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(54) **VAPE DEVICES, INCLUDING CARTRIDGES, TABLETS, SENSORS, AND CONTROLS FOR VAPE DEVICES, AND METHODS FOR MAKING AND USING THE SAME**

(71) Applicant: **CANOPY GROWTH CORPORATION**, SMITHS FALLS (CA)

(72) Inventors: **STEPHEN DAVIS**, OTTAWA (CA); **STEVEN PENNEY**, OTTAWA (CA); **JOHN PICCOLI**, SMITHS FALLS (CA); **PETER POPPLEWELL**, OTTAWA (CA); **ANDREW STEWART**, OTTAWA (CA); **MICHAEL WONG**, SMITHS FALLS (CA)

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§ 371 (c)(1),
(2) Date: **Sep. 8, 2020**

Related U.S. Application Data

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(60) Provisional application No. 62/797,694, filed on Jan. 28, 2019, provisional application No. 62/733,286, filed on Sep. 19, 2018, provisional application No. 62/696,943, filed on Jul. 12, 2018, provisional application No. 62/696,937, filed on Jul. 12, 2018, provisional application No. 62/696,930, filed on Jul. 12, 2018, provisional application No. 62/680,057, filed on Jun. 4, 2018, provisional application No. 62/668,380, filed on May 8, 2018, provisional application No. 62/661,306, filed on Apr. 23, 2018, provisional application No. 62/642,825, filed on Mar. 14, 2018, provisional application No. 62/642,805, filed on Mar. 14, 2018.

Publication Classification

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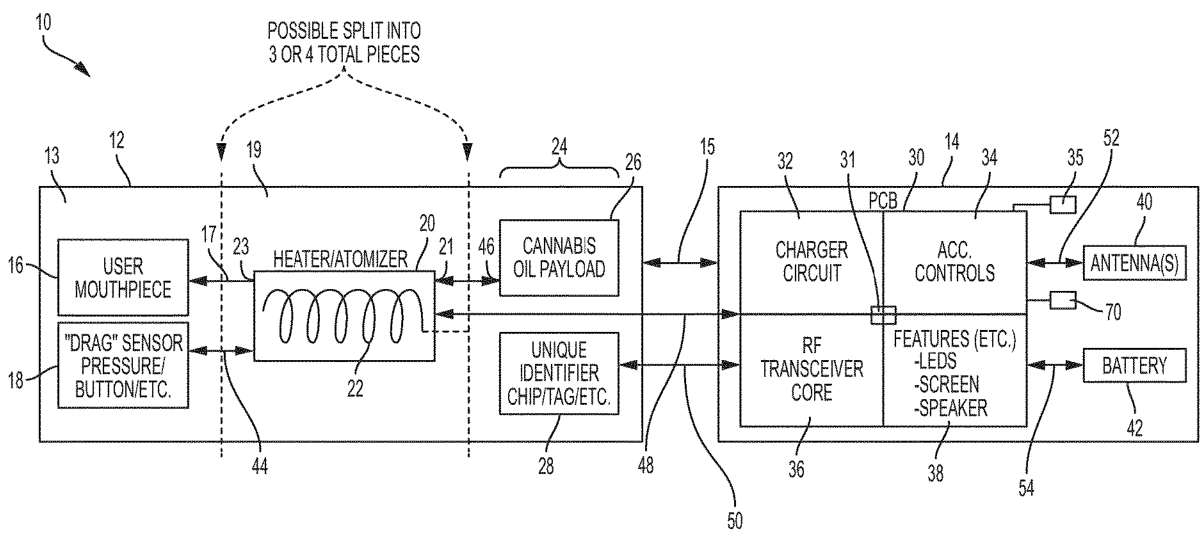
A24F 40/51	(2006.01)
A24F 40/60	(2006.01)
A24F 40/65	(2006.01)

(52) **U.S. Cl.**

CPC ***A24F 40/57*** (2020.01); ***A24F 40/42*** (2020.01); ***A24F 40/65*** (2020.01); ***A24F 40/51*** (2020.01); ***A24F 40/60*** (2020.01); ***A24F 40/53*** (2020.01)

(57) **ABSTRACT**

Vape devices and methods of operating the same to prevent unauthorized use, allow for remote, centralized storage of operational settings associated with unique payload identifiers, and to optimize operation based on historical usage data, real-time operating conditions, and/or user information. Vape devices for vaporizing dry material and methods of operating the same. Tablets comprising dry material for vaporization and methods of making and using the same. Vape devices and cartridges to improve flow of a fluid payload to an atomizer and to prevent leaking and spurting of the fluid payload, including vape devices and cartridges that pressurize the fluid payload. Vapor measurement systems to determine dosage based on a measured capacitance of vaporized payload. A two-lead communication system that enables the communication of a plurality of electrical signals between a control assembly and cartridge. A cartridge temperature control system that provides localized temperature control for the cartridge.



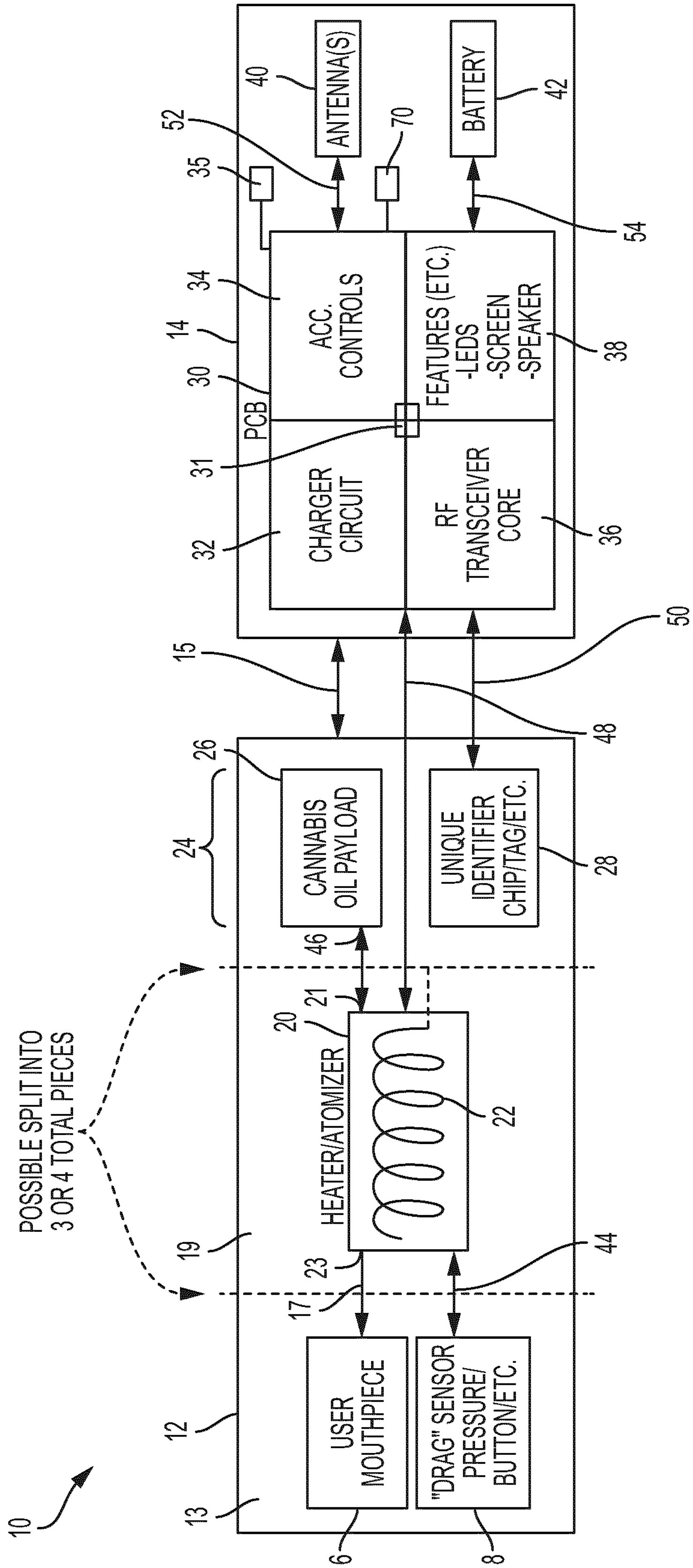

10
POSSIBLE SPLIT INTO
3 OR 4 TOTAL PIECES
13
12
19
USER
MOUTHPIECE
16
"DRAG" SENSOR
PRESSURE/
BUTTON/ETC.
18
17
23
44
HEATER/ATOMIZER
20
21
22
46
CANNABIS
OIL PAYLOAD
26
24
UNIQUE
IDENTIFIER
CHIP/TAG/ETC.
28
15
48
50
PCB
30
14
CHARGER
CIRCUIT
32
31
RF
TRANSCEIVER
CORE
36
ACC.
CONTROLS
34
FEATURES (ETC.)
-LEDS
-SCREEN
-SPEAKER
38
35
52
70
54
ANTENNA(S)
40
BATTERY
42

FIG. 1

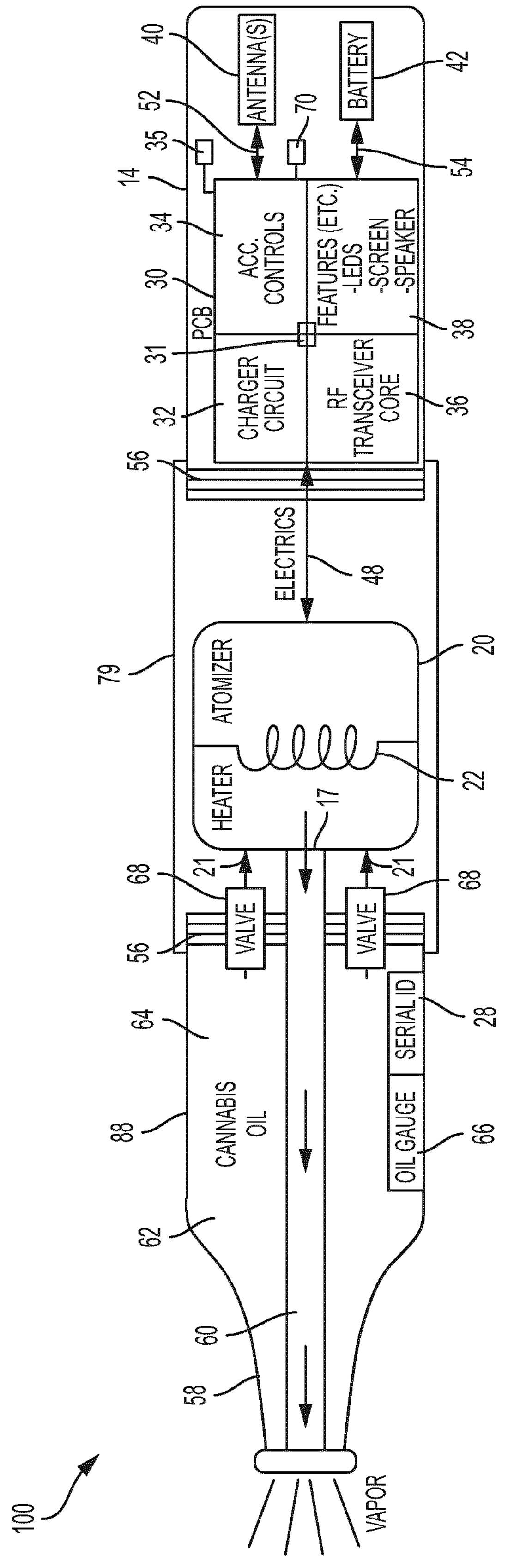

40
ANTENNA(S)
52
70
BATTERY
42
35
54
14
34
ACC.
CONTROLS
30
PCB
FEATURES (ETC.)
-LEDS
-SCREEN
-SPEAKER
38
31
32
CHARGER
CIRCUIT
RF
TRANSCEIVER
CORE
36
56
ELECTRICS
48
79
ATOMIZER
20
HEATER
22
17
21
21
68
68
VALVE
VALVE
56
64
SERIAL ID
28
88
CANNABIS
OIL
OIL GAUGE
66
62
60
58
100
VAPOR

FIG. 2

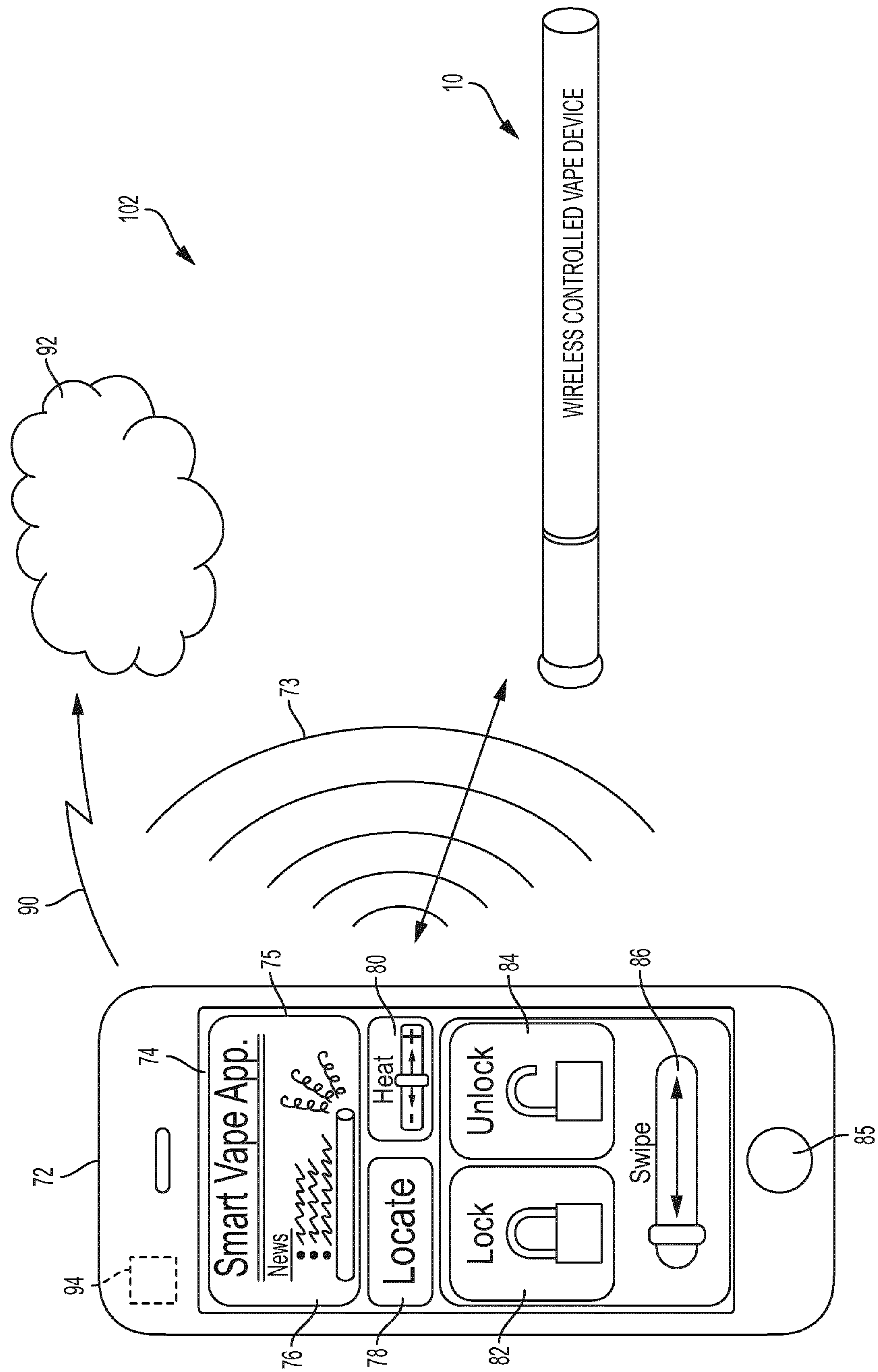

10
WIRELESS CONTROLLED VAPE DEVICE
102
92
73
90
72
74
75
76
78
80
82
84
85
86
94
Smart Vape App.
News
Heat
Locate
Unlock
Lock
Swipe

FIG. 3

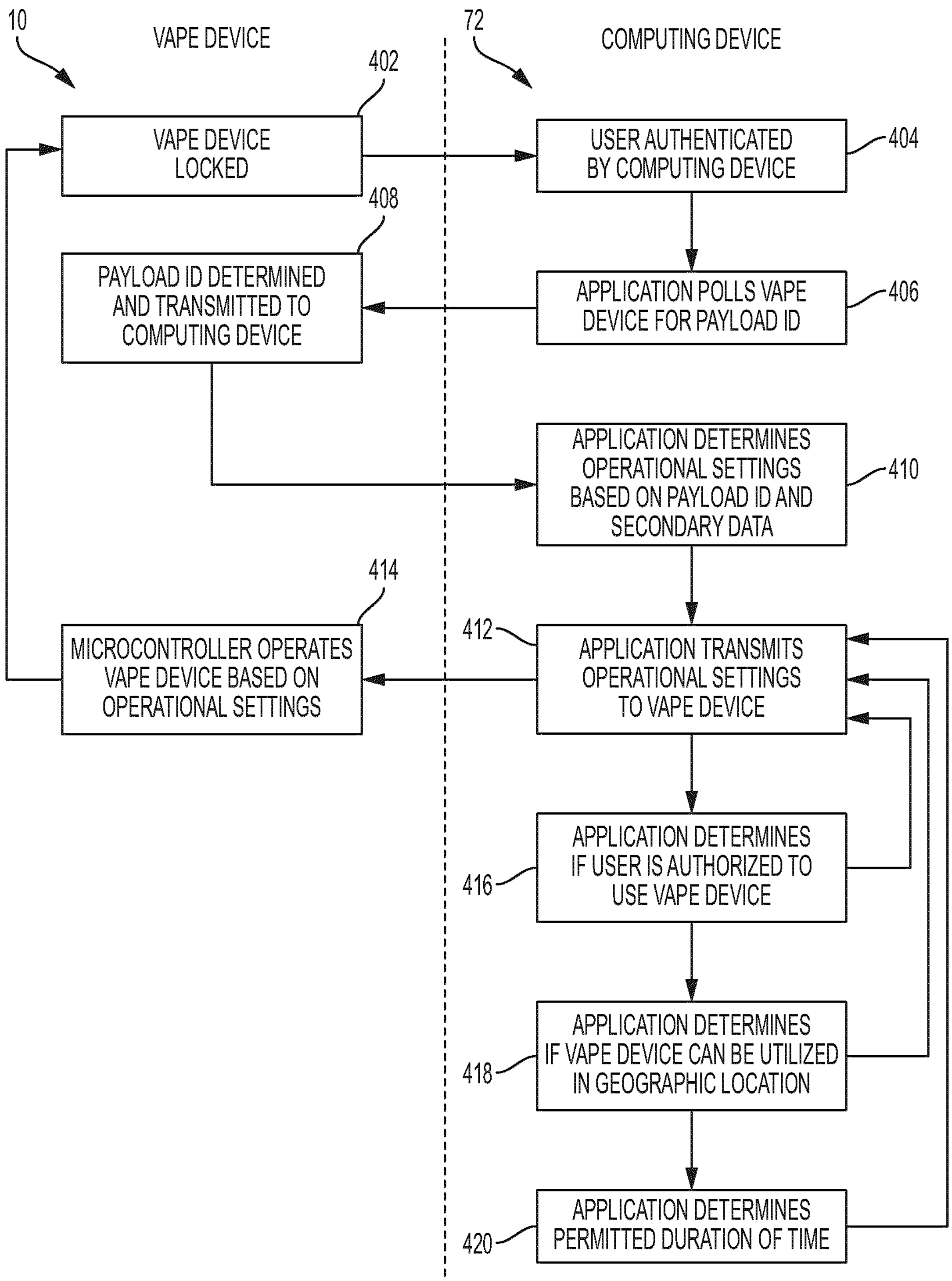
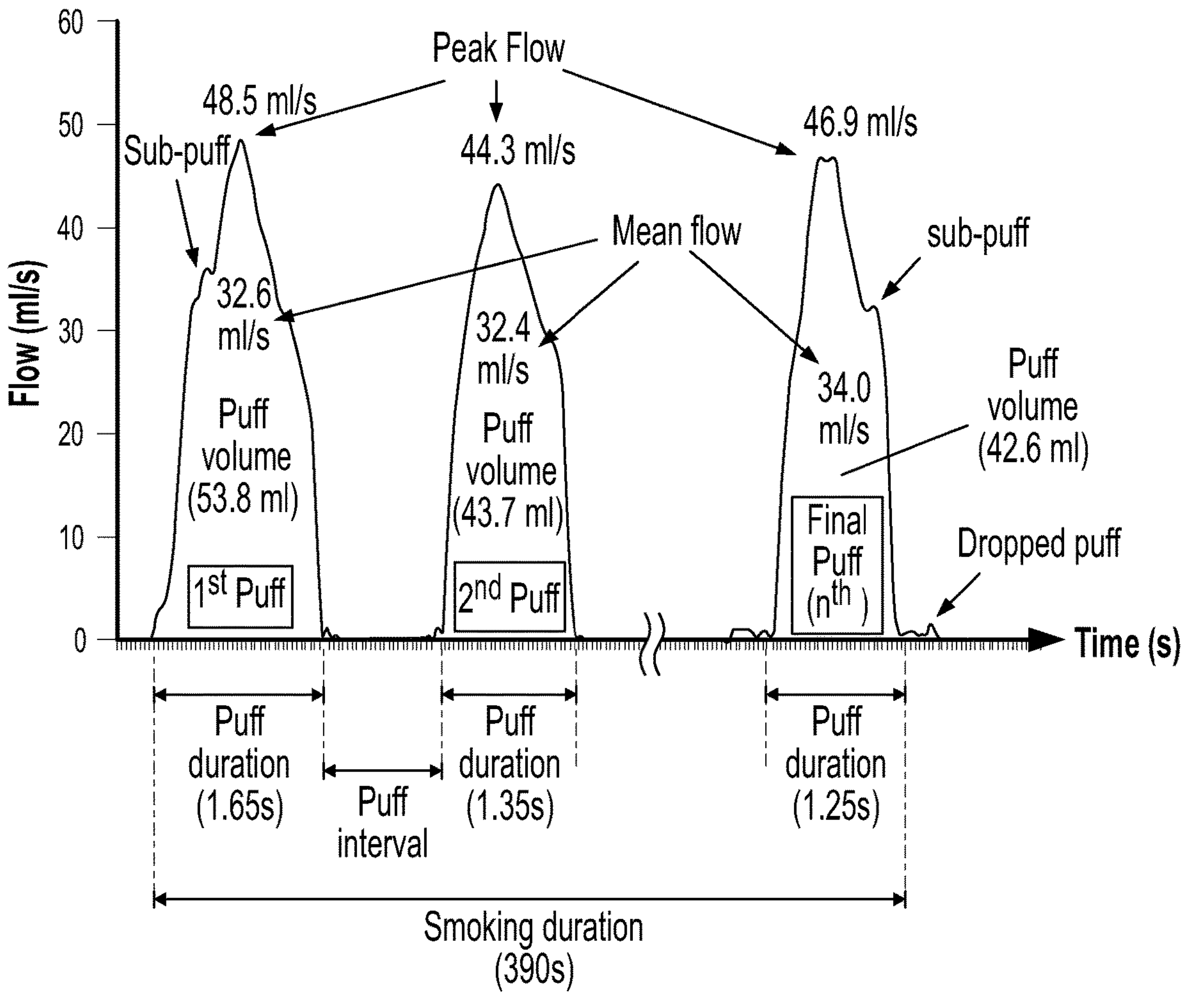

10
VAPE DEVICE
72
COMPUTING DEVICE
402
VAPE DEVICE LOCKED
USER AUTHENTICATED BY COMPUTING DEVICE
404
408
PAYLOAD ID DETERMINED AND TRANSMITTED TO COMPUTING DEVICE
APPLICATION POLLS VAPE DEVICE FOR PAYLOAD ID
406
APPLICATION DETERMINES OPERATIONAL SETTINGS BASED ON PAYLOAD ID AND SECONDARY DATA
410
414
MICROCONTROLLER OPERATES VAPE DEVICE BASED ON OPERATIONAL SETTINGS
412
APPLICATION TRANSMITS OPERATIONAL SETTINGS TO VAPE DEVICE
416
APPLICATION DETERMINES IF USER IS AUTHORIZED TO USE VAPE DEVICE
418
APPLICATION DETERMINES IF VAPE DEVICE CAN BE UTILIZED IN GEOGRAPHIC LOCATION
420
APPLICATION DETERMINES PERMITTED DURATION OF TIME

FIG. 4



60
50
40
30
20
10
0
Flow (ml/s)
Time (s)
Peak Flow
48.5 ml/s
44.3 ml/s
46.9 ml/s
Sub-puff
sub-puff
Mean flow
32.6 ml/s
32.4 ml/s
34.0 ml/s
Puff volume (53.8 ml)
Puff volume (43.7 ml)
Puff volume (42.6 ml)
1st Puff
2nd Puff
Final Puff (nth)
Dropped puff
Puff duration (1.65s)
Puff interval
Puff duration (1.35s)
Puff duration (1.25s)
Smoking duration (390s)

