



ELECTRONIC CIGARETTE EVOLUTION

FROM FIRST TO FOURTH GENERATION PRODUCTS AND BEYOND

Konstantinos Farsalinos, MD

Onassis Cardiac Surgery Center, Greece

University of Patras, Greece

COI

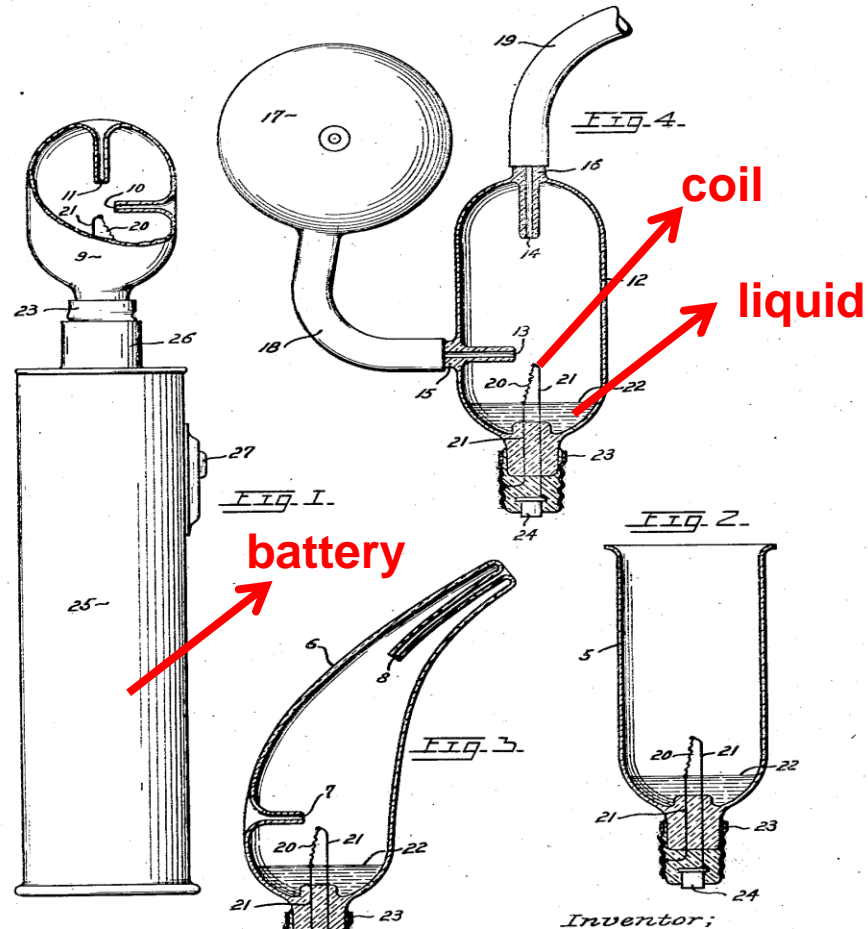
- 2 (unpublished yet) studies using unrestricted funds provided to the institution by e-cigarette companies
 - In 2 studies, institutions unrelated to me were funded by e-cigarette companies
 - 2 studies funded by a non-profit association (1 of them in press)
 - 1 study funded by crowdfunding campaign
 - 25 publications with no funding or other support
 - No funding from tobacco industry
 - No funding from pharmaceutical industry
-

E-CIGARETTE INVENTION

July 31, 1934.

F. E. TIFFANY
THERAPEUTIC APPARATUS
Filed July 13, 1932

1,968,509



E-CIGARETTE INVENTION

Oct. 13, 1936.

C. L. WHITTEMORE, JR

2,057,353

VAPORIZING UNIT FOR THERAPEUTIC APPARATUS

Filed Sept. 27, 1935

Fig. 1.

