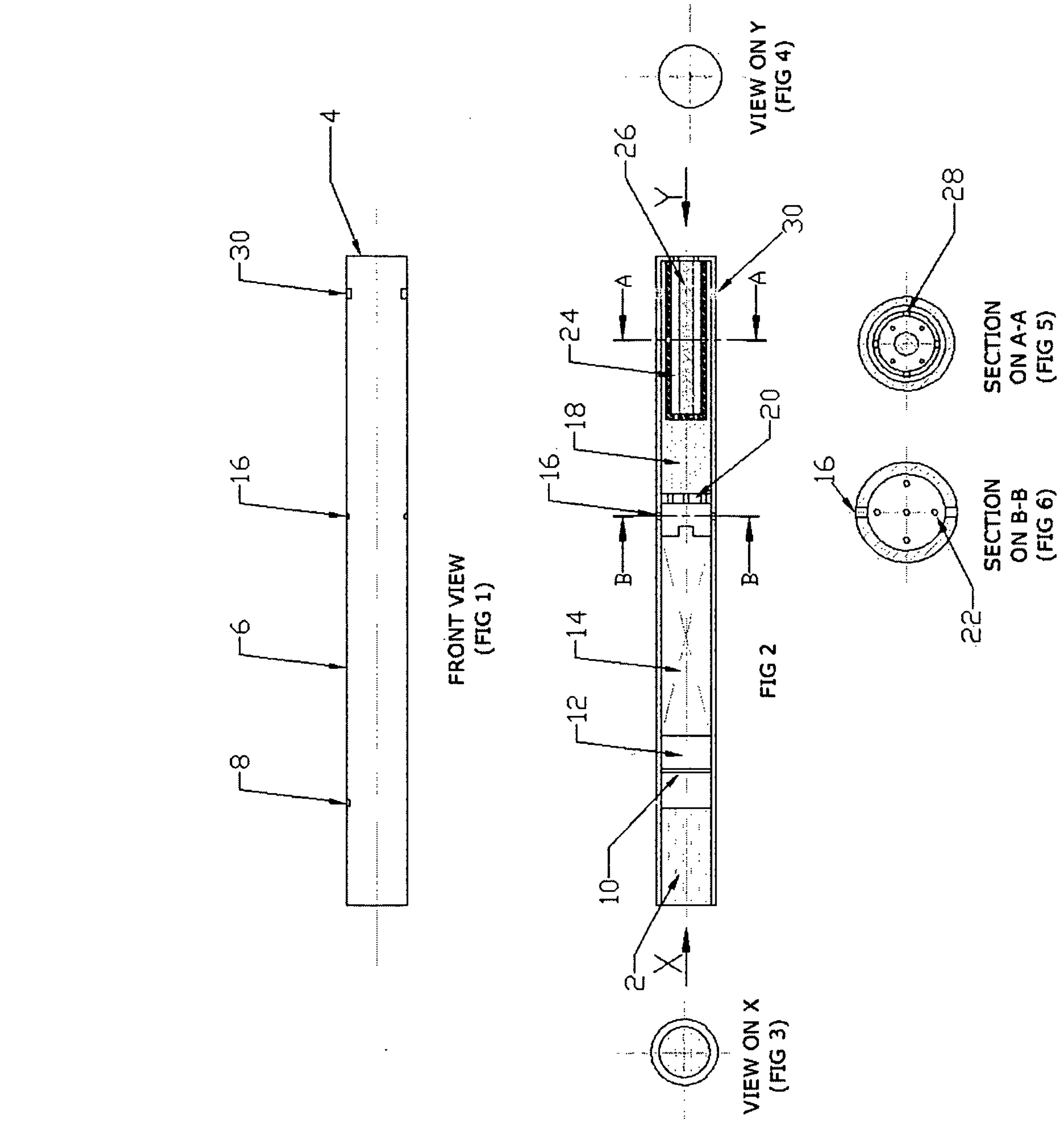
6. A no-tar electronic smoking utensils according to any preceding claim wherein the liquid includes a controlled amount of nicotine.

7. A no-tar electronic smoking utensils according to any preceding claim including indicator means for the purpose of indicating when a pre-set level of nicotine has been reached.

8. A no-tar electronic smoking utensils according to any preceding claim including simulated tobacco at a first or tip end of the smoking article to give the article the appearance of a conventional smoking article.

9. A simulated cigarette according to any preceding claim including electrical supply means to supply power to the heater and/or the indicator means, power supply switch means located adjacent the second or mouthpiece end of the cigarette, said power supply switch means being adapted to be activated by the lips of the user.

10. A simulated cigarette including a container formed of a porous material for storing a liquid mixture, the container communicating with a heater vapouriser via a series of apertures, said vapouriser including a spirally wound electrical heater mounted on an electrical insulating support, battery supply means for the heater, said heater vapouriser communicating with a mouthpiece, whereby in use, suction on the mouthpiece by the user causes air to be drawn through the porous container for liquid, over the heated vapouriser, into the mouthpiece and into the mouth of the user.


FRONT VIEW
(FIG 1)
FIG 2
VIEW ON X
(FIG 3)
VIEW ON Y
(FIG 4)
SECTION
ON A-A
(FIG 5)
SECTION
ON B-B
(FIG 6)
2
4
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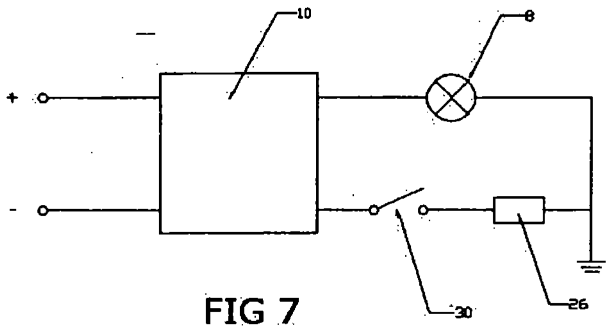

FIG 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US05/46546

A CLASSIHCA I ION OF SUBJECT MATTER
rPC Λ 24 F 01/24

USPC m/194.329,347
According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U S 13 1/194,329.347

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C DOCUMbNl S CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X -- Y	US 4,947, 874 A (BROOKS et al) 14 August 1990 (14 08 1990), see entire document	1-5 ---------- 6-10

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Date of the actual completion of the international search	Dale of mailing of the international search report
22 Mav 2006 (22 05 2006)	27 JUN 2006

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Mail Slop PCT. \lln 1SA/LS Commissioner tnr Patents P O Box 1450 \lc\.incl πa Virginia 2231 3-1450 facsimile No (571) 271-3201	Dionn β Walls Maves Telephone No (57 1) 272- 1700

Form PCT r ISA. 2 10 (second sheet) (April 2005)

Emulation aerosol sucker

Abstract

An emulation aerosol sucker includes a battery assembly, an atomizer assembly and a cigarette bottle assembly. An external thread electrode is located in one end of battery assembly. An internal thread electrode is located in one end of atomizer assembly. Said battery assembly and said atomizer assembly are connected by the screwthread electrode. Said cigarette bottle assembly is inserted into the other end of said atomizer assembly and both form one cigarette type or cigar type body.

Classifications

A24F40/40 Constructional details, e.g. connection of cartridges and battery parts

View 24 more classifications

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WIPO (PCT)

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Other languages: French, Chinese

Inventor: Lik Hon

Worldwide applications

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2006-05-16 • Priority to CN200620090805.0

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Info: Patent citations (209), Non-patent citations (1), Cited by (682), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, PatentScope, Discuss

Claims

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What is claimed is: 1. A simulated aerosol inhaler, comprising: a battery assembly, an atomizer assembly and a cigarette bottle assembly, the cigarette bottle assembly comprising a liquid smoke bottle, the atomizer assembly comprising an atomizer, a cigarette bottle thereof The components are plugged into one end of the nebulizer assembly to form a single cigarette or cigar type.

2. The simulated aerosol inhaler according to claim 1, wherein: one end of the battery assembly is provided with an externally threaded electrode, and one end of the atomizer assembly is provided with an internally threaded electrode, and the two are connected by a threaded electrode. .

3. The simulated aerosol inhaler according to claim 1, wherein: the battery assembly comprises a battery, a MOSFET circuit board, a sensor, a first threaded electrode, a first negative pressure cavity, and a first housing, One end of the housing is provided with an externally threaded electrode, and the other side is connected to the battery and the MOSFET circuit board in turn, and a sensor is provided on the MOSFET circuit board.

4. The simulated aerosol inhaler according to claim 3, wherein: the battery assembly further comprises a silicone rubber corrugated diaphragm, and a silicone rubber corrugated diaphragm is mounted between the first threaded electrode and the sensor, and the The first negative pressure port, the sensor is connected to the silicone rubber corrugated diaphragm by a reed switch fixed thereto.

5. The simulated aerosol inhaler according to claim 3, wherein: the battery assembly further comprises an indicator light, the other end of the first housing is provided with an indicator light, and one side of the cover is covered with an indicator cover, and the indicator cover There is a micro hole in the upper surface; an MCU is added between the MOSFET circuit board and the sensor; and a display screen is added to the surface of the first housing.

6. The simulated aerosol inhaler according to claim 5, wherein: the MCU scans the sensor in a pulsed power saving mode, and implements an integral function of frequency versus single working time according to a signal parameter of the sensor. At the same time, the MCU completes the pulse width modulation and

overdischarge protection for the current constant power output, the automatic cleaning function for thousands of operations per minute, the fade-in and fade-out control of the indicator light, the number of operations and the battery capacity display, and the sensor malfunction. Automatic shutdown control; the indicator lights are two red LEDs.

7. The simulated aerosol inhaler according to claim 3, wherein the sensor is a switch sensor made of an elastic alloy sheet, a linear output Hall device, a semiconductor force sensitive chip, and a semiconductor matrix thermoelectric bridge chip. Or capacitive and inductive sensors.

8. A simulated aerosol inhaler according to claim 4 wherein said silicone rubber The corrugated diaphragm is made of a fluororubber, a nitrile rubber or an elastic alloy film.

9. The simulated aerosol inhaler according to claim 3, wherein said externally threaded electrode is made of a stainless steel or brass plated gold plated open hole; said battery is a lithium battery, said lithium battery being rechargeable A polymer lithium battery or a rechargeable lithium ion battery.

10. The simulated aerosol inhaler of claim 1 wherein said atomizer assembly comprises an internally threaded electrode, an atomizer and a second housing, one end of the second housing being interposed with the cigarette holder assembly The other end is provided with an internally threaded electrode, and a second negative pressure cavity is provided thereon.

11. The simulated aerosol inhaler of claim 3 wherein said atomizer assembly comprises an internally threaded electrode, an atomizer and a second housing, one end of the second housing being interposed with the cigarette holder assembly The other end is provided with an internally threaded electrode, and a second negative pressure cavity is provided thereon.

12. The simulated aerosol inhaler of claim 6 wherein said atomizer assembly comprises an internally threaded electrode, an atomizer and a second housing, one end of the second housing being interposed with the cigarette holder assembly The other end is provided with an internally threaded electrode, and a second negative pressure cavity is provided thereon.

13. The simulated aerosol inhaler of claim 7 wherein said atomizer assembly comprises an internally threaded electrode, an atomizer and a second housing, one end of the second housing being interposed with the cigarette holder assembly The other end is provided with an internally threaded electrode, and a second negative pressure cavity is provided thereon.

14. A simulated aerosol inhaler according to claim 10, 11, 12 or 13 wherein said atomizer assembly comprises a gas-liquid separator, the gas-liquid separator and the atomizer in sequence with the internally threaded electrode Connection; an air intake channel is opened in the second housing.

15. The simulated aerosol inhaler according to claim 14, wherein said internally threaded electrode is made of a stainless steel or brass plated gold plated open hole; said gas-liquid separator is made of stainless steel or plastic. to make.

16. The simulated aerosol inhaler according to claim 10, 11, 12 or 13, wherein the atomizer is a capillary immersion atomizer or a jet atomizer, and the atomizer is provided with heating The spray atomizer has an injection hole.

17. The simulated aerosol inhaler according to claim 15, wherein the atomizer is a capillary immersion atomizer or a spray atomizer, and the atomizer is provided with a heating body; There are spray holes on the device.

18. The simulated aerosol inhaler according to claim 16, wherein the injection hole is formed by foaming ceramic, microporous ceramic, foamed metal, stainless steel fiber felt or chemical fiber. production.

19. The simulated aerosol inhaler according to claim 16, wherein the heating body is made of a nickel-chromium alloy wire, an iron-chromium-aluminum alloy wire or a platinum wire electrothermal material on a microporous ceramic skeleton, or A porous body with a sintered electrode made directly of a conductive ceramic or PTC ceramic material; the surface of the heating body is sintered into a high temperature glaze to fix the zeolite particles, and the zeolite particles are made of natural zeolite, artificial inorganic microporous ceramic or alumina particles.

20. The simulated aerosol inhaler according to claim 3, wherein the cigarette bottle assembly comprises a liquid bottle, a fiber and a nozzle, and the fiber with the liquid is contained at one end of the liquid bottle, the end Inserted in the second housing, abutting on the atomizer, the nozzle is located at the other end of the liquid bottle, and an air suction channel is left between the fiber and the inner wall of the liquid bottle

21. The simulated aerosol inhaler according to claim 10, 11, 12 or 13, wherein said cigarette bottle assembly comprises a liquid liquid bottle, a fiber and a suction nozzle, and the fiber with the liquid smoke is contained in the liquid smoke One end of the bottle is inserted into the second casing and abuts on the atomizer, and the nozzle is located at the other end of the liquid bottle, and an air suction hole is left between the fiber and the inner wall of the liquid bottle.

22. The simulated aerosol inhaler according to claim 21, wherein: the liquid bottle and the nozzle are made of a non-toxic plastic: the fiber is made of polypropylene fiber or nylon fiber.

The smog of 0. 1 - 3. 5 % of nicotine, 0. 05 - 5 % Tobacco flavor, 0. 1-3% organic acid, 0. 1 - 0.5% stabilizer, the balance is propylene glycol.

Description

Simulated aerosol inhaler

This invention relates to an electron inhalation device, and more particularly to a simulated aerosol inhaler that does not contain tar and contains only nicotine (nicotine). Background technique

In today's "smoking is harmful to health" has become common sense, there are still 1 billion people worldwide who smoke, and this number is still expanding every year. The first international non-smoking agreement, the Framework Convention on Tobacco Control, adopted by the World Health Organization (WHO) on March 1, 2003. According to figures provided by the WHO, smoking causes 4.9 million deaths each year, although smoking can cause severe breathing. Systemic diseases and cancers make it extremely difficult for smokers to quit completely.

The active ingredient of cigarettes is nicotine (ie, nicotine). When smoking, nicotine is rapidly absorbed into the alveoli after a large amount of tar droplets generated by burning cigarettes. Nicotine is absorbed into the blood and acts on the receptors of the central nervous system. A "intoxication" that causes stimulants, such as the feeling of dizziness or swaying experienced by smokers.

Nicotine is a small molecule alkaloid that is essentially harmless to humans in small doses and has a very short half-life in the blood. The harmful substances of tobacco are mainly tar. Tobacco tar is composed of thousands of ingredients, dozens of which are carcinogens. Passive smoking has been shown to be more harmful to non-smokers.

In order to find cigarette substitutes that contain only nicotine and do not contain tar, many inventions are made with relatively pure nicotine such as "quit smoking sticks", "nicotine containing water", "packaging in high pressure with propellant". Gas tank sprays, "nicotine chewing gum", "nicotine beverage" and other products, although these products do not have the harm of tar, but due to the slow absorption of nicotine, can not establish an effective peak concentration in the blood, can not solve the demand for nicotine The feeling of "addictiveness" also deprives smokers of the habit of "sucking" and "sucking", so similar products cannot be used as smoking cessation supplies or cigarette substitutes.

Summary of the invention

SUMMARY OF THE INVENTION It is an object of the present invention to provide a simulated aerosol inhaler having the function of smoking cessation and cigarette replacement, which can be viewed as a liquid particulate suspended in air for the present application.

The technical solution of the present invention is that the application number of the inventor applied for at the China Intellectual Property Office on April 14, 2000 is: 200420031182. 0 The international application number is: PCT / CN2005 / 000337 The utility model name is "Atomized Electronic Cigarette" Further innovative inventions of patents.

The object of the present invention is achieved by the following technical solutions: The present invention comprises a battery assembly, an atomizer assembly and a cigarette bottle assembly, the battery assembly is connected to one end of the atomizer assembly, and the cigarette bottle assembly is inserted in the atomizer assembly At the other end, they form a cigarette or cigar-type whole.