FIG. 5

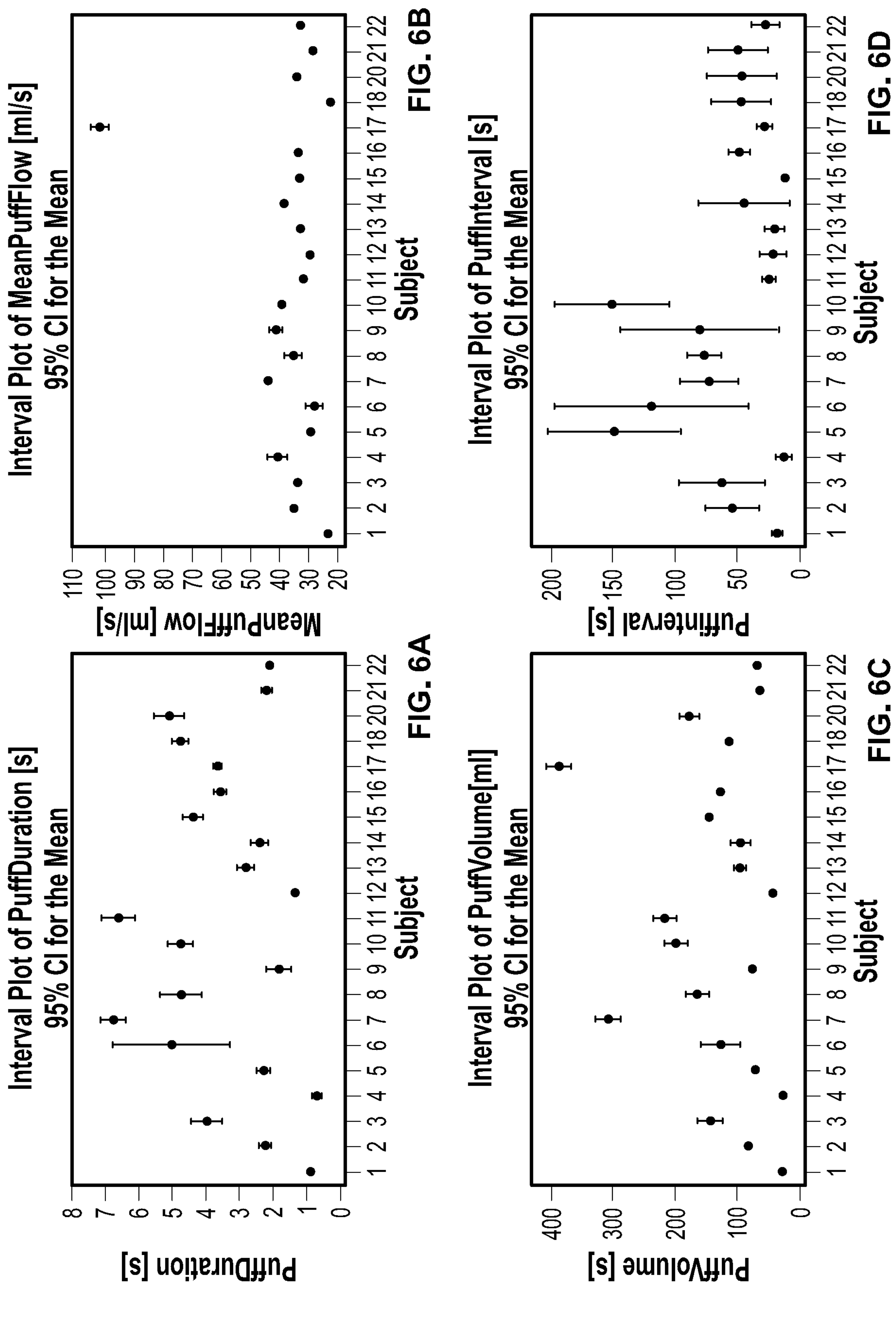


FIG. 6A

FIG. 6B

FIG. 6C

FIG. 6D

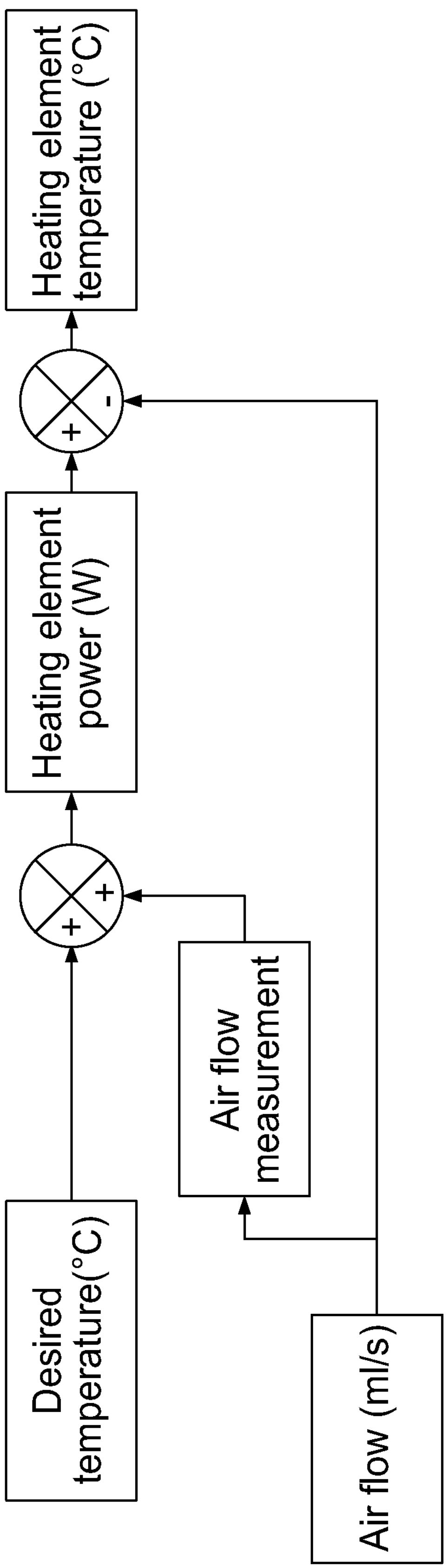

Desired temperature(°C)
Air flow measurement
Air flow (ml/s)
+
+
Heating element power (W)
+
-
Heating element temperature (°C)

FIG. 7A

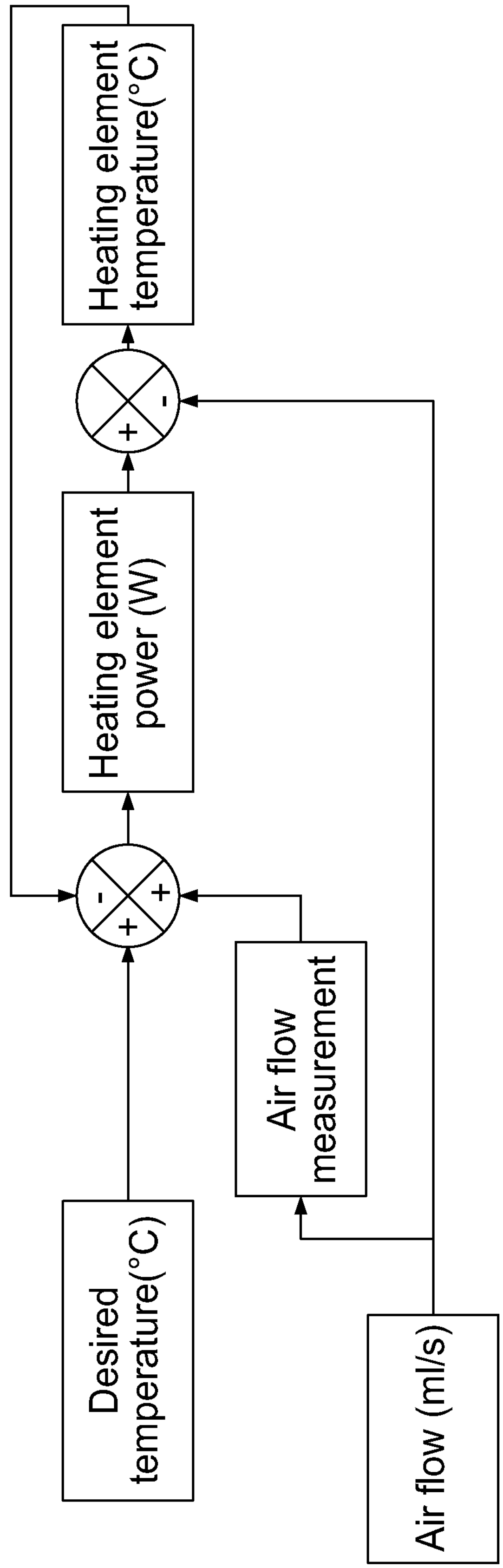

Desired temperature(°C)
Air flow measurement
Air flow (ml/s)
+
+
-
Heating element power (W)
+
-
Heating element temperature(°C)

FIG. 7B

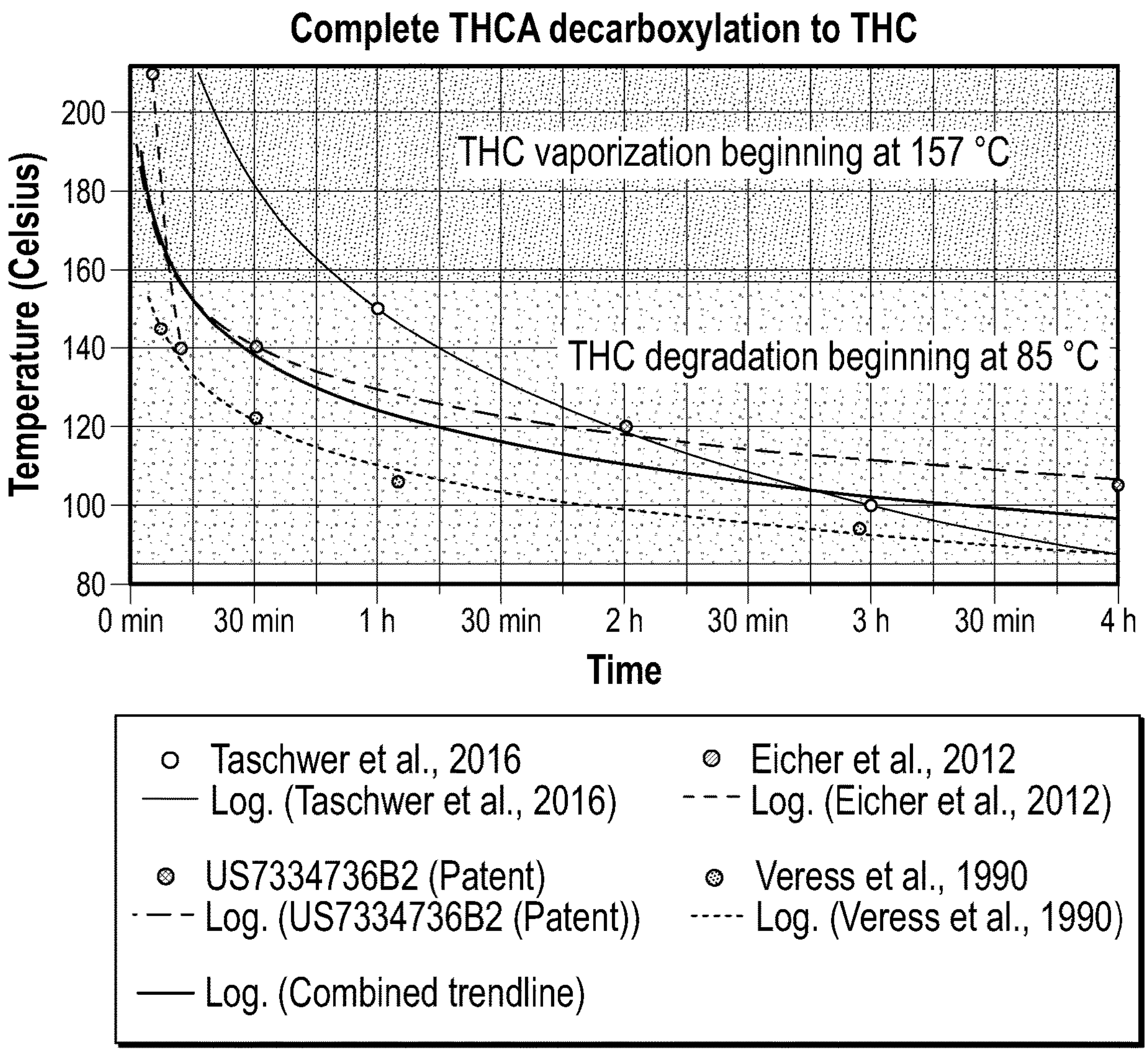
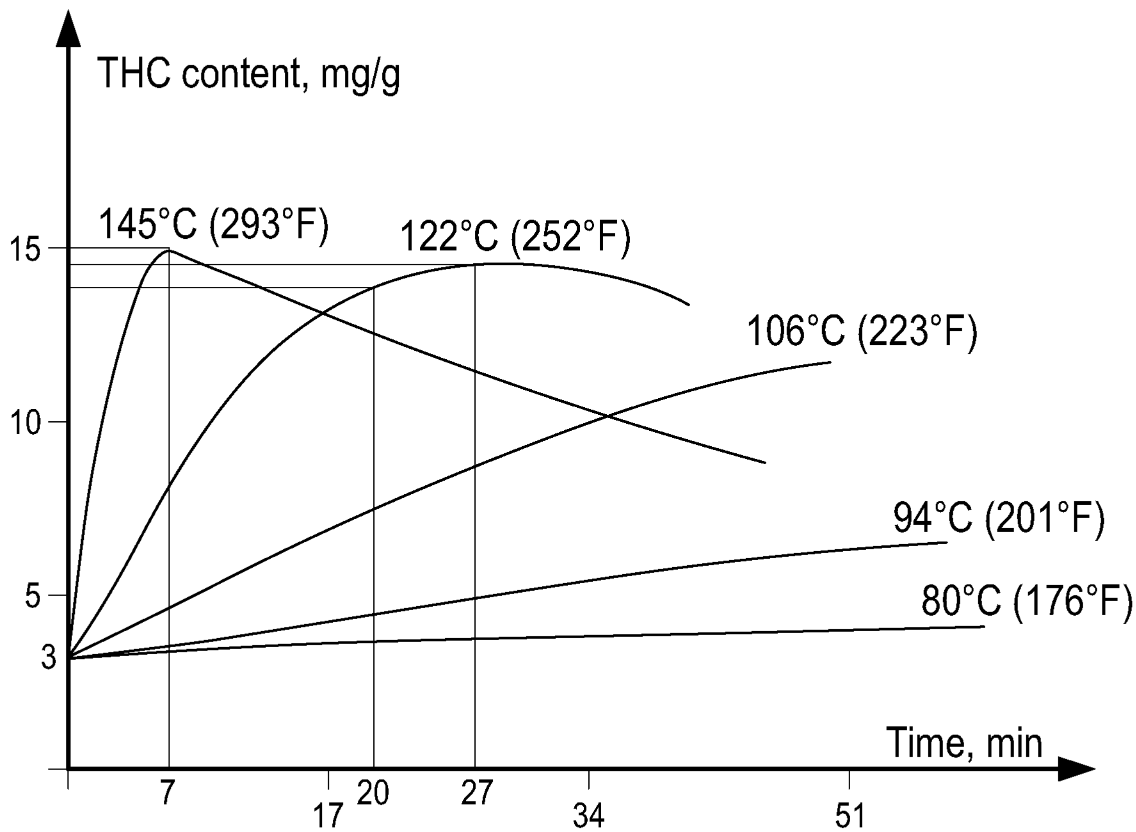

Complete THCA decarboxylation to THC
Temperature (Celsius)
200
180
160
140
120
100
80
THC vaporization beginning at 157 °C
THC degradation beginning at 85 °C
0 min
30 min
1 h
30 min
2 h
30 min
3 h
30 min
4 h
Time
Taschwer et al., 2016
Log. (Taschwer et al., 2016)
Eicher et al., 2012
Log. (Eicher et al., 2012)
US7334736B2 (Patent)
Log. (US7334736B2 (Patent))
Veress et al., 1990
Log. (Veress et al., 1990)
Log. (Combined trendline)

FIG. 8A



Effect of heating time and temperature on the THC content of an *n*-hexane marihuana extract after heating on the glass surface in an open reactor.