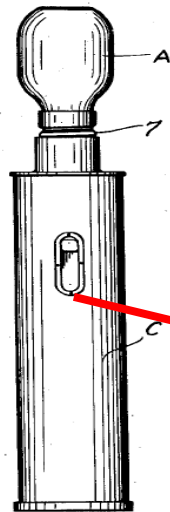
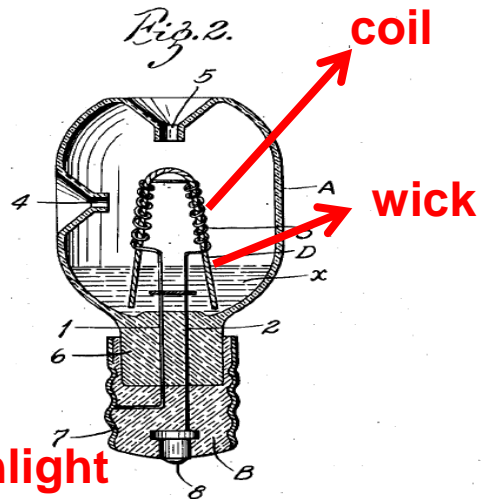


Fig. 2.

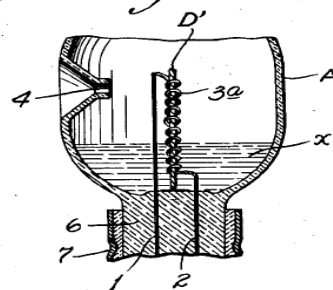


coil

wick

Flashlight
battery

Fig. 3.



INVENTOR
CLINTON L. WHITTEMORE, JR.

E-CIGARETTE INVENTION

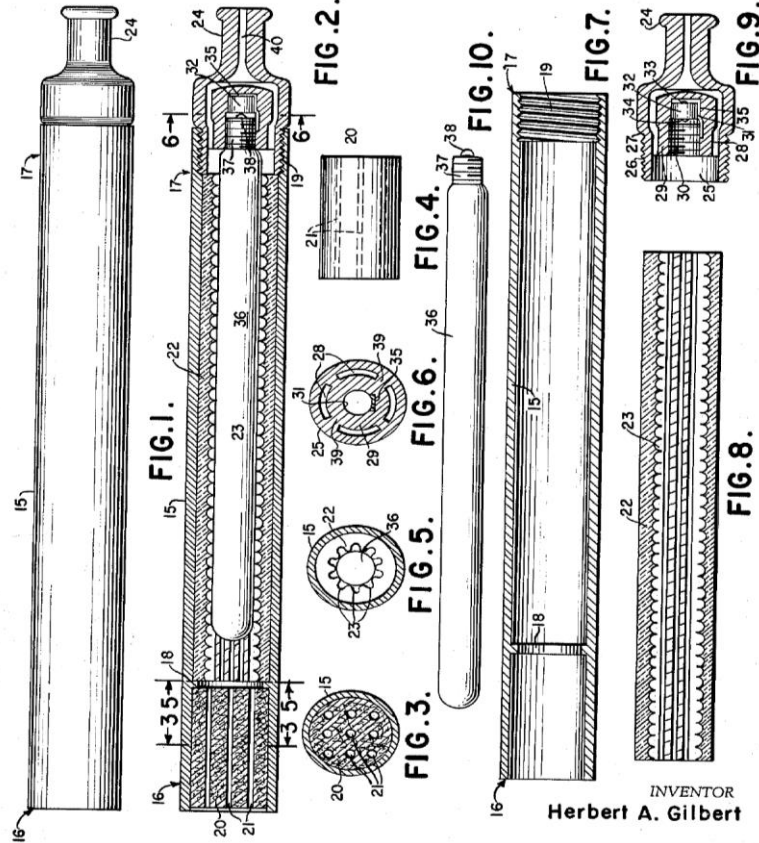
Aug. 17, 1965

H. A. GILBERT

3,200,819

SMOKELESS NON-TOBACCO CIGARETTE

Filed April 17, 1963



E-CIGARETTE INVENTION

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Hon

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(54) **ELECTRONIC ATOMIZATION CIGARETTE**

(57)

ABSTRACT

(76) Inventor: **Lik Hon**, Hong Kong (CN)

Correspondence Address:

PERKINS COIE LLP
POST OFFICE BOX 1208
SEATTLE, WA 98111-1208 (US)

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§ 371(c)(1),

(2), (4) Date: **Mar. 9, 2007**

(30) **Foreign Application Priority Data**

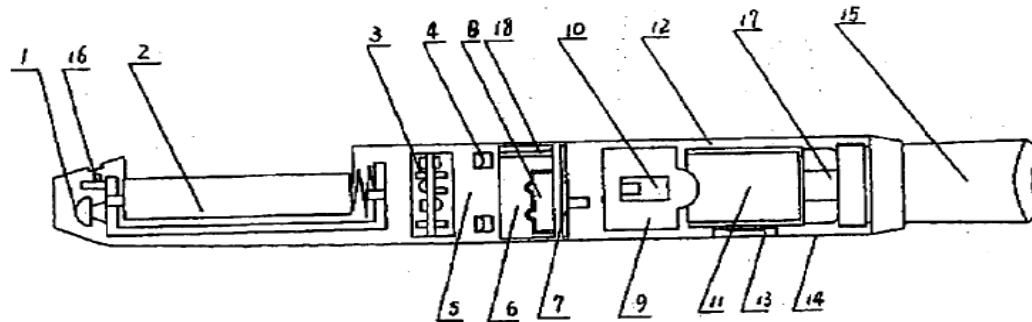
Apr. 14, 2004 (CN) 20040031182.0

Publication Classification

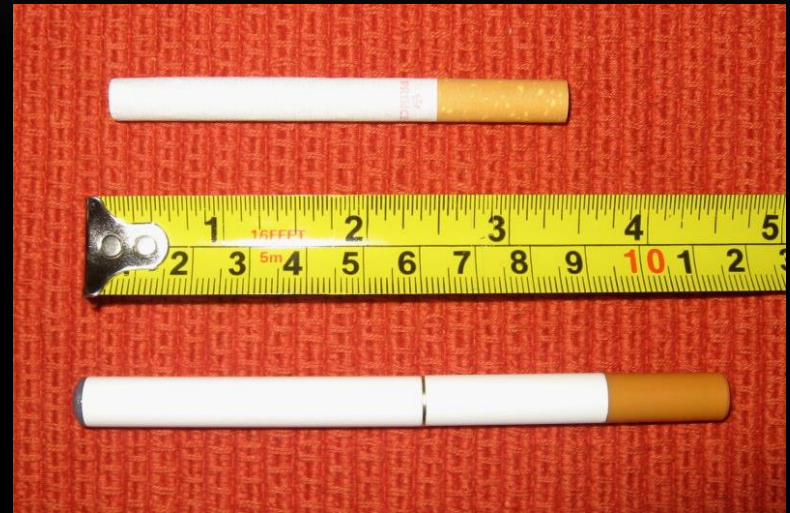
(51) **Int. Cl.**
A24F 47/00 (2006.01)

(52) **U.S. Cl.** **131/273; 131/359**

The present invention relates to an electronic atomization cigarette which only contains nicotine without harmful tar. The electronic atomization cigarette includes a shell and a mouthpiece. The external wall of the shell has an air inlet. An electronic circuit board, a normal pressure cavity, a sensor, a vapor-liquid separator, an atomizer, a liquid-supplying bottle are sequentially provided within the shell, wherein the electronic circuit board comprises an electronic switching circuit and a high frequency generator. A stream passage of the sensor is provided on one side of the sensor, and a negative pressure cavity is provided in the sensor. The atomizer and the liquid-supplying bottle is in contact with each other. An atomization cavity is arranged in the atomizer. A retaining ring for locking the liquid-supplying bottle is provided between one side of the liquid-supplying bottle and the shell, and an aerosol passage is provided on the other side of the liquid-supplying bottle. The air inlet, normal pressure cavity, vapor-liquid separator, atomizer, aerosol passage, gas vent and mouthpiece are sequentially interconnected. The advantages of the present invention include smoking without tar, significantly reducing the cancerogenic risk. Furthermore, users still feel as if they are smoking and experiencing the same excitement, and the cigarette is no need to be lit and is no fire risk.