Wherein: one end of the battery assembly is provided with an externally threaded electrode, and one end of the atomizer assembly is internally threaded An electrode, the two are connected by a threaded electrode, the battery component comprises an indicator light, a battery, a MOSFET circuit board, a sensor, a silicone rubber corrugated diaphragm, a first threaded electrode, a first negative pressure cavity and a first housing, the first housing One end is provided with an externally threaded electrode, the other end is provided with an indicator light, one side is covered with a light cover, the indicator cover is provided with a micro hole, the other side is connected to the battery and the MOSFET circuit board in turn, and the M0SFET circuit board is provided with a sensor. A silicone rubber corrugated diaphragm is mounted between the first threaded electrode and the sensor, and a first negative pressure cavity is opened thereon, and the sensor is connected to the silicone rubber corrugated diaphragm through a reed switch fixed thereto; on the MOSFET circuit board An MCU is disposed between the sensor; a display screen is added to the surface of the first casing; the MCU scans the sensor in a pulse-saving mode, and realizes an integral function of frequency to a single working time according to the signal parameter of the sensor. At the same time, the MCU completes the pulse width modulation and over-discharge protection for the current constant power output, and the automatic cleaning function for each thousand operations Control of light fade-out control, work frequency and battery capacity display, automatic recovery of sensor malfunction and shutdown; the sensor can be a switch sensor made of elastic alloy sheet, a linear output Hall device, a semiconductor force sensitive chip, a semiconductor a matrix thermoelectric bridge chip or a capacitor and an inductive sensor; the indicator light is two red light emitting diodes; the silicone rubber corrugated diaphragm may also be made of a fluororubber, a nitrile rubber or an elastic alloy film; The stainless steel or brass piece is made of a gold plated open hole; the battery is a lithium battery, the lithium battery is a rechargeable polymer lithium battery or a rechargeable lithium ion battery; the atomizer assembly includes an internally threaded electrode, a gas-liquid separator, an atomizer and a second casing, one end of the second casing is inserted into the cigarette bottle assembly, and the other end is provided with an internally threaded electrode, and the second negative pressure cavity is provided thereon, and the gas-liquid separation And the atomizer are sequentially connected with the internal thread electrode; the second housing has an air inlet channel; the internal thread electrode is made of stainless steel or brass plated gold plated open hole; The liquid separator is made of stainless steel or plastic opening; the atomizer can be a capillary immersion atomizer or a spray atomizer, and the atomizer is provided with a heating body; the spray atomizer is opened a spray hole; the spray hole is made of a foamed ceramic, a microporous ceramic, a foamed metal, a stainless steel fiber felt or a chemical fiber; and the heating body is made of a nickel-chromium alloy wire wound on a microporous ceramic skeleton. Made of electrothermal material such as iron-chromium-aluminum alloy wire or platinum wire, or directly made of conductive ceramic or PTC ceramic material with a sintered electrode; the surface of the heating body is sintered into a high-temperature glaze to fix the zeolite particles, and the zeolite particles are Made of natural zeolite, artificial inorganic microporous ceramic or alumina particles; the cigarette bottle assembly comprises a liquid bottle, a fiber and a nozzle, and the fiber with the liquid is contained at one end of the liquid bottle, and the end is inserted The second casing is abutted on the atomizer, and the nozzle is located at the other end of the liquid bottle, and an air suction hole is left between the fiber and the inner wall of the liquid bottle; the liquid bottle and the nozzle are non-toxic. Made of plastic: the fiber is made of polypropylene The smoky liquid used for atomization in the fiber contains 0.1 to 3.5% nicotine, 0.05 to 5% of tobacco flavor, 0.1 to 3% organic Acid, 0. 1 - 0.5% stabilizer, the balance is propylene glycol; the inhaler and its connection structure can be loaded into a conventional drug as an intrapulmonary inhalation drug delivery device.

The advantages and positive effects of the invention are as follows: the invention has no tar burning, greatly reduces the risk of cancer, the user still has the feeling and excitement of smoking, no need to ignite, no fire hazard. Device and connection of the present invention The connection structure can be loaded with a conventional drug as an intrapulmonary inhalation drug delivery device.

DRAWINGS

Figure 1 is a schematic view showing the appearance of a cigarette type of the present invention;

2A is a schematic structural view of a battery assembly of the present invention;

2B is another schematic structural view of a battery assembly of the present invention;

Figure 3 is a schematic view of the atomizer assembly of the present invention;

Figure 4 is a schematic view of the cigarette bottle assembly of the present invention;

Figure 5A is a schematic view showing an internal structure of the present invention;

Figure 5B is a schematic view showing another internal structure of the present invention;

6 is a schematic structural view of a charger of the present invention;

7 is a circuit schematic diagram of an MCU and a MOSFET of the present invention;

Figure 8 is a schematic structural view of a capillary immersion atomizer of the present invention;

Figure 9 is a left side view of Figure 8;

Figure 10 is a schematic structural view of a spray atomizer of the present invention;

Figure 11 is a left side view of Figure 10:

Figure 12 is a schematic view showing the structure of the cigar-shaped outer shape of the present invention.

detailed description

The invention will be further described in detail below with reference to the accompanying drawings.

Example 1

As shown in FIG. 1, the appearance of the present invention is similar to that of a cigarette inserted into a cigarette holder, including a battery assembly,

, the atomizer assembly and the cigarette bottle assembly, one end of the battery assembly is provided with an externally threaded electrode 209, and one end of the atomizer assembly is provided with an internally threaded electrode 302, which is connected by a threaded electrode to form a simulated cigarette body, and the cigarette bottle assembly is inserted Connected to the other end of the nebulizer assembly to form a cigarette-type simulated aerosol inhaler.

As shown in FIG. 2A, the battery assembly includes an indicator light 202, a lithium battery 203, a MOSFET circuit board 205, a sensor 207, a silicone rubber corrugated diaphragm 208, a first threaded electrode 209, a first negative pressure chamber 210, and a first housing 211. One end of the first housing 211 is provided with an externally threaded electrode 209, and the other end is provided with an indicator light 202, one side of which is covered with an indicator cover 201, the indicator cover 201 is provided with a micro hole 501, and the other side is connected with a lithium battery 203 in sequence. And a MOSFET (Metal Oxide Semiconductor Field Effect Transistor) circuit board 205, the MOSFET circuit board 205 is provided with a sensor 207, and a silicone rubber corrugated diaphragm 208 is mounted between the first screw electrode 209 and the sensor 207, and the first one is opened thereon. The negative pressure port 210, the sensor 207 is connected to the silicone rubber corrugated diaphragm 208 by a reed switch 212 attached thereto.

Wherein: the sensor 207 can be a switch sensor made of an elastic alloy sheet, a linear output Hall device, a semiconductor force sensitive chip, a semiconductor matrix thermobridge chip or a capacitive and inductive sensor. The indicator light 202 is two red light emitting diodes. The lithium battery 203 can be a rechargeable polymer lithium battery or a rechargeable lithium ion battery. The externally threaded electrode 209 is made of a stainless steel or brass plated gold plated opening. The silicone rubber corrugated diaphragm 208 can also be made of a fluororubber, a nitrile rubber or an elastomeric alloy film. As shown in FIG. 3, the atomizer assembly includes an internally threaded electrode 302, a gas-liquid separator 303, an atomizer 307, and a second housing 306. One end of the second housing 306 is inserted into the cigarette holder assembly, and the other end is connected. An internal threaded electrode 302 is disposed on which a second negative pressure cavity 301 is disposed, and the gas-liquid separator 303 and the atomizer 307 are sequentially connected to the internal thread electrode 302; and the second housing 306 is provided with an intake port. 502. Wherein: the gas-liquid separator 303 is made of stainless steel or plastic opening; the internal thread electrode 302 is made of stainless steel or brass plated gold plated open holes.

The atomizer 307 can be a capillary immersion atomizer as shown in Figs. 8 and 9, or as a jet atomizer as shown in Figs. This embodiment is a jet atomizer.

As shown in FIG. 4, the cigarette bottle assembly includes a liquid liquid bottle 401, a fiber 402, and a suction nozzle 403. The fiber 402 with the liquid smoke is accommodated at one end of the liquid liquid bottle 401, and the end is inserted into the second housing 306. Abutting on the atomizer 307, the suction nozzle 403 is located at the other end of the liquid medicine bottle 401, and an air suction hole 503 is left between the fiber 402 and the inner wall of the liquid medicine bottle 401.

As shown in FIG. 5A, the standby state of the present invention is to screw the fully charged battery assembly shown in FIG. 2A onto the atomizer assembly shown in FIG. 3, and then insert the cigarette bottle assembly shown in FIG. . When the user gently sucks the nozzle 403, the suction hole 503 and the first and second negative pressure chambers 210, 301 form a negative pressure on the silicone rubber corrugated diaphragm 208, and the silicone rubber corrugated diaphragm 208 is in the suction pressure difference. The deformation causes the reed switch 212 and the sensor 207 to activate the MOSFET circuit board 205. At this time, the indicator light 202 is gradually illuminated, and the lithium battery 203 supplies power to the heating body 305 in the atomizer 307 through the MOSFET circuit board 205 and the inner and outer thread electrodes 302, 209, so that the heating body 305 in the atomizer 307 is generated. Heat. The fiber 402 in the liquid bottle 401 contains the liquid smoke, and the liquid smoke infiltrates the microporous ceramic 801 in the atomizer through the fiber 402; the air enters through the air inlet 502, passes through the vent hole in the gas-liquid separator 303, and is in the mist. A gas-liquid mixture is formed in the injection hole 304 of the chemicalizer 307, and the gas-liquid mixture is sprayed onto the heating body 305 to be vaporized, and is quickly condensed into an aerosol by the gas stream of the suction gas, and is sucked into the white mist by the suction nozzle 403 through the suction hole 503. Aerosol.

When the inhalation is stopped, the reed switch 212 and the sensor 207 are reset, the atomizer 307 is stopped, the indicator light 202 is gradually extinguished, and when the number of operations reaches a preset value, the atomizer 307 is operated for 5 to 20 seconds. To clean a trace of scale on the heating body 305.

The liquid supply material of the atomizer 307 may be selected from the group consisting of foam ceramics, microporous glass, foamed metal, stainless steel fiber felt, polyester fiber, nylon fiber, acrylic fiber, aryl fiber or rigid porous plastic. The heating body 305 can be made of an electrothermal material such as a nickel-chromium alloy wire, an iron-chromium-aluminum alloy wire, a platinum wire or the like on a microporous ceramic skeleton, or a conductive ceramic or a PTC (positive temperature coefficient thermal ceramic) material. A porous body of the sintered electrode. The surface of the heating body 305 is sintered into a high temperature glaze to fix the zeolite particles, and the zeolite particles are made of natural zeolite, artificial inorganic microporous ceramic or alumina particles. The liquid liquid bottle 401 and the suction nozzle 403 in the cigarette bottle assembly are made of non-toxic plastic, and the fiber 402 made of polypropylene fiber or nylon fiber is adhered to adsorb the smoke liquid. In the battery assembly, the indicator cover 201 is provided with micro holes 501 for balancing the pressure difference across the silicone rubber corrugated diaphragm 208. 5%的有机酸。 0. 1〜3. 5 % of the organic acid, 0. 1~0. Stabilizer, the balance is propylene glycol.

The first and second outer casings 211, 306 of the present invention are made of stainless steel tubes or copper alloy tubes, and are decorated with the paint color of the real cigarette.

As shown in FIG. 12, the present invention can also proportionally enlarge the diameter of the battery assembly to match the diameter of the atomizer assembly, and decorate the outer shell with plant vein texture and matt brown paint to become a cigar type simulation. Aerosol inhaler.

The recharging of the lithium battery 203 of the present invention can be interfaced by using the threaded electrode 601 shown in Fig. 6 with the externally threaded electrode 209 on the battery pack.

Example 2

As shown in FIG. 2B, the difference between the embodiment and the embodiment 1 is that an MCU 206 is disposed between the MOSFET circuit board 205 and the sensor 207. The display surface 204 of the first housing 211 is provided for displaying lithium. The amount of electricity of the battery 203 and the number of times of smoking.

As shown in FIG. 5B, the standby state of the present invention is to screw the fully charged battery assembly shown in FIG. 2B onto the atomizer assembly shown in FIG. 3, and then insert the cigarette bottle assembly shown in FIG. . When the user gently sucks the nozzle 403, the suction hole 503 and the first and second negative pressure chambers 210, 301 form a negative pressure on the silicone rubber corrugated diaphragm 208, and the silicone rubber corrugated diaphragm 208 is in the suction pressure difference. The deformation causes the reed switch 212 and the sensor 207 to activate the MCU 206 and the MOSFET circuit board 205. At this time, the indicator light 202 is gradually illuminated, and the lithium battery 203 supplies power to the heating body 305 in the atomizer 307 through the MOSFET circuit board 205 and the inner and outer thread electrodes 302, 209, so that the heating body 305 in the atomizer 307 is generated. Heat. The fiber 402 in the liquid liquid bottle 401 contains the liquid smoke, and the liquid smoke infiltrates the microporous ceramic 801 in the atomizer through the fiber 402, and the air enters through the air inlet channel 502 through the vent hole in the gas-liquid separator 303 in the mist. A gas-liquid mixture is formed in the injection hole 304 of the chemicalizer 307, and the gas-liquid mixture is sprayed onto the heating body 305 to be vaporized, and is quickly condensed into an aerosol by the gas stream of the suction gas, and is sucked into the white mist by the suction nozzle 403 through the suction hole 503. Aerosol.

As shown in Fig. 7, when the inhalation action causes the sensor to start, the MCU 206 scans the sensor 207 in a pulsed power saving mode, and based on the signal parameter of the sensor 207, realizes the atomization dose limitation by the integral function of the frequency for a single working time. At the same time, MCU206 completes the pulse width modulation and over-discharge protection for the constant power output of the power supply, the automatic cleaning function for thousands of operations per minute, the fade-in and fade-out control of the indicator light, the number of working times and the battery capacity display, the self-recovery of the sensor malfunction and shutdown, etc. control function.

The device and the connection structure of the present invention can also be incorporated into a conventional drug as an intrapulmonary inhalation drug delivery device. In addition, the above description of the specific embodiments and application examples of the present invention are not intended to limit the scope of the present invention, and equivalent changes or modifications made in accordance with the design spirit of the present invention should be considered as falling. It is within the scope of protection of the present invention.

Patent Citations (209)

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US1968509A	1932-07-13	1934-07-31	Tiffany Technical Corp	Therapeutic apparatus
US2104266A	1935-09-23	1938-01-04	William J Mccormick	Means for the production and inhalation of tobacco fumes
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GB588117A	1945-01-29	1947-05-14	John Terry Hayward Butt	Improvements in or relating to inhalers for analgesic or anaesthetic purposes
US2631219A *	1949-05-06	1953-03-10	Charles T Suchy	Electrical heating element
US2597195A *	1950-03-18	1952-05-20	Garland D Runnels	Vaporizer
CH401788A	1961-11-02	1965-10-31	Seuthe Eberhard	Device for generating steam, in particular for use with a toy
US3200819A *	1963-04-17	1965-08-17	Herbert A Gilbert	Smokeless non-tobacco cigarette
US3281637A	1963-09-23	1966-10-25	American Optical Corp	Rechargeable flashlight-directly accessible batteries
US3431393A	1965-09-07	1969-03-04	Dainippon Jochugiku Kk	Apparatus for vaporizing chemicals and perfumes by heating
US3479561A	1967-09-25	1969-11-18	John L Janning	Breath operated device
US3551643A	1967-10-12	1970-12-29	Sylvania Electric Prod	Electric heater for heating fluids flowing longitudinally therethrough
US3703042A *	1970-12-09	1972-11-21	Sally J Smith	Portable hand-operated pressing device for clothing or the like
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US4228925A *	1977-09-22	1980-10-21	Isaac Mendelovich	Toothpaste holder and dispenser
US4207457A	1978-06-29	1980-06-10	The Kanthal Corporation	Porcupine wire coil electric resistance fluid heater
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US4756318A *	1985-10-28	1988-07-12	R. J. Reynolds Tobacco Company	Smoking article with tobacco jacket
US4765347A *	1986-05-09	1988-08-23	R. J. Reynolds Tobacco Company	Aerosol flavor delivery system
US4771295B1	1986-07-01	1995-08-01	Hewlett Packard Co	Thermal ink jet pen body construction having improved ink storage and feed capability
US4735217A *	1986-08-21	1988-04-05	The Procter & Gamble Company	Dosing device to provide vaporized medicament to the lungs as a fine aerosol
US4771796A *	1987-01-07	1988-09-20	Fritz Myer	Electrically operated simulated cigarette
US4819665A *	1987-01-23	1989-04-11	R. J. Reynolds Tobacco Company	Aerosol delivery article
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JPS64498U	1987-06-23	1989-01-05		
IN172374B	1988-05-16	1993-07-10	Reynolds Tobacco Co R	
US5159940A	1988-07-22	1992-11-03	Philip Morris Incorporated	Smoking article
US4981522A	1988-07-22	1991-01-01	Philip Morris Incorporated	Thermally releasable flavor source for smoking articles
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DE3908160C2 *	1989-03-13	1992-09-17	B.A.T. Cigarettenfabriken Gmbh, 2000 Hamburg, De	
US4945448A	1989-03-17	1990-07-31	Allen-Bradley Company, Inc.	Memory cartridge for a circuit board module
DE3910899C2 *	1989-04-04	1992-06-17	B.A.T. Cigarettenfabriken Gmbh, 2000 Hamburg, De	
CN2047485U	1989-05-24	1989-11-15	赵玉忠	Cigarette with electronic device
US5042470A	1989-05-30	1991-08-27	Nozomi Kanesaka	Ventilating system for respiration of a patient
US4945931A *	1989-07-14	1990-08-07	Brown & Williamson Tobacco Corporation	Simulated smoking device
US5144962A *	1989-12-01	1992-09-08	Philip Morris Incorporated	Flavor-delivery article
US5060671A *	1989-12-01	1991-10-29	Philip Morris Incorporated	Flavor generating article
US5224498A *	1989-12-01	1993-07-06	Philip Morris Incorporated	Electrically-powered heating element
US5117482A	1990-01-16	1992-05-26	Automated Dynamics Corporation	Porous ceramic body electrical resistance fluid heater

US4968263A	1990-03-28	1990-11-06	Molex Incorporated	Multi-pin electrical connector with floating terminal pins
US5396911A	1990-08-15	1995-03-14	R. J. Reynolds Tobacco Company	Substrate material for smoking articles
CN2084236U	1990-10-14	1991-09-04	田俊	Telescopic plug for charging
US5095921A	1990-11-19	1992-03-17	Philip Morris Incorporated	Flavor generating article
JP2875076B2	1990-11-29	1999-03-24	三井化学株式会社	Flexible wiring board
FI86477C	1991-02-28	1992-08-25	Neste Oy	FOERVARINGS- OCH TRANSPORTFOERPACKNING AV PLAST Foer LOESPATRONER.
US5388594A *	1991-03-11	1995-02-14	Philip Morris Incorporated	Electrical smoking system for delivering flavors and method for making same
US5505214A *	1991-03-11	1996-04-09	Philip Morris Incorporated	Electrical smoking article and method for making same
TW245766B	1992-09-11	1995-04-21	Philip Morris Prod	
US5591368A *	1991-03-11	1997-01-07	Philip Morris Incorporated	Heater for use in an electrical smoking system
US5249586A	1991-03-11	1993-10-05	Philip Morris Incorporated	Electrical smoking
US5613505A	1992-09-11	1997-03-25	Philip Morris Incorporated	Inductive heating systems for smoking articles
US6322268B1	1993-11-12	2001-11-27	Avery Dennison Corporation	Efficient fluid dispensing utensil
US5261424A	1991-05-31	1993-11-16	Philip Morris Incorporated	Control device for flavor-generating article
US5285798A *	1991-06-28	1994-02-15	R. J. Reynolds Tobacco Company	Tobacco smoking article with electrochemical heat source
US5177424A	1991-09-20	1993-01-05	Welch Allyn, Inc.	Instrument handle for use with interchangeable batteries
JPH0593516A	1991-10-01	1993-04-16	Ricoh Co Ltd	Smoke generating device
GB2291605B	1991-11-12	1996-05-01	Medix Ltd	A nebuliser and nebuliser control system
US5322075A *	1992-09-10	1994-06-21	Philip Morris Incorporated	Heater for an electric flavor-generating article
JPH06114105A	1992-10-02	1994-04-26	Masanobu Iguchi	Smokeless suction and intake implement and method for cigarette or chemical component
WO1994009842A1	1992-10-28	1994-05-11	Rosen Charles A	Method and devices for delivering drugs by inhalation
US5452711A	1992-12-24	1995-09-26	Exar Corporation	Small form factor atomizer
US5372148A	1993-02-24	1994-12-13	Philip Morris Incorporated	Method and apparatus for controlling the supply of energy to a heating load in a smoking article
GB9307710D0 *	1993-04-14	1993-06-02	Rothmans Benson & Hedges	Smoking apparatus-l
US5666977A *	1993-06-10	1997-09-16	Philip Morris Incorporated	Electrical smoking article using liquid tobacco flavor medium delivery system
US5894841A	1993-06-29	1999-04-20	Ponwell Enterprises Limited	Dispenser
DE4328243C1 *	1993-08-19	1995-03-09	Sven Mielordt	Smoke or inhalation device
DE4328001C2	1993-08-20	1997-03-20	Dia Nielsen Gmbh	Ink tank
US5438978A *	1993-09-23	1995-08-08	Weh, Inc.	Device for enhancing moisture content of inspired air in a closed respiratory system
IE72523B1 *	1994-03-10	1997-04-23	Elan Med Tech	Nicotine oral delivery device
US5512001A	1995-02-03	1996-04-30	Stephen Schwartz Design	Toy vehicle
JP2693925B2	1995-04-17	1997-12-24	静岡日本電気株式会社	Wireless selective call receiver