FIG. 8B

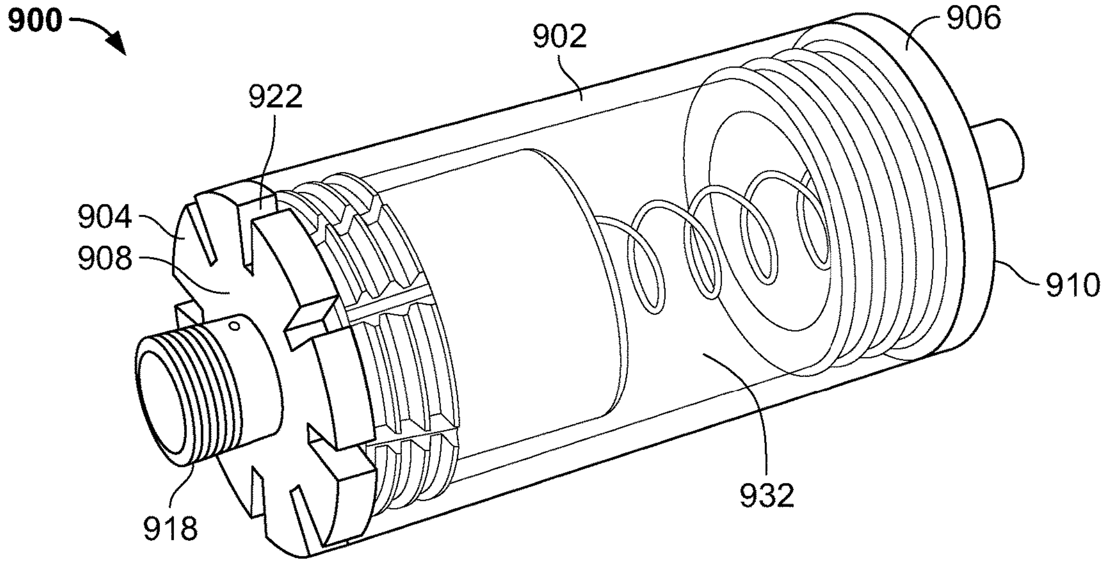


FIG. 9A

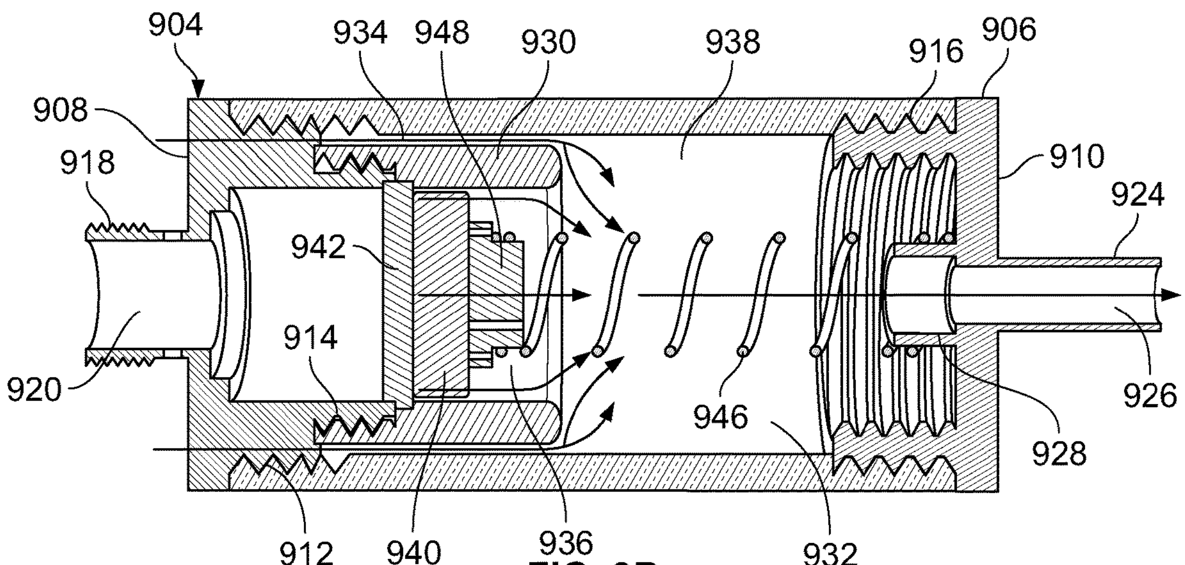


FIG. 9B

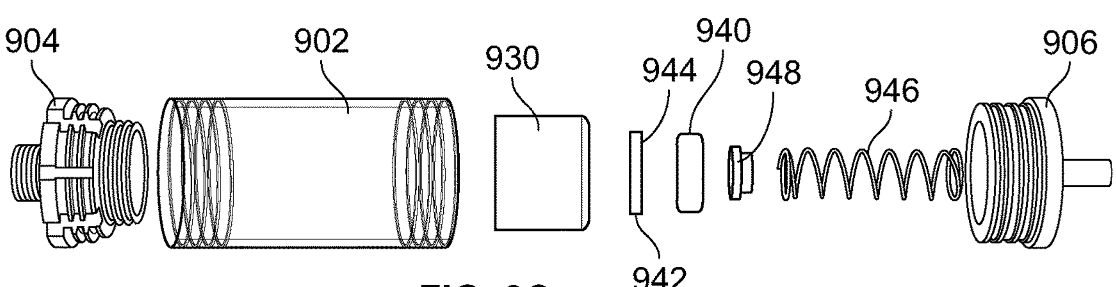


FIG. 9C

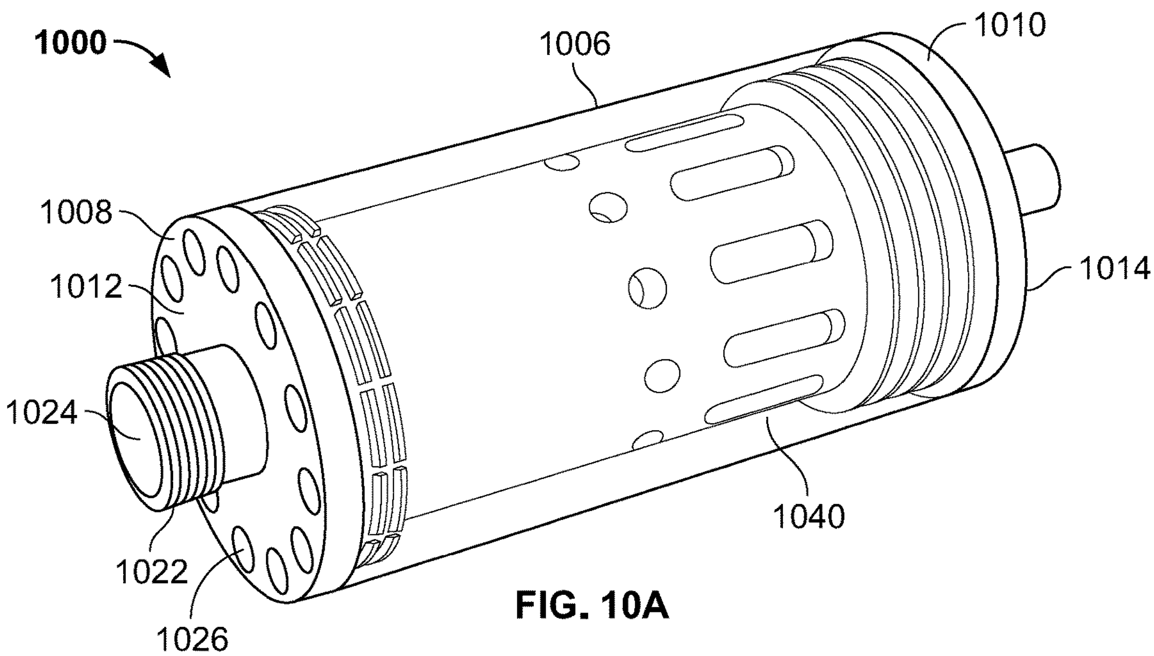


FIG. 10A

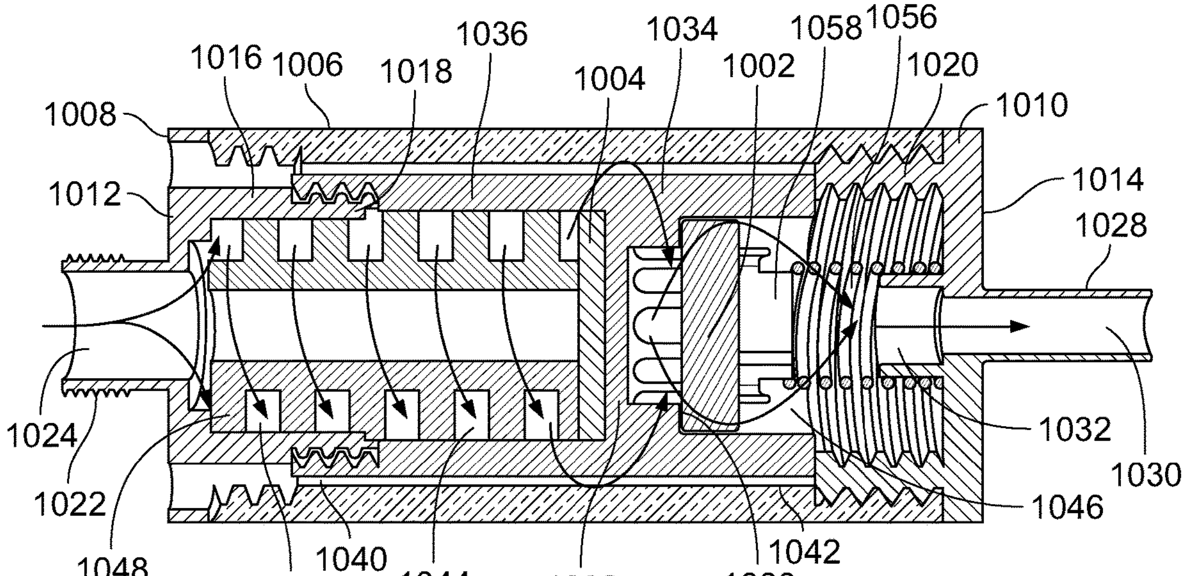


FIG. 10B

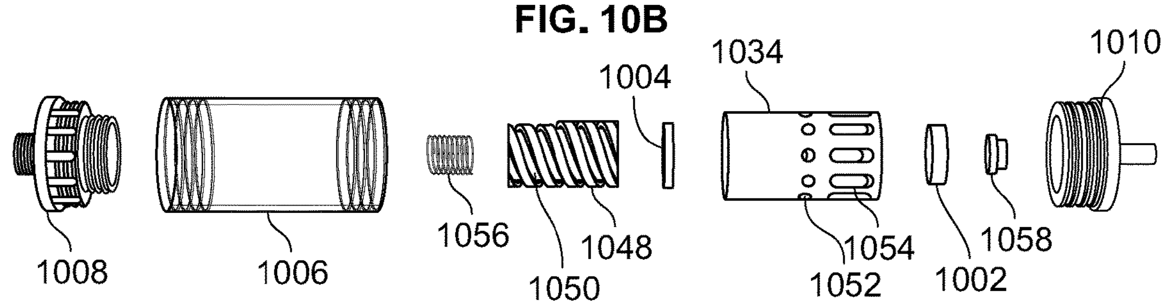


FIG. 10C

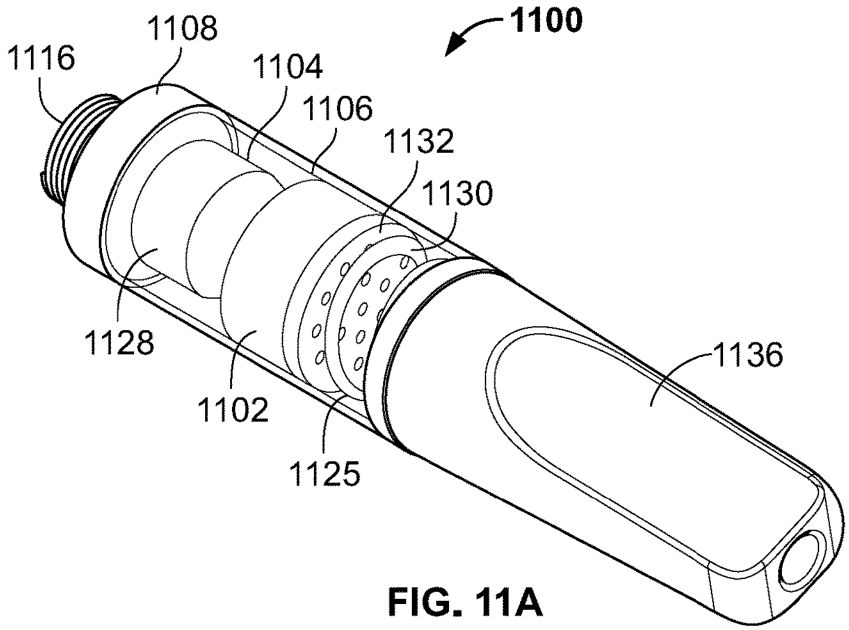


FIG. 11A

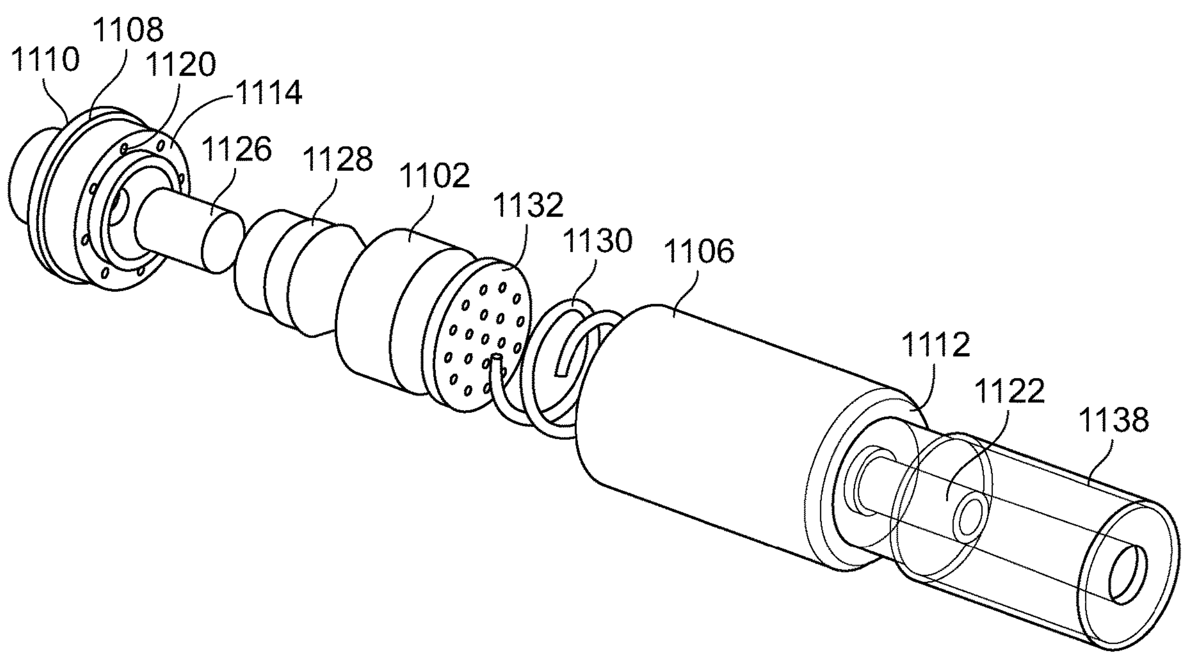


FIG. 11B

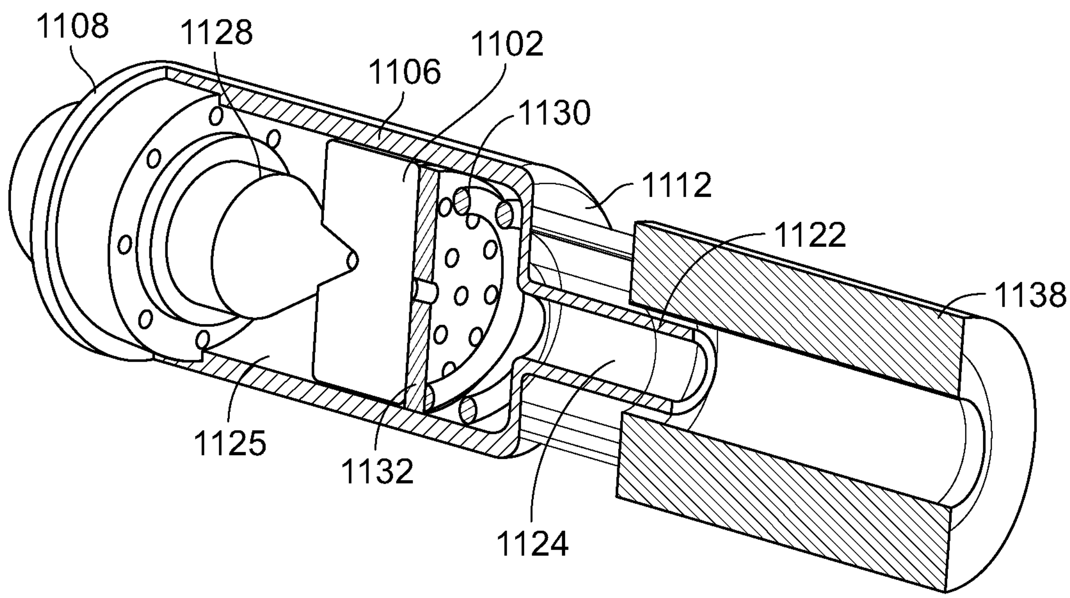


FIG. 11C

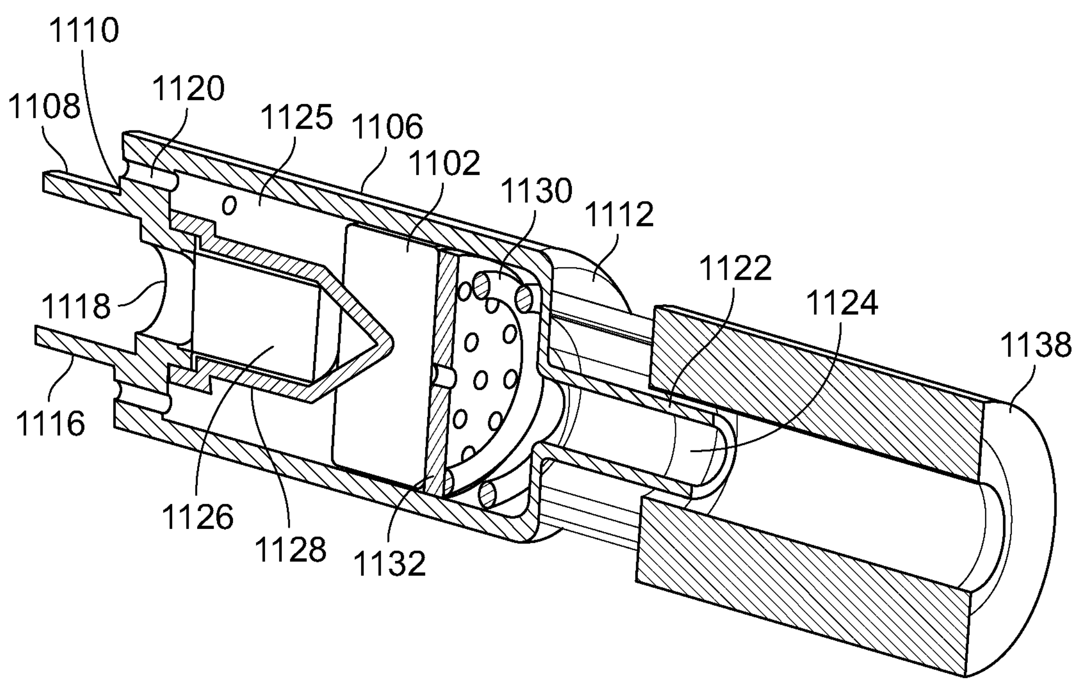


FIG. 11D

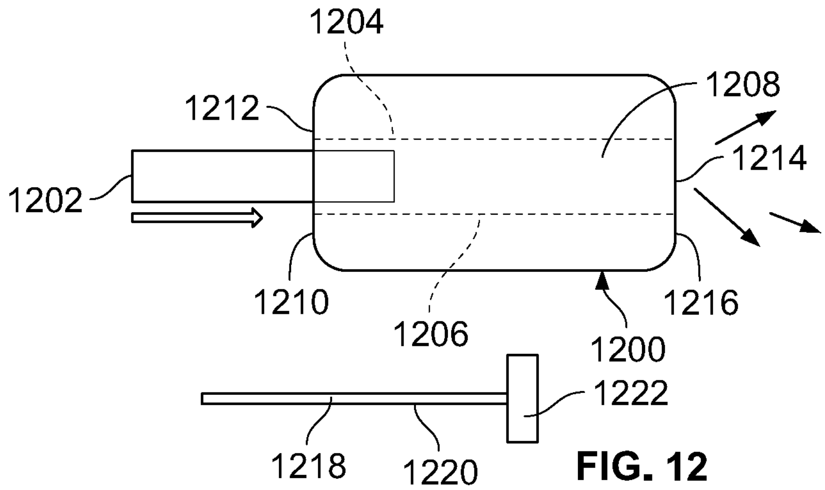


FIG. 12

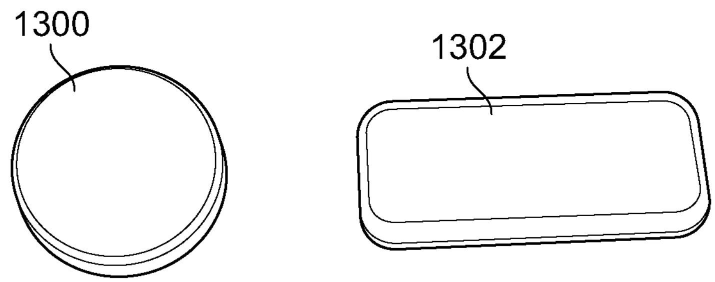


FIG. 13A

FIG. 13B

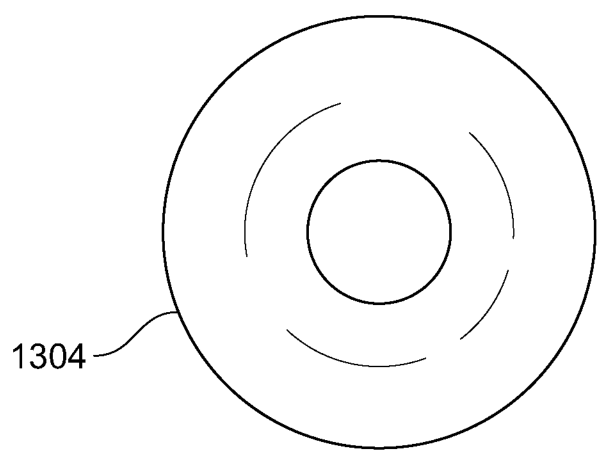


FIG. 13C

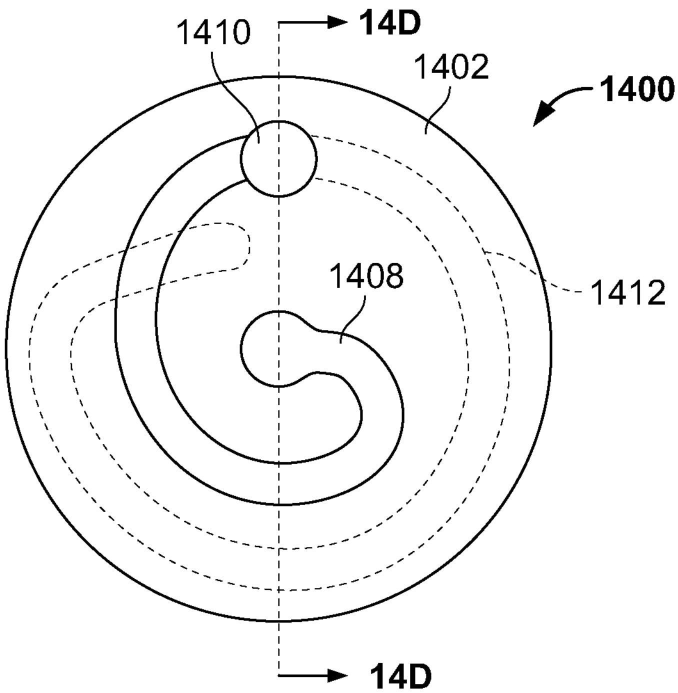


FIG. 14A

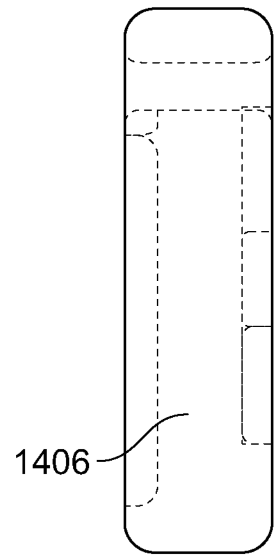


FIG. 14B

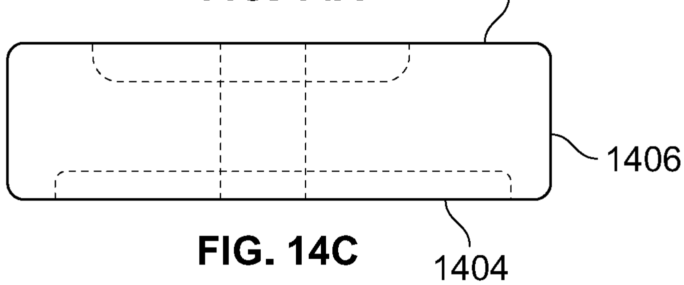


FIG. 14C

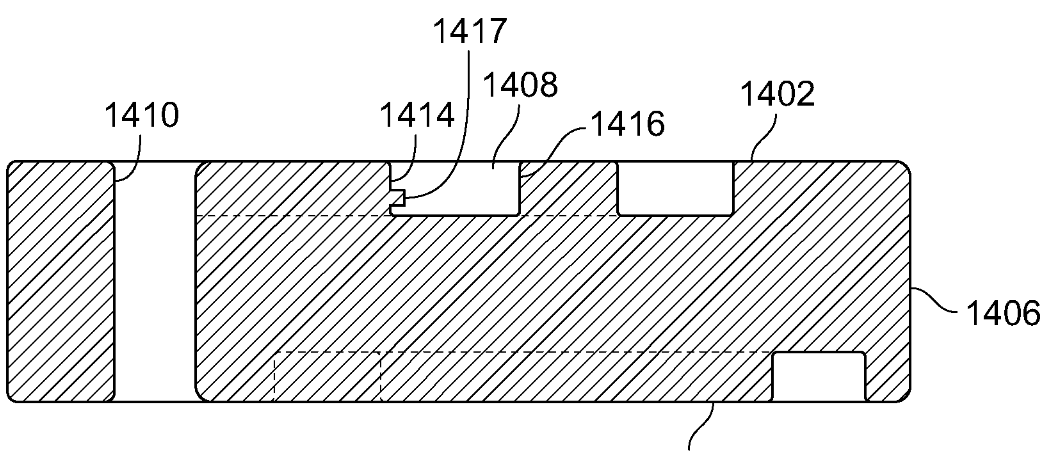


FIG. 14D

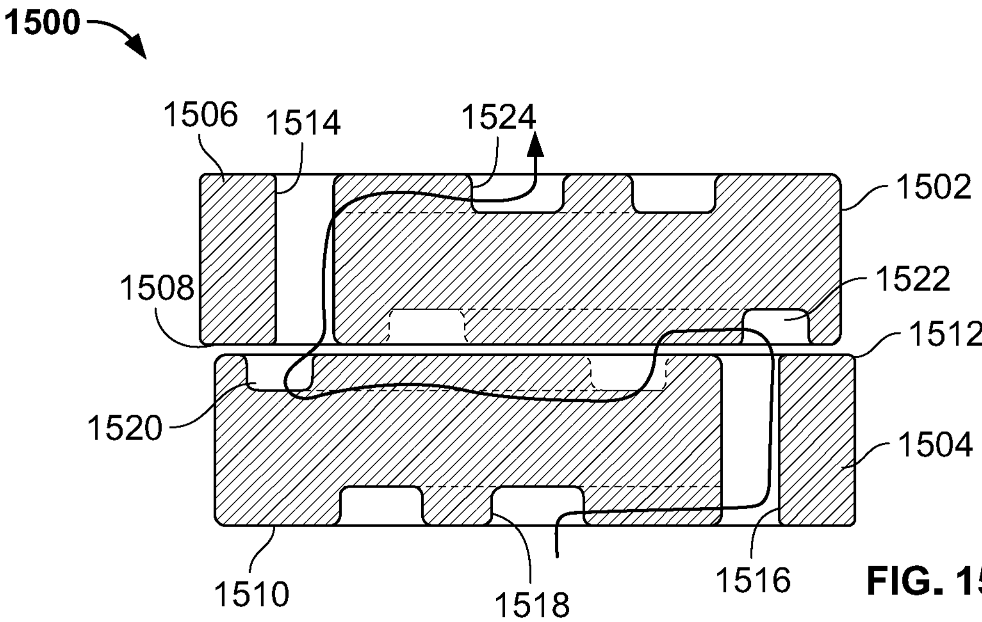


FIG. 15

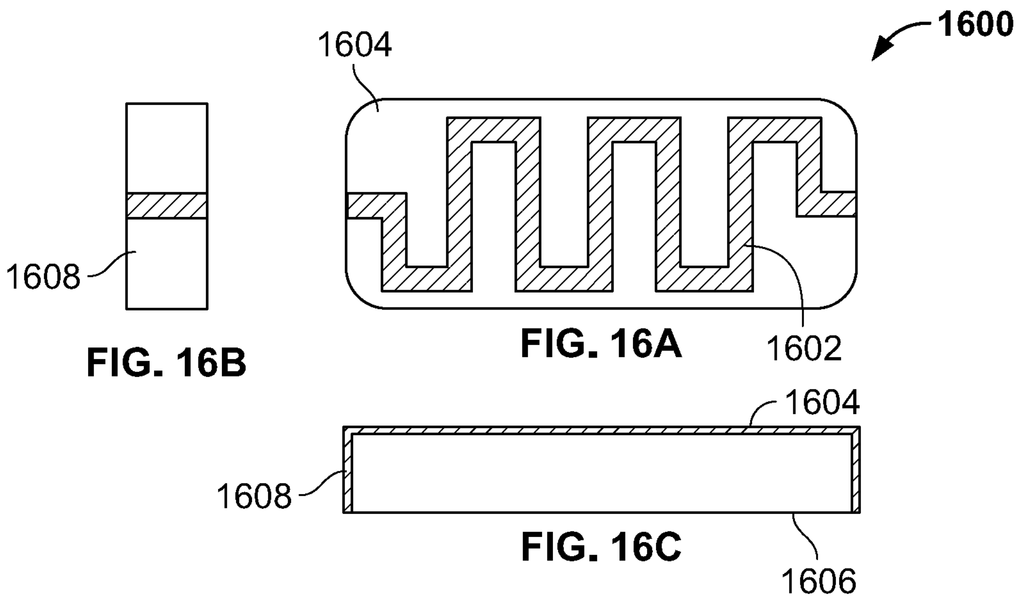


FIG. 16B

FIG. 16A

FIG. 16C

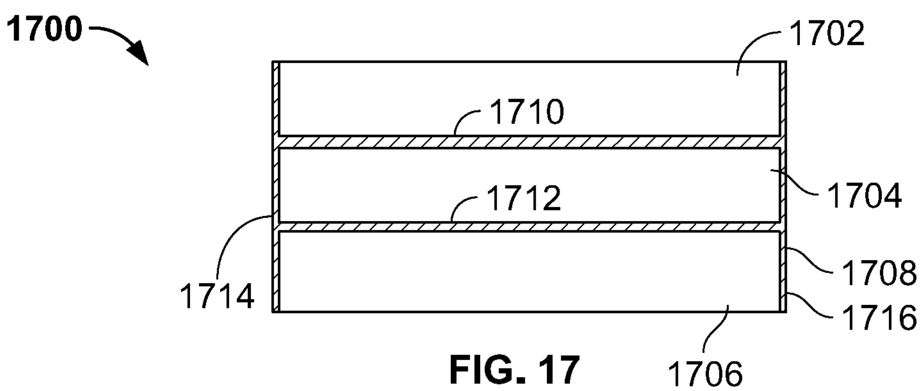