E-CIGARETTES EVOLUTION



- First generation-disposables
- Single use only
- Fixed atomizer and battery device (low capacity)

NICOTINE DELIVERY

- Minimal (if any) nicotine delivery from 1st generation devices, but suppressed craving.

Table 2 Secondary analyses using multivariate* comparisons of change in desire to smoke from baseline between all products

Product comparison	Mean difference (95% CI)	Adjusted p value
0 versus 16 mg ENDD	0.80 (-0.27 to 1.86)	0.21
0 mg ENDD versus Nicorette inhalator	0.69 (-0.38 to 1.77)	0.33
0 mg ENDD versus usual cigarette	2.23 (1.17 to 3.30)	<0.0001
16 mg ENDD versus Nicorette inhalator	-0.10 (-1.16, 0.95)	0.99
16 mg ENDD versus usual cigarette	1.44 (0.39 to 2.48)	0.003
Nicorette inhalator versus usual cigarette	1.54 (0.48 to 2.59)	0.001

ENDD, electronic nicotine delivery device.

*Adjusted for treatment period, baseline craving, within-participant correlation as a random effect and multiple comparisons using Tukey-Kramer method.

Table 3 Pharmacokinetic properties of usual cigarette, 16 mg ENDD and Nicorette inhalator

Product	Mean tmax (min) (95% CI)	Mean Cmax (ng/mL) (95% CI)*
Usual cigarette (n=9)	14.3 (8.8 to 19.9)	13.4 (6.5 to 20.3)
16 mg ENDD (n=8)	19.6 (4.9 to 34.2)	1.3 (0.0 to 2.6)
Nicorette inhalator (n=10)	32.0 (18.7 to 45.3)	2.1 (1.0 to 3.1)

ENDD, electronic nicotine delivery device.

*Corrected for baseline nicotine levels.