US5745985A	1995-06-23	1998-05-05	Texas Instruments Incorporated	Method of attaching a semiconductor microchip to a circuit board
JPH0975058A	1995-09-18	1997-03-25	Masaya Nagai	Nicotine inhalator
SK285318B6	1996-04-25	2006-10-05	Astrazeneca Ab	Inhaler
CN1135860A	1996-05-09	1996-11-20	徐度	Atomized cigarette
US5743251A	1996-05-15	1998-04-28	Philip Morris Incorporated	Aerosol and a method and apparatus for generating an aerosol
US5746251A	1996-05-23	1998-05-05	Bullard; Horace	Multi-port fluid valve
EP0857431B1	1996-06-17	2003-03-12	Japan Tobacco Inc.	Flavor generating product and flavor generating tool
DE69724559T2	1996-06-17	2004-07-15	Japan Tobacco Inc.	FLAVORED ARTICLE
IT1289590B1	1996-08-19	1998-10-15	Guido Belli	Device for the delivery of nebulised substances to induce drug cessation and in particular from smoking and to cure
US6040560A	1996-10-22	2000-03-21	Philip Morris Incorporated	Power controller and method of operating an electrical smoking system
US5934289A	1996-10-22	1999-08-10	Philip Morris Incorporated	Electronic smoking system
JP3285502B2 *	1996-10-30	2002-05-27	株式会社東海	Combustion appliances for liquid fuel
US5878752A *	1996-11-25	1999-03-09	Philip Morris Incorporated	Method and apparatus for using, cleaning, and maintaining electrical heat sources and lighters useful in smoking systems and other apparatuses
US5944025A	1996-12-30	1999-08-31	Brown & Williamson Tobacco Company	Smokeless method and article utilizing catalytic heat source for controlling products of combustion
CN2293957Y	1997-05-23	1998-10-14	赵玉忠	Electronic controlled cigarette holder
KR100289448B1	1997-07-23	2001-05-02	미즈노 마사루	Flavor generator
CN1044314C *	1997-12-01	1999-07-28	蒲邯名	Healthy cigarette
US6311561B1	1997-12-22	2001-11-06	Rosemount Aerospace Inc.	Media compatible pressure sensor
US5996589A	1998-03-03	1999-12-07	Brown & Williamson Tobacco Corporation	Aerosol-delivery smoking article
CN1233436A	1998-04-27	1999-11-03	高洪斌	Liquid odour type cigarette
US6164287A	1998-06-10	2000-12-26	R. J. Reynolds Tobacco Company	Smoking method
US6095153A *	1998-06-19	2000-08-01	Kessler; Stephen B.	Vaporization of volatile materials
US6234167B1	1998-10-14	2001-05-22	Chrysalis Technologies, Incorporated	Aerosol generator and methods of making and using an aerosol generator
DE19854005C2	1998-11-12	2001-05-17	Reemtsma H F & Ph	Inhalable aerosol delivery system
US6041789A	1999-01-28	2000-03-28	K&B Technologies, L.L.C.	Cigarette substitute device and composition for use therein
SE9900369D0 *	1999-02-04	1999-02-04	Siemens Elema Ab	Ultrasonic nebuliser
US6196218B1 *	1999-02-24	2001-03-06	Ponwell Enterprises Ltd	Piezo inhaler
KR20010108248A	1999-02-26	2001-12-07	추후제출	Smokable product
US6354293B1 *	1999-03-16	2002-03-12	Foster E. Madison	Breathing humidifier
CA2378913C	1999-07-16	2010-02-23	Aradigm Corporation	System for effecting smoke cessation
US6354301B2 *	1999-08-02	2002-03-12	Mccoy Mark Scott	Two-piece smoking pipe vaporization chamber with directed heat intake
EP1214153A1	1999-09-22	2002-06-19	MicroCoating Technologies, Inc.	Liquid atomization methods and devices

US6792199B2	2000-02-25	2004-09-14	The Dial Corporation	Variable temperature vaporizer
DE10008924A1	2000-02-25	2001-09-06	Phenolchemie Gmbh & Co Kg	Process for the production of phenol
DE10051792A1	2000-10-18	2002-05-08	Rainer Puellen	System for providing enjoyment similar to enjoyment obtained by smoking comprises cigarette-sized inhalation device, portable filler unit and stationary filler unit for filling portable filler units
US6681998B2	2000-12-22	2004-01-27	Chrysalis Technologies Incorporated	Aerosol generator having inductive heater and method of use thereof
SE518354C2	2001-01-31	2002-10-01	Svensk Konstruktionstjaenst Aa	Device for generating fog / smoke
EP2495004B1	2001-07-31	2014-04-16	Philip Morris Products S.a.s.	Method and apparatus for generating a volatilized material
FI20011787A	2001-09-10	2003-03-11	Marioff Corp Oy	Method at the spray head and at the spray head
US6532965B1 *	2001-10-24	2003-03-18	Brown & Williamson Tobacco Corporation	Smoking article using steam as an aerosol-generating source
US6598607B2	2001-10-24	2003-07-29	Brown & Williamson Tobacco Corporation	Non-combustible smoking device and fuel element
US6804458B2 *	2001-12-06	2004-10-12	Chrysalis Technologies Incorporated	Aerosol generator having heater arranged to vaporize fluid in fluid passage between bonded layers of laminate
SE0104388D0	2001-12-27	2001-12-27	Pharmacia Ab	New formulation and use and manufacture thereof
US6772756B2	2002-02-09	2004-08-10	Advanced Inhalation Revolutions Inc.	Method and system for vaporization of a substance
US6880951B2	2002-04-04	2005-04-19	Altec Co., Ltd.	Flashlight using a light emitting diode as a lamp
WO2003092750A1	2002-05-03	2003-11-13	Givaudan Sa	Dispensing device
US6854461B2 *	2002-05-10	2005-02-15	Philip Morris Usa Inc.	Aerosol generator for drug formulation and methods of generating aerosol
SE0201669D0	2002-06-03	2002-06-03	Pharmacia Ab	New formulation and use thereof
US6803545B2 *	2002-06-05	2004-10-12	Philip Morris Incorporated	Electrically heated smoking system and methods for supplying electrical power from a lithium ion power source
GB0214611D0	2002-06-25	2002-08-07	Asthmo Alert	Electrochemical sensor for the analysis of carbon dioxide gas
US7015796B2	2002-09-06	2006-03-21	Brady Development, Inc.	Device for weaning an addiction
US6810883B2 *	2002-11-08	2004-11-02	Philip Morris Usa Inc.	Electrically heated cigarette smoking system with internal manifolding for puff detection
US20040149282A1	2002-12-02	2004-08-05	Scott Laboratories, Inc.	Respiratory monitoring systems and methods
US7051540B2	2003-01-27	2006-05-30	Battelle Memorial Institute	Methods for fluid separations, and devices capable of separating fluids
US20040182403A1	2003-02-28	2004-09-23	Sven-Borje Andersson	Container comprising nicotine and the use and manufacture thereof
CN2643681Y	2003-03-14	2004-09-29	韩力	Incombustible electronic atomized cigarette
WO2004089126A1	2003-04-01	2004-10-21	Shusei Takano	Nicotine suction pipe and nicotine holder
CN2648836Y	2003-04-29	2004-10-20	韩力	Non-combustible electronic spray cigarette
CN101084801A	2003-04-29	2007-12-12	韩力	Non-combustible electronic spraying cigarette
US7100618B2 *	2003-05-05	2006-09-05	Armando Dominguez	Sensory smoking simulator
US7293565B2	2003-06-30	2007-11-13	Philip Morris Usa Inc.	Electrically heated cigarette smoking system
JP4411901B2	2003-08-11	2010-02-10	セイコーエプソン株式会社	Atomizer

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US7997280B2 *	2004-01-30	2011-08-16	Joshua Rosenthal	Portable vaporizer
JP4278549B2	2004-03-30	2009-06-17	長野計器株式会社	Pressure sensor
US20050236006A1 *	2004-04-24	2005-10-27	Anderson Cowan	Smoking cessation devices, methods of use and methods of conducting business therewith
GB0416250D0	2004-07-20	2004-08-25	Unilever Plc	Cosmetic dispenser housing and method
JP2006032246A *	2004-07-21	2006-02-02	Sanyo Electric Co Ltd	Separator for nonaqueous electrolyte battery and nonaqueous electrolyte battery
KR20070108215A	2005-02-02	2007-11-08	오글레스비 앤 버틀러 리서치 앤 디벨롭먼트 리미티드	A device for vaporising vaporisable matter
GB0508318D0 *	2005-04-25	2005-06-01	Novartis Ag	Organic compounds
JP5008207B2	2005-05-16	2012-08-22	ベイポーア・インコーポレイテッドＶａｐｏｒｅ Ｉｎｃｏｒｐｏｒａｔｅｄ	Improved capillary force vaporizer
US9675109B2 *	2005-07-19	2017-06-13	J. T. International Sa	Method and system for vaporization of a substance
CN2887086Y	2005-09-01	2007-04-11	王山红	A pure cigarette
WO2007078273A1	2005-12-22	2007-07-12	Augite Incorporation	No-tar electronic smoking utensils
FR2895644B1 *	2006-01-03	2008-05-16	Didier Gerard Martzel	SUBSTITUTE OF CIGARETTE
CN2870485Y	2006-01-23	2007-02-21	张�诚	Electronic cigarette
DE102006004484A1	2006-01-29	2007-08-09	Karsten Schmidt	Re-usable part for smoke-free cigarette, has filament preheated by attaching filter, where filament is brought to operating temperature, when pulling on entire construction of cigarette
CN201067079Y	2006-05-16	2008-06-04	韩力	Simulation aerosol inhaler
US7726320B2 *	2006-10-18	2010-06-01	R. J. Reynolds Tobacco Company	Tobacco-containing smoking article
CN200966824Y *	2006-11-10	2007-10-31	韩力	Absorbing atomization device
CN100536951C	2006-11-11	2009-09-09	达福堡国际有限公司	Device for feeding drug into pulmones
CN200997909Y	2006-12-15	2008-01-02	王玉民	Disposable electric purified cigarette
WO2008077271A1	2006-12-25	2008-07-03	Bernard Maas	A computerized healthy smoking device
CN201018927Y	2007-01-04	2008-02-13	王月华	Electronic liquid cigarette
EP1972215A1 *	2007-03-20	2008-09-24	Wedegree GmbH	Smoke-free cigarette substitute
US7845359B2	2007-03-22	2010-12-07	Pierre Denain	Artificial smoke cigarette
US20080257367A1 *	2007-04-23	2008-10-23	Greg Paterno	Electronic evaporable substance delivery device and method
EP1989946A1 *	2007-05-11	2008-11-12	Rauchless Inc.	Smoking device, charging means and method of using it
CN100593982C	2007-09-07	2010-03-17	中国科学院理化技术研究所	Electronic cigarette having nanometer sized hyperfine space warming atomizing functions
CN201085044Y	2007-09-18	2008-07-16	方晓林	Electronic cigarette
US8991402B2	2007-12-18	2015-03-31	Pax Labs, Inc.	Aerosol devices and methods for inhaling a substance and uses thereof
DE202008018338U1 *	2008-02-29	2013-04-16	Yunqiang Xiu	Electronic simulation cigarette and associated nebulizing liquid, smoking device for the electronic, simulated cigarette with associated liquid capsule
EP2100525A1	2008-03-14	2009-09-16	Philip Morris Products S.A.	Electrically heated aerosol generating system and method

EP2110033A1	2008-03-25	2009-10-21	Philip Morris Products S.A.	Method for controlling the formation of smoke constituents in an electrical aerosol generating system
EP2113178A1 *	2008-04-30	2009-11-04	Philip Morris Products S.A.	An electrically heated smoking system having a liquid storage portion
GB0808154D0	2008-05-06	2008-06-11	British American Tobacco Co	Aerosol dispensing device
GB0813686D0	2008-07-25	2008-09-03	Gamucci Ltd	A method and apparatus relating to electronic smoking-substitute devices
EP2186537A1	2008-11-07	2010-05-19	Inhaleness B.V.	Inhaler, comprising a hydrogen generator
US20100200008A1 *	2009-02-09	2010-08-12	Eli Taieb	E-Cigarette With Vitamin Infusion
CN201379072Y	2009-02-11	2010-01-13	韩力	Improved atomizing electronic cigarette
CN101518361B *	2009-03-24	2010-10-06	北京格林世界科技发展有限公司	High-simulation electronic cigarette
US8851068B2 *	2009-04-21	2014-10-07	Aj Marketing Llc	Personal inhalation devices
DE102009029768B4	2009-06-18	2013-02-21	Zetzig Ab	Device for delivering nicotine
CN201445686U	2009-06-19	2010-05-05	李文博	High-frequency induction atomizing device
CN101606758B	2009-07-14	2011-04-13	方晓林	Electronic cigarette
ITNA20090023U1	2009-07-21	2011-01-22	Rml S R L	ELECTRONIC CIGARETTE WITH ATOMISER INCORPORATED IN THE FAILED FILTER.
UA47514U	2009-08-04	2010-02-10	Национальный Университет Пищевых Технологий	Rye bread
WO2011022431A1	2009-08-17	2011-02-24	Chong Corporation	Vaporized tobacco product and methods of use
US20100181387A1 *	2009-12-01	2010-07-22	Zaffaroni Alejandro C	Aerosol delivery system and uses thereof
CN201797997U	2010-09-28	2011-04-20	深圳市如烟生物科技有限公司	Solid tobacco tar atomizer
CN202026802U	2011-02-28	2011-11-09	深圳市如烟生物科技有限公司	Atomizer capable of repetitively adding solid tobacco tar
CN202026804U	2011-03-14	2011-11-09	深圳市如烟生物科技有限公司	Smokeless cotton atomizer

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EP2110033A1	2008-03-25	2009-10-21	Philip Morris Products S.A.	Method for controlling the formation of smoke constituents in an electrical aerosol generating system
EP2110034A1	2008-04-17	2009-10-21	Philip Morris Products S.A.	An electrically heated smoking system

EP2201850A1	2008-12-24	2010-06-30	Philip Morris Products S.A.	An article including identification information for use in an electrically heated smoking system
US20110265806A1 *	2010-04-30	2011-11-03	Ramon Alarcon	Electronic smoking device
US8156944B2	2006-05-16	2012-04-17	Ruyan Investments (Holdings) Limited	Aerosol electronic cigarette
JP2012517229A *	2009-02-11	2012-08-02	力韓	Improved spray electronic cigarette
USD691765S1	2013-01-14	2013-10-15	Altria Client Services Inc.	Electronic smoking article
USD691766S1	2013-01-14	2013-10-15	Altria Client Services Inc.	Mouthpiece of a smoking article
USD695449S1	2013-01-14	2013-12-10	Altria Client Services Inc.	Electronic smoking article
US8794231B2	2008-04-30	2014-08-05	Philip Morris Usa Inc.	Electrically heated smoking system having a liquid storage portion
US8903228B2	2011-03-09	2014-12-02	Chong Corporation	Vapor delivery devices and methods
US8997754B2	2012-01-31	2015-04-07	Altria Client Services Inc.	Electronic cigarette
US9084440B2	2009-11-27	2015-07-21	Philip Morris Usa Inc.	Electrically heated smoking system with internal or external heater
WO2016005600A1	2014-07-11	2016-01-14	Philip Morris Products S.A.	Aerosol-generating system with improved air flow control
WO2016005602A1	2014-07-11	2016-01-14	Philip Morris Products S.A.	Aerosol-generating system comprising cartridge detection
WO2016023809A1	2014-08-13	2016-02-18	Philip Morris Products S.A.	Aerosol-generating system comprising multi-purpose computing device
US9289014B2	2012-02-22	2016-03-22	Altria Client Services Llc	Electronic smoking article and improved heater element
US9357803B2	2011-09-06	2016-06-07	British American Tobacco (Investments) Limited	Heat insulated apparatus for heating smokable material
US9399110B2	2011-03-09	2016-07-26	Chong Corporation	Medicant delivery system
US9414629B2	2011-09-06	2016-08-16	Britsh American Tobacco (Investments) Limited	Heating smokable material
US9420829B2	2009-10-27	2016-08-23	Philip Morris Usa Inc.	Smoking system having a liquid storage portion
US9499332B2	2009-05-21	2016-11-22	Philip Morris Usa Inc.	Electrically heated smoking system
US9532597B2	2012-02-22	2017-01-03	Altria Client Services Llc	Electronic smoking article
US9609894B2	2011-09-06	2017-04-04	British American Tobacco (Investments) Limited	Heating smokable material
US9717278B2	2004-04-14	2017-08-01	Fontem Holdings 1 B.V.	Electronic cigarette
US9848645B2	2013-07-24	2017-12-26	Sis Resources Ltd.	Cartomizer structure for automated assembly
US9913950B2	2011-03-09	2018-03-13	Chong Corporation	Medicant delivery system
WO2018050701A1	2016-09-14	2018-03-22	Philip Morris Products S.A.	Aerosol-generating system and method for controlling the same
US9943114B2	2014-07-11	2018-04-17	Philip Morris Products S.A.	Aerosol-forming cartridge comprising a tobacco-containing material
US9986767B2	2014-07-11	2018-06-05	Philip Morris Products S.A.	Aerosol-forming cartridge comprising a liquid nicotine source
US10034988B2	2012-11-28	2018-07-31	Fontem Holdings I B.V.	Methods and devices for compound delivery
EP3378339A1	2013-12-03	2018-09-26	Philip Morris Products S.a.s.	Aerosol-generating article and electrically operated system incorporating a taggant
US10123569B2	2003-04-29	2018-11-13	Fontem Holdings 1 B.V.	Electronic cigarette