FIG. 17

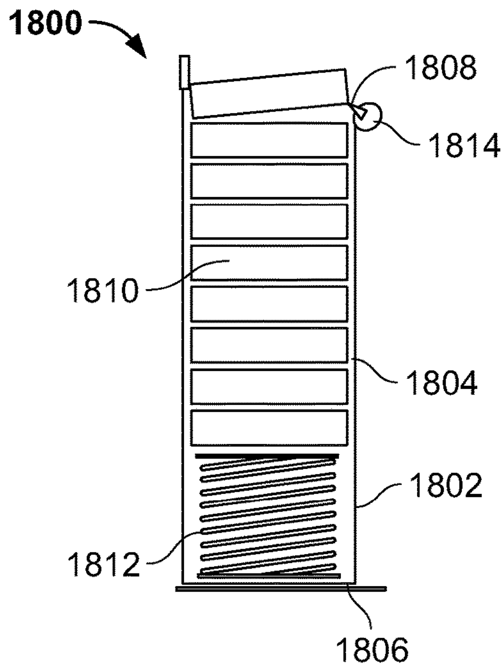


FIG. 18

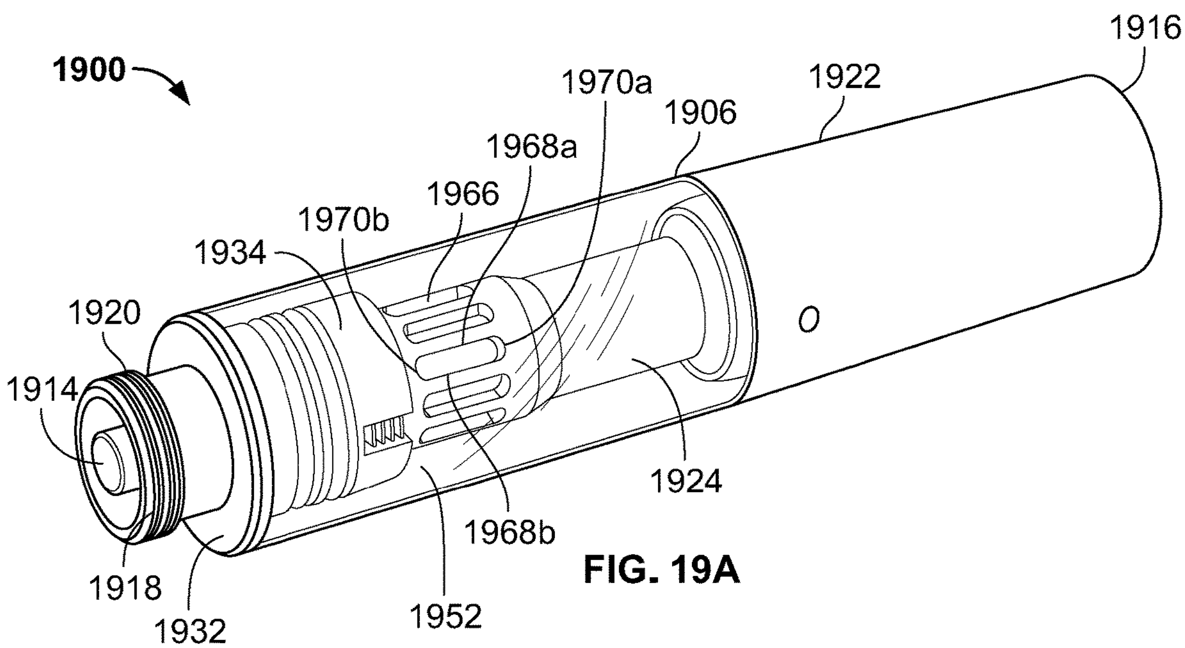


FIG. 19A

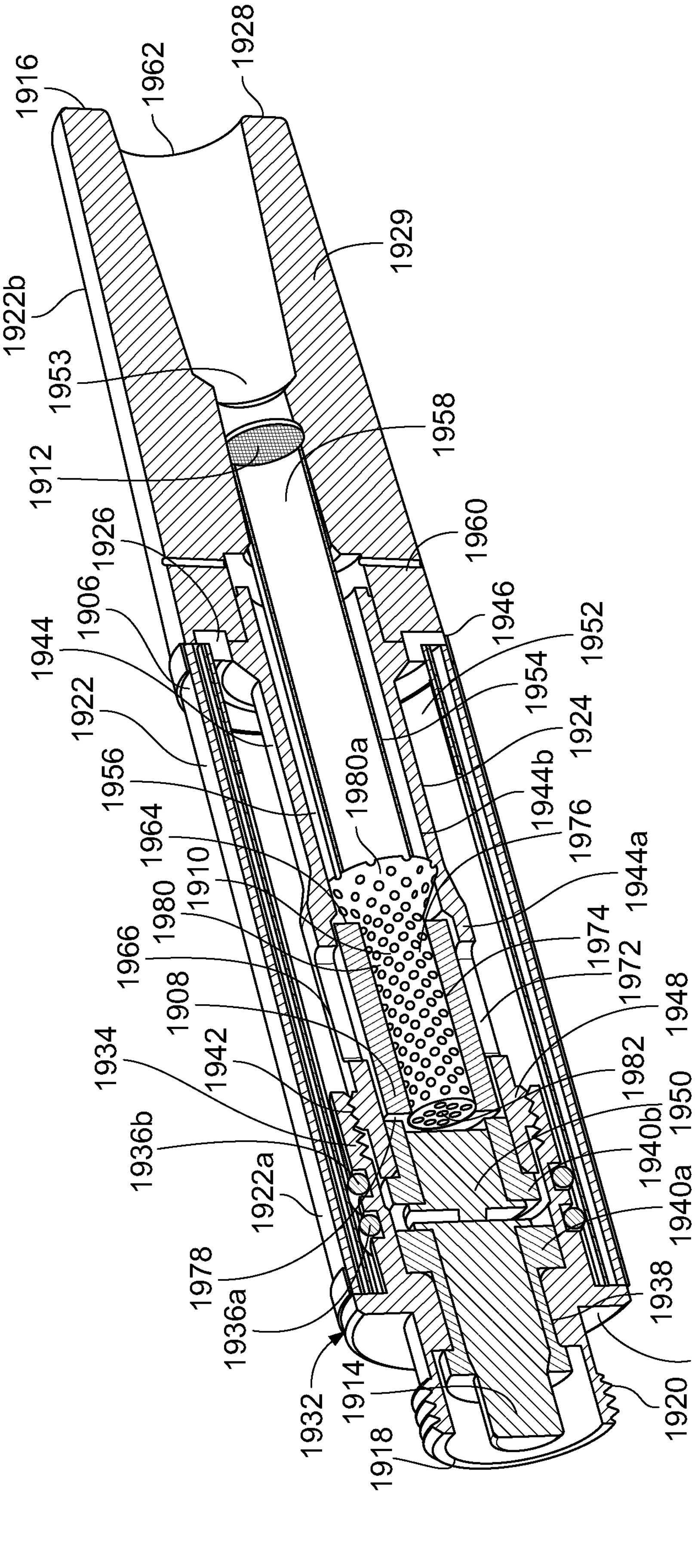

1916
1962
1928
1929
1922b
1953
1958
1912
1926
1960
1906
1946
1944
1952
1954
1922
1924
1956
1944b
1980a
1976
1964
1944a
1910
1974
1980
1972
1966
1948
1908
1982
1942
1950
1934
1940b
1936b
1940a
1922a
1978
1938
1936a
1930
1932
1914
1920
1918

FIG. 19B

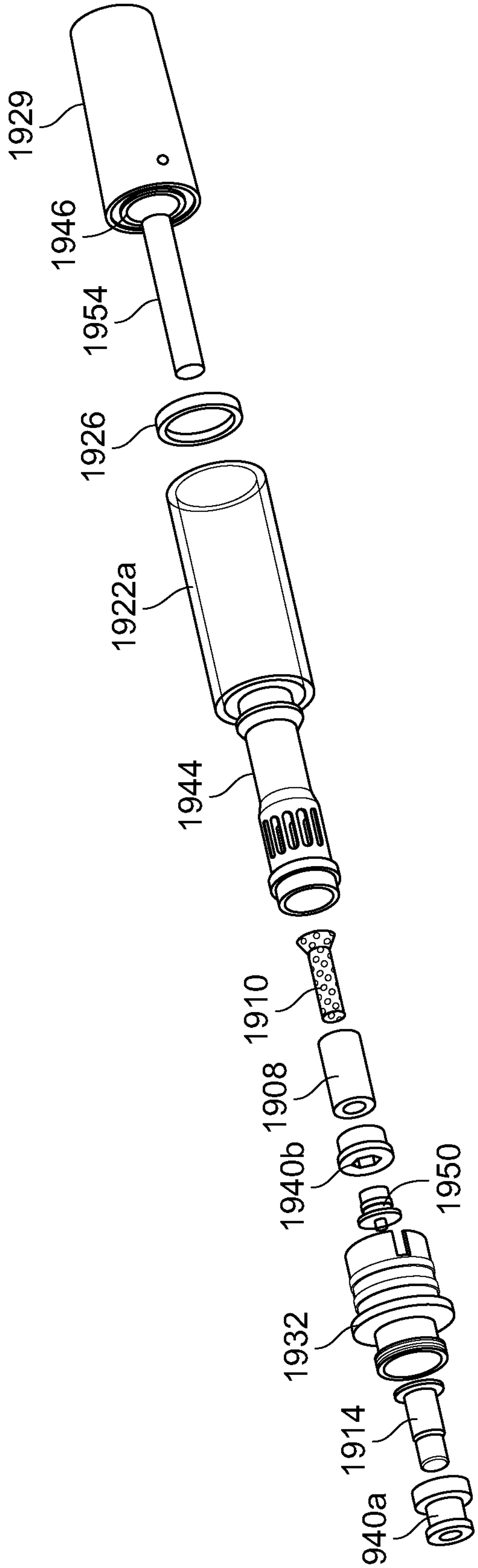

1929
1946
1954
1926
1922a
1944
1910
1908
1940b
1950
1932
1914
1940a

FIG. 19C

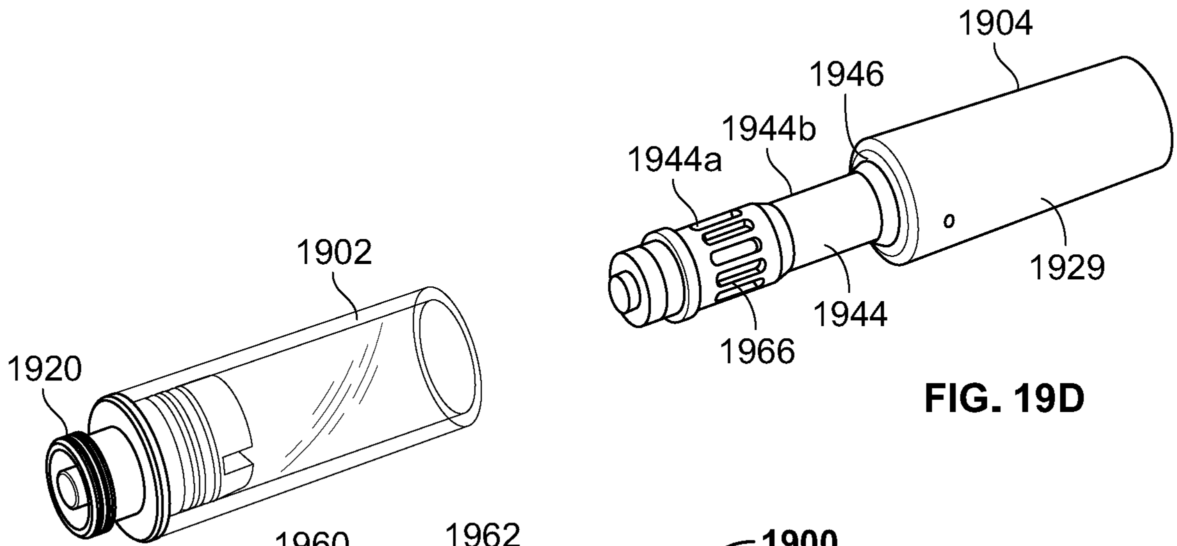


FIG. 19D

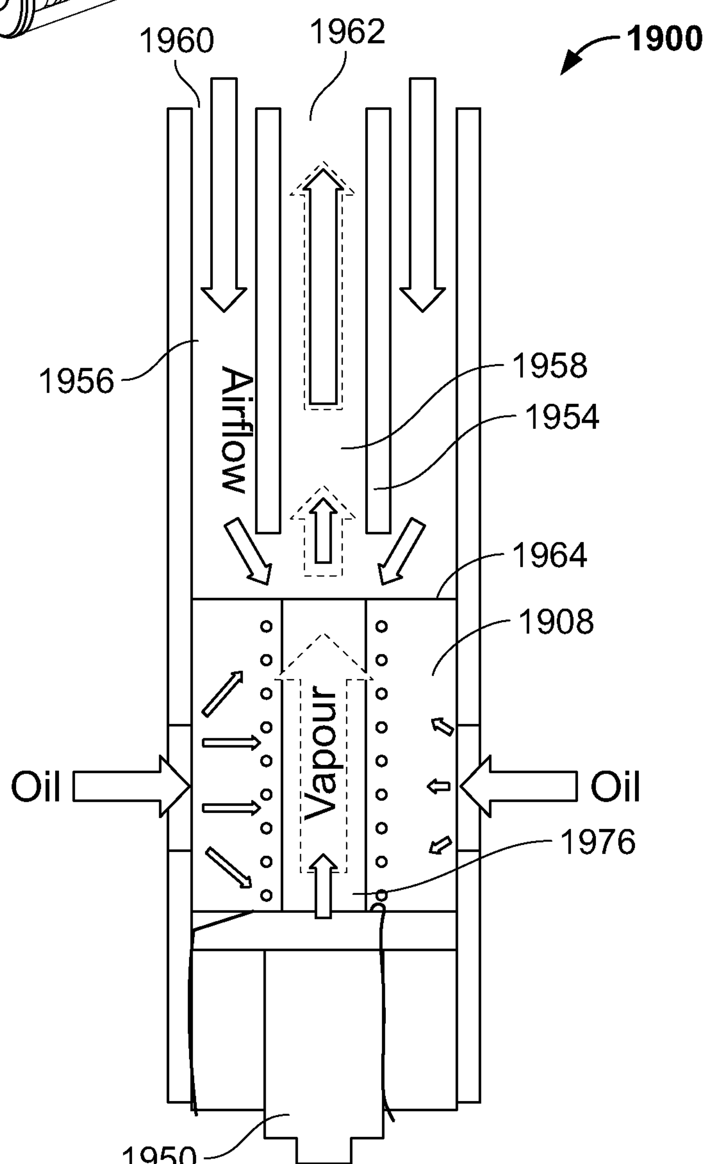


FIG. 20

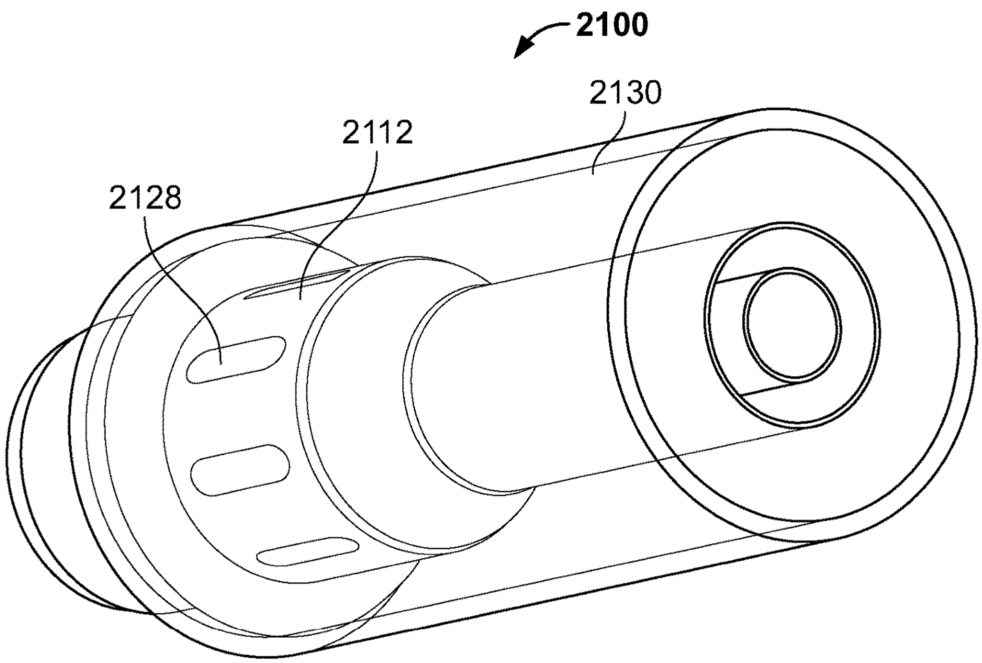

2100
2130
2112
2128

FIG. 21

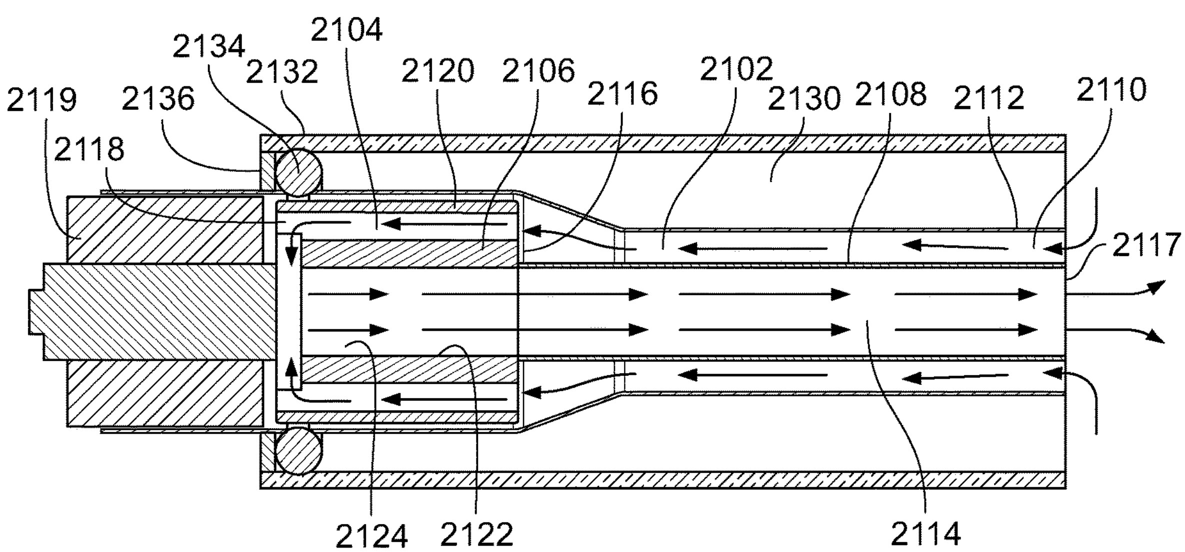

2104
2134
2132
2120
2106
2116
2102
2130
2108
2112
2110
2119
2136
2118
2117
2124
2122
2114

FIG. 22

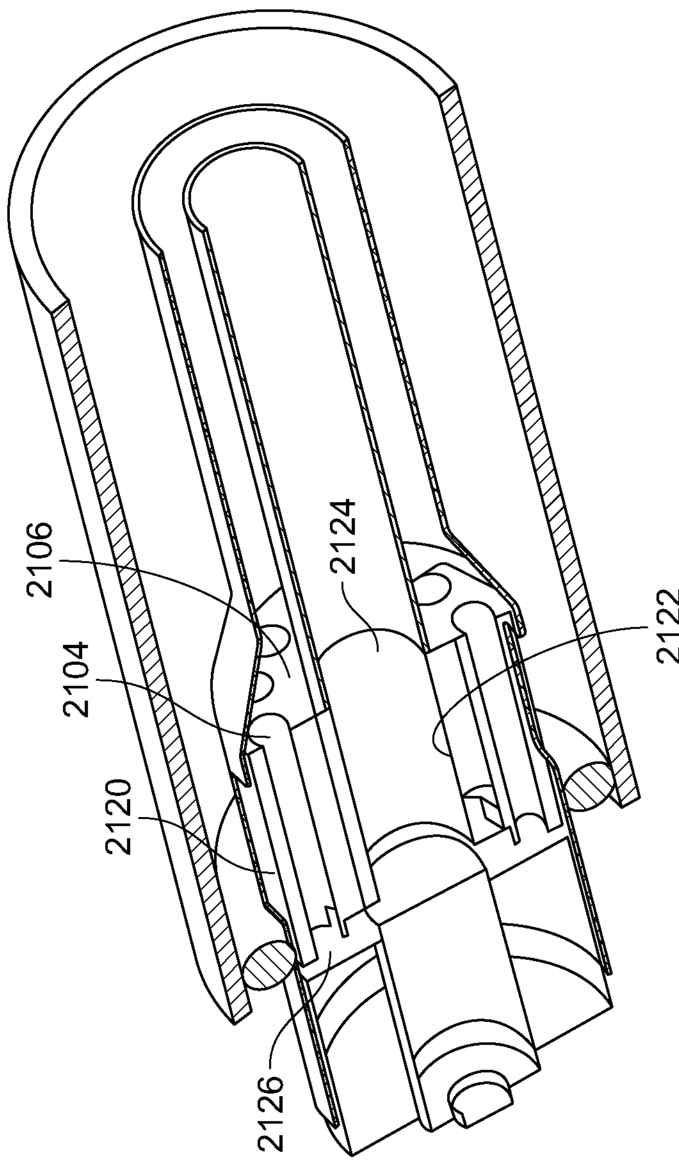


FIG. 23A

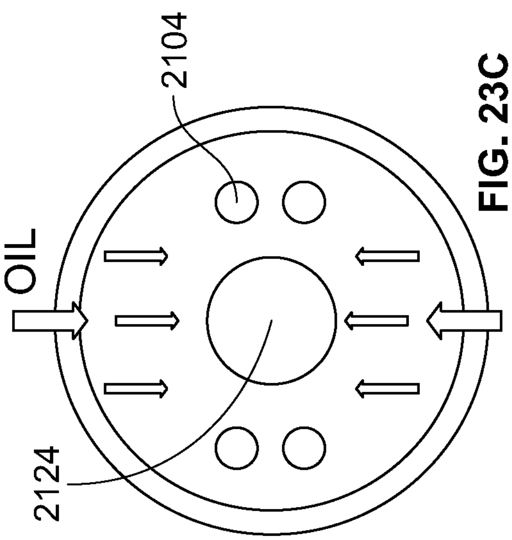


FIG. 23C

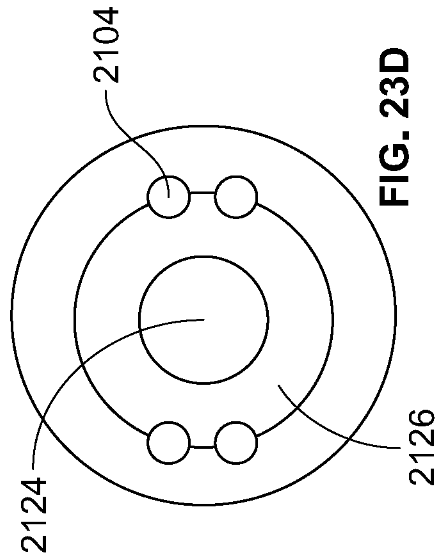


FIG. 23D

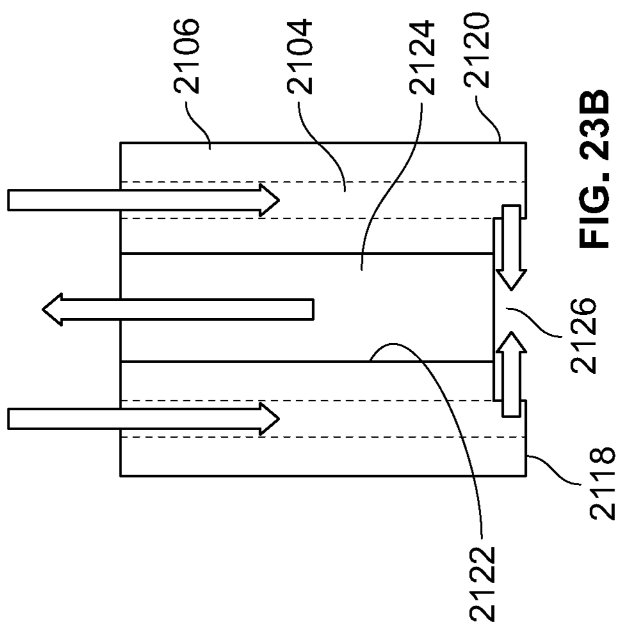
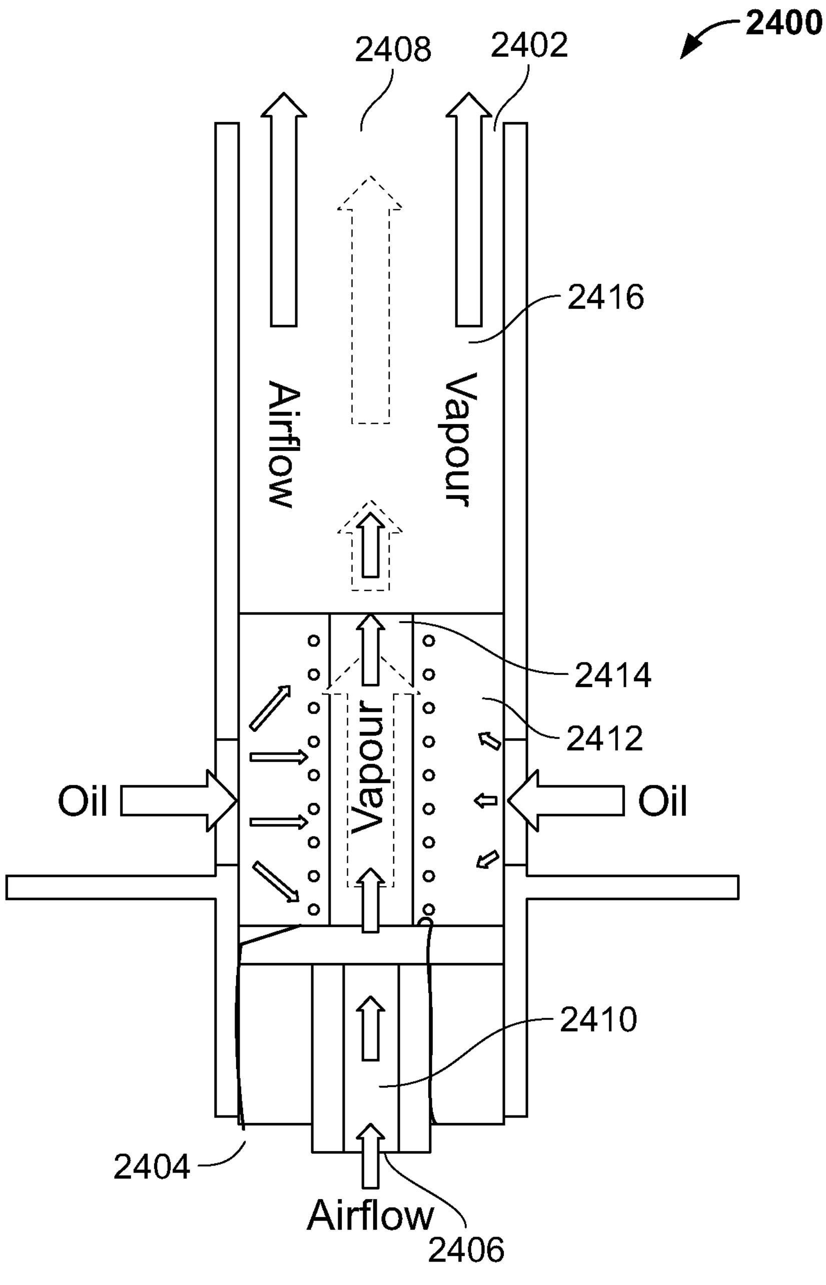