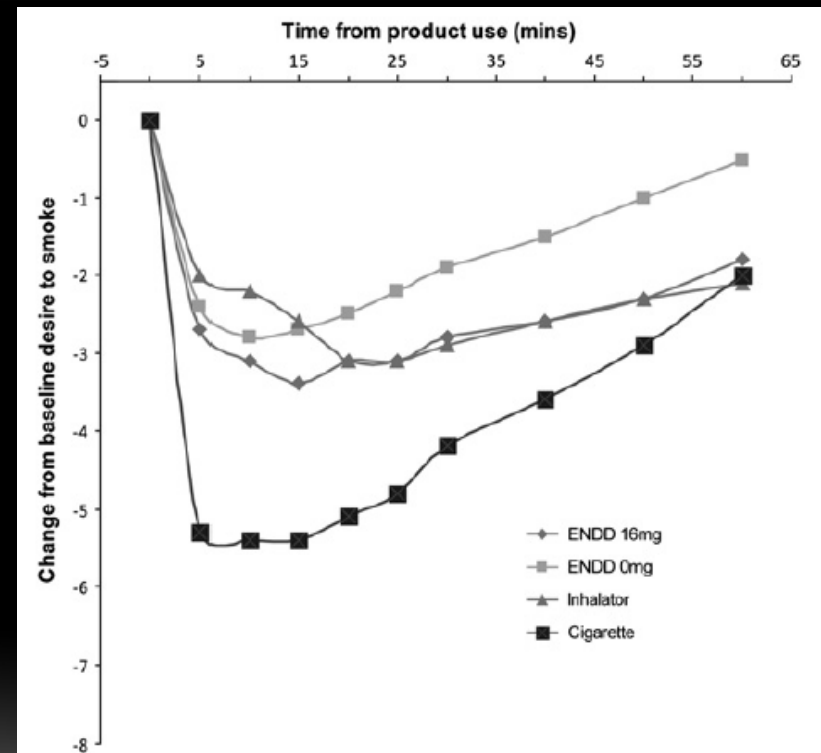


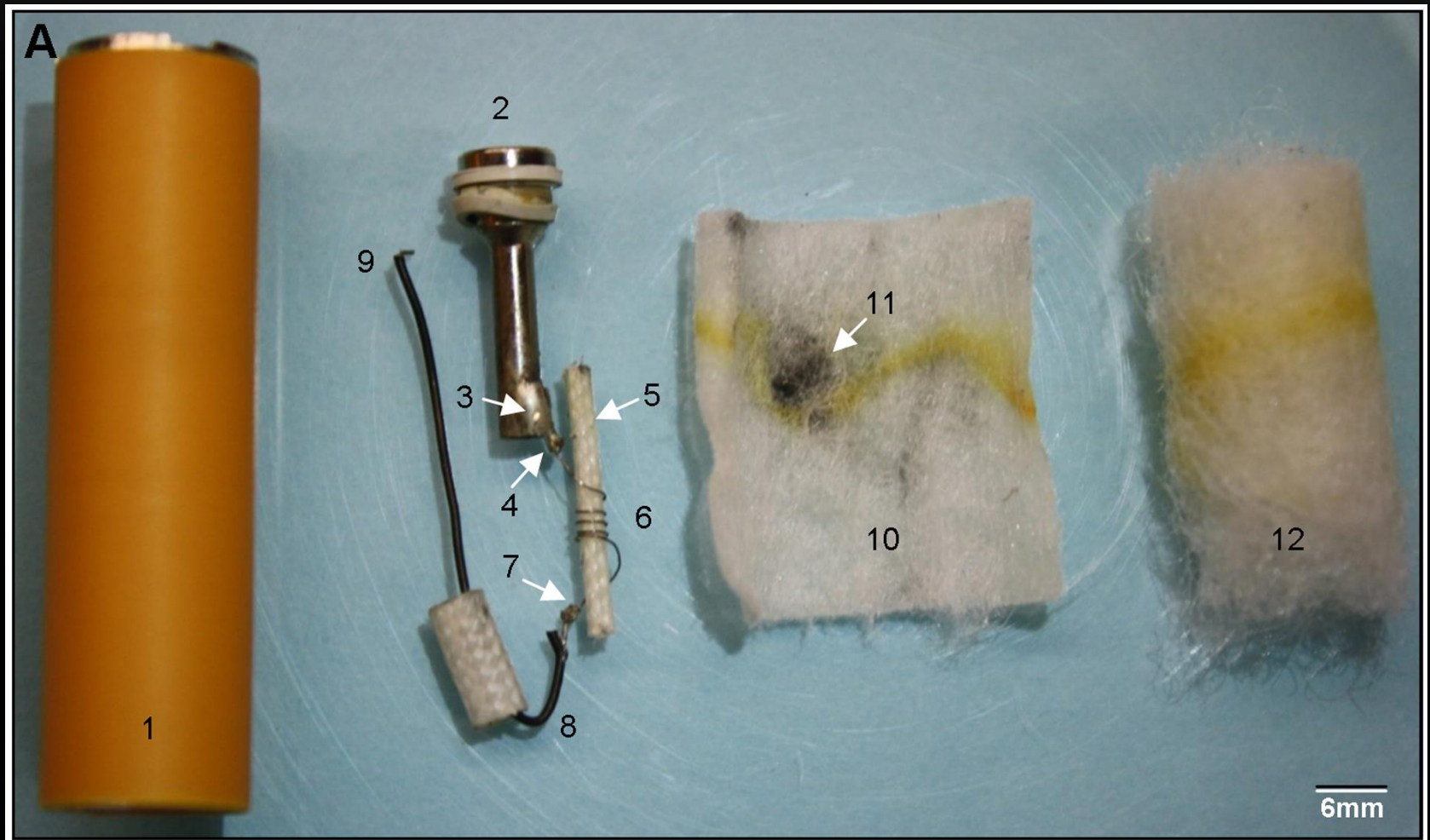
Figure 2 Change in desire to smoke from baseline over the first hour after each product use.