USD834743S1	2013-10-14	2018-11-27	Altria Client Services Llc	Smoking article
EP3406148A1	2014-05-21	2018-11-28	Philip Morris Products S.a.s.	Aerosol-forming article comprising magnetic particles
US10194693B2	2013-09-20	2019-02-05	Fontem Holdings 1 B.V.	Aerosol generating device
USD841231S1	2013-01-14	2019-02-19	Altria Client Services, Llc	Electronic vaping device mouthpiece
USD849993S1	2013-01-14	2019-05-28	Altria Client Services	Electronic smoking article
US10300225B2	2010-05-15	2019-05-28	Rai Strategic Holdings, Inc.	Atomizer for a personal vaporizing unit
US10334881B1	2009-07-27	2019-07-02	Fuma International, Llc	Electronic vaporizer
US10349684B2	2015-09-15	2019-07-16	Rai Strategic Holdings, Inc.	Reservoir for aerosol delivery devices
US10357060B2	2016-03-11	2019-07-23	Altria Client Services Llc	E-vaping device cartridge holder
US10368580B2	2016-03-08	2019-08-06	Altria Client Services Llc	Combined cartridge for electronic vaping device
US10368581B2	2016-03-11	2019-08-06	Altria Client Services Llc	Multiple dispersion generator e-vaping device
US10433580B2	2016-03-03	2019-10-08	Altria Client Services Llc	Methods to add menthol, botanic materials, and/or non-botanic materials to a cartridge, and/or an electronic vaping device including the cartridge
US10455863B2	2016-03-03	2019-10-29	Altria Client Services Llc	Cartridge for electronic vaping device
US10602776B2	2014-07-11	2020-03-31	Philip Morris Products S.A.	Aerosol-forming cartridge with protective foil
US10729176B2	2011-09-06	2020-08-04	British American Tobacco (Investments) Limited	Heating smokeable material
US10757975B2	2014-07-11	2020-09-01	Philip Morris Products S.A.	Aerosol-generating system comprising a removable heater
US10881138B2	2012-04-23	2021-01-05	British American Tobacco (Investments) Limited	Heating smokeable material
US11039644B2	2013-10-29	2021-06-22	Nicoventures Trading Limited	Apparatus for heating smokeable material
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US10279934B2	2013-03-15	2019-05-07	Juul Labs, Inc.	Fillable vaporizer cartridge and method of filling
US9675109B2	2005-07-19	2017-06-13	J. T. International Sa	Method and system for vaporization of a substance
US7726320B2	2006-10-18	2010-06-01	R. J. Reynolds Tobacco Company	Tobacco-containing smoking article
WO2008133091A1	2007-04-18	2008-11-06	Japan Tobacco Inc.	Smoking tool
US8991402B2	2007-12-18	2015-03-31	Pax Labs, Inc.	Aerosol devices and methods for inhaling a substance and uses thereof
US20090283103A1 *	2008-05-13	2009-11-19	Nielsen Michael D	Electronic vaporizing devices and docking stations
EP2143346A1	2008-07-08	2010-01-13	Philip Morris Products S.A.	A flow sensor system
GB0813686D0 *	2008-07-25	2008-09-03	Gamucci Ltd	A method and apparatus relating to electronic smoking-substitute devices
JP2010035732A *	2008-08-04	2010-02-18	Canon Inc	Inhaler
AT507187B1	2008-10-23	2010-03-15	Helmut Dr Buchberger	INHALER
KR200455132Y1 *	2009-01-08	2011-08-19	조여언	Liquid vaporization suction device

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US20100200008A1 *	2009-02-09	2010-08-12	Eli Taieb	E-Cigarette With Vitamin Infusion
WO2010118644A1 *	2009-04-15	2010-10-21	中国科学院理化技术研究所	Heating atomization electronic-cigarette adopting capacitor for power supply
US8851068B2 *	2009-04-21	2014-10-07	Aj Marketing Llc	Personal inhalation devices
CN201445686U *	2009-06-19	2010-05-05	李文博	High-frequency induction atomizing device
CN101606758B *	2009-07-14	2011-04-13	方晓林	Electronic cigarette
ITNA20090023U1 *	2009-07-21	2011-01-22	Rml S R L	ELECTRONIC CIGARETTE WITH ATOMISER INCORPORATED IN THE FAILED FILTER.
CN101627837B *	2009-08-07	2011-02-02	岑利明	Electronic cigarette
US9072321B2	2009-09-18	2015-07-07	Minilogic Device Corporation Ltd.	Electronic smoke
US10420374B2	2009-09-18	2019-09-24	Altria Client Services Llc	Electronic smoke apparatus
AT509046B1 *	2010-03-10	2011-06-15	Helmut Dr Buchberger	FLAT EVAPORATOR
US9204670B2 *	2010-04-09	2015-12-08	Huizhou Kimree Technology Co., Ltd. Shenzhen Branch	Electronic cigarette atomization device
US20110277780A1 *	2010-05-15	2011-11-17	Nathan Andrew Terry	Personal vaporizing inhaler with mouthpiece cover
US9095175B2 *	2010-05-15	2015-08-04	R. J. Reynolds Tobacco Company	Data logging personal vaporizing inhaler
US9743691B2	2010-05-15	2017-08-29	Rai Strategic Holdings, Inc.	Vaporizer configuration, control, and reporting
US10136672B2	2010-05-15	2018-11-27	Rai Strategic Holdings, Inc.	Solderless directly written heating elements
US8550068B2 *	2010-05-15	2013-10-08	Nathan Andrew Terry	Atomizer-vaporizer for a personal vaporizing inhaler
US9861772B2	2010-05-15	2018-01-09	Rai Strategic Holdings, Inc.	Personal vaporizing inhaler cartridge
US9259035B2	2010-05-15	2016-02-16	R. J. Reynolds Tobacco Company	Solderless personal vaporizing inhaler
US10159278B2	2010-05-15	2018-12-25	Rai Strategic Holdings, Inc.	Assembly directed airflow
US9999250B2	2010-05-15	2018-06-19	Rai Strategic Holdings, Inc.	Vaporizer related systems, methods, and apparatus
WO2011146174A2 *	2010-05-15	2011-11-24	Nathan Andrew Terry	Volume liquid storage reservoir in a personal vaporizing inhaler
US8746240B2	2010-05-15	2014-06-10	Nate Terry & Michael Edward Breede	Activation trigger for a personal vaporizing inhaler
CN201830899U *	2010-06-09	2011-05-18	李永海	Power supply device for electronic cigarette
CN201830900U *	2010-06-09	2011-05-18	李永海	Tobacco juice atomization device for electronic cigarette
WO2012062247A1 *	2010-08-16	2012-05-18	Cetin Sungur	Electric inhaler
ES2543045T3	2010-08-24	2015-08-14	Eli Alelov	Inhalation device that includes substance use controls
US8499766B1	2010-09-15	2013-08-06	Kyle D. Newton	Electronic cigarette with function illuminator
CN102160906B *	2010-11-01	2012-08-08	常州市富艾发进出口有限公司	Oral-suction type portable atomizer
EP2454956A1 *	2010-11-19	2012-05-23	Philip Morris Products S.A.	An electrically heated smoking system comprising at least two units
US9315890B1 *	2010-11-19	2016-04-19	Markus Frick	System and method for volatilizing organic compounds

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US8975764B1 *	2010-11-29	2015-03-10	Benyamin Abehasera	Electronic cigarette with integrated charging mechanism
EA019736B1 *	2010-12-01	2014-05-30	Евгений Иванович Евсюков	Inhaling device
EP2460422A1 *	2010-12-03	2012-06-06	Philip Morris Products S.A.	An aerosol generating system with provention of condensate leakage
EP2460423A1 *	2010-12-03	2012-06-06	Philip Morris Products S.A.	An electrically heated aerosol generating system having improved heater control
EP2460424A1 *	2010-12-03	2012-06-06	Philip Morris Products S.A.	An aerosol generating system with leakage prevention
KR101057774B1 *	2010-12-13	2011-08-19	신종수	Electronic cigarette
EP2468117A1	2010-12-24	2012-06-27	Philip Morris Products S.A.	An aerosol generating system having means for determining depletion of a liquid substrate
US8757169B2	2010-12-29	2014-06-24	David Gysland	Electronic cigarette refilling apparatus
US20120174914A1 *	2011-01-08	2012-07-12	Nasser Pirshafiey	Electronic vapor inhaling device
US9149586B2 *	2011-02-07	2015-10-06	Seibo Ping-Cheng SHEN	Herbal vaporization apparatus and method
US20120199146A1 *	2011-02-09	2012-08-09	Bill Marangos	Electronic cigarette
EP2672847B1	2011-02-11	2015-04-22	Batmark Limited	Inhaler component
KR101246816B1 *	2011-03-09	2013-03-26	이영인	Supplying Block for Supplying Nicotine Solution in Electric Cigarette
US8752544B2	2011-03-21	2014-06-17	General Electric Company	Medical vaporizer and method of monitoring of a medical vaporizer
EA201391511A1	2011-04-12	2014-06-30	Роберт Левиц	BATTERY CONNECTOR FOR ELECTRONIC CIGARETTE WITH SIDE AIR INTAKE
US9040582B2 *	2011-05-04	2015-05-26	Raymond M. Keller	Formulation and method to induce a deep state of relaxation
CN102326869B *	2011-05-12	2013-04-03	陈志平	Atomization nozzle of electronic atomization inhaler
US20120312313A1 *	2011-06-07	2012-12-13	Vapor Corp.	Padded cartridge for an electronic smoking apparatus
NZ593272A *	2011-06-07	2013-02-22	Scott Pearson	Breathing pipe with compartment having moutpiece and fan drivingly connected to a fan in another separated compartment to force air with active substance to outlet, typically near users nose to avoid nuisance to others
US20120325228A1 *	2011-06-23	2012-12-27	Williams Jonnie R	Alkaloid composition for e-cigarette
US8528569B1	2011-06-28	2013-09-10	Kyle D. Newton	Electronic cigarette with liquid reservoir
AT510837B1	2011-07-27	2012-07-15	Helmut Dr Buchberger	INHALATORKOMPONENTE
US9078473B2	2011-08-09	2015-07-14	R.J. Reynolds Tobacco Company	Smoking articles and use thereof for yielding inhalation materials
CA2749077A1 *	2011-08-11	2013-02-11	Wisplite Technology Group Incorporated	Portable electronic vapor-producing device and method
US20140205272A1 *	2011-08-15	2014-07-24	Porex Corporation	Conductive composite wick and method of making and using the same
EA028767B1	2011-08-16	2017-12-29	Пакс Лэбс, Инк.	Low temperature electronic vaporization device
WO2013034452A1 *	2011-09-06	2013-03-14	British American Tobacco (Investments) Limited	Heating smokeable material
EP2753859B1 *	2011-09-06	2017-12-20	British American Tobacco (Investments) Limited	Insulating
HUE045286T2	2011-09-28	2019-12-30	Philip Morris Products Sa	Permeable electric heat resistant foil for evaporating liquids out of disposable mouthpieces with evaporator nozzles
AT511344B1 *	2011-10-21	2012-11-15	Helmut Dr Buchberger	INHALATORKOMPONENTE

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US8820330B2	2011-10-28	2014-09-02	Evolv, Llc	Electronic vaporizer that simulates smoking with power control
DK2775865T3	2011-11-07	2016-06-27	Philip Morris Products Sa	Smoking article having a liquid supply material.
JP6005369B2 *	2011-11-14	2016-10-12	ホーチキ株式会社	Smoke test equipment
JP6005368B2 *	2011-11-14	2016-10-12	ホーチキ株式会社	Smoke generator for smoke test equipment, smoke test equipment and smoke test method
RS54959B1	2011-11-21	2016-11-30	Philip Morris Products Sa	Ejector for an aerosol-generating device
ITBO20110672A1 *	2011-11-24	2013-05-25	Montrade Srl	ELECTRONIC CIGARETTE
CN202385728U *	2011-11-25	2012-08-22	周学武	Electronic cigarette with built-in atomizer
RU2616556C2	2011-12-08	2017-04-17	Филип Моррис Продактс С.А.	Aerosol generating device with air ventilation nozzles
CN109892702A *	2011-12-08	2019-06-18	菲利普莫里斯生产公司	Inhalator generator with internal heater
TWI595839B *	2011-12-08	2017-08-21	菲利浦莫里斯製品股份有限公司	An aerosol generating device with a capillary interface
MY154105A *	2011-12-15	2015-04-30	Foo Kit Seng	An electronic vaporisation cigarette
EP3369328A3 *	2011-12-18	2018-11-21	Nu Mark Innovations Ltd	Charging electronic cigarette
CA2843247C *	2011-12-23	2016-10-11	Qiuming Liu	Electronic cigarette suction nozzle
CA150612S	2011-12-23	2014-11-06	Philip Morris Products Sa	Electronic aerosol generating smoking device
CN202474905U *	2011-12-29	2012-10-03	深圳市合元科技有限公司	Contact charging device for electronic cigarette
EP2609821A1	2011-12-30	2013-07-03	Philip Morris Products S.A.	Method and apparatus for cleaning a heating element of aerosol-generating device
HUE030730T2	2011-12-30	2017-05-29	Philip Morris Products Sa	Aerosol generating device with air flow detection
TWI629009B *	2012-01-03	2018-07-11	菲利浦莫里斯製品股份有限公司	Elongate aerosol-generating device and system
US20140363145A1 *	2012-01-03	2014-12-11	Philip Morris Products S.A.	Non-rolling aerosol-generating device and system
CA2862472C	2012-01-03	2019-07-16	Philip Morris Products S.A.	Polygonal aerosol-generating device and system
KR101184758B1 *	2012-01-13	2012-09-19	이영인	Cartridge of electric cigarette for preventing leakage
CN103596457A *	2012-01-25	2014-02-19	中汇远东实业有限公司	Heating element atomizer, and electronic simulation cigarette for use in atomization
KR101281269B1 *	2012-02-28	2013-07-03	박선순	Electronic cigarette atomizer structure including differential heating part and crucible
US20130220314A1 *	2012-02-29	2013-08-29	General Electric Company	Medical vaporizer with porous vaporization element
US20130248385A1	2012-03-23	2013-09-26	Njoy, Inc.	Electronic cigarette container
US20130247924A1	2012-03-23	2013-09-26	Mark Scatterday	Electronic cigarette having a flexible and soft configuration
US20130255702A1	2012-03-28	2013-10-03	R.J. Reynolds Tobacco Company	Smoking article incorporating a conductive substrate
CN202618275U *	2012-04-01	2012-12-26	惠州市吉瑞科技有限公司	Electronic cigarette and suction nozzle thereof
KR101316347B1 *	2012-04-03	2013-10-08	박선순	Electronic cigarette
CN203457800U	2012-04-12	2014-03-05	Jt国际公司	Smog generating device
CN104394721B *	2012-04-18	2018-05-25	富特姆控股第一有限公司	Electronic cigarette
WO2013159245A1	2012-04-26	2013-10-31	Ruyan Investment (Holdings) Limited	Electronic cigarette with sealed cartridge

GB2502053B	2012-05-14	2014-09-24	Nicoventures Holdings Ltd	Electronic smoking device
US20130319431A1 *	2012-05-30	2013-12-05	Gilbert Cyphert	Electronic cigarette
CN204292191U *	2012-06-04	2015-04-29	惠州市吉瑞科技有限公司	Electronic cigarette and atomizer thereof
CN203952417U *	2012-06-04	2014-11-26	惠州市吉瑞科技有限公司	Electronic cigarette circuit
CN202714190U *	2012-06-04	2013-02-06	深圳市康泓威科技有限公司	Integral cotton-free disposable electronic cigarette
CN202714191U *	2012-06-04	2013-02-06	深圳市康泓威科技有限公司	Cotton-free electronic cigarette atomizer
CN104023571B *	2012-06-05	2017-02-08	惠州市吉瑞科技有限公司	Electronic Cigarette And Suction Rod Thereof
US9155336B2 *	2012-06-16	2015-10-13	Huizhou Kimree Technology Co., Ltd., Shenzhen Branch	Electronic cigarette and electronic cigarette device
US10004259B2	2012-06-28	2018-06-26	Rai Strategic Holdings, Inc.	Reservoir and heater system for controllable delivery of multiple aerosolizable materials in an electronic smoking article
WO2014008646A1	2012-07-12	2014-01-16	Shenzhen L-Rider Technology Co, Ltd.	Tip charging electronic cigarette and system and method for charging the same
GB2504076A *	2012-07-16	2014-01-22	Nicoventures Holdings Ltd	Electronic smoking device
GB2504077A *	2012-07-16	2014-01-22	Nicoventures Holdings Ltd	Electronic smoking device
GB2504075A *	2012-07-16	2014-01-22	Nicoventures Holdings Ltd	Electronic smoking device
GB2504074A	2012-07-16	2014-01-22	Nicoventures Holdings Ltd	Electronic cigarette
US20140041655A1 *	2012-08-11	2014-02-13	Grenco Science, Inc	Portable Vaporizer
US10517530B2	2012-08-28	2019-12-31	Juul Labs, Inc.	Methods and devices for delivering and monitoring of tobacco, nicotine, or other substances
US8881737B2	2012-09-04	2014-11-11	R.J. Reynolds Tobacco Company	Electronic smoking article comprising one or more microheaters
US8910639B2	2012-09-05	2014-12-16	R. J. Reynolds Tobacco Company	Single-use connector and cartridge for a smoking article and related method
US9308336B2	2012-09-19	2016-04-12	Kyle D. Newton	Refill diverter for electronic cigarette
RU2617984C2 *	2012-09-28	2017-04-28	Кимри Хай-Тек Инк.	Electronic cigarette and respective electronic cigarette apparatus
CN103404969A *	2012-10-05	2013-11-27	佛山市新芯微电子有限公司	Electronic cigarette device
US10117460B2	2012-10-08	2018-11-06	Rai Strategic Holdings, Inc.	Electronic smoking article and associated method
US9854841B2	2012-10-08	2018-01-02	Rai Strategic Holdings, Inc.	Electronic smoking article and associated method
GB2507104A *	2012-10-19	2014-04-23	Nicoventures Holdings Ltd	Electronic inhalation device
US20140123989A1 *	2012-11-05	2014-05-08	The Safe Cig, Llc	Device and method for vaporizing a fluid
CN104010534B *	2012-11-12	2016-04-20	惠州市吉瑞科技有限公司	Electronic cigarette device, electronic cigarette and atomising device thereof
WO2014085719A1 *	2012-11-28	2014-06-05	E-Nicotine Technology, Inc.	Methods and devices for compound delivery
US9210738B2	2012-12-07	2015-12-08	R.J. Reynolds Tobacco	Apparatus and method for winding a substantially continuous