FIG. 23B



2400
2408
2402
2416
Airflow
Vapour
2414
2412
Vapour
Oil
Oil
2410
2404
Airflow
2406

FIG. 24

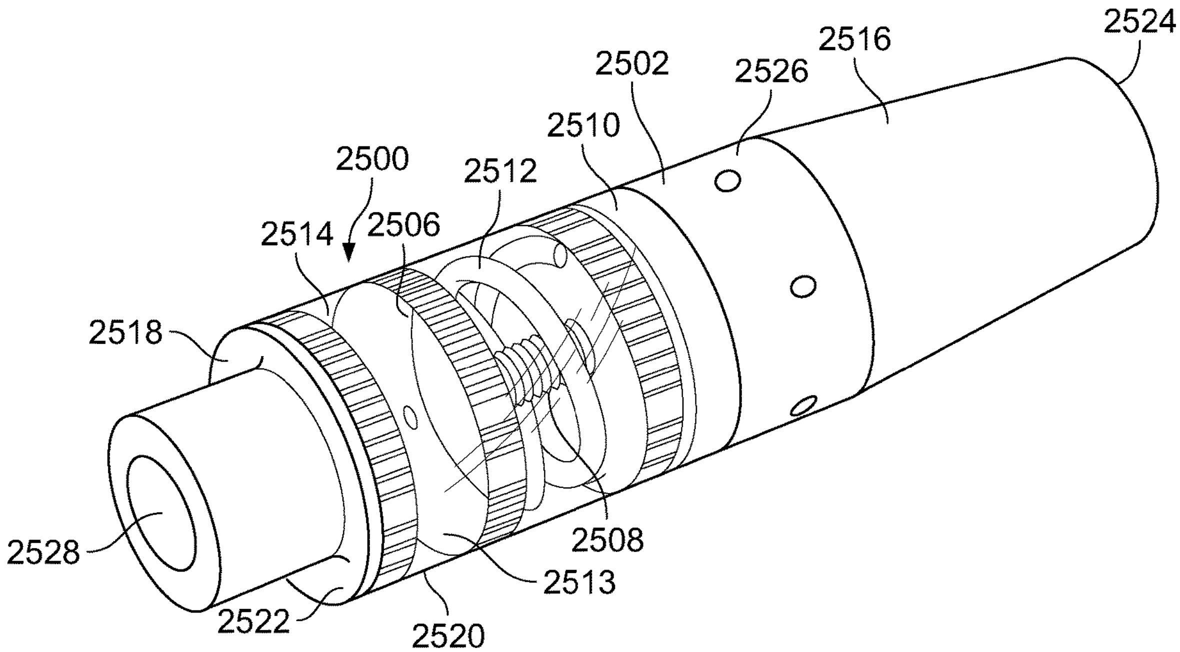


FIG. 25A

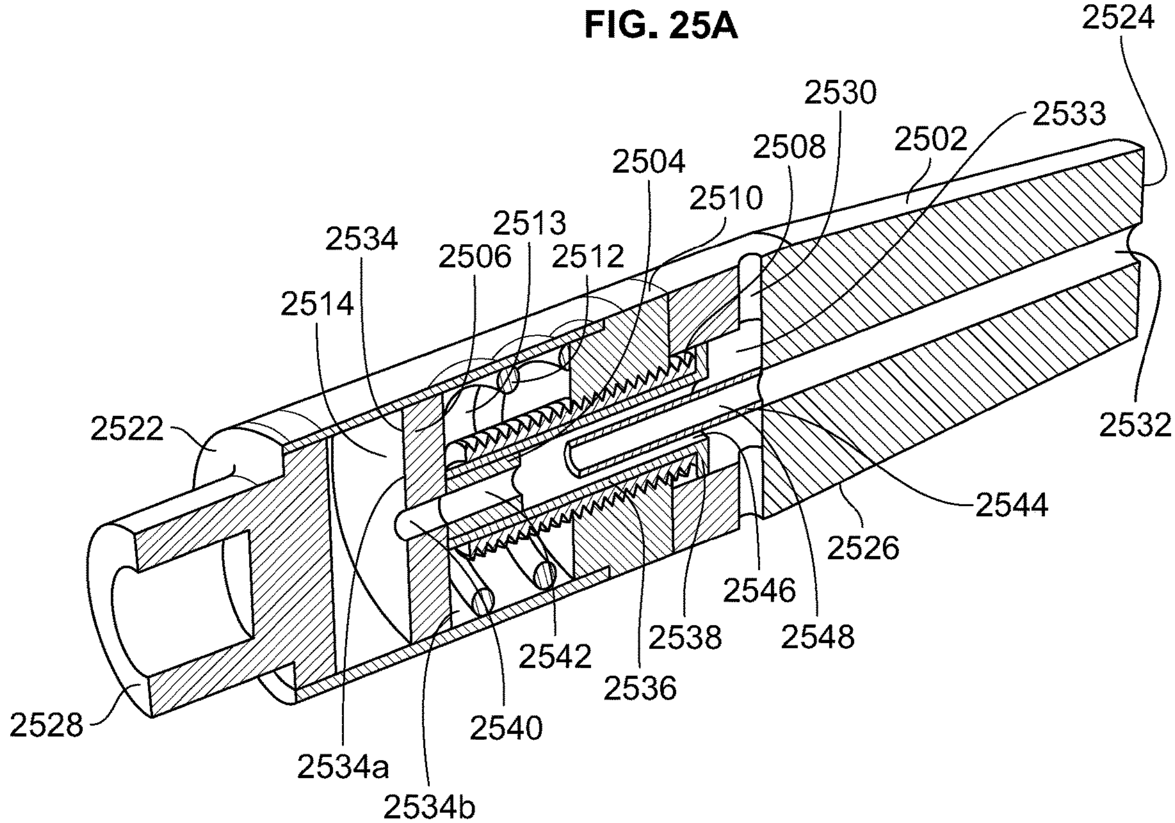


FIG. 25B

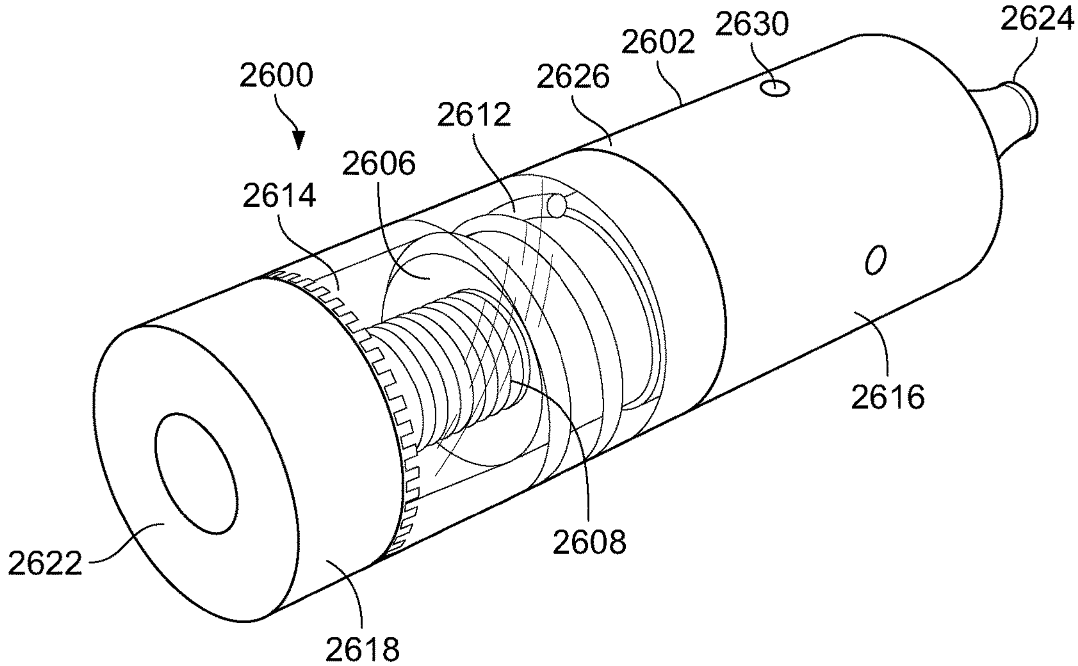


FIG. 26A

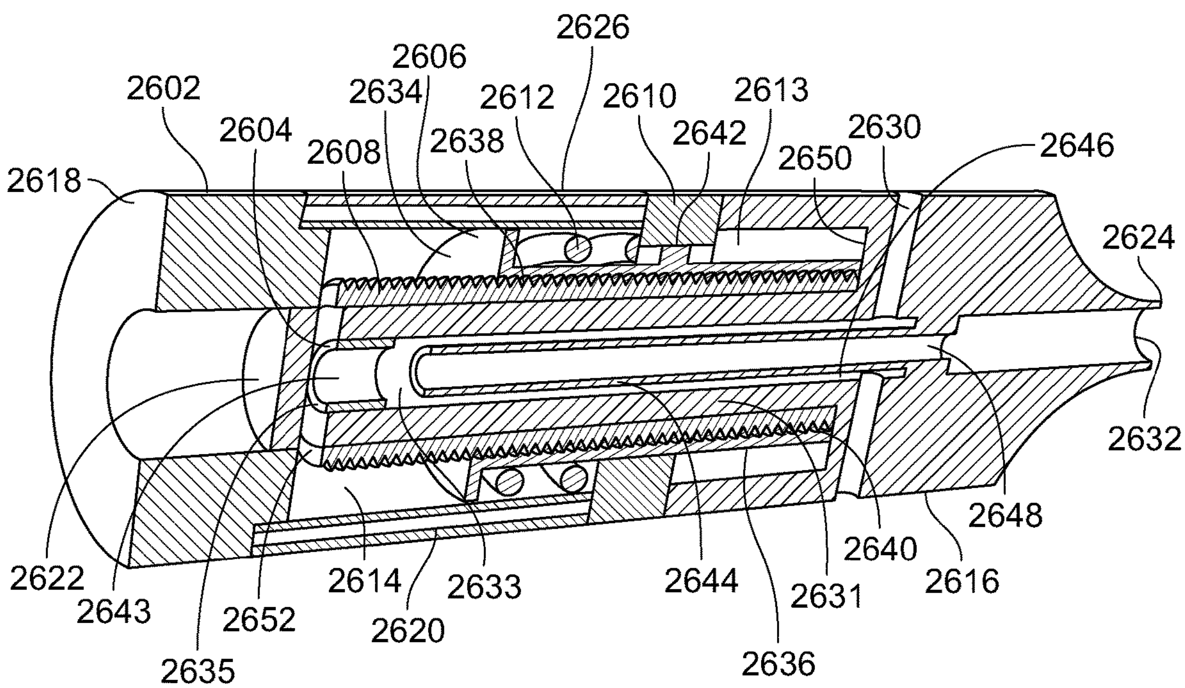


FIG. 26B

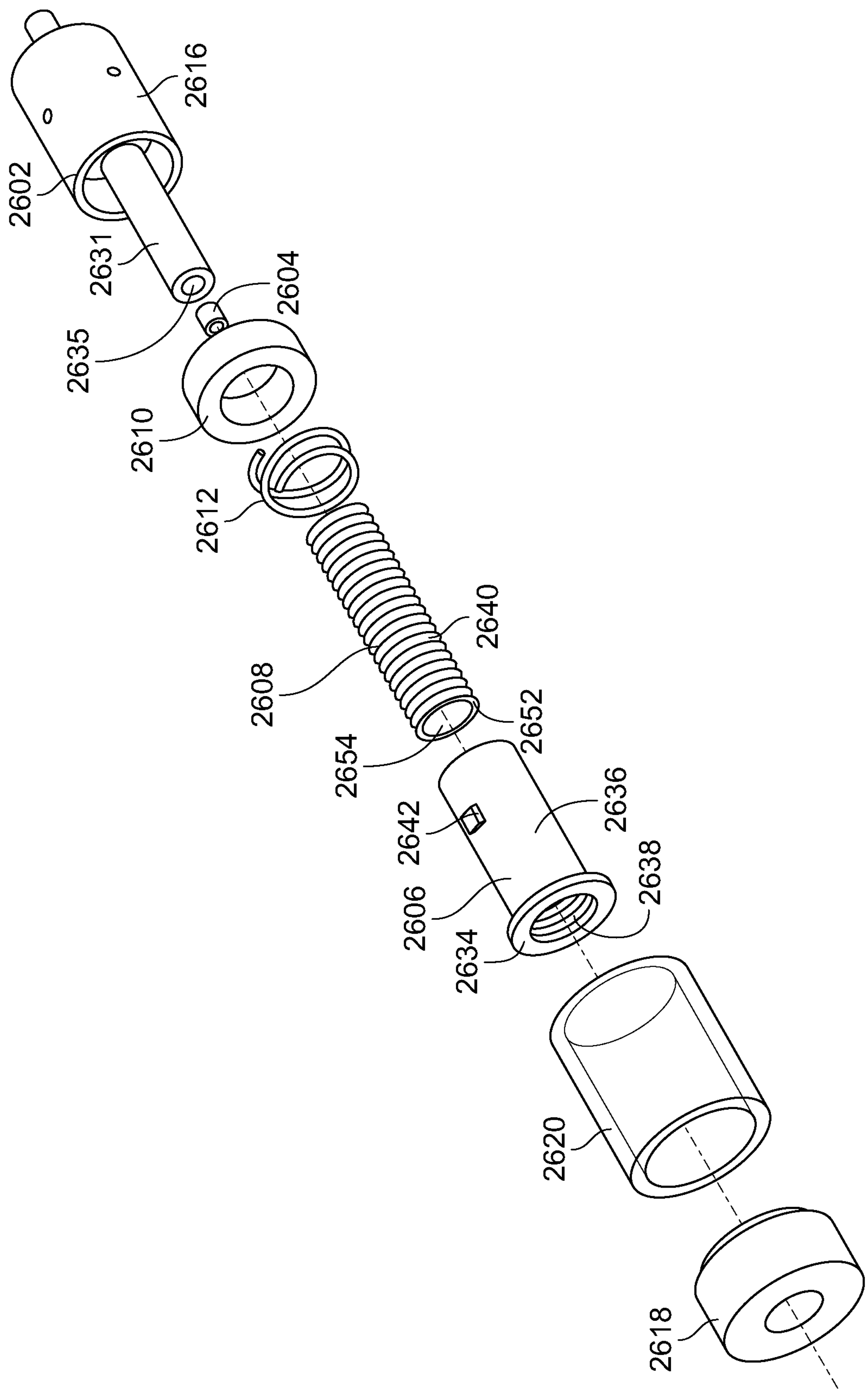

2616
2602
2631
2604
2635
2610
2612
2640
2608
2652
2654
2636
2642
2638
2606
2634
2620
2618