E-CIGARETTES EVOLUTION

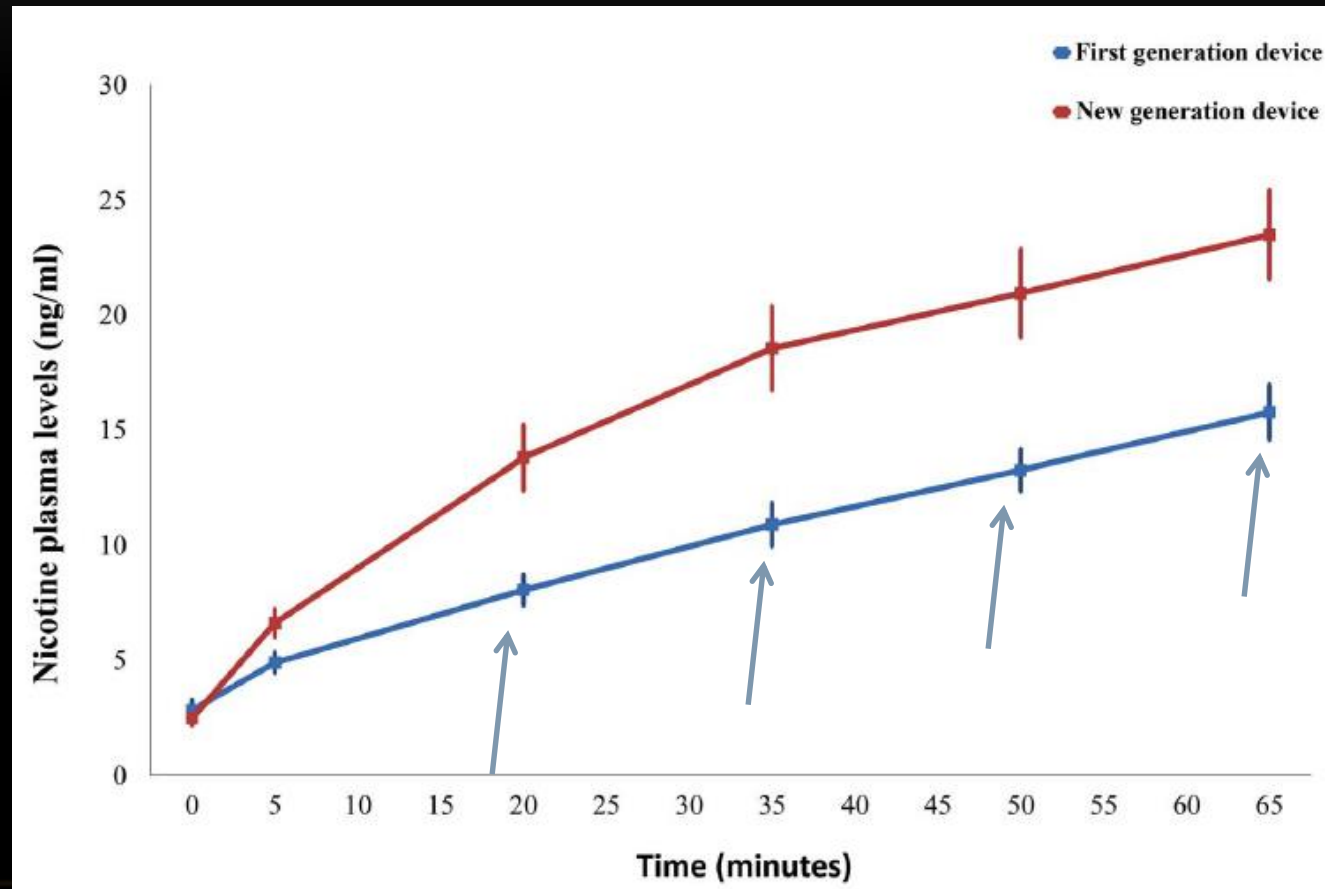


- First generation-rechargeable
- Re-usable battery
- Replacement cartomizers, prefilled with liquid (or refillable)