			Company	heating element about a substantially continuous wick
WO2014089757A1 *	2012-12-11	2014-06-19	Liu Quiming	Electronic cigarette and electronic cigarette device thereof
US8910640B2	2013-01-30	2014-12-16	R.J. Reynolds Tobacco Company	Wick suitable for use in an electronic smoking article
WO2014118787A1 *	2013-02-04	2014-08-07	ZILFA, Noam	Electronic coal
US9379364B2	2013-02-05	2016-06-28	Atmos Nation Llc	Spring loaded rechargeable battery assembly
GB2511305A *	2013-02-27	2014-09-03	British American Tobacco Co	A smoking device and a component for a smoking device
CN104014452A *	2013-03-01	2014-09-03	戴伟	Minitype atomization heater using heat energy generated by electronic component under excess-rated power
CN104026742A *	2013-03-05	2014-09-10	向智勇	Heating control method and device for electronic cigarette
US10031183B2	2013-03-07	2018-07-24	Rai Strategic Holdings, Inc.	Spent cartridge detection method and system for an electronic smoking article
US20140261486A1 *	2013-03-12	2014-09-18	R.J. Reynolds Tobacco Company	Electronic smoking article having a vapor-enhancing apparatus and associated method
US20140261487A1	2013-03-14	2014-09-18	R. J. Reynolds Tobacco Company	Electronic smoking article with improved storage and transport of aerosol precursor compositions
US9277770B2	2013-03-14	2016-03-08	R. J. Reynolds Tobacco Company	Atomizer for an aerosol delivery device formed from a continuously extending wire and related input, cartridge, and method
RU2656089C2	2013-03-14	2018-05-30	Р. Дж. Рейнолдс Тобакко Компани	Atomiser for aerosol delivery device and related workpiece, aerosol production assembly, cartridge and method
US9609893B2	2013-03-15	2017-04-04	Rai Strategic Holdings, Inc.	Cartridge and control body of an aerosol delivery device including anti-rotation mechanism and related method
US9491974B2	2013-03-15	2016-11-15	Rai Strategic Holdings, Inc.	Heating elements formed from a sheet of a material and inputs and methods for the production of atomizers
US9220302B2	2013-03-15	2015-12-29	R.J. Reynolds Tobacco Company	Cartridge for an aerosol delivery device and method for assembling a cartridge for a smoking article
US9723876B2 *	2013-03-15	2017-08-08	Altria Client Services Llc	Electronic smoking article
CN105050436B *	2013-03-15	2021-02-02	菲利普莫里斯生产公司	Smoke forming system with replaceable mouthpiece cover
US9423152B2 *	2013-03-15	2016-08-23	R. J. Reynolds Tobacco Company	Heating control arrangement for an electronic smoking article and associated system and method
US20150181941A1 *	2013-03-20	2015-07-02	Kimree Hi-Tech Inc.	Electronic cigarette
ITSO20130004A1 *	2013-03-26	2014-09-27	Raffaele Pettinato	ELECTRONIC CIGARETTE OR AEROSOL OF THE TYPE WITH A DISPOSABLE CARTRIDGE
CN204579885U *	2013-03-29	2015-08-26	惠州市吉瑞科技有限公司	Electronic cigarette
CN204519359U *	2013-04-08	2015-08-05	吉瑞高新科技股份有限公司	Electronic cigarette and circuit thereof
US9629394B2 *	2013-04-09	2017-04-25	Alan Benet Aronie	Portable vaporizer with central pin heater having heat diffuser-mixer blades
WO2014166079A1 *	2013-04-10	2014-10-16	吉瑞高新科技股份有限公司	Electronic cigarette built in power supply rod
EP2983534A1 *	2013-04-10	2016-02-17	Sino Business Limited	Electronic smoking substitutive device
JP6034488B2	2013-04-25	2016-11-30	日本たばこ産業株式会社	Method for producing component of luxury product including flavor component and component of luxury product including flavor component
GB2513637A	2013-05-02	2014-11-05	Nicoventures Holdings Ltd	Electronic cigarette

GB2513638A	2013-05-02	2014-11-05	Nicoventures Holdings Ltd	Electronic cigarette
GB2513639A	2013-05-02	2014-11-05	Nicoventures Holdings Ltd	Electronic cigarette
WO2014182736A1	2013-05-06	2014-11-13	Ploom, Inc.	Nicotine salt formulations for aerosol devices and methods thereof
CN203327951U *	2013-05-07	2013-12-11	深圳市合元科技有限公司	Electronic cigarette atomizer structure and electronic cigarette
CN103504478B *	2013-05-07	2016-01-27	深圳市合元科技有限公司	Electronic smoke atomizer and electronic cigarette
WO2014183283A1 *	2013-05-15	2014-11-20	吉瑞高新科技股份有限公司	Electronic cigarette
CA2910549A1 *	2013-05-21	2014-11-27	Philip Morris Products S.A.	Electrically heated aerosol delivery system
WO2014190500A1 *	2013-05-28	2014-12-04	吉瑞高新科技股份有限公司	Apparatus and method for efficient charging of electronic cigarettes
US20140355969A1 *	2013-05-28	2014-12-04	Sis Resources, Ltd.	One-way valve for atomizer section in electronic cigarettes
PL2810570T3 *	2013-06-03	2019-06-28	Fontem Holdings 1 B.V.	System with electronic smoking device and capsule
GB2514893B	2013-06-04	2017-12-06	Nicoventures Holdings Ltd	Container
EP3007306A4 *	2013-06-05	2017-01-18	Kimree Hi-Tech Inc.	Electronic cigarette charging method and electronic cigarette case
CN105473012B	2013-06-14	2020-06-19	尤尔实验室有限公司	Multiple heating elements with individual vaporizable materials in electronic vaporization devices
GB201311620D0	2013-06-28	2013-08-14	British American Tobacco Co	Devices Comprising a Heat Source Material and Activation Chambers for the Same
US10251422B2 *	2013-07-22	2019-04-09	Altria Client Services Llc	Electronic smoking article
US10010109B2	2013-07-24	2018-07-03	Altria Client Services Llc	Electronic smoking article with alternative air flow paths
US20150027468A1 *	2013-07-25	2015-01-29	Altria Client Services Inc.	Electronic smoking article
US10694782B2	2013-07-30	2020-06-30	Altria Client Services Llc	Electronic vaping device and vapor generating apparatus
CN203378561U *	2013-07-31	2014-01-08	刘秋明	Electronic cigarette
FR3009164B1 *	2013-08-05	2016-07-01	Maxime Taglione	CONTACT DEVICE FOR ELECTRONIC CIGARETTE.
CN203424294U *	2013-08-14	2014-02-12	刘秋明	Electronic cigarette
WO2015021656A1 *	2013-08-16	2015-02-19	吉瑞高新科技股份有限公司	Battery assembly and electronic cigarette manufactured by using battery assembly
WO2015021659A1 *	2013-08-16	2015-02-19	吉瑞高新科技股份有限公司	Battery component and electronic cigarette
WO2015021653A1	2013-08-16	2015-02-19	吉瑞高新科技股份有限公司	Battery assembly and electronic cigarette
CN203434223U *	2013-08-16	2014-02-12	刘秋明	Electronic cigarette package, electronic cigarette as well as battery assembly thereof
CN203424299U *	2013-08-16	2014-02-12	刘秋明	Electronic cigarette set, electronic cigarette, battery assembly of electronic cigarette and charging structure of electronic cigarette
CN203482897U *	2013-08-22	2014-03-19	刘秋明	Electronic cigarette
US10172387B2	2013-08-28	2019-01-08	Rai Strategic Holdings, Inc.	Carbon conductive substrate for electronic smoking article
CN105682724A *	2013-08-29	2016-06-15	富特姆4有限公司	Electronic smoking device configured for automated assembly
GB2518598B	2013-08-30	2016-06-01	Nicoventures Holdings	Apparatus with battery power control

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CN203434232U *	2013-08-30	2014-02-12	刘秋明	Electronic cigarette and battery assembly thereof
CN203504217U *	2013-09-10	2014-03-26	向智勇	Electronic cigarette case
US9901114B2 *	2013-09-25	2018-02-27	Huizhou Kimree Technology Co., Ltd. Shenzhen Branch	Battery rod assembly, electronic cigarette, and electronic cigarette charging apparatus
CN103960781A *	2013-09-29	2014-08-06	深圳市麦克韦尔科技有限公司	Electronic cigarette
CN103960782B *	2013-09-29	2016-09-21	深圳麦克韦尔股份有限公司	Electronic cigarette
CN108433184A *	2013-09-30	2018-08-24	日本烟草产业株式会社	Non-combustion-type fragrance extractor
US9806549B2	2013-10-04	2017-10-31	Rai Strategic Holdings, Inc.	Accessory for an aerosol delivery device and related method and computer program product
US9820509B2	2013-10-10	2017-11-21	Kyle D. Newton	Electronic cigarette with encoded cartridge
CN203492792U *	2013-10-15	2014-03-26	刘秋明	Electronic cigarette
CN105939620B *	2013-10-17	2018-11-02	吉瑞高新科技股份有限公司	The match control method of electronic cigarette and its battery bar assembly and atomizer assembly
WO2015054871A1 *	2013-10-17	2015-04-23	吉瑞高新科技股份有限公司	Electronic cigarette and assembly method thereof
ITTO20130869A1 *	2013-10-28	2015-04-29	Buzzi Srl	MODIFIED ELECTRONIC CIGARETTE AND ITS USE FOR MEDICAL APPLICATIONS
US10292424B2	2013-10-31	2019-05-21	Rai Strategic Holdings, Inc.	Aerosol delivery device including a pressure-based aerosol delivery mechanism
CN103519352A *	2013-11-07	2014-01-22	袁恩泽	Electronic cigarette
US20150128969A1	2013-11-11	2015-05-14	R.J. Reynolds Tobacco Company	Mouthpiece for smoking article
US20150128968A1	2013-11-11	2015-05-14	R.J. Reynolds Tobacco Company	Mouthpiece for smoking article
USD788697S1	2014-03-04	2017-06-06	VMR Products, LLC	Battery portion for a vaporizer
US10039321B2	2013-11-12	2018-08-07	Vmr Products Llc	Vaporizer
USD763502S1	2014-03-04	2016-08-09	Vmr Products Llc	Cartomizer for a vaporizer
EP3068244A4	2013-11-15	2017-07-05	VMR Products, LLC	Vaporizer with cover sleeve
WO2015073854A2 *	2013-11-15	2015-05-21	Jj 206, Llc	Systems and methods for a vaporization device and product usage control and documentation
USD721577S1	2013-11-21	2015-01-27	Njoy, Inc.	Packaging assembly
US9839237B2	2013-11-22	2017-12-12	Rai Strategic Holdings, Inc.	Reservoir housing for an electronic smoking article
CN113142679A	2013-12-05	2021-07-23	尤尔实验室有限公司	Nicotine liquid formulations for aerosol devices and methods thereof
AU2014359185B2 *	2013-12-05	2018-12-20	Philip Morris Products S.A.	Heated aerosol generating article with air-flow barrier
CN105792689B *	2013-12-16	2019-10-01	菲利普莫里斯生产公司	Apparatus for aerosol creation including heat exchanger
USD764701S1	2013-12-17	2016-08-23	Anil K. Malhi	Electronic smoking device
ITBO20130706A1 *	2013-12-20	2015-06-21	Sino Business Ltd	Composition for electronic cigarettes
US10159282B2	2013-12-23	2018-12-25	Juul Labs, Inc.	Cartridge for use with a vaporizer device

US9549573B2	2013-12-23	2017-01-24	Pax Labs, Inc.	Vaporization device systems and methods
DE202014011309U1	2013-12-23	2019-03-29	Juul Labs Uk Holdco Limited	Systems for an evaporation device
US20160366947A1	2013-12-23	2016-12-22	James Monsees	Vaporizer apparatus
US10058129B2	2013-12-23	2018-08-28	Juul Labs, Inc.	Vaporization device systems and methods
US10076139B2	2013-12-23	2018-09-18	Juul Labs, Inc.	Vaporizer apparatus
US10117463B2	2014-01-03	2018-11-06	Robert P Thomas, Jr.	Vapor delivery device
US9820510B2	2014-01-03	2017-11-21	Robert P Thomas, Jr.	Vapor delivery device
CN105916397B *	2014-01-14	2019-05-17	吉瑞高新科技股份有限公司	Electronic smoke atomizer and electronic cigarette
CN105916398B *	2014-01-14	2019-08-06	吉瑞高新科技股份有限公司	The assemble method of battery component, electronic cigarette and battery component
US9974334B2	2014-01-17	2018-05-22	Rai Strategic Holdings, Inc.	Electronic smoking article with improved storage of aerosol precursor compositions
WO2015106434A1 *	2014-01-17	2015-07-23	吉瑞高新科技股份有限公司	Battery assembly and electronic cigarette
CN103720058A *	2014-01-21	2014-04-16	陈伟	Oval atomizer electronic cigarette
US20150216237A1	2014-01-22	2015-08-06	E-Nicotine Technology, Inc.	Methods and devices for smoking urge relief
EA201691523A1 *	2014-01-27	2016-12-30	Сис Рисорсез Лтд.	WIRE COMMUNICATION IN ELECTRONIC SMOKING DEVICE
GB201401520D0 *	2014-01-29	2014-03-12	Batmark Ltd	Aerosol-forming member
US10575558B2	2014-02-03	2020-03-03	Rai Strategic Holdings, Inc.	Aerosol delivery device comprising multiple outer bodies and related assembly method
US20150217064A1 *	2014-02-04	2015-08-06	Michael Alexander Trzecieski	Aromatherapy Vaporization Device and Method
US9451791B2	2014-02-05	2016-09-27	Rai Strategic Holdings, Inc.	Aerosol delivery device with an illuminated outer surface and related method
TWI684414B	2014-02-06	2020-02-11	美商尤爾實驗室有限公司	Vaporization device systems and methods
US20150224268A1	2014-02-07	2015-08-13	R.J. Reynolds Tobacco Company	Charging Accessory Device for an Aerosol Delivery Device and Related System, Method, Apparatus, and Computer Program Product for Providing Interactive Services for Aerosol Delivery Devices
US9980515B2	2014-02-12	2018-05-29	Vapor 4 Life, LLC	Mouthpiece assembly for an electronic cigar or cigarette
WO2015120592A1 *	2014-02-12	2015-08-20	吉瑞高新科技股份有限公司	Electronic cigarette
CN203828068U *	2014-02-12	2014-09-17	刘秋明	Electronic cigarette
CN203723449U *	2014-02-12	2014-07-23	刘秋明	Electronic cigarette
US9833019B2	2014-02-13	2017-12-05	Rai Strategic Holdings, Inc.	Method for assembling a cartridge for a smoking article
CN203723451U *	2014-02-20	2014-07-23	刘秋明	Electronic cigarette
WO2015131038A2	2014-02-28	2015-09-03	Mullen Stephen J	System and method for dispensing pills
US9839238B2 *	2014-02-28	2017-12-12	Rai Strategic Holdings, Inc.	Control body for an electronic smoking article
US9918495B2	2014-02-28	2018-03-20	Rai Strategic Holdings, Inc.	Atomizer for an aerosol delivery device and related input, aerosol production assembly, cartridge, and method
GB201413032D0	2014-02-28	2014-09-03	Beyond Twenty Ltd	Beyond 7

USD752278S1	2014-03-07	2016-03-22	VMR Products, LLC	Battery portion of a vaporizer
USD749505S1	2014-03-07	2016-02-16	VMR Products, LLC	Charger for a vaporizer
USD752280S1	2014-03-07	2016-03-22	VMR Products, LLC	Cartomizer for a vaporizer
US9597466B2	2014-03-12	2017-03-21	R. J. Reynolds Tobacco Company	Aerosol delivery system and related method, apparatus, and computer program product for providing control information to an aerosol delivery device via a cartridge
US20150257445A1	2014-03-13	2015-09-17	R.J. Reynolds Tobacco Company	Aerosol Delivery Device and Related Method and Computer Program Product for Controlling an Aerosol Delivery Device Based on Input Characteristics
US10021909B2	2014-03-13	2018-07-17	Lubby Holdings, LLC	Apparatus and methods for vaporizing essential oils and waxes
CN103859607B *	2014-03-18	2016-03-30	深圳市博迪科技开发有限公司	There is electronic cigarette packet and the electronic cigarette of magnetic-type charge function
GB2524296B *	2014-03-19	2018-10-24	Kind Consumer Ltd	An inhaler
US10111467B1	2014-03-24	2018-10-30	Scott M. Arnel	Wearable electronic simulated smoking device with interchangeable vaporization cartridges
US9820508B2 *	2014-03-24	2017-11-21	Scott M. Arnel	Wearable electronic simulated smoking device
GB2524736B	2014-03-31	2021-02-24	Nicoventures Holdings Ltd	Re-charging pack for an e-cigarette
US9642397B2	2014-03-31	2017-05-09	Westfield Limited (Ltd.)	Personal vaporizer with liquid supply by suction
RS58459B1	2014-07-24	2019-04-30	Nicoventures Holdings Ltd	Re-charging pack for an e-cigarette
JP2017517246A *	2014-04-01	2017-06-29	ジー．デー ソチエタ ペル アツィオニＧ．Ｄ Ｓｏｃｉｅｔａ Ｐｅｒ Ａｚｉｏｎｉ	Disposable electronic cigarette cartridge and manufacturing method thereof
US9877510B2	2014-04-04	2018-01-30	Rai Strategic Holdings, Inc.	Sensor for an aerosol delivery device
USD804090S1	2014-04-08	2017-11-28	VMR Products, LLC	Vaporizer with indicators
GB201407426D0	2014-04-28	2014-06-11	Batmark Ltd	Aerosol forming component
EP2946679B1 *	2014-04-28	2019-09-25	Shenzhen First Union Technology Co., Ltd.	Atomizer and electronic cigarette having same
RU2676994C2 *	2014-04-30	2019-01-14	Филип Моррис Продактс С.А.	Aerosol generating device with battery indication
US20150313282A1	2014-05-01	2015-11-05	R.J. Reynolds Tobacco Company	Electronic smoking article
US20150314085A1 *	2014-05-05	2015-11-05	Isaac Banoun	Vapor medicine dispensing and nano-mist lung cleanser system
US9924741B2	2014-05-05	2018-03-27	Rai Strategic Holdings, Inc.	Method of preparing an aerosol delivery device
US9089166B1	2014-05-09	2015-07-28	Njoy, Inc.	Packaging for vaporizing device
DE102014106589A1 *	2014-05-09	2015-11-12	Aie Investments S.A.	Electric cigarette
DE102014106590A1 *	2014-05-09	2015-11-12	Aie Investments S.A.	Electric cigarette
TR201818794T4	2014-05-12	2019-01-21	Loto Labs Inc	Improved vaporizer device.
US9010335B1	2014-05-13	2015-04-21	Njoy, Inc.	Mechanisms for vaporizing devices
US20150335070A1	2014-05-20	2015-11-26	R.J. Reynolds Tobacco Company	Electrically-powered aerosol delivery system
USD752727S1	2014-05-20	2016-03-29	Vape Holdings, Inc.	Ceramic vaporizer