FIG. 26C

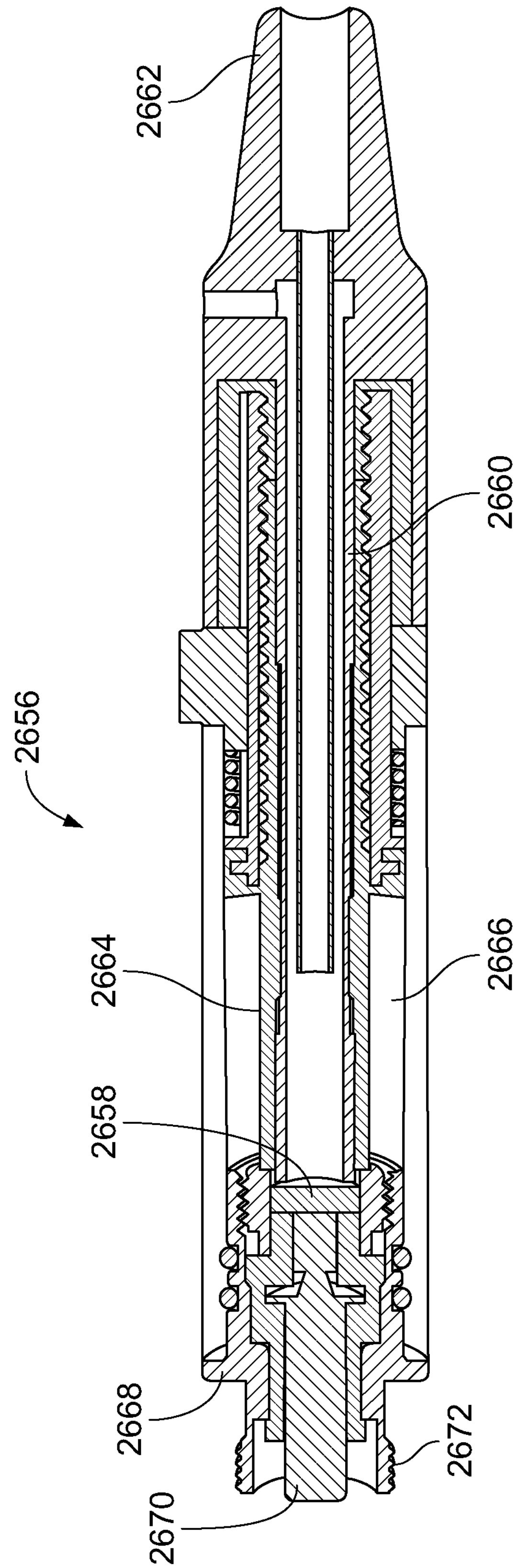


FIG. 26D

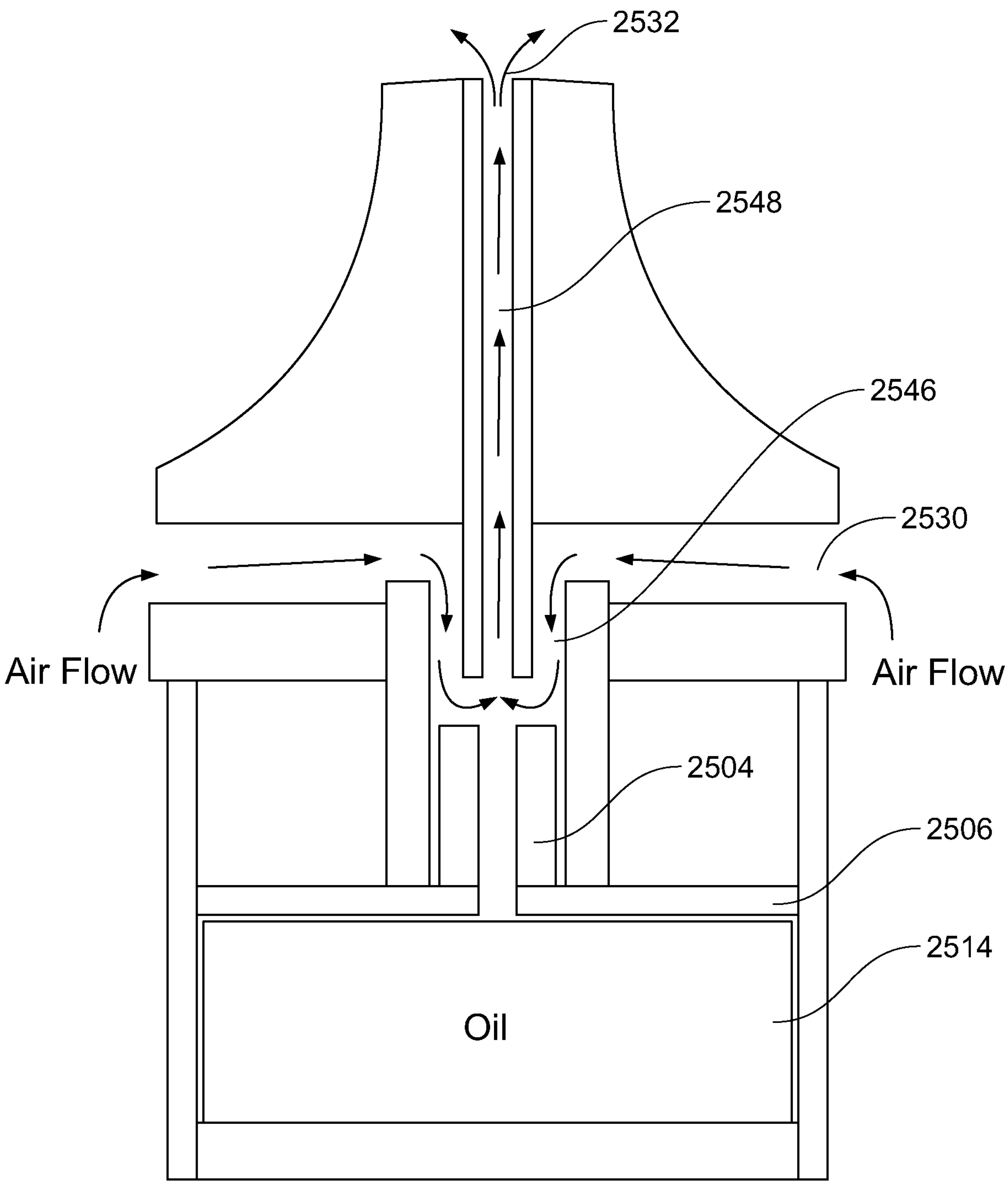


FIG. 27

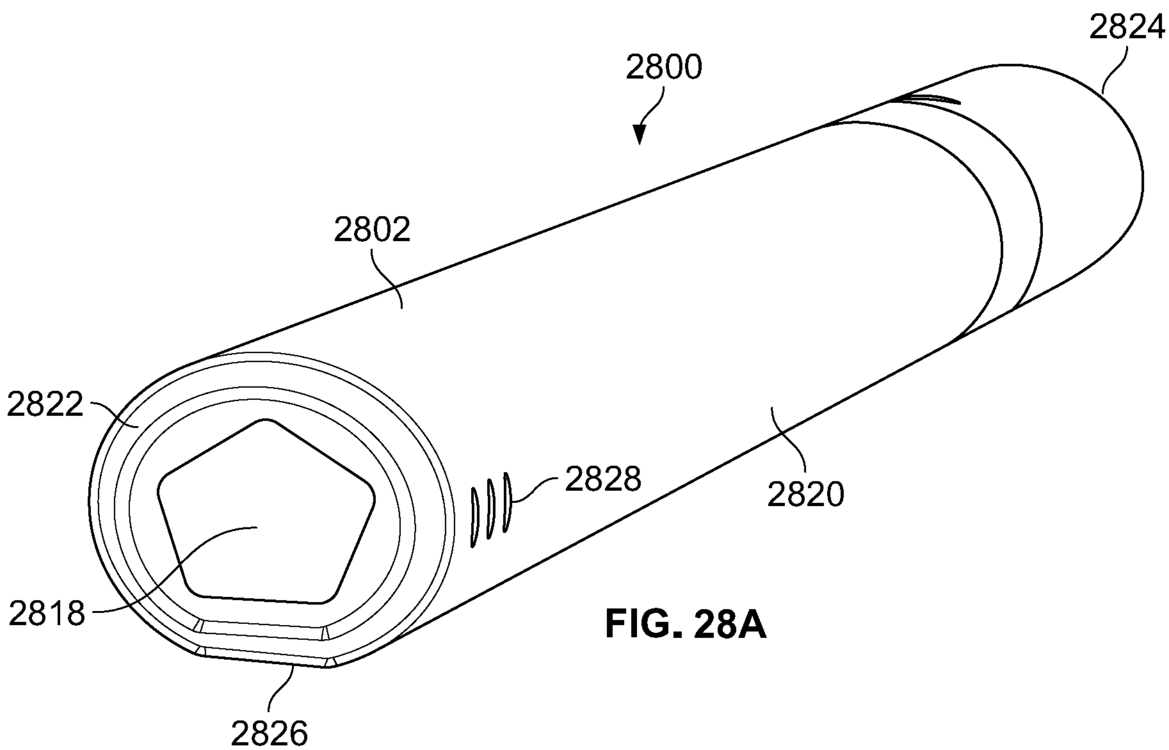


FIG. 28A

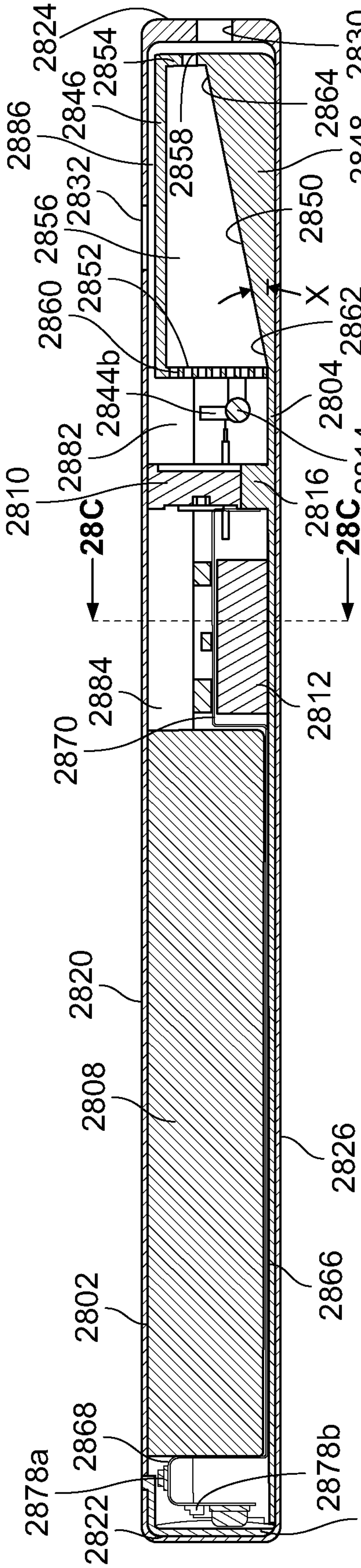


FIG. 28B

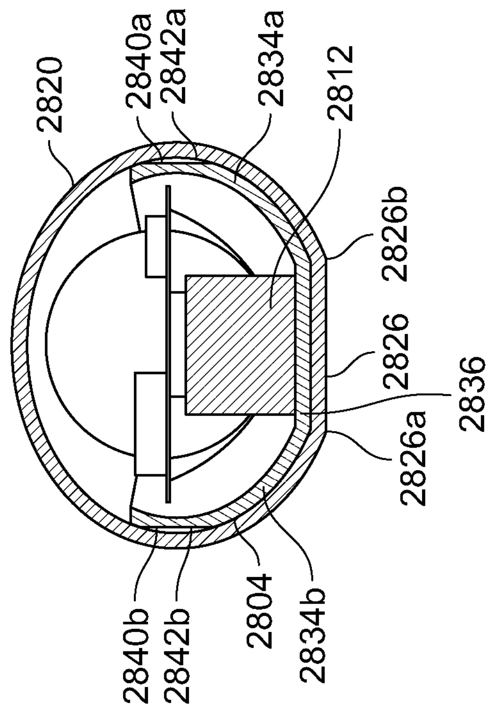


FIG. 28C

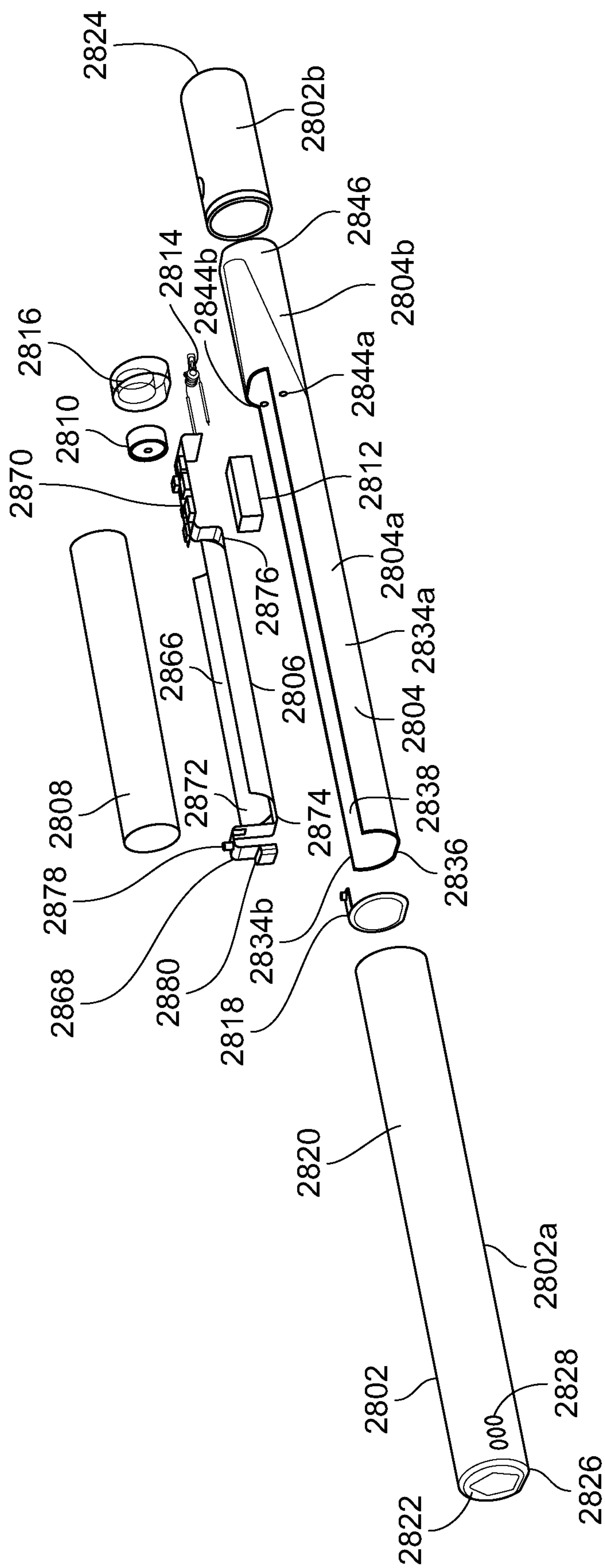

2824
2802b
2846
2804b
2814
2844b
2816
2844a
2810
2870
2812
2804a
2876
2834a
2866
2806
2804
2808
2872
2838
2874
2836
2878
2834b
2868
2880
2818
2820
2802a
2802
2828
2826
2822

FIG. 28D

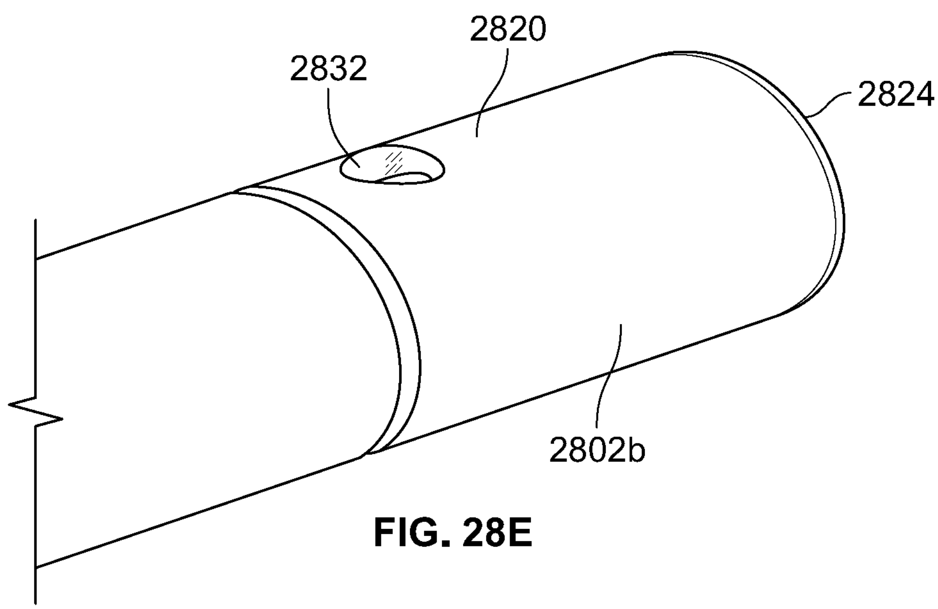


FIG. 28E

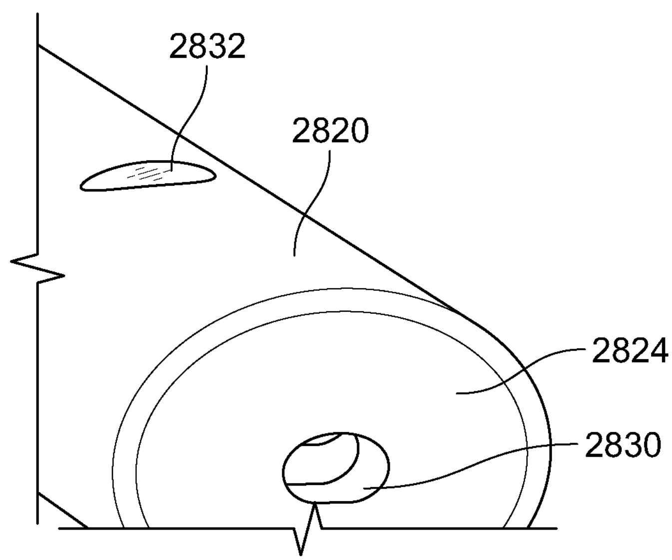


FIG. 28F

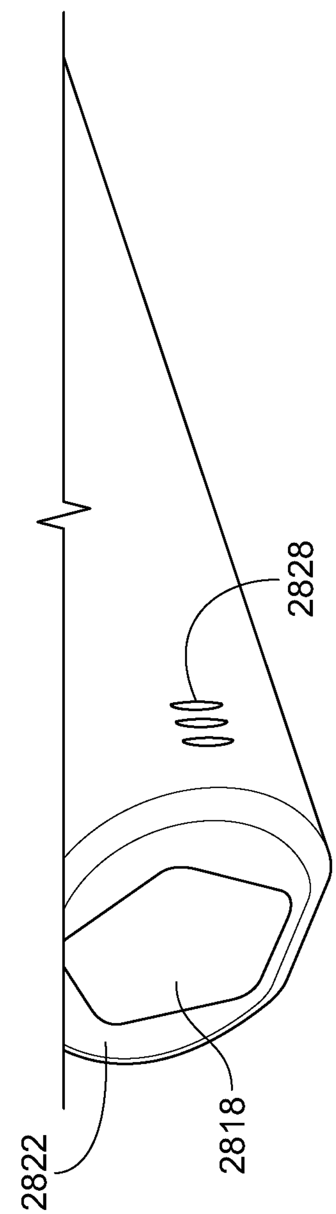


FIG. 28G

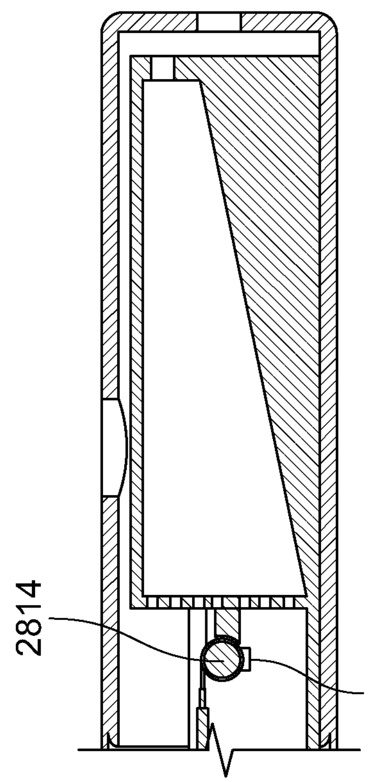


FIG. 29B

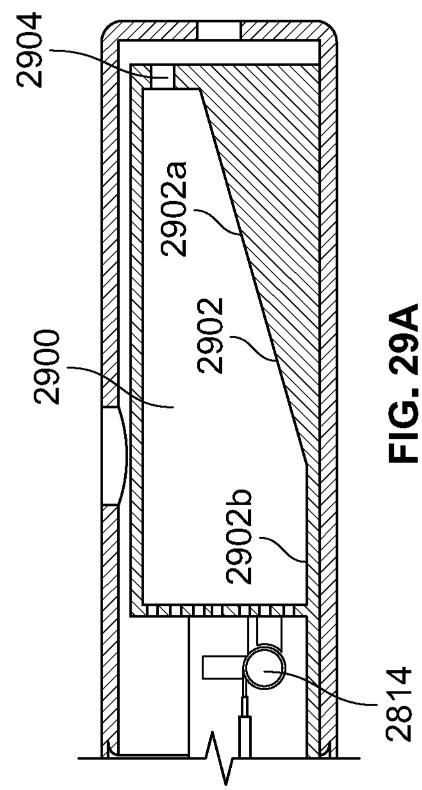


FIG. 29A

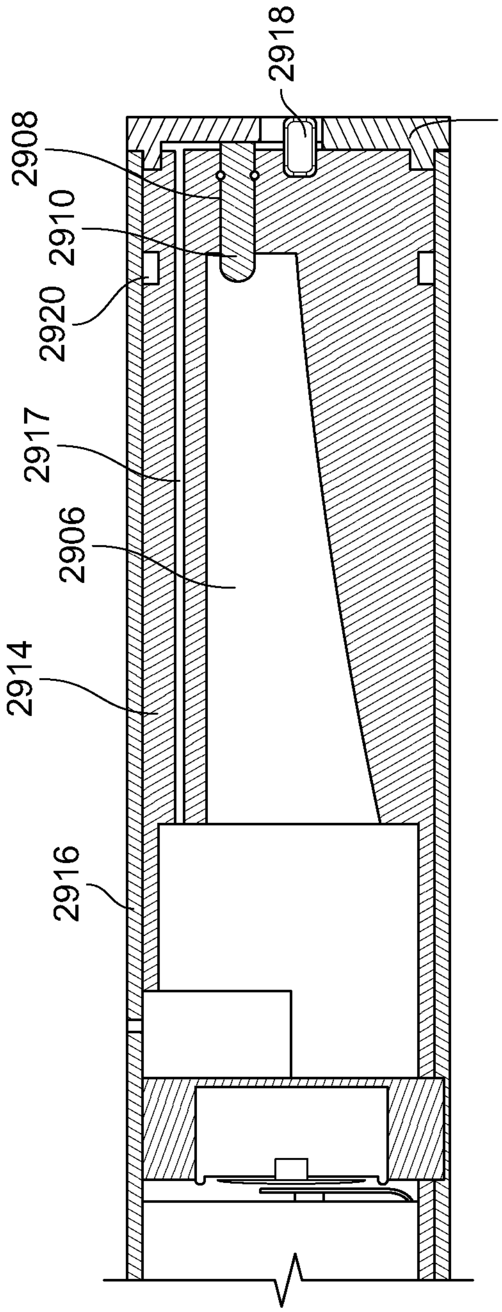


FIG. 29C

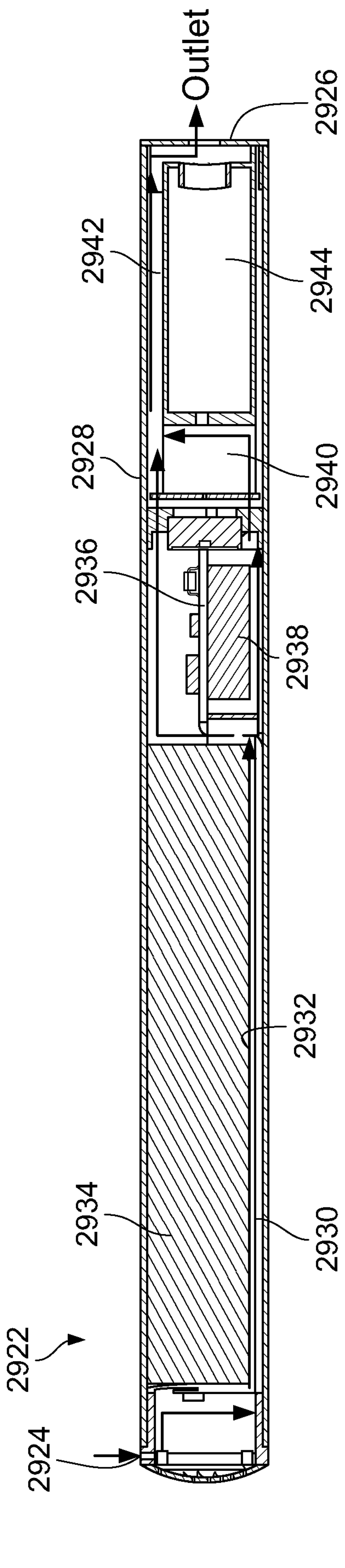


FIG. 29D

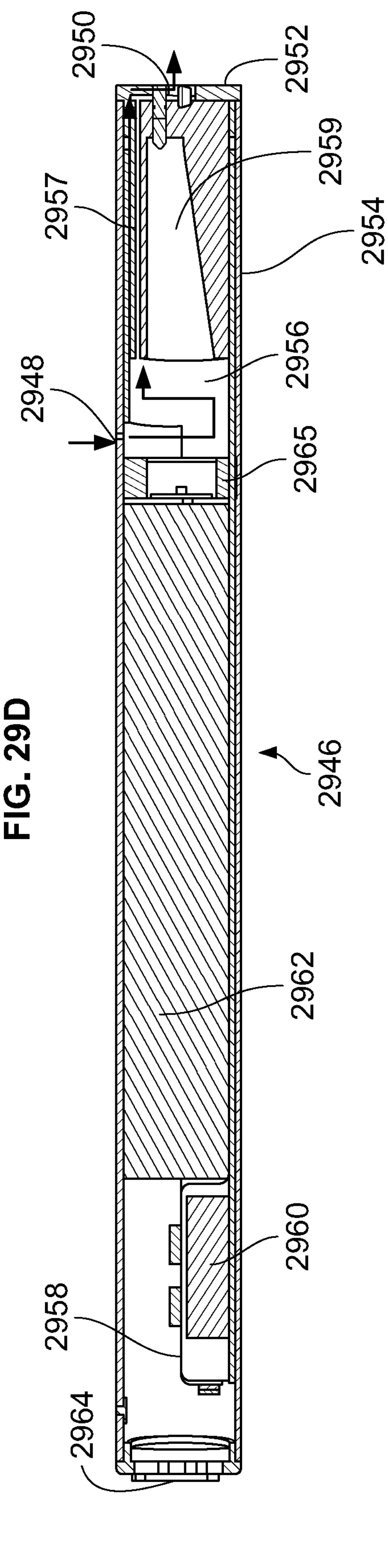


FIG. 29E

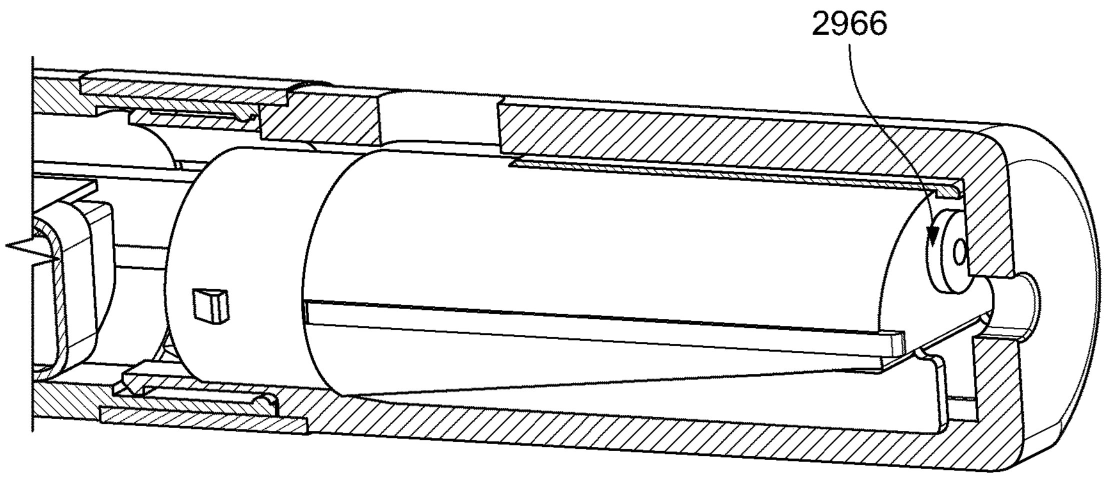


FIG. 29F

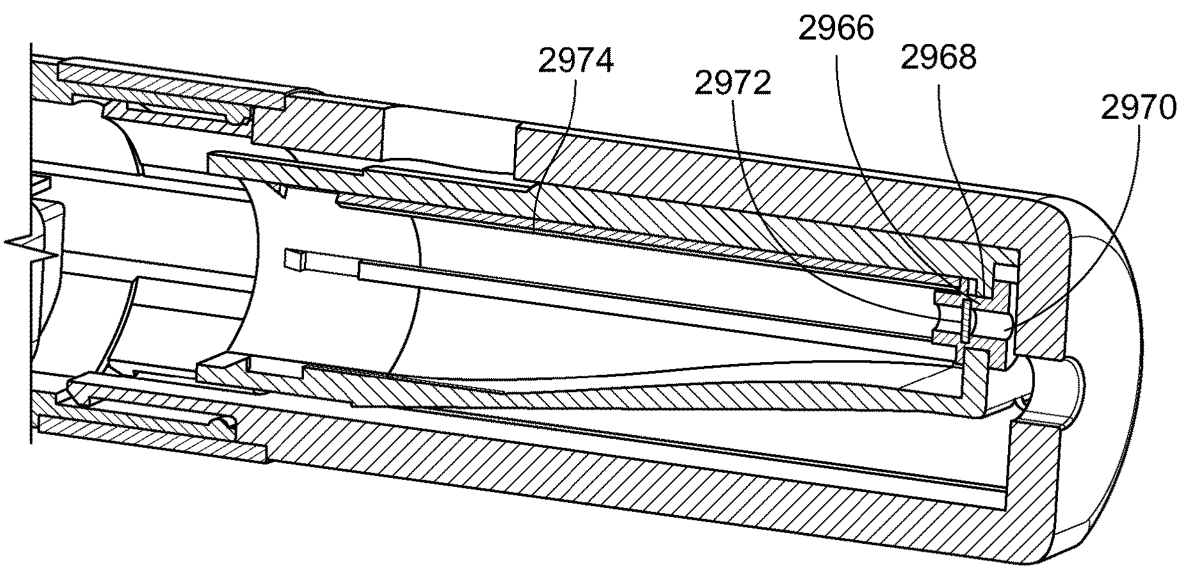


FIG. 29G

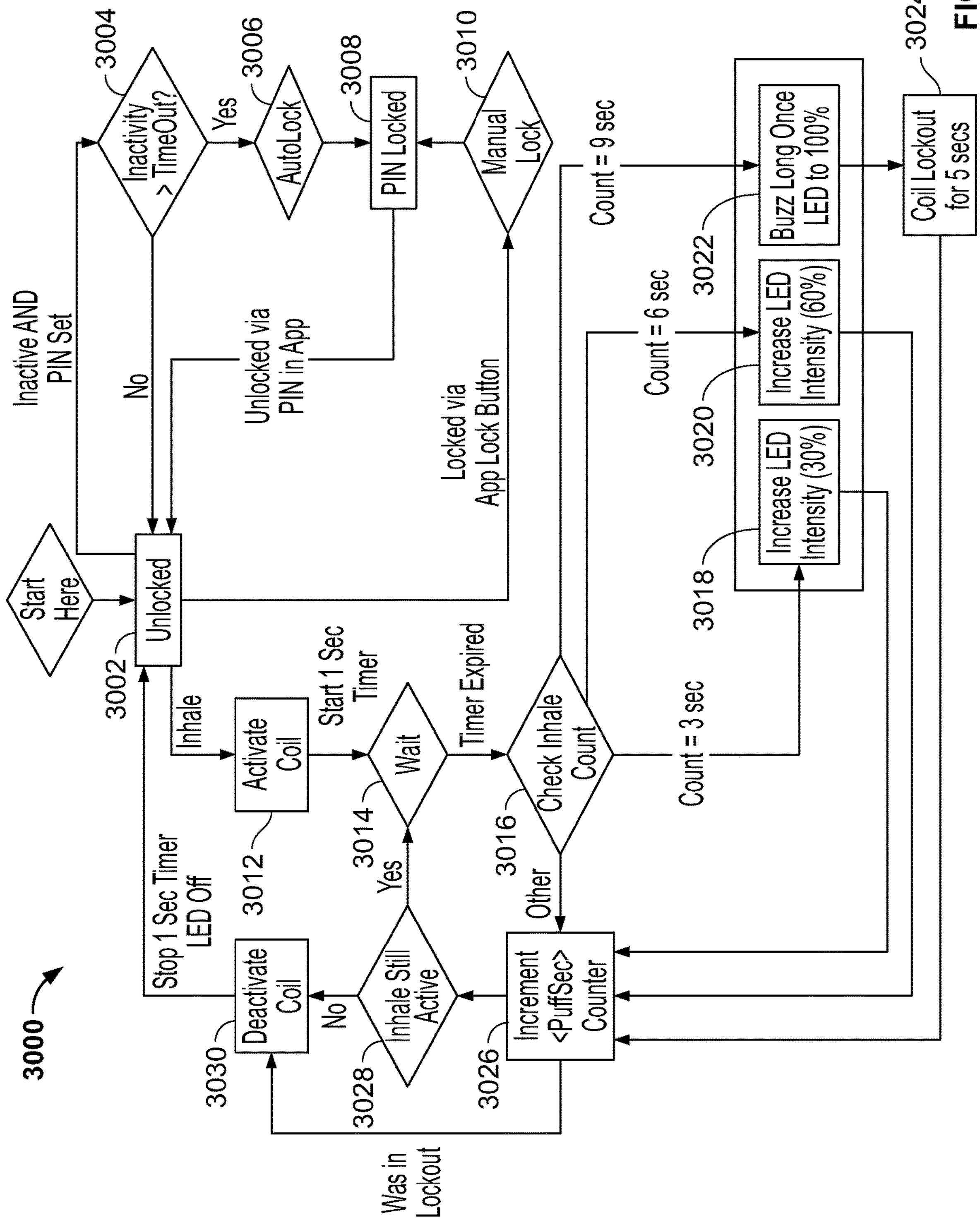

3000
Start Here
Unlocked
3002
Inactive AND PIN Set
Inactivity > TimeOut?
3004
No
Yes
AutoLock
3006
PIN Locked
3008
Unlocked via PIN in App
Manual Lock
3010
Locked via App Lock Button
Inhale
Activate Coil
3012
Start 1 Sec Timer
Wait
3014
Timer Expired
Check Inhale Count
3016
Count = 3 sec
Count = 6 sec
Count = 9 sec
Increase LED Intensity (30%)
3018
Increase LED Intensity (60%)
3020
Buzz Long Once LED to 100%
3022
Coil Lockout for 5 secs
3024
Other
Increment <PuffSec> Counter
3026
Inhale Still Active
3028
Yes
No
Deactivate Coil
3030
Stop 1 Sec Timer LED Off
Was in Lockout