CARTOMIZER DISSECTION



1ST GENERATION - NICOTINE DELIVERY



E-CIGARETTES EVOLUTION



- Second generation – eGo-style
- Higher capacity rechargeable battery (350-1300mAh)
- Universal connector for different atomizers

E-CIGARETTES EVOLUTION



- eGo batteries with puff counter and with variable voltage
- First type of adjustable battery device
- A bit larger is size (length) than regular eGo batteries, due to the electronics

ATOMIZER EVOLUTION



- So called “clearomizers”
- Ability to check liquid levels
- Initially “top coil”

ATOMIZER EVOLUTION



- Improved design
- Still top-coil (capillary flow but against gravity)

ATOMIZER EVOLUTION



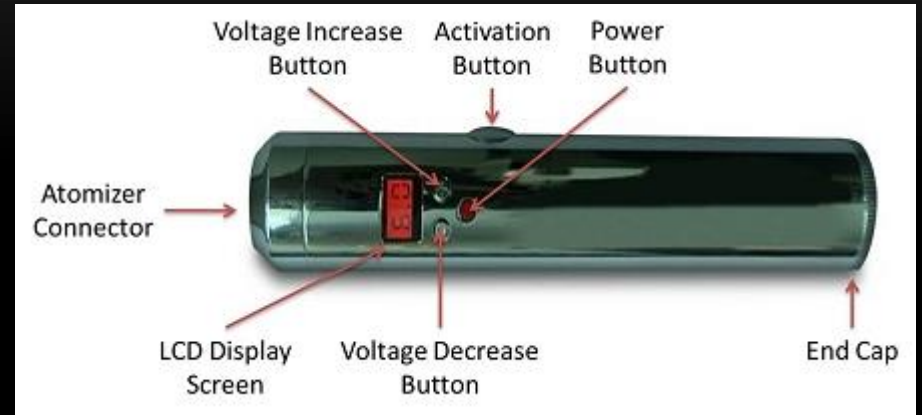
- Bottom-coil
- Flow facilitated by gravity
- Lower temperature of the aerosol (due to distance from the mouthpiece)

MECHANICAL MODS



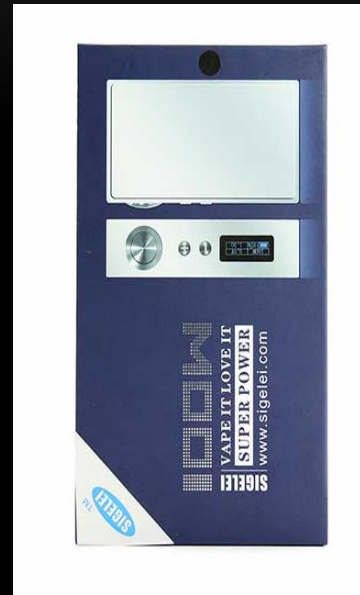
- Tubes for batteries, with no electronic components
- Some are pieces of art
- Could increase power by using low resistance atomizer coil
- No electrical safety (shorts etc)

ELECTRONICS DOMINATE



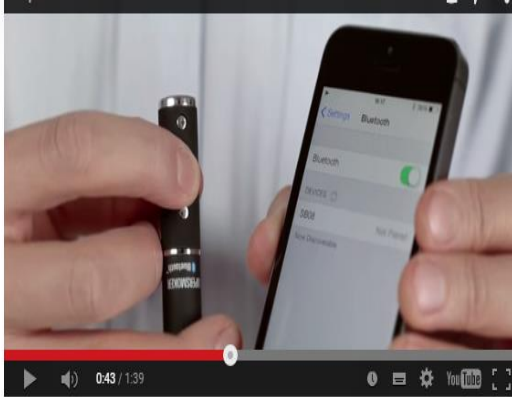
- Variable voltage devices
- Electronic circuits for stable voltage delivery until the battery gets discharged
- Safety features like protection from over-discharging and short-circuit

HIGH POWER



- Variable wattage devices
- High capacity – high amperage rechargeable batteries
- Electronic circuits for power adjustments, voltage boosters

FANCY FEATURES



①

MAKING CALLS

Make and receive calls with the Supersmoker Bluetooth.