TWI661782B	2014-05-21	2019-06-11	瑞士商菲利浦莫里斯製品股份有限公司	Electrically heated aerosol-generating system,electrically heated aerosol-generating deviceand method of generating an aerosol
TWI660685B *	2014-05-21	2019-06-01	瑞士商菲利浦莫里斯製品股份有限公司	Electrically heated aerosol-generating system and cartridge for use in such a system
JP6663357B2 *	2014-05-21	2020-03-11	フィリップ・モーリス・プロダクツ・ソシエテ・アノニム	Electric heating type aerosol generation system with end heater
ES2833012T3 *	2014-05-22	2021-06-14	Nuryan Holdings Ltd	Pocket vaporizer device
US20150335075A1 *	2014-05-22	2015-11-26	R.J. Reynolds Tobacco Company	Cartridge and fluid reservoir for a vaporizer
US9955726B2	2014-05-23	2018-05-01	Rai Strategic Holdings, Inc.	Sealed cartridge for an aerosol delivery device and related assembly method
CN203952443U *	2014-06-13	2014-11-26	深圳市合元科技有限公司	Atomizer and electronic cigarette
CN104068474B *	2014-06-26	2017-01-04	深圳市康尔科技有限公司	Squash type electronic cigarette
GB201411483D0	2014-06-27	2014-08-13	Batmark Ltd	Vaporizer Assembly
US10888119B2	2014-07-10	2021-01-12	Rai Strategic Holdings, Inc.	System and related methods, apparatuses, and computer program products for controlling operation of a device based on a read request
US10058123B2	2014-07-11	2018-08-28	R. J. Reynolds Tobacco Company	Heater for an aerosol delivery device and methods of formation thereof
US10499689B2 *	2014-07-18	2019-12-10	Fontem Holdings 1 B.V.	Electronic cigarette with soft housing
CN104116140A *	2014-07-23	2014-10-29	宋锦谋	Electronic cigarette
GB2528673B	2014-07-25	2020-07-01	Nicoventures Holdings Ltd	Aerosol provision system
KR101698016B1	2014-07-26	2017-01-19	이상훈	Evaporating Module Having a Plural of Heaters for Atomizer
CN104432536A *	2014-07-28	2015-03-25	冯林	Novel electronic cigarette
GB2528712B	2014-07-29	2019-03-27	Nicoventures Holdings Ltd	E-cigarette and re-charging pack
WO2016015298A1 *	2014-07-31	2016-02-04	向智勇	Electronic cigarette and charging method therefor
USD750320S1	2014-08-05	2016-02-23	VMR Products, LLC	Vaporizer
US10238764B2	2014-08-19	2019-03-26	Vapium Inc.	Aromatherapy vaporization device
US9609895B2	2014-08-21	2017-04-04	Rai Strategic Holdings, Inc.	System and related methods, apparatuses, and computer program products for testing components of an aerosol delivery device
US9913493B2	2014-08-21	2018-03-13	Rai Strategic Holdings, Inc.	Aerosol delivery device including a moveable cartridge and related assembly method
US10765144B2	2014-08-21	2020-09-08	Rai Strategic Holdings, Inc.	Aerosol delivery device including a moveable cartridge and related assembly method
CN106998808B *	2014-08-22	2020-05-01	富特姆4有限公司	Method, system and device for controlling a heating element
CN106572702A *	2014-09-03	2017-04-19	德国瀚辉包装机械责任有限公司	Electric cigarette
CN107847696B	2014-09-10	2020-11-06	方特慕控股第一私人有限公司	Method and apparatus for regulating gas flow in a delivery device
US20160089508A1 *	2014-09-25	2016-03-31	ALTR, Inc.	Vapor inhalation device
DE102014114133A1 *	2014-09-29	2016-03-31	Aie Investments S.A.	Electric cigarette
WO2016054219A1	2014-10-01	2016-04-07	Altria Client Services Llc.	Portable charging case

RU2017115353A3	2014-10-02	2019-02-06		
EP3009019B1	2014-10-17	2019-05-01	Fontem Holdings 1 B.V.	Cartridge having a liquid transporting element for uses with an electronic smoking device
US10219541B2	2014-10-29	2019-03-05	Lubby Holdings, LLC	Cartridge cover for personal vaporizer
GB2535427A	2014-11-07	2016-08-24	Nicoventures Holdings Ltd	Solution
GB2532062A	2014-11-07	2016-05-11	Nicoventures Holdings Ltd	Container
US11051554B2	2014-11-12	2021-07-06	Rai Strategic Holdings, Inc.	MEMS-based sensor for an aerosol delivery device
CN204232301U *	2014-11-13	2015-04-01	深圳市合元科技有限公司	Atomizer and electronic cigarette
WO2016074236A1 *	2014-11-14	2016-05-19	惠州市吉瑞科技有限公司	Electronic cigarette and electronic cigarette atomization control method
ES2738730T3	2014-11-17	2020-01-24	Mcneil Ab	Electronic nicotine administration system
US10226076B2	2014-11-17	2019-03-12	Mcneil Ab	Disposable cartridge for use in an electronic nicotine delivery system
EP3226704B1	2014-12-05	2021-01-20	Juul Labs, Inc.	Calibrated dose control
US10500600B2	2014-12-09	2019-12-10	Rai Strategic Holdings, Inc.	Gesture recognition user interface for an aerosol delivery device
CN104605481B *	2014-12-18	2016-03-02	深圳市劲嘉科技有限公司	A kind of internal heating electronic smoking set
CN105707981A *	2014-12-19	2016-06-29	上海烟草集团有限责任公司	Atomizer and electronic cigarette
GB201423318D0 *	2014-12-29	2015-02-11	British American Tobacco Co	Cartridge for use with apparatus for heating smokable material
GB201423315D0 *	2014-12-29	2015-02-11	British American Tobacco Co	Apparatus for heating smokable material
GB201423312D0	2014-12-29	2015-02-11	British American Tobacco Co	Heating device for apparatus for heating smokable material and method of manufacture
US10244792B2	2014-12-30	2019-04-02	Lubby Holdings, LLC	Personal vaporizer
EP3042579A1 *	2015-01-09	2016-07-13	Fontem Holdings 1 B.V.	Electronic smoking device
CN106901405B *	2015-01-14	2019-09-27	杭州天时亿科技有限公司	Electronic cigarette
GB201500582D0	2015-01-14	2015-02-25	British American Tobacco Co	Apparatus for heating or cooling a material contained therein
PT3250059T *	2015-01-28	2019-10-15	Philip Morris Products Sa	Aerosol-generating article with integral heating element
US10321711B2	2015-01-29	2019-06-18	Rai Strategic Holdings, Inc.	Proximity detection for an aerosol delivery device
WO2017155635A1 *	2016-02-01	2017-09-14	Brandon Nedelman	Plurality of product concepts
CN104664607B *	2015-02-05	2017-11-14	湖南中烟工业有限责任公司	A kind of dropping type electronic cigarette
EP3153037B1 *	2015-02-06	2020-05-06	O-Net Automation Technology Shenzhen Limited	Atomizer of electronic cigarette
US10471052B2	2015-02-19	2019-11-12	Mymd Pharmaceuticals, Inc.	Method of treating addictions to opioids
CN104605484A *	2015-03-03	2015-05-13	华健	Organic tobacco tar capable of relieving cough and reducing sputum and preparation method for organic tobacco tar
US10010111B2	2015-03-04	2018-07-03	Altria Client Services Llc	E-vaping device

US10027016B2	2015-03-04	2018-07-17	Rai Strategic Holdings Inc.	Antenna for an aerosol delivery device
US9980516B2	2015-03-09	2018-05-29	Rai Strategic Holdings, Inc.	Aerosol delivery device including a wave guide and related method
US10172388B2	2015-03-10	2019-01-08	Rai Strategic Holdings, Inc.	Aerosol delivery device with microfluidic delivery component
US9989552B2	2015-03-25	2018-06-05	Arcus Hunting, Llc	Air movement visualization device
CN112656038A *	2015-03-27	2021-04-16	菲利普莫里斯生产公司	Resealable aerosol-generating article
CN104770879B *	2015-03-27	2020-05-22	河南中烟工业有限责任公司	Cigarette holder filter equipment with atomizing flue gas release and mixed function
EP2921065A1 *	2015-03-31	2015-09-23	Philip Morris Products S.a.s.	Extended heating and heating assembly for an aerosol generating system
GB201505593D0	2015-03-31	2015-05-13	British American Tobacco Co	Article for use with apparatus for heating smokable material
EA036430B1 *	2015-04-02	2020-11-10	Джапан Тобакко Инк.	Flavor inhaler
US11026449B2	2015-04-07	2021-06-08	Philip Morris Products S.A.	Sachet of aerosol-forming substrate, method of manufacturing same, and aerosol-generating device for use with sachet
US11071490B1	2015-04-09	2021-07-27	Heartbeam, Inc.	Electrocardiogram patch devices and methods
EP3280326A4	2015-04-09	2018-12-05	Heartbeam, Inc.	Mobile three-lead cardiac monitoring device and method for automated diagnostics
US9585981B2	2015-04-23	2017-03-07	Fourth Arrow, LLC	Device for creating and distributing vaporized scent
US9894893B2	2015-04-23	2018-02-20	Wyndscent, Llc	Breath-powered vapor distribution device
US9426977B1	2015-04-23	2016-08-30	Robert M. Wynalda, Jr.	Aromatic hunting lure vaporizing device
US10136679B1	2015-05-04	2018-11-27	Skapa Holdings, LLC	Electronic cigarette
US9936735B1 *	2015-05-04	2018-04-10	Bonvi Water, Inc.	Electronic cigarette
WO2016179776A1 *	2015-05-11	2016-11-17	惠州市吉瑞科技有限公司深圳分公司	Atomization assembly
KR20160134582A	2015-05-15	2016-11-23	석인선	laser vaporizer
US11000069B2	2015-05-15	2021-05-11	Rai Strategic Holdings, Inc.	Aerosol delivery device and methods of formation thereof
US10238145B2	2015-05-19	2019-03-26	Rai Strategic Holdings, Inc.	Assembly substation for assembling a cartridge for a smoking article
US20160353799A1 *	2015-06-05	2016-12-08	Gregory Otto	Non-porous Atomizer Chamber
US10226073B2	2015-06-09	2019-03-12	Rai Strategic Holdings, Inc.	Electronic smoking article including a heating apparatus implementing a solid aerosol generating source, and associated apparatus and method
US10362803B2	2015-06-10	2019-07-30	Evolv, Llc	Electronic vaporizer having reduced particle size
USD797368S1 *	2015-06-15	2017-09-12	Paule Rockferry	Electronic cigarette
US10010114B2	2015-06-25	2018-07-03	Altria Client Services Llc	Charger assembly and charging system for an electronic vaping device
US10736356B2	2015-06-25	2020-08-11	Altria Client Services Llc	Electronic vaping device having pressure sensor
CN108135260B *	2015-06-26	2021-06-29	日本烟草产业株式会社	Method for producing atomizing unit and atomizing unit
US10251425B2	2015-07-06	2019-04-09	Njoy, Llc	Vaporizing device with power component
US10874139B2 *	2015-07-07	2020-12-29	Altria Client Services Llc	E-vapor device including capsule containing pre-vapor formulation

KR20180028493A *	2015-07-10	2018-03-16	쥴 랩스, 인크.	Non-Atmospheric Vaporizer and Method
USD809190S1	2015-07-13	2018-01-30	Njoy, Llc	Vaporizer
US10039323B2	2015-07-16	2018-08-07	Njoy, Llc	Vaporizer tank with atomizer
US20170013880A1	2015-07-17	2017-01-19	R. J. Reynolds Tobacco Company	Contained liquid system for refilling aerosol delivery devices
US10966460B2	2015-07-17	2021-04-06	Rai Strategic Holdings, Inc.	Load-based detection of an aerosol delivery device in an assembled arrangement
US10206429B2	2015-07-24	2019-02-19	Rai Strategic Holdings, Inc.	Aerosol delivery device with radiant heating
US11033054B2	2015-07-24	2021-06-15	Rai Strategic Holdings, Inc.	Radio-frequency identification (RFID) authentication system for aerosol delivery devices
US10015987B2	2015-07-24	2018-07-10	Rai Strategic Holdings Inc.	Trigger-based wireless broadcasting for aerosol delivery devices
US20170027223A1 *	2015-07-29	2017-02-02	Cloud V Enterprises	Vaporizer With Multiple-Chamber Heating
US10869502B2 *	2015-07-31	2020-12-22	14Th Round Inc.	Disposable assembly for vaporizing e-liquid and a method of using the same
DE102015113124A1 *	2015-08-10	2017-02-16	Schott Ag	Open-pore sintered glasses for use in electronic cigarettes
US10492528B2 *	2015-08-11	2019-12-03	Altria Client Services Llc	Power supply section configuration for an electronic vaping device and electronic vaping device
EP3337341B1 *	2015-08-20	2020-01-15	Fontem Holdings 1 B.V.	Electronic smoking device with capillary buffer
US20170055575A1	2015-08-31	2017-03-02	British American Tobacco (Investments) Limited	Material for use with apparatus for heating smokable material
CN205143486U *	2015-09-02	2016-04-13	深圳市合元科技有限公司	Atomising head, atomizer and electron cigarette
RU2018115123A	2015-09-25	2019-10-28	ЛАББИ ХОЛДИНГС ЭлЭлСи	PERSONAL STEAM RETURN AIR INHIBITOR
US10004264B2	2015-09-28	2018-06-26	Lubby Holdings, LLC	Vaporizer and detachable power source
GB201517089D0	2015-09-28	2015-11-11	Nicoventures Holdings Ltd	Vaping heat map system and method for electronic vapour provision systems
GB2542838A *	2015-10-01	2017-04-05	Nicoventures Holdings Ltd	Aerosol provision system
US10058125B2	2015-10-13	2018-08-28	Rai Strategic Holdings, Inc.	Method for assembling an aerosol delivery device
KR20190086759A	2016-12-01	2019-07-23	레이 스트라티직 홀딩스, 인크.	Rechargeable Lithium-Ion Capacitors for Aerosol Transfer Devices
US10582726B2	2015-10-21	2020-03-10	Rai Strategic Holdings, Inc.	Induction charging for an aerosol delivery device
US20170112194A1	2015-10-21	2017-04-27	Rai Strategic Holdings, Inc.	Rechargeable lithium-ion capacitor for an aerosol delivery device
CN110036551A	2016-12-02	2019-07-19	莱战略控股公司	Induction charging for aerosol delivery equipment
US10918134B2	2015-10-21	2021-02-16	Rai Strategic Holdings, Inc.	Power supply for an aerosol delivery device
US20170119052A1	2015-10-30	2017-05-04	R.J. Reynolds Tobacco Company	Application specific integrated circuit (asic) for an aerosol delivery device
US10201187B2	2015-11-02	2019-02-12	Rai Strategic Holdings, Inc.	User interface for an aerosol delivery device
US20170119044A1 *	2015-11-03	2017-05-04	Hydra Vapor Tech, Llc	Vaporizer case
USD776869S1	2015-11-06	2017-01-17	National Concessions Group Inc.	Vaporizer