FIG. 30

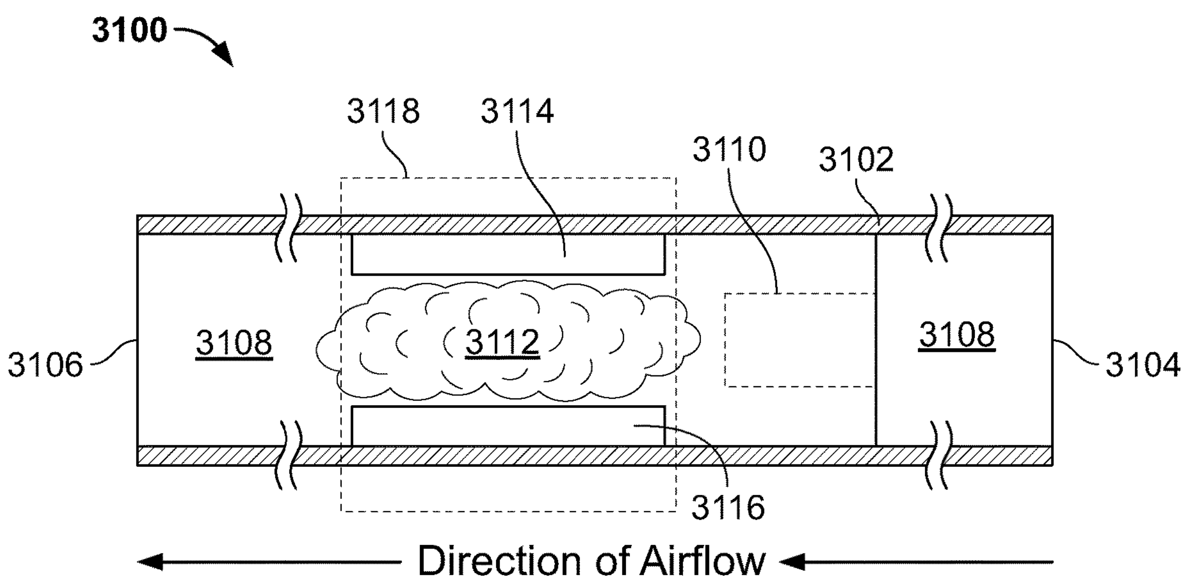

3100
3118
3114
3110
3102
3106
3108
3112
3108
3104
3116
Direction of Airflow

FIG. 31

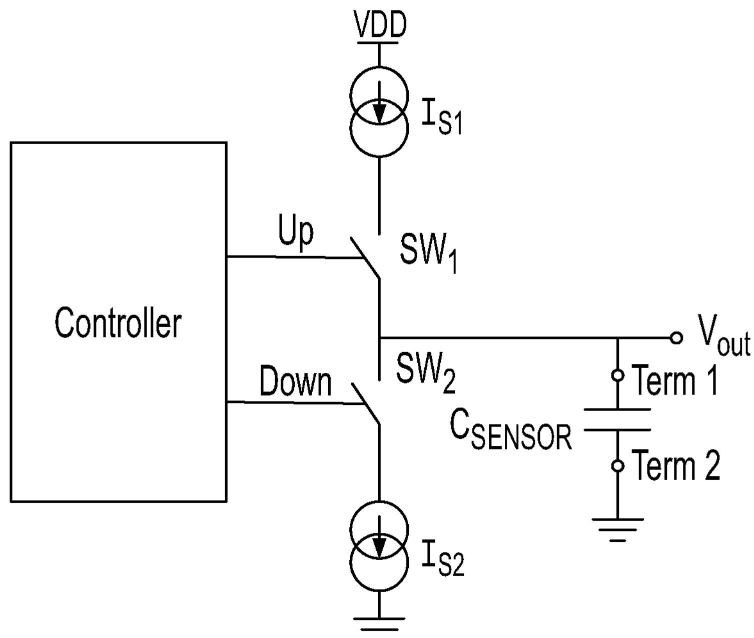

VDD
I_{S1}
Controller
Up
SW_1
V_{out}
Down
SW_2
Term 1
C_{SENSOR}
Term 2
I_{S2}

FIG. 32

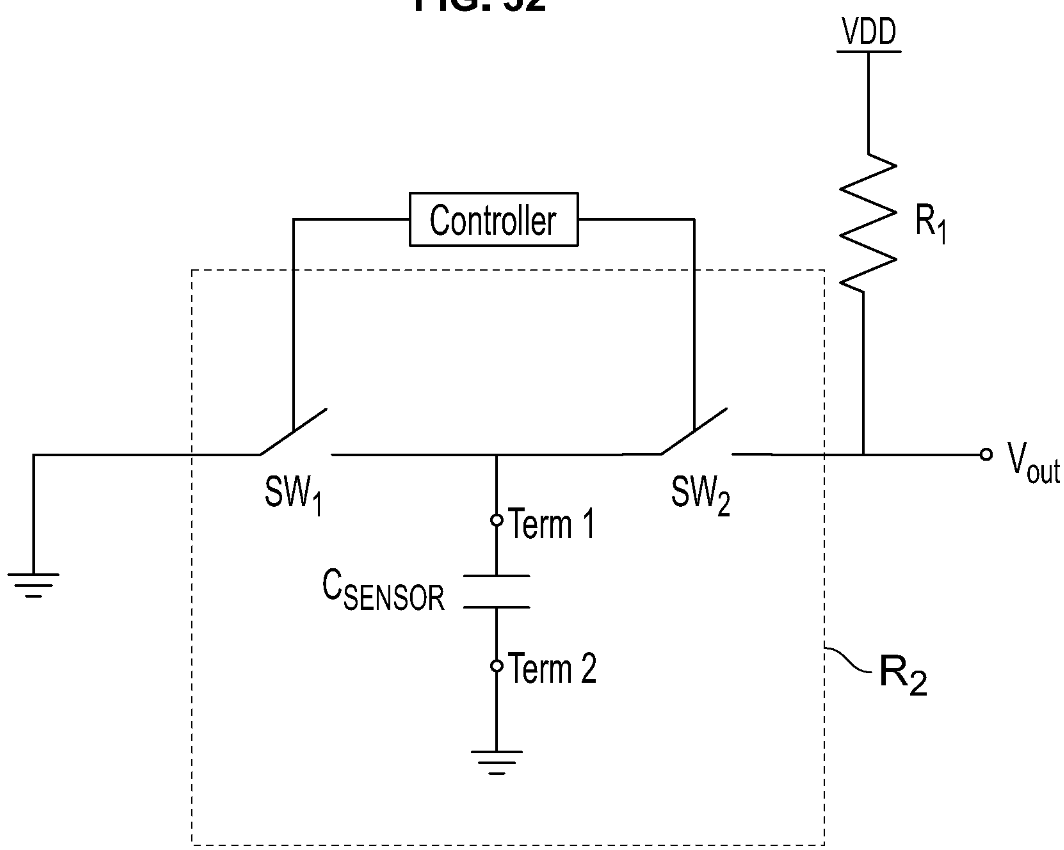
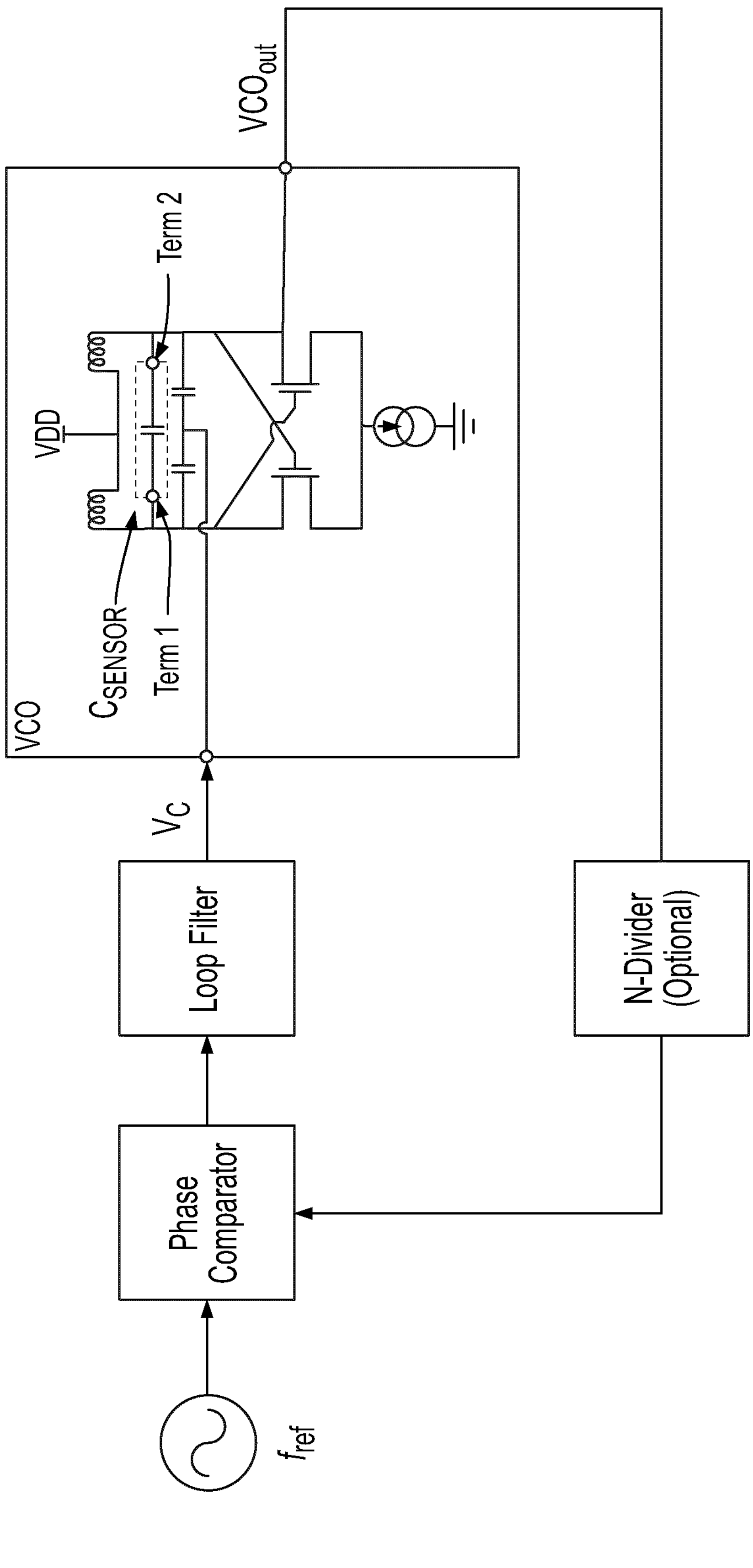

VDD
Controller
R_1
SW_1
SW_2
V_{out}
Term 1
C_{SENSOR}
Term 2
R_2

FIG. 33



VCO
VDD
C_{SENSOR}
Term 1
Term 2
VCO_{out}
V_C
Loop Filter
Phase Comparator
N-Divider (Optional)
f_{ref}

FIG. 34

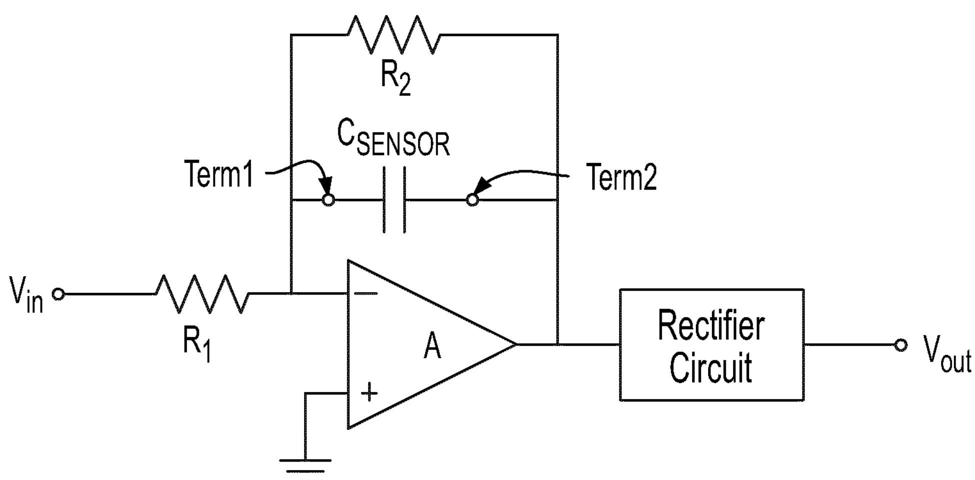

R2
CSENSOR
Term1
Term2
Vin
R1
A
Rectifier Circuit
Vout

FIG. 35

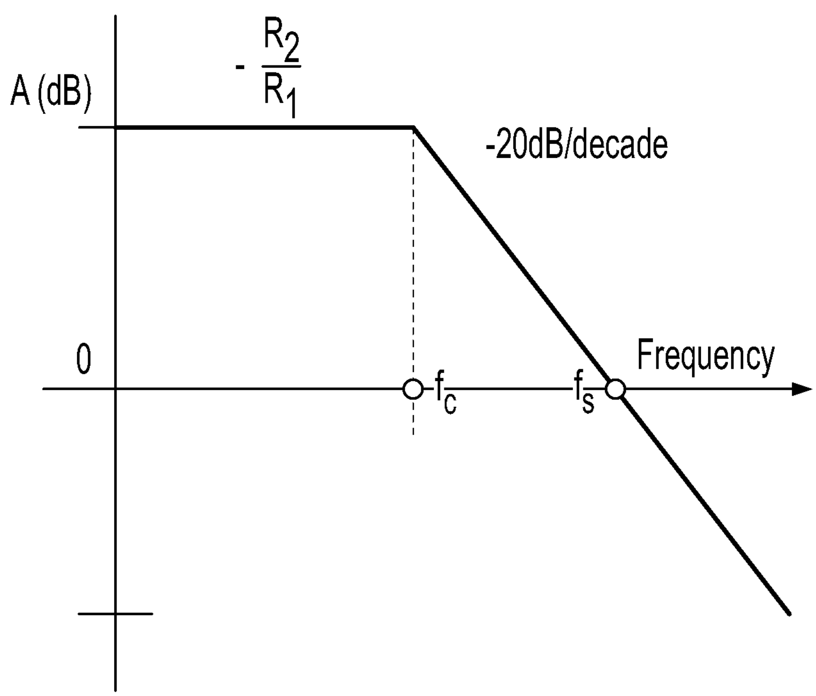
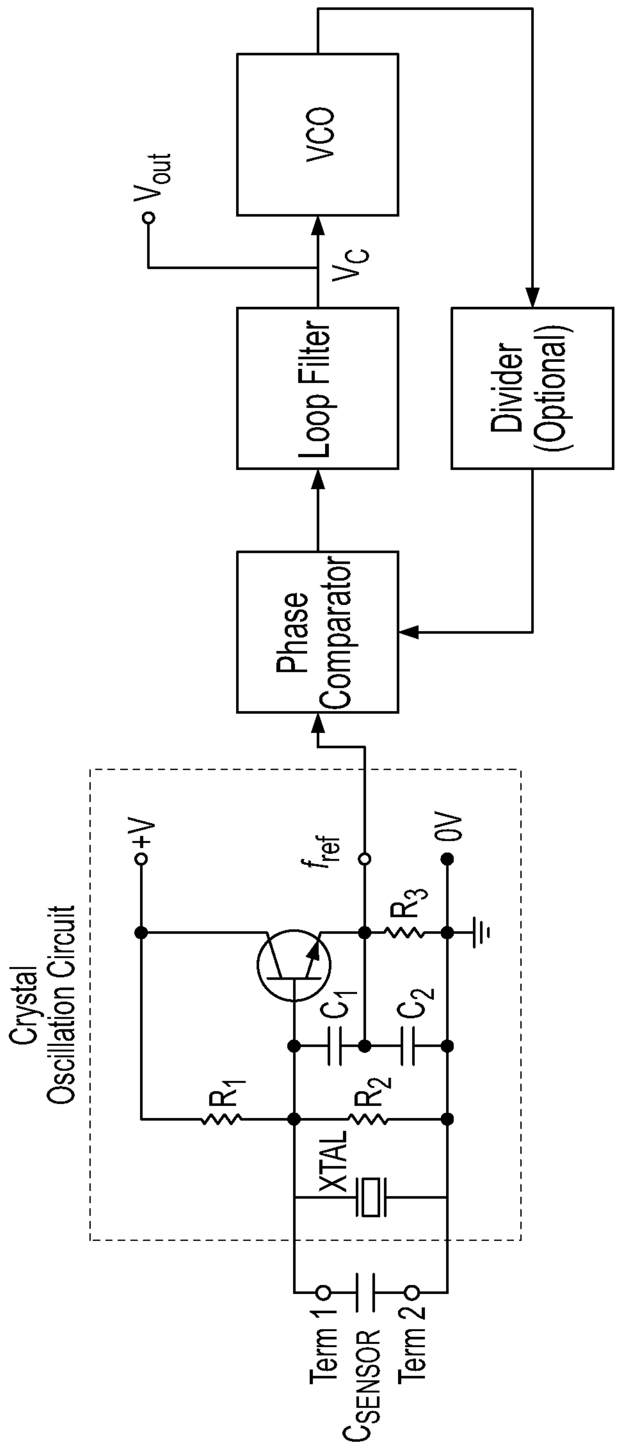

A (dB)
- R2/R1
-20dB/decade
0
Frequency
fc
fs

FIG. 36



Crystal
Oscillation Circuit
+V
f_{ref}
0V
R_1
R_2
R_3
C_1
C_2
XTAL
Term 1
C_{SENSOR}
Term 2
Phase
Comparator
Loop Filter
V_C
V_{out}
VCO
Divider
(Optional)

FIG. 37

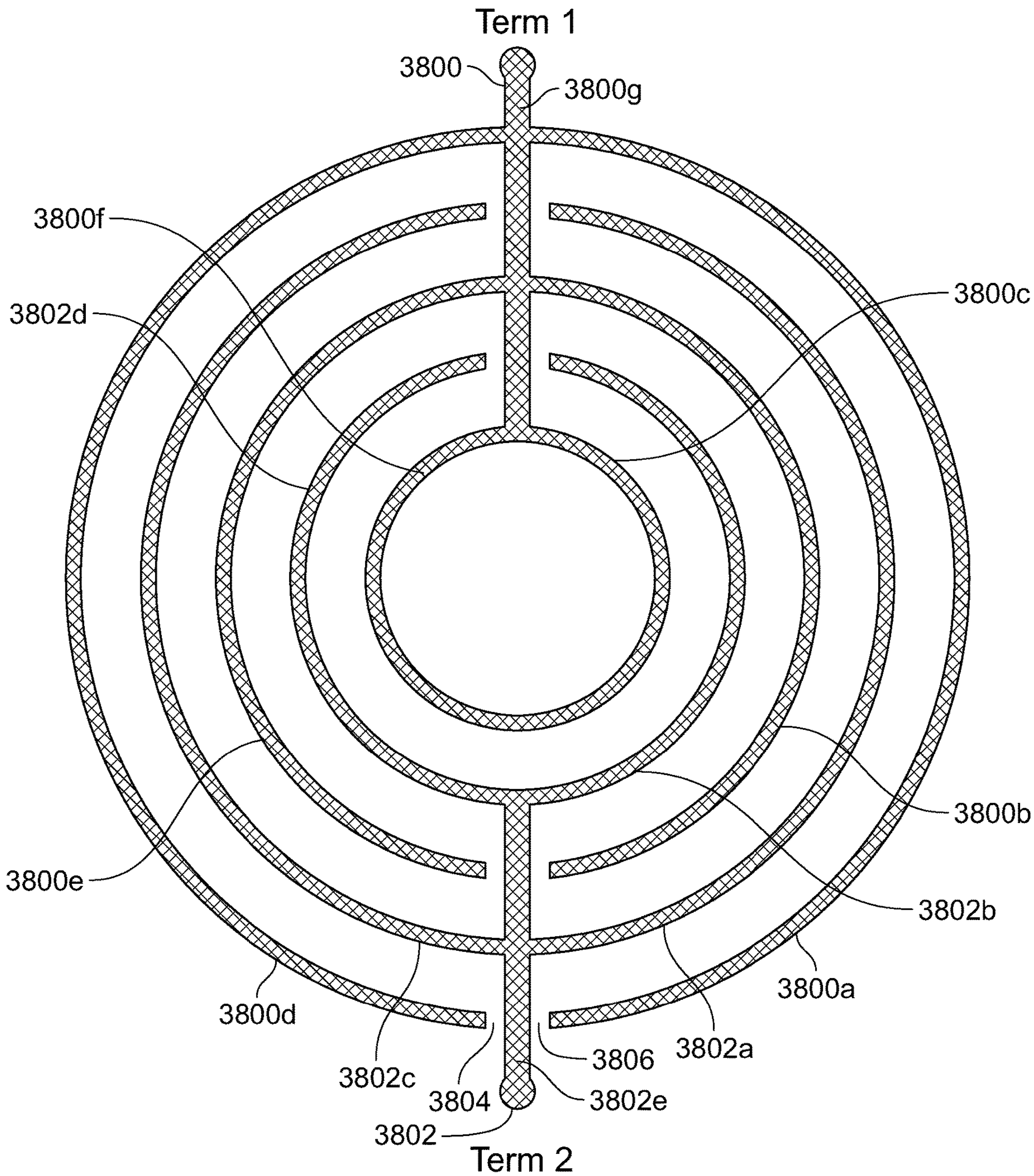

Term 1
3800
3800g
3800f
3802d
3800c
3800b
3800e
3802b
3800a
3800d
3802a
3802c
3806
3804
3802e
3802
Term 2