②

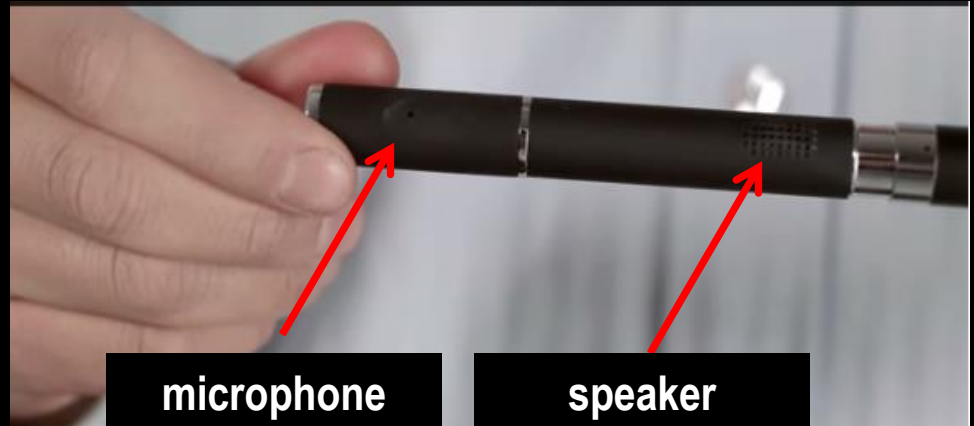
PLAYING MUSIC

Listen to your favourite playlist with your Supersmoker Bluetooth.

③

BLUETOOTH E-CIGARETTE

Connect with your phone via Bluetooth.



microphone

speaker

RBA



- Rebuildable atomizers
- DIY coils and wick setup
- Trend of “subohm” vaping with thick coil wires and need for high power
- “Direct lung inhalation” vaping

NEW GENERATION ATOMIZERS



- Subohm atomizers, adjustable airflow for conventional and DLI vaping
- Either ready or rebuildable coils
- Stainless steel and pyrex glass, almost no plastics
- Subohm vaping: huge puff volumes (>1000 mL), huge liquid consumption per puff (can be more than 30 mg/puff), similar temperature of evaporation – significant elevation in daily liquid consumption

E-CIGARETTES EVOLUTION



- Bottles of different shape and size (usually 10-30mL, max 10 mL in EU from 2016)
- Nicotine content from 0 – 36 mg/mL (max 20 mg/mL in EU from 2016)
- Higher nicotine concentration to be used after dilution
- Huge variability of flavors
- Little research on materials

CURRENT DEVELOPMENTS

- Temperature control is already in the market



TEMPERATURE CONTROL

- Based on temperature coefficient of resistance

$$R(T) = R(T_0)(1 + \alpha\Delta T)$$

- Effective with wires having stable α value
 - Ni200 (pure nickel), Titanium grade 1 (titanium dioxide?)
 - One issue is the low resistance of the coils → makes difficult the accurate determination of the resistance change
 - Some other materials (safer?) could be used but have not been thoroughly examined yet
-

FUTURE DEVELOPMENTS

- Deliver high power levels but control temperature to predetermined limits
- Improve battery efficiency (smaller in size but high in capacity)
- Improved design of atomizer heads (better liquid re-supply to the wick → more aerosol production with less chance of overheating)
- Balance between resistance value, coil thickness and power delivery
- Avoid heating and metal coils
- Avoid contact between e-liquid (corrosive) and metal parts of the atomizer
- Ways of further reducing aldehyde emissions (either trap aldehydes or find alternative compounds as base ingredients)

Dr Konstantinos Farsalinos

Researcher, Onassis Cardiac Surgery Center,
Greece

Researcher, University of Patras, Greece



E-CIGARETTE RESEARCH

ABOUT

LINKS

RESEARCH

WHAT'S NEW

SEARCH

CONTACT

www.ecigarette-research.org