US10820630B2	2015-11-06	2020-11-03	Rai Strategic Holdings, Inc.	Aerosol delivery device including a wirelessly-heated atomizer and related method
PL3167728T3 *	2015-11-12	2020-10-05	Fontem Holdings 1 B.V.	Electronic smoking device with cavity for liquid reservoir
US10412995B2 *	2015-12-01	2019-09-17	Altria Client Services Llc	E-vapor device including puncture device and sealed packet of pre-vapor formulation
US9955733B2	2015-12-07	2018-05-01	Rai Strategic Holdings, Inc.	Camera for an aerosol delivery device
US10440992B2	2015-12-07	2019-10-15	Rai Strategic Holdings, Inc.	Motion sensing for an aerosol delivery device
US20170181223A1	2015-12-18	2017-06-22	R.J. Reynolds Tobacco Company	Proximity sensing for an aerosol delivery device
CN105433443A *	2015-12-25	2016-03-30	深圳市合元科技有限公司	Atomizer and electronic smoking device
US10092036B2	2015-12-28	2018-10-09	Rai Strategic Holdings, Inc.	Aerosol delivery device including a housing and a coupler
CN105455198B *	2015-12-31	2018-07-03	惠州市新泓威科技有限公司	The battery rod of electronic cigarette
US10051891B2	2016-01-05	2018-08-21	Rai Strategic Holdings, Inc.	Capacitive sensing input device for an aerosol delivery device
US10194694B2	2016-01-05	2019-02-05	Rai Strategic Holdings, Inc.	Aerosol delivery device with improved fluid transport
US10258086B2	2016-01-12	2019-04-16	Rai Strategic Holdings, Inc.	Hall effect current sensor for an aerosol delivery device
US10104912B2	2016-01-20	2018-10-23	Rai Strategic Holdings, Inc.	Control for an induction-based aerosol delivery device
US9999255B2	2016-01-21	2018-06-19	Shenzhen First Union Technology Co., Ltd.	Electronic cigarette with a blocking module
US10015989B2	2016-01-27	2018-07-10	Rai Strategic Holdings, Inc.	One-way valve for refilling an aerosol delivery device
CN205456063U *	2016-01-29	2016-08-17	深圳市合元科技有限公司	Electronic cigarette atomizer and electronic cigarette
BR112018016412A2	2016-02-11	2018-12-26	Juul Labs Inc	rechargeable vaporizer cartridge and refill method
MX2018009703A	2016-02-11	2019-07-08	Juul Labs Inc	Securely attaching cartridges for vaporizer devices.
US20170231274A1	2016-02-12	2017-08-17	Rai Strategic Holdings, Inc.	Adapters for refilling an aerosol delivery device
US11006668B2	2016-02-12	2021-05-18	Altria Client Services Llc	Aerosol-generating system with electrodes
KR20180111806A *	2016-02-12	2018-10-11	필립모리스 프로덕츠 에스.에이.	Aerosol generation system with electrodes
KR20160021437A	2016-02-15	2016-02-25	김한기	Cartridge Capable of Regulating the Inhaled Amount for Electrical Cigarette
US10238146B2	2016-02-27	2019-03-26	Brandon Nedelman	Hookah vaporizer machine
US20170251724A1	2016-03-04	2017-09-07	Rai Strategic Holdings, Inc.	Flexible display for an aerosol delivery device
US9936733B2	2016-03-09	2018-04-10	Rai Strategic Holdings, Inc.	Accessory configured to charge an aerosol delivery device and related method
US10405582B2	2016-03-10	2019-09-10	Pax Labs, Inc.	Vaporization device with lip sensing
US10258087B2 *	2016-03-10	2019-04-16	Altria Client Services Llc	E-vaping cartridge and device
US9936734B2	2016-03-11	2018-04-10	Altria Client Services, Llc.	Personal carrying case for electronic vaping device
US10264821B2 *	2016-03-21	2019-04-23	Altria Client Services Llc	Electronic vaping device

US10251424B2	2016-03-22	2019-04-09	Altria Client Services Llc	Electronic vaping device
BR112019023958A2	2017-05-17	2020-06-09	Rai Strategic Holdings Inc	aerosol delivery device
US20170273356A1	2016-03-25	2017-09-28	Rai Strategic Holdings, Inc.	Aerosol production assembly including surface with micro-pattern
US10334880B2	2016-03-25	2019-07-02	Rai Strategic Holdings, Inc.	Aerosol delivery device including connector comprising extension and receptacle
US10321712B2 *	2016-03-29	2019-06-18	Altria Client Services Llc	Electronic vaping device
US10617152B2	2016-03-31	2020-04-14	Altria Client Services Llc	Aerosol-generating system with separate capsule and vaporizer
CA3011956A1 *	2016-03-31	2017-10-05	Philip Morris Products S.A.	Aerosol generating system with separate capsule and vaporizing unit
US10945462B2	2016-04-12	2021-03-16	Rai Strategic Holdings, Inc.	Detachable power source for an aerosol delivery device
US10333339B2	2016-04-12	2019-06-25	Rai Strategic Holdings, Inc.	Charger for an aerosol delivery device
US10028534B2	2016-04-20	2018-07-24	Rai Strategic Holdings, Inc.	Aerosol delivery device, and associated apparatus and method of formation thereof
CN205624475U *	2016-04-25	2016-10-12	深圳市合元科技有限公司	Connector and contain power supply , atomizer, electron cigarette of this connector
US10405579B2	2016-04-29	2019-09-10	Rai Strategic Holdings, Inc.	Methods for assembling a cartridge for an aerosol delivery device, and associated systems and apparatuses
CN109963606A *	2016-05-25	2019-07-02	尤尔实验室有限公司	The control of electronic anesthetic vaporizer
WO2017201716A1 *	2016-05-26	2017-11-30	惠州市吉瑞科技有限公司深圳分公司	Liquid storage bottle and liquid storage bottle assembly
US10179690B2	2016-05-26	2019-01-15	Rai Strategic Holdings, Inc.	Aerosol precursor composition mixing system for an aerosol delivery device
US10918135B2 *	2016-05-31	2021-02-16	Altria Client Services Llc	Heat diffuser for an aerosol-generating system
US10660368B2 *	2016-05-31	2020-05-26	Altria Client Services Llc	Aerosol generating article with heat diffuser
US10952472B2 *	2016-05-31	2021-03-23	Altria Client Services Llc	Heat diffuser for an aerosol-generating system
RU2736745C2 *	2016-05-31	2020-11-19	Филип Моррис Продактс С.А.	Device for heat dissipation for aerosol generating system
CN105901775A *	2016-06-03	2016-08-31	深圳市合元科技有限公司	Jet-type atomization device
CN105852226B *	2016-06-16	2019-07-16	深圳市新宜康科技股份有限公司	Upper core full-closed electronic tobacco atomizer and electronic cigarette device out
USD849996S1	2016-06-16	2019-05-28	Pax Labs, Inc.	Vaporizer cartridge
US10959458B2	2016-06-20	2021-03-30	Rai Strategic Holdings, Inc.	Aerosol delivery device including an electrical generator assembly
USD851830S1	2016-06-23	2019-06-18	Pax Labs, Inc.	Combined vaporizer tamp and pick tool
US10566582B2 *	2016-06-23	2020-02-18	Intel Corporation	Battery utilizing device cavity
USD848057S1	2016-06-23	2019-05-07	Pax Labs, Inc.	Lid for a vaporizer
USD836541S1	2016-06-23	2018-12-25	Pax Labs, Inc.	Charging device
EP3469926A4 *	2016-06-27	2020-02-19	Japan Tobacco, Inc.	Flavor inhaler cartridge and flavor inhaler having flavor inhaler cartridge
US10085485B2	2016-07-06	2018-10-02	Rai Strategic Holdings, Inc.	Aerosol delivery device with a reservoir housing and a vaporizer assembly
US10881139B2 *	2016-07-07	2021-01-05	Altria Client Services Llc	Non-combustible vaping element with tobacco insert
US10405581B2	2016-07-08	2019-09-10	Rai Strategic Holdings,	Gas sensing for an aerosol delivery device

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			Inc.	
US10231485B2	2016-07-08	2019-03-19	Rai Strategic Holdings, Inc.	Radio frequency to direct current converter for an aerosol delivery device
US10463078B2	2016-07-08	2019-11-05	Rai Strategic Holdings, Inc.	Aerosol delivery device with condensing and non-condensing vaporization
US10602775B2	2016-07-21	2020-03-31	Rai Strategic Holdings, Inc.	Aerosol delivery device with a unitary reservoir and liquid transport element comprising a porous monolith and related method
US10278424B2	2016-07-21	2019-05-07	Altria Client Services Llc	Electronic vaping device
US10617151B2	2016-07-21	2020-04-14	Rai Strategic Holdings, Inc.	Aerosol delivery device with a liquid transport element comprising a porous monolith and related method
EP3272236B1 *	2016-07-22	2021-06-16	Fontem Holdings 1 B.V.	Electronic smoking device
USD805246S1	2016-07-22	2017-12-12	Al Fakher International Co.	Electronic cigarette
USD842536S1	2016-07-28	2019-03-05	Juul Labs, Inc.	Vaporizer cartridge
USD825102S1	2016-07-28	2018-08-07	Juul Labs, Inc.	Vaporizer device with cartridge
US11019847B2	2016-07-28	2021-06-01	Rai Strategic Holdings, Inc.	Aerosol delivery devices including a selector and related methods
CN105996135A *	2016-07-29	2016-10-12	陈铭	Electronic cigarette
USD829978S1	2016-07-31	2018-10-02	Altria Client Services Llc	Electronic cigarette
US10729177B2 *	2016-07-31	2020-08-04	Altria Client Services Llc	Electronic vaping device, battery section, and charger
USD829974S1	2016-07-31	2018-10-02	Altria Client Services Llc	Electronic cigarette
US20180035713A1 *	2016-08-02	2018-02-08	Altria Client Services Llc	Collapsible fiber matrix reservoir for an e-vaping device
US20180036496A1 *	2016-08-02	2018-02-08	James Riviello	Medication Delivery System
US11000065B2	2016-08-04	2021-05-11	The Regents Of The University Of California	Aerosol generation and exposure system
US10765146B2	2016-08-08	2020-09-08	Rai Strategic Holdings, Inc.	Boost converter for an aerosol delivery device
KR20190039183A *	2016-08-12	2019-04-10	인트레피드 브랜즈, 엘엘씨	Wis. Chris Katomizer
CN107788577B *	2016-08-29	2020-05-26	卓尔悦欧洲控股有限公司	Atomizing tube subassembly, atomizer and have electron cigarette of this atomizer
US20180055090A1 *	2016-08-31	2018-03-01	Altria Client Services Llc	Methods and systems for cartridge identification
US20180070633A1	2016-09-09	2018-03-15	Rai Strategic Holdings, Inc.	Power source for an aerosol delivery device
US20180070634A1	2016-09-09	2018-03-15	Rai Strategic Holdings, Inc.	Analog control component for an aerosol delivery device
US20180070632A1	2016-09-09	2018-03-15	Rai Strategic Holdings, Inc.	Fluidic control for an aerosol delivery device
GB201616036D0	2016-09-21	2016-11-02	Nicoventures Holdings Ltd	Device with liquid flow restriction
US10021911B2 *	2016-09-23	2018-07-17	Yongjie James Xu	Disposable cartridge with resealable trapdoor
US10080387B2	2016-09-23	2018-09-25	Rai Strategic Holdings, Inc.	Aerosol delivery device with replaceable wick and heater assembly
CA3039146C *	2016-10-05	2021-07-13	Japan Tobacco Inc.	Flavor inhaler and atomizing unit
US10477896B2	2016-10-12	2019-11-19	Rai Strategic Holdings, Inc.	Photodetector for measuring aerosol precursor composition in an aerosol delivery device

GB201618481D0 *	2016-11-02	2016-12-14	British American Tobacco (Investments) Ltd	Aerosol provision article
US20180132526A1	2016-11-11	2018-05-17	Rai Strategic Holdings, Inc.	Real-time temperature control for an aerosol delivery device
US20180132529A1	2016-11-14	2018-05-17	Rai Strategic Holdings, Inc.	Aerosol delivery device with integrated wireless connectivity for temperature monitoring
US20180132528A1	2016-11-14	2018-05-17	Rai Strategic Holdings, Inc.	Photoelectric proximity sensor for gesture-based control of an aerosol delivery device
US10524508B2	2016-11-15	2020-01-07	Rai Strategic Holdings, Inc.	Induction-based aerosol delivery device
US9864947B1	2016-11-15	2018-01-09	Rai Strategic Holdings, Inc.	Near field communication for a tobacco-based article or package therefor
US10492530B2	2016-11-15	2019-12-03	Rai Strategic Holdings, Inc.	Two-wire authentication system for an aerosol delivery device
US20180136338A1	2016-11-17	2018-05-17	Rai Strategic Holdings, Inc.	Satellite navigation for an aerosol delivery device
US10524509B2	2016-11-18	2020-01-07	Rai Strategic Holdings, Inc.	Pressure sensing for an aerosol delivery device
US10206431B2	2016-11-18	2019-02-19	Rai Strategic Holdings, Inc.	Charger for an aerosol delivery device
US10172392B2	2016-11-18	2019-01-08	Rai Strategic Holdings, Inc.	Humidity sensing for an aerosol delivery device
US10653183B2	2016-11-18	2020-05-19	Rai Strategic Holdings, Inc.	Power source for an aerosol delivery device
US10537137B2	2016-11-22	2020-01-21	Rai Strategic Holdings, Inc.	Rechargeable lithium-ion battery for an aerosol delivery device
MX2019005886A *	2016-11-30	2019-08-12	Philip Morris Products Sa	Aerosol-generating system having an outer housing.
US11013266B2	2016-12-09	2021-05-25	Rai Strategic Holdings, Inc.	Aerosol delivery device sensory system including an infrared sensor and related method
US10842188B2	2016-12-14	2020-11-24	Rai Strategic Holdings, Inc.	Smoking article for selective delivery of an aerosol precursor composition, a cartridge, and a related method
US10092039B2	2016-12-14	2018-10-09	Rai Strategic Holdings, Inc.	Smoking article for on-demand delivery of an increased quantity of an aerosol precursor composition, a cartridge, and a related method
KR102035313B1 *	2017-05-26	2019-10-22	주식회사 케이티앤지	Heater assembly and aerosol generating apparatus having the same
US20200093177A1 *	2016-12-16	2020-03-26	Kt & G Corporation	Aerosol generation method and apparatus
CN109982587A *	2016-12-19	2019-07-05	菲利普莫里斯生产公司	The aerosol for forming matrix and liquid transmission element including a variety of aerosols generates system
US11045615B2 *	2016-12-19	2021-06-29	Altria Client Services Llc	Vapor-generating systems
US10820633B2	2016-12-19	2020-11-03	Altria Client Services Llc	Aerosol-generating system comprising multiple aerosol-forming substrates and a transfer element
JP2020501608A *	2016-12-19	2020-01-23	フィリップ・モーリス・プロダクツ・ソシエテ・アノニム	Aerosol generation system with external cartridge
US10366641B2	2016-12-21	2019-07-30	R.J. Reynolds Tobacco Company	Product display systems and related methods
US9980522B1 *	2016-12-30	2018-05-29	National Concessions Group Inc.	Self-locking cartridge
US10080388B2	2017-01-25	2018-09-25	Rai Strategic Holdings, Inc.	Aerosol delivery device including a shape-memory alloy and a related method

US10517326B2	2017-01-27	2019-12-31	Rai Strategic Holdings, Inc.	Secondary battery for an aerosol delivery device
USD829370S1	2017-01-27	2018-09-25	Altria Client Services Llc	Electronic cigarette
US10827783B2	2017-02-27	2020-11-10	Rai Strategic Holdings, Inc.	Digital compass for an aerosol delivery device
US10440995B2	2017-03-29	2019-10-15	Rai Strategic Holdings, Inc.	Aerosol delivery device including substrate with improved absorbency properties
US10674765B2	2017-03-29	2020-06-09	Rai Strategic Holdings, Inc.	Aerosol delivery device with improved atomizer
US10314340B2	2017-04-21	2019-06-11	Rai Strategic Holdings, Inc.	Refillable aerosol delivery device and related method
US10285444B2	2017-04-27	2019-05-14	Rai Strategic Holdings, Inc.	Aerosol delivery device including a ceramic wicking element
CN107006896B *	2017-05-05	2019-04-09	湖北中烟工业有限责任公司	A kind of compound ceramic atomizer and preparation method thereof
WO2021137139A1	2019-12-30	2021-07-08	Rai Strategic Holdings, Inc.	A heart rate monitor for an aerosol delivery device
US10517330B2	2017-05-23	2019-12-31	RAI Stategic Holdings, Inc.	Heart rate monitor for an aerosol delivery device
US10779576B2	2017-05-24	2020-09-22	VMR Products, LLC	Flavor disk
CN207040875U *	2017-05-25	2018-02-27	深圳市合元科技有限公司	It is a kind of can upside-down mounting suction nozzle electronic cigarette
US10383369B2	2017-06-07	2019-08-20	Rai Strategic Holdings, Inc.	Fibrous filtration material for electronic smoking article
US10575562B2	2017-06-30	2020-03-03	Rai Strategic Holdings, Inc.	Smoking article for identifying an attribute of an aerosol-generating element for adaptive power output and an associated method
US10842197B2	2017-07-12	2020-11-24	Rai Strategic Holdings, Inc.	Detachable container for aerosol delivery having pierceable membrane
US10349674B2	2017-07-17	2019-07-16	Rai Strategic Holdings, Inc.	No-heat, no-burn smoking article
US20190014823A1	2017-07-17	2019-01-17	Rai Strategic Holdings, Inc.	Video analytics camera system for an aerosol delivery device
US10201189B1 *	2017-08-02	2019-02-12	Joyetech Europe Holding Gmbh	Atomization core device and electronic cigarette
US10791761B2	2017-08-17	2020-10-06	Rai Strategic Holdings, Inc.	Microtextured liquid transport element for aerosol delivery device
CN207927762U *	2017-09-04	2018-10-02	赫斯提亚深圳生物科技有限公司	Apparatus for aerosol creation, product and system
USD887632S1	2017-09-14	2020-06-16	Pax Labs, Inc.	Vaporizer cartridge
US10667554B2	2017-09-18	2020-06-02	Rai Strategic Holdings, Inc.	Smoking articles
US10505383B2	2017-09-19	2019-12-10	Rai Strategic Holdings, Inc.	Intelligent charger for an aerosol delivery device
US11039645B2	2017-09-19	2021-06-22	Rai Strategic Holdings, Inc.	Differential pressure sensor for an aerosol delivery device
US10157265B1	2017-09-21	2018-12-18	Rai Strategic Holdings, Inc.	Clinical study product dispensing device
DE102017123000B4 *	2017-10-04	2021-05-12	Schott Ag	Sintered body with conductive coating, method for producing a sintered body with conductive coating and its use
US10772356B2	2017-10-11	2020-09-15	Altria Client Services Llc	Electronic vaping device including transfer pad with oriented

				fibers
USD870375S1	2017-10-11	2019-12-17	Altria Client Services Llc	Battery for an electronic vaping device
US10660370B2	2017-10-12	2020-05-26	Rai Strategic Holdings, Inc.	Aerosol delivery device including a control body, an atomizer body, and a cartridge and related methods
US10314342B2	2017-10-20	2019-06-11	Altria Client Services Llc	E-vaping device using a jet dispensing cartridge, and method of operating the e-vaping device
US20190116863A1	2017-10-24	2019-04-25	Rai Strategic Holdings, Inc.	Method for formulating aerosol precursor for aerosol delivery device
US10517332B2	2017-10-31	2019-12-31	Rai Strategic Holdings, Inc.	Induction heated aerosol delivery device
USD863666S1 *	2017-11-10	2019-10-15	Boulder (Shenzhen) Technologies, Inc	Electronic cigarette
US10806181B2	2017-12-08	2020-10-20	Rai Strategic Holdings, Inc.	Quasi-resonant flyback converter for an induction-based aerosol delivery device
US10786010B2	2017-12-15	2020-09-29	Rai Strategic Holdings, Inc.	Aerosol delivery device with multiple aerosol delivery pathways
US10687557B2	2017-12-29	2020-06-23	Altria Client Services Llc	Electronic vaping device with outlet-end illumination
US10555558B2	2017-12-29	2020-02-11	Rai Strategic Holdings, Inc.	Aerosol delivery device providing flavor control
JP6768772B2 *	2018-01-02	2020-10-14	シャンハイ ニュー タバコ プロダクト リサーチ インスティテュート カンパニー，リミティド	Aerosol generators, cartridges and e-cigarettes
CN108236131B *	2018-01-31	2020-10-30	安徽集友新材料股份有限公司	Atomizer and atomization device
US11019850B2	2018-02-26	2021-06-01	Rai Strategic Holdings, Inc.	Heat conducting substrate for electrically heated aerosol delivery device
US10813385B2	2018-03-09	2020-10-27	Rai Strategic Holdings, Inc.	Buck regulator with operational amplifier feedback for an aerosol delivery device
US20190274354A1	2018-03-09	2019-09-12	Rai Strategic Holdings, Inc.	Electronically heated heat-not-burn smoking article
US10945465B2	2018-03-15	2021-03-16	Rai Strategic Holdings, Inc.	Induction heated susceptor and aerosol delivery device
US10798969B2	2018-03-16	2020-10-13	R. J. Reynolds Tobacco Company	Smoking article with heat transfer component
US20190289908A1	2018-03-20	2019-09-26	Rai Strategic Holdings, Inc.	Aerosol delivery device with indexing movement
US20190289909A1	2018-03-26	2019-09-26	Rai Strategic Holdings, Inc.	Aerosol delivery device providing flavor control
CN108552589B *	2018-03-29	2020-11-03	贵州中成科技开发有限公司	Portable water smoking pipe
US10959459B2	2018-05-16	2021-03-30	Rai Strategic Holdings, Inc.	Voltage regulator for an aerosol delivery device
US10932490B2	2018-05-16	2021-03-02	Rai Strategic Holdings, Inc.	Atomizer and aerosol delivery device
US20190387787A1	2018-06-22	2019-12-26	Rai Strategic Holdings, Inc.	Aerosol source member having combined susceptor and aerosol precursor material
KR20200005075A *	2018-07-05	2020-01-15	주식회사 케이티앤지	A wrapper comprising metal particles
US20200015519A1	2018-07-13	2020-01-16	R.J. Reynolds Tobacco Company	Smoking article with detachable cartridge

US10897925B2	2018-07-27	2021-01-26	Joseph Pandolfino	Articles and formulations for smoking products and vaporizers
US20200035118A1	2018-07-27	2020-01-30	Joseph Pandolfino	Methods and products to facilitate smokers switching to a tobacco heating product or e-cigarettes
US20200046021A1	2018-08-10	2020-02-13	Rai Strategic Holdings, Inc.	Charge circuitry for an aerosol delivery device
US10939707B2	2018-08-23	2021-03-09	Rai Strategic Holdings, Inc.	Aerosol delivery device with segmented electrical heater
US20200060341A1	2018-08-27	2020-02-27	Rai Strategic Holdings, Inc.	Aerosol delivery device with integrated thermal conductor
US20200077703A1	2018-09-11	2020-03-12	Rai Strategic Holdings, Inc.	Wicking element for aerosol delivery device
US20200093181A1	2018-09-20	2020-03-26	Rai Strategic Holdings, Inc.	Flavorants
US20200093182A1	2018-09-26	2020-03-26	Rai Strategic Holdings, Inc.	Aerosol delivery device with conductive inserts
US20200113242A1	2018-10-12	2020-04-16	Rai Strategic Holdings, Inc.	Aerosol delivery device with improved connectivity, airflow, and aerosol paths
US20200113239A1	2018-10-12	2020-04-16	Rai Strategic Holdings, Inc.	Aerosol delivery device with visible indicator
KR102187259B1 *	2018-10-26	2020-12-04	주식회사 케이티앤지	Heater assembly and aerosol generating apparatus including the same
WO2020090375A1 *	2018-10-30	2020-05-07	日本たばこ産業株式会社	Power supply unit of aerosol generation device, control method of power supply unit of aerosol generation device, and program for power supply unit of aerosol generation device
US20200128880A1	2018-10-30	2020-04-30	R.J. Reynolds Tobacco Company	Smoking article cartridge
KR20210073595A *	2018-11-08	2021-06-18	쥴 랩스, 인크.	Evaporator apparatus having more than one heating element
US20200154788A1	2018-11-19	2020-05-21	Rai Strategic Holdings, Inc.	Power control for an aerosol delivery device
US20200154779A1	2018-11-19	2020-05-21	Rai Strategic Holdings, Inc.	Charging control for an aerosol delivery device
US20200154787A1	2018-11-19	2020-05-21	Rai Strategic Holdings, Inc.	Temperature control in an aerosol delivery device
US20200154784A1	2018-11-20	2020-05-21	R.J. Reynolds Tobacco Company	Conductive aerosol generating composite substrate for aerosol source member
US20200154785A1	2018-11-20	2020-05-21	R.J. Reynolds Tobacco Company	Overwrap material containing aerosol former for aerosol source member
US20200163389A1	2018-11-28	2020-05-28	Rai Strategic Holdings, Inc.	Micropump for an aerosol delivery device
US10301077B1	2018-12-03	2019-05-28	Keir Finlow-Bates	Electronic cigarette tank
USD862795S1 *	2019-01-22	2019-10-08	Lerman Container Corporation	Cartridge tube
US20200237018A1	2019-01-29	2020-07-30	Rai Strategic Holdings, Inc.	Susceptor arrangement for induction-heated aerosol delivery device
US20200236993A1	2019-01-29	2020-07-30	Rai Strategic Holdings, Inc.	Air pressure sensor for an aerosol delivery device
US20200245696A1	2019-02-06	2020-08-06	Rai Strategic Holdings, Inc.	Buck-boost regulator circuit for an aerosol delivery device
US20200253287A1	2019-02-07	2020-08-13	Rai Strategic Holdings, Inc.	Non-inverting amplifier circuit for an aerosol delivery device
WO2020174073A1 *	2019-02-28	2020-09-03	Philip Morris Products S.A.	Aerosol-generating system and aerosol-generating article comprising an aerosol-forming substrate

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US20200278707A1	2019-03-01	2020-09-03	Rai Strategic Holdings, Inc.	Temperature control circuitry for an aerosol delivery device
US20200281249A1	2019-03-06	2020-09-10	R.J. Reynolds Tobacco Company	Aerosol delivery device with nanocellulose substrate
USD877409S1	2019-03-07	2020-03-03	JDI Vape Inc.	Electronic vaporization device
WO2020183324A1	2019-03-08	2020-09-17	Rai Strategic Holdings, Inc.	Method for hydrolysis of lactic acid for aerosol delivery device
US20200288787A1	2019-03-14	2020-09-17	Rai Strategic Holdings, Inc.	Aerosol delivery device providing flavor control
US20200315259A1	2019-04-02	2020-10-08	Rai Strategic Holdings, Inc.	Authentication and age verification for an aerosol delivery device
US20200342507A1	2019-04-24	2020-10-29	Rai Strategic Holdings, Inc.	Decentralized identity storage for tobacco products
US20200337382A1	2019-04-25	2020-10-29	Rai Strategic Holdings, Inc.	Artificial intelligence in an aerosol delivery device
US20200352256A1	2019-05-10	2020-11-12	Rai Strategic Holdings, Inc.	Flavor article for an aerosol delivery device
US20200359703A1	2019-05-17	2020-11-19	Rai Strategic Holdings, Inc.	Age verification with registered cartridges for an aerosol delivery device
US20200367553A1	2019-05-22	2020-11-26	Rai Strategic Holdings, Inc.	Reservoir configuration for aerosol delivery device
US20200367572A1	2019-05-24	2020-11-26	Rai Strategic Holdings, Inc.	Shape memory material for controlled liquid delivery in an aerosol delivery device
CN111990693A *	2019-05-27	2020-11-27	湖南中烟工业有限责任公司	Ultrasonic atomization core and ultrasonic atomizer
CN110332563A *	2019-06-06	2019-10-15	陈方健	Cigarette lighter assembly
US20210015173A1	2019-07-18	2021-01-21	R.J. Reynolds Tobacco Company	Aerosol delivery device with consumable cartridge
US20210015174A1	2019-07-19	2021-01-21	R.J. Reynolds Tobacco Company	Holder for aerosol delivery device with detachable cartridge
US20210015175A1	2019-07-19	2021-01-21	R.J. Reynolds Tobacco Company	Aerosol delivery device with sliding sleeve
US20210015176A1	2019-07-19	2021-01-21	R.J. Reynolds Tobacco Company	Aerosol delivery device with rotatable enclosure for cartridge
US20210015172A1	2019-07-19	2021-01-21	R.J. Reynolds Tobacco Company	Aerosol delivery device with clamshell holder for cartridge
US20210015177A1	2019-07-19	2021-01-21	R.J. Reynolds Tobacco Company	Aerosol delivery device with separable heat source and substrate
US20210052014A1	2019-08-19	2021-02-25	Rai Strategic Holdings, Inc.	Detachable atomization assembly for aerosol delivery device
US20210059301A1	2019-08-29	2021-03-04	Rai Strategic Holdings, Inc.	Dual-chamber aerosol dispenser
US20210084970A1	2019-09-23	2021-03-25	Rai Strategic Holdings, Inc.	Arrangement of atomization assemblies for aerosol delivery device
US20210100291A1	2019-10-04	2021-04-08	Rai Strategic Holdings, Inc.	Use of infrared temperature detection in an aerosol delivery device
CA3103590A1	2019-10-15	2021-04-15	Canopy Growth Corporation	Vaporizer charging structure
WO2021072529A1 *	2019-10-15	2021-04-22	Canopy Growth Corporation	Vaporizer charging structure
US20210112882A1	2019-10-18	2021-04-22	Rai Strategic Holdings,	Surface acoustic wave atomizer for aerosol delivery device

			Inc.	
US20210112881A1	2019-10-18	2021-04-22	Rai Strategic Holdings, Inc.	Aerosol delivery device with dual reservoir
WO2021116895A2	2019-12-09	2021-06-17	Nicoventures Trading Limited	Stimulus-responsive pouch
US20210169140A1	2019-12-10	2021-06-10	Rai Strategic Holdings, Inc.	Aerosol delivery device with downstream flavor cartridge
RU2728625C1 *	2019-12-16	2020-07-30	Никовентчерс Холдингс Лимитед	Electronic device for steam production
KR102172540B1	2019-12-17	2020-11-02	석인선	Modularized vaporizer
US20210195938A1	2019-12-27	2021-07-01	Nicoventures Trading Limited	Substrate with multiple aerosol forming materials for aerosol delivery device
US20210204593A1	2020-01-02	2021-07-08	R.J. Reynolds Tobacco Company	Smoking article with downstream flavor addition
US20210205552A1	2020-01-08	2021-07-08	Rai Strategic Holdings, Inc.	Inductively-heated substrate tablet for aerosol delivery device
US20210219616A1	2020-01-16	2021-07-22	Nicoventures Trading Limited	Susceptor arrangement for an inductively-heated aerosol delivery device
US11064736B1	2020-08-06	2021-07-20	Bidi Vapor, LLC	Vaporization device with heating component
US11013261B1	2020-08-06	2021-05-25	Bidi Vapor, LLC	Vaporization device
US10932491B1	2020-08-06	2021-03-02	Bidi Vapor, LLC	Vaporization device with nozzle cap
US11064735B1	2020-08-06	2021-07-20	Bidi Vapor, LLC	Vaporization device with bottom cap
KR102278621B1	2020-10-22	2021-07-15	석인선	Modularized vaporizer
KR102210810B1	2020-10-22	2021-02-01	석인선	Modularized vaporizer

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
WO2007131450A1	2007-11-22	Emulation aerosol sucker
WO2005099494A1	2005-10-27	An aerosol electronic cigarette
WO2008077271A1	2008-07-03	A computerized healthy smoking device
TWM275721U	2005-09-21	Electronic smoke atomization

Priority And Related Applications

Child Applications (3)

Application	Priority date	Filing date	Relation	Title
US12/226,819	2006-05-16	2007-05-15	A-371-Of-International	Electronic cigarette
US22681909A	2009-01-15	2009-01-15	Substitution	
US13/754,521	2006-05-16	2013-01-30	Continuation	Electronic cigarette

Priority Applications (2)

Application	Priority date	Filing date	Title

CNU2006200908050U	2006-05-16	2006-05-16	Simulation aerosol inhaler
CN200620090805.0		2006-05-16	

Applications Claiming Priority (22)

Application	Filing date	Title
MX2008013527A	2007-05-15	Emulation aerosol sucker.
KR1020087026880A	2007-05-15	Emulation Aerosol Sucker
NZ572310A	2007-05-15	Emulation aerosol sucker
AU2007250368A	2007-05-15	Electronic cigarette
BRPI0711401-0A	2007-05-15	emulation aerosol sucker
EA200802046A	2007-05-15	IMITATION AEROSOL INHALER
CA002647234A	2007-05-15	An emulation aerosol sucker
EP07721149A	2007-05-15	Emulation aerosol sucker
US12/226,819	2007-05-15	Electronic cigarette
JP2009510262A	2007-05-15	Emulation aerosol inhaler
KR1020117026503A	2007-05-15	Electronic Smoking Emulation Device
IL194769A	2008-10-22	Emulation aerosol sucker
US13/754,521	2013-01-30	Electronic cigarette
US13/915,427	2013-06-11	Electronic Cigarette
US14/720,288	2015-05-22	Electronic cigarette
US14/723,209	2015-05-27	Electronic cigarette
US14/723,244	2015-05-27	Electronic cigarette
US15/158,421	2016-05-18	Electronic cigarette
US15/908,250	2018-02-28	Electronic cigarette
US16/206,394	2018-11-30	Electronic cigarette
US16/849,963	2020-04-15	Electronic cigarette
US17/132,245	2020-12-23	Electronic cigarette

Legal Events

Date	Code	Title	Description
2008-03-26	121	Ep: the epo has been informed by wipo that ep was designated in this application	**Ref document number**: 07721149 **Country of ref document**: EP **Kind code of ref document**: A1
2008-09-24	WWE	Wipo information: entry into national phase	**Ref document number**: 2647234 **Country of ref document**: CA
2008-10-10	WWE	Wipo information: entry into national phase	**Ref document number**: PI20084039 **Country of ref document**: MY

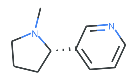
2008-10-16	WWE	Wipo information: entry into national phase	**Ref document number**: 2007250368 **Country of ref document**: AU
2008-10-21	WWE	Wipo information: entry into national phase	**Ref document number**: MX/a/2008/013527 **Country of ref document**: MX
2008-10-22	WWE	Wipo information: entry into national phase	**Ref document number**: 194769 **Country of ref document**: IL
2008-10-25	WWE	Wipo information: entry into national phase	**Ref document number**: 2007721149 **Country of ref document**: EP
2008-10-27	WWE	Wipo information: entry into national phase	**Ref document number**: 200802046 **Country of ref document**: EA
2008-10-28	WWE	Wipo information: entry into national phase	**Ref document number**: 572310 **Country of ref document**: NZ
2008-10-31	WWE	Wipo information: entry into national phase	**Ref document number**: 2009510262 **Country of ref document**: JP **Ref document number**: 1020087026880 **Country of ref document**: KR
2008-11-13	ENP	Entry into the national phase	**Ref document number**: 2007250368 **Country of ref document**: AU **Date of ref document**: 20070515 **Kind code of ref document**: A
2008-11-18	NENP	Non-entry into the national phase	**Ref country code**: DE
2009-01-15	WWE	Wipo information: entry into national phase	**Ref document number**: 12226819 **Country of ref document**: US
2011-11-01	ENP	Entry into the national phase	**Ref document number**: PI0711401 **Country of ref document**: BR **Kind code of ref document**: A2 **Effective date**: 20081112
2011-11-07	WWE	Wipo information: entry into national phase	**Ref document number**: 1020117026503 **Country of ref document**: KR

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
aerosol		title,claims,abstract,description	33	0.000
Catostomidae		title,abstract	2	0.000
cigarettes		claims,abstract,description	36	0.000
cigar		claims,abstract,description	3	0.000

liquid	claims,description	54	0.000
fiber	claims,description	29	0.000
ceramic	claims,description	17	0.000
silicone rubber	claims,description	17	0.000
silicone rubber	claims,description	17	0.000
heat treatment	claims,description	16	0.000
Nicotine 	claims,description	15	0.000
Nicotine	claims,description	15	0.000
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smoke	claims,description	10	0.000
particle	claims,description	9	0.000
spray	claims,description	9	0.000
zeolite	claims,description	9	0.000
plastic	claims,description	7	0.000
semiconductor	claims,description	7	0.000
Abomasum	claims,description	6	0.000
Brass	claims,description	6	0.000
Phragmites communis	claims,description	6	0.000
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brass	claims,description	6	0.000
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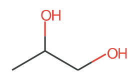
Capillaries		claims,description	5	0.000
Nicotiana tabacum		claims,description	5	0.000
immersion		claims,description	5	0.000
iron-chromium-aluminum		claims,description	5	0.000
material		claims,description	5	0.000
injection		claims,description	4	0.000
injection		claims,description	4	0.000
platinum	Pt	claims,description	4	0.000
propylene glycol		claims,description	4	0.000
Al alloy		claims,description	3	0.000
Lithium Ion	Li^{+}	claims,description	3	0.000
Nitrile rubber		claims,description	3	0.000
Polypropylene		claims,description	3	0.000
Skeleton		claims,description	3	0.000
cleaning		claims,description	3	0.000
fluoroelastomer		claims,description	3	0.000
inductive effect		claims,description	3	0.000
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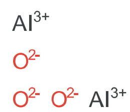
flavors		claims,description	2	0.000
nebulizer		claims,description	2	0.000
Al2O3		claims	1	0.000
Nicotiana tabacum		claims	1	0.000
foaming		claims	1	0.000
manufacturing process		claims	1	0.000

Show all concepts from the description section

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