FIG. 38A

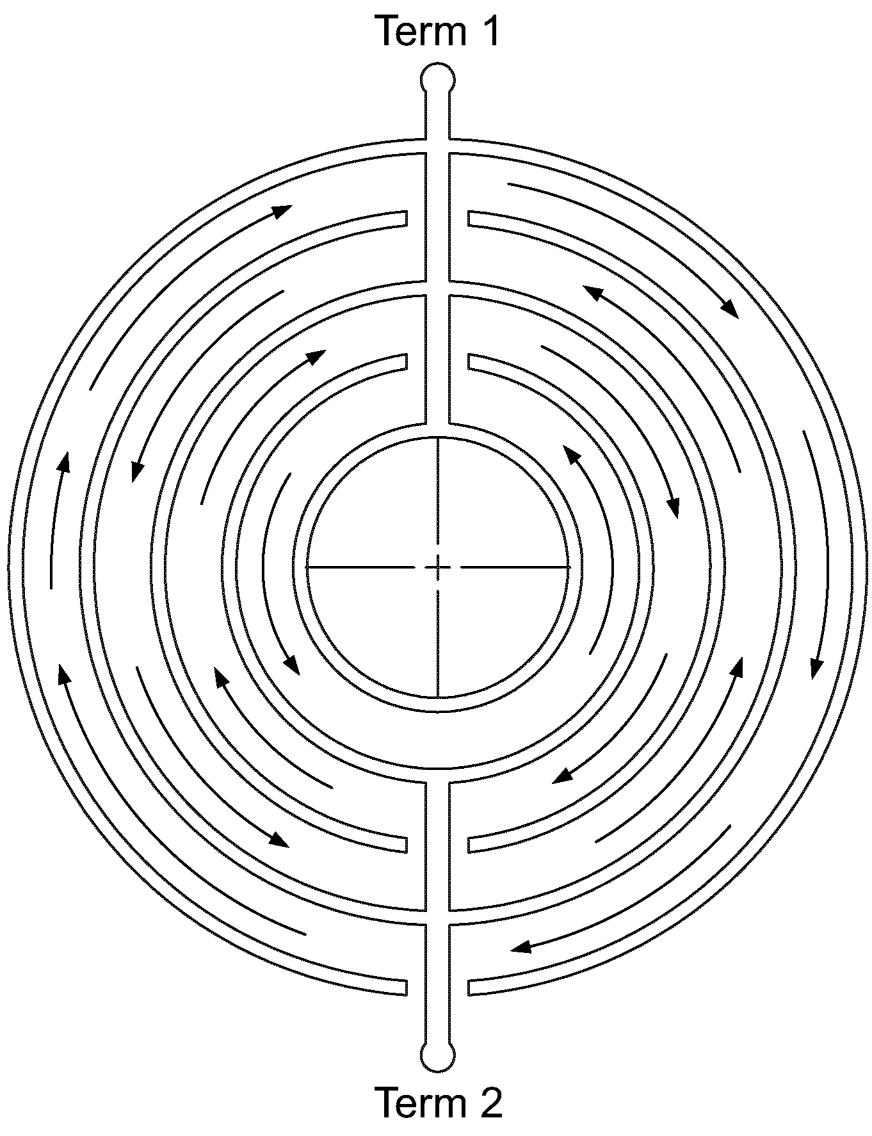


FIG. 38B

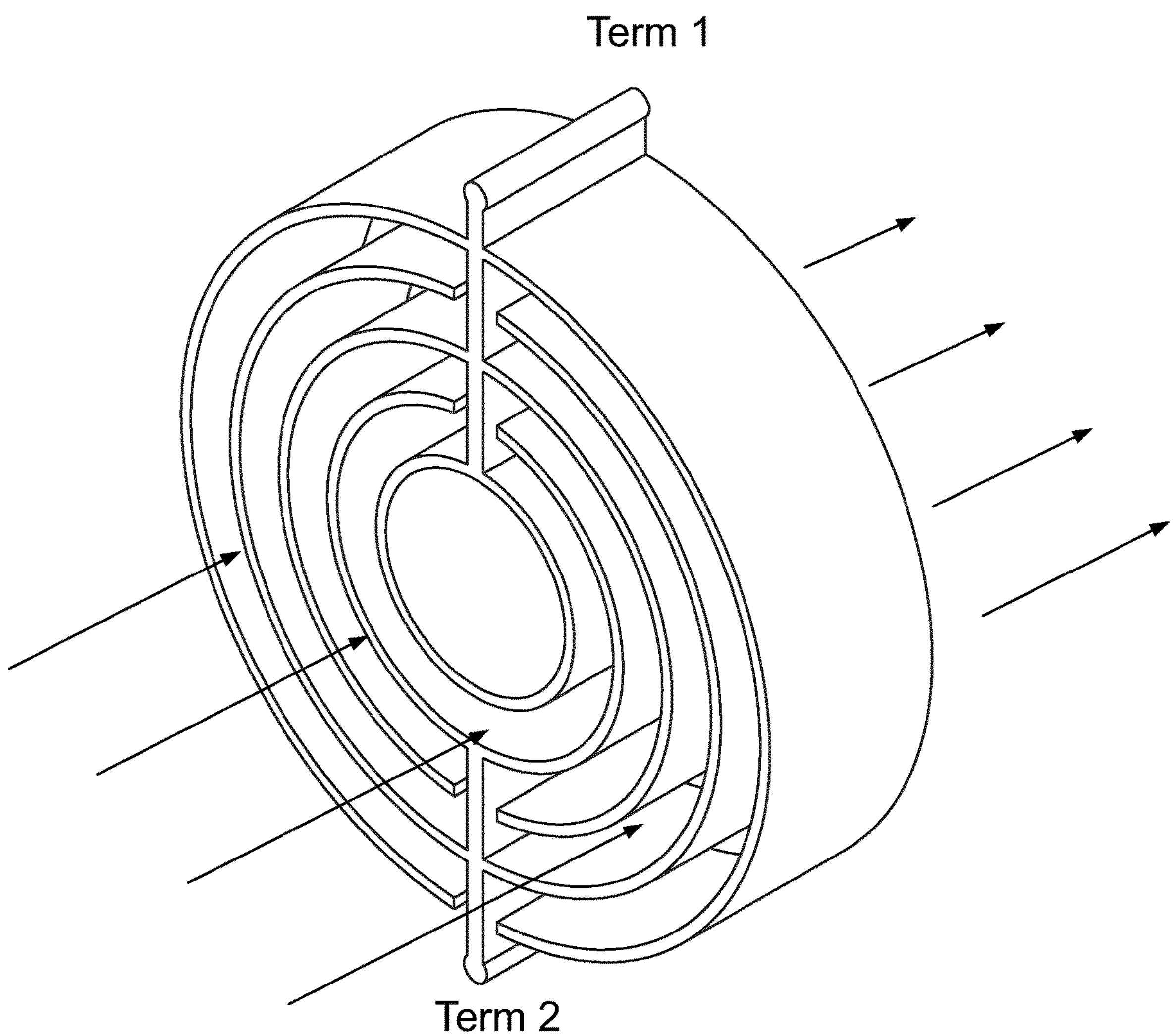


FIG. 38C

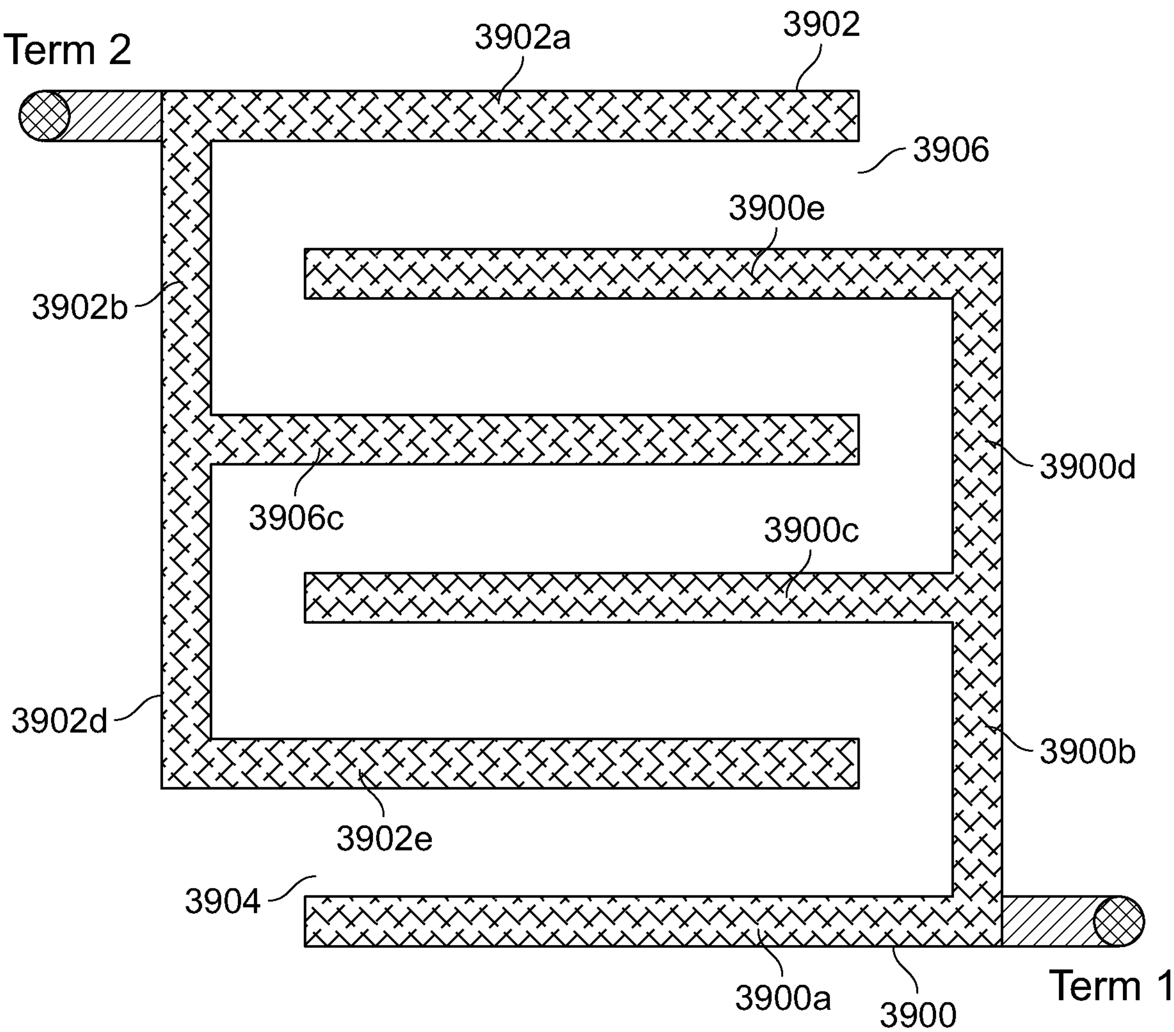

Term 2
3902a
3902
3906
3900e
3902b
3900d
3906c
3900c
3902d
3900b
3902e
3904
3900a
3900
Term 1

FIG. 39A

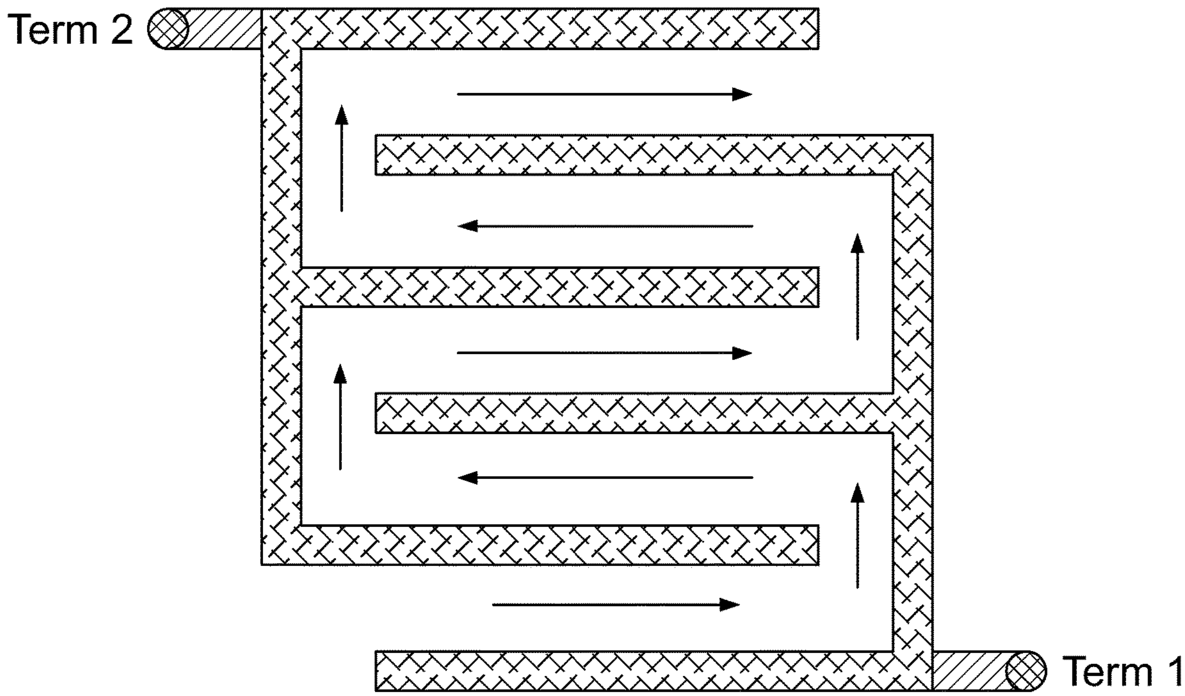


FIG. 39B

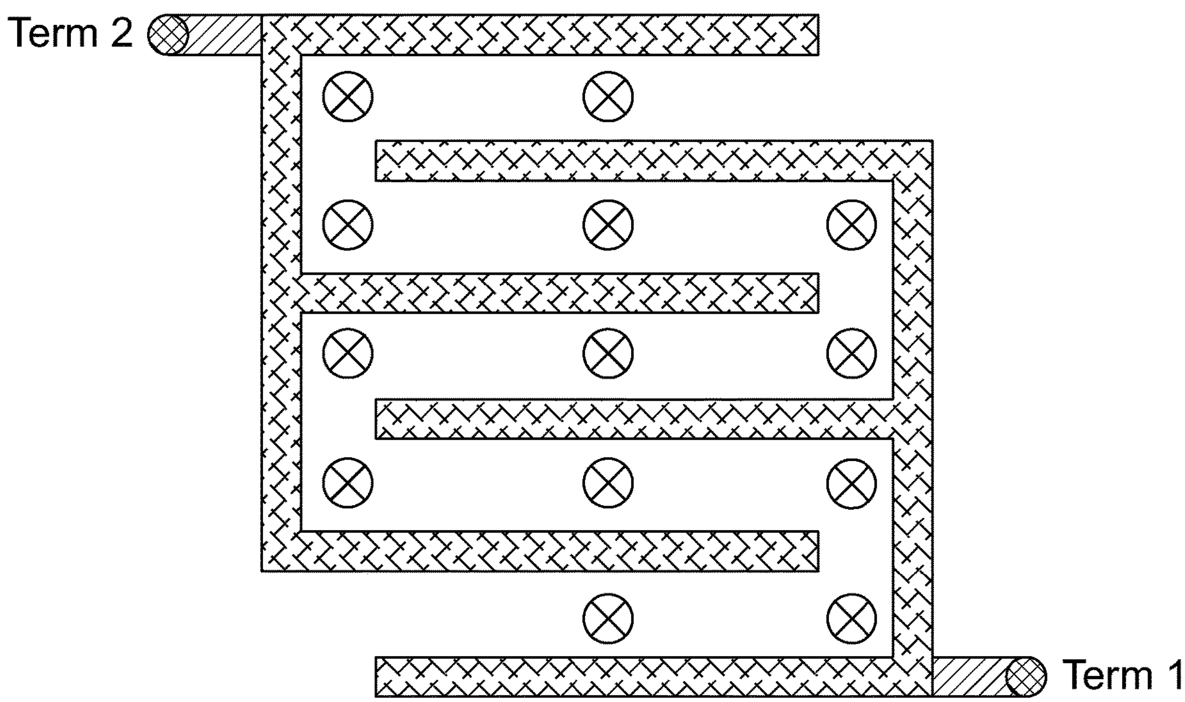


FIG. 39C

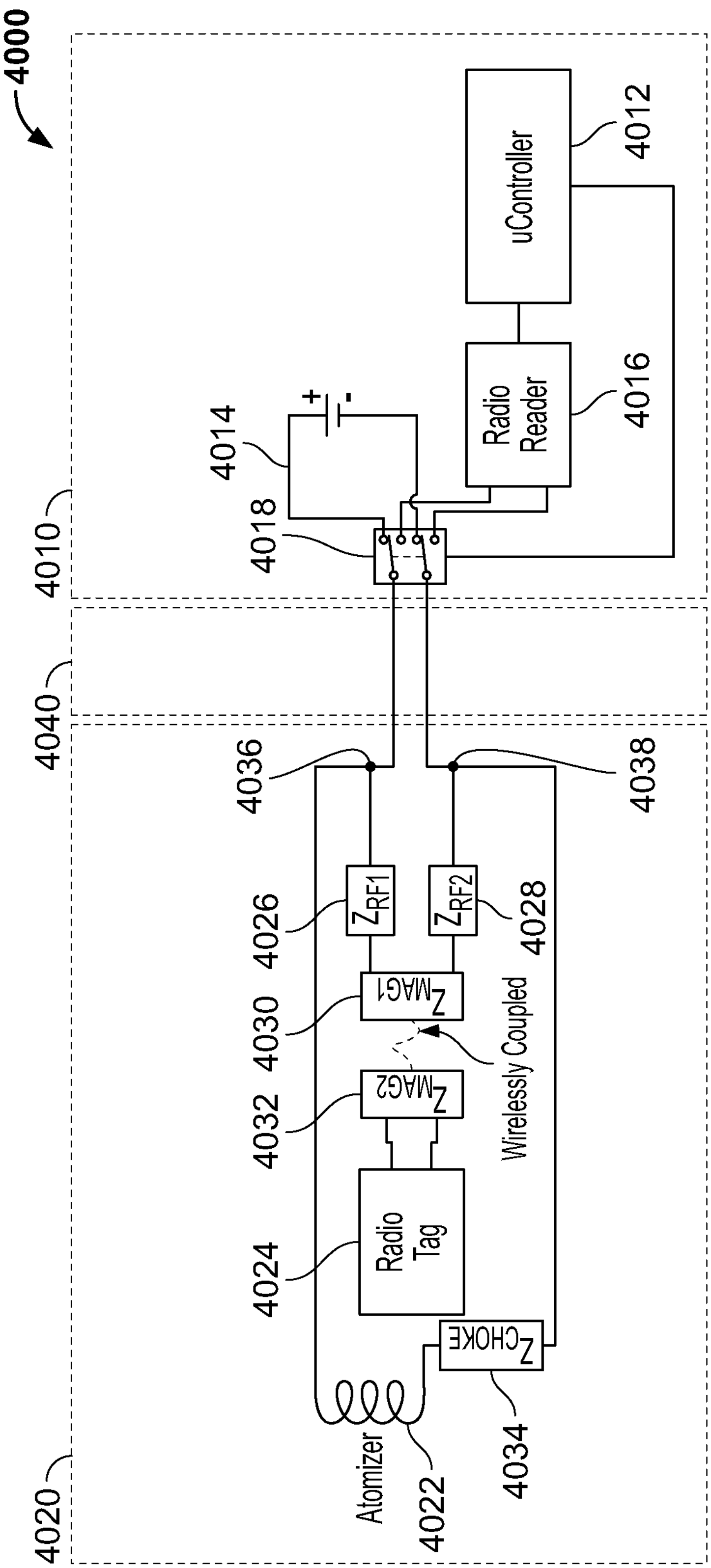

4000
uController
4012
Radio Reader
4016
4014
+
-
4018
4010
4040
4036
4038
Z_{RF1}
Z_{RF2}
4026
4028
Z_{MAG1}
4030
Wirelessly Coupled
Z_{MAG2}
4032
Radio Tag
4024
Z_{CHOKE}
4034
Atomizer
4022
4020

FIG. 40

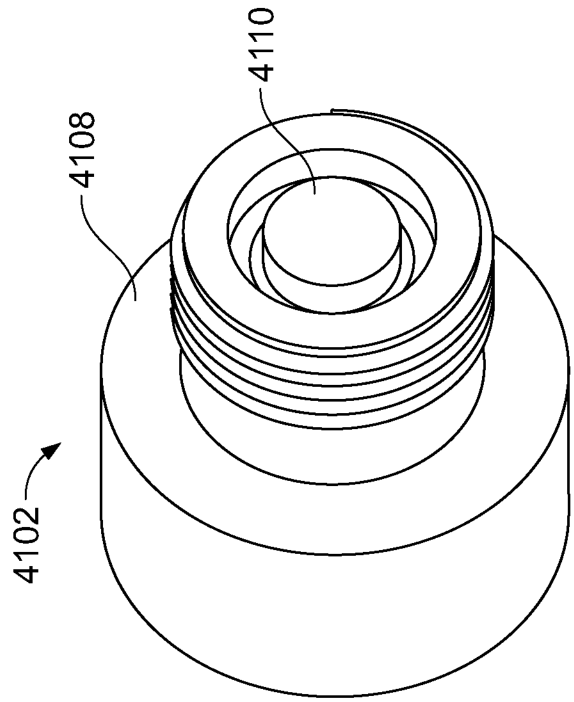


FIG. 41B

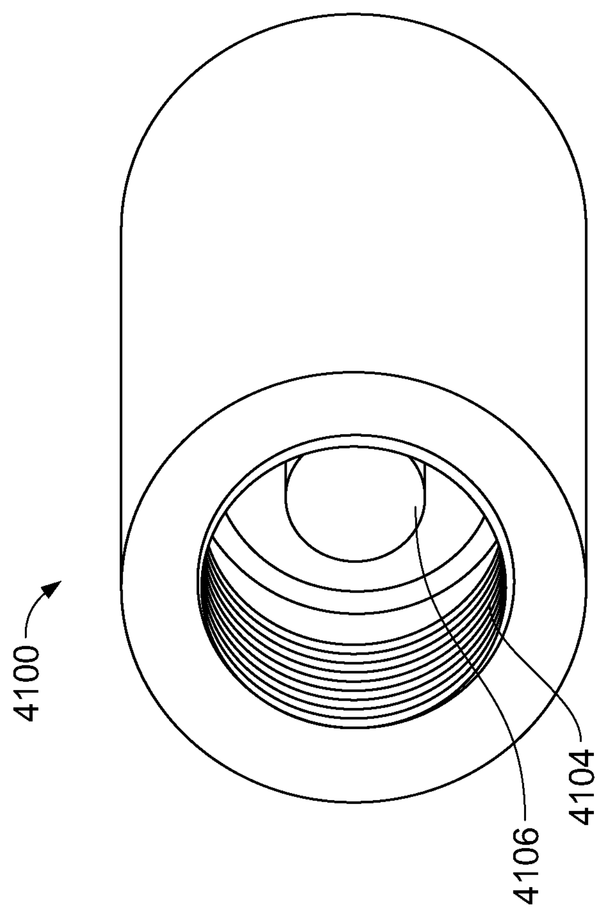


FIG. 41A

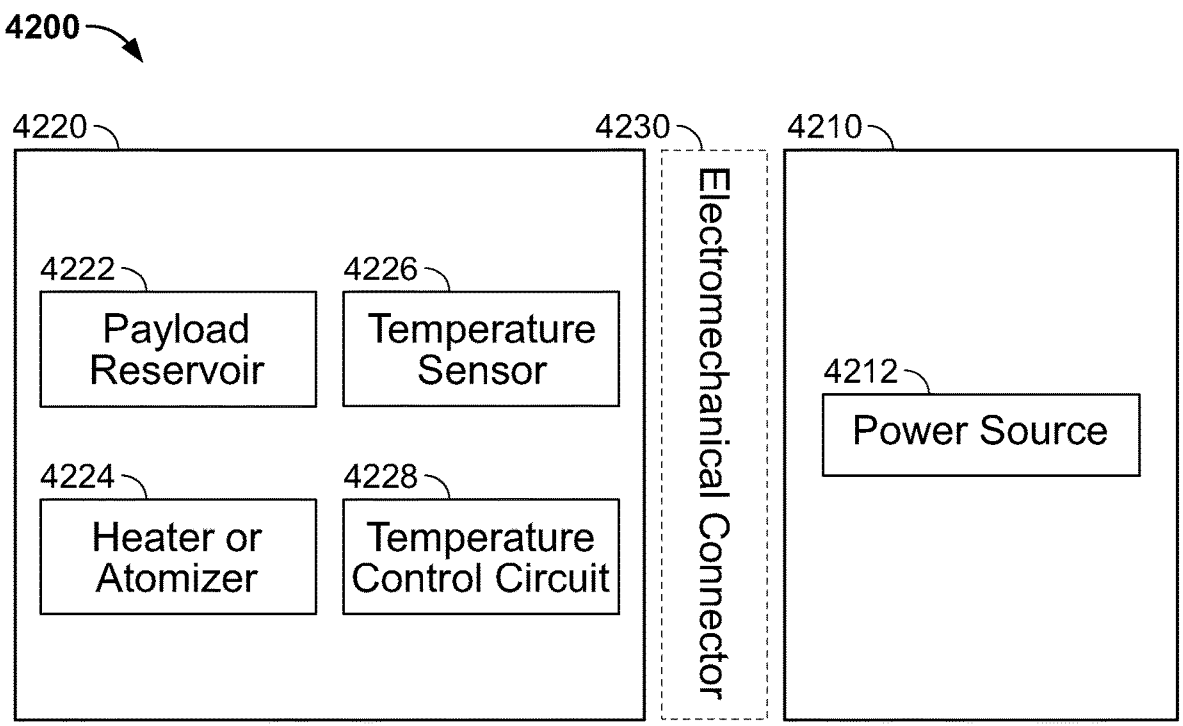

4200
4220
4230
4210
4222
Payload Reservoir
4226
Temperature Sensor
4224
Heater or Atomizer
4228
Temperature Control Circuit
Electromechanical Connector
4212
Power Source

FIG. 42

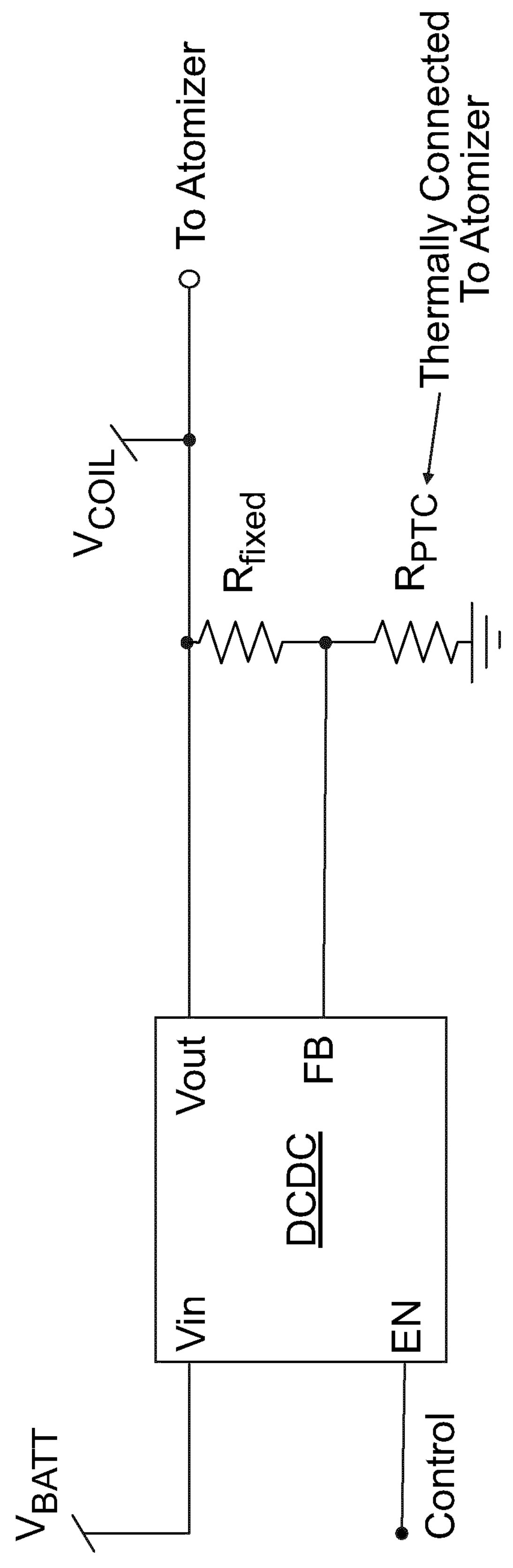

To Atomizer
V_{COIL}
R_{fixed}
R_{PTC}
Thermally Connected
To Atomizer
Vout
FB
DCDC
Vin
EN
V_{BATT}
Control

FIG. 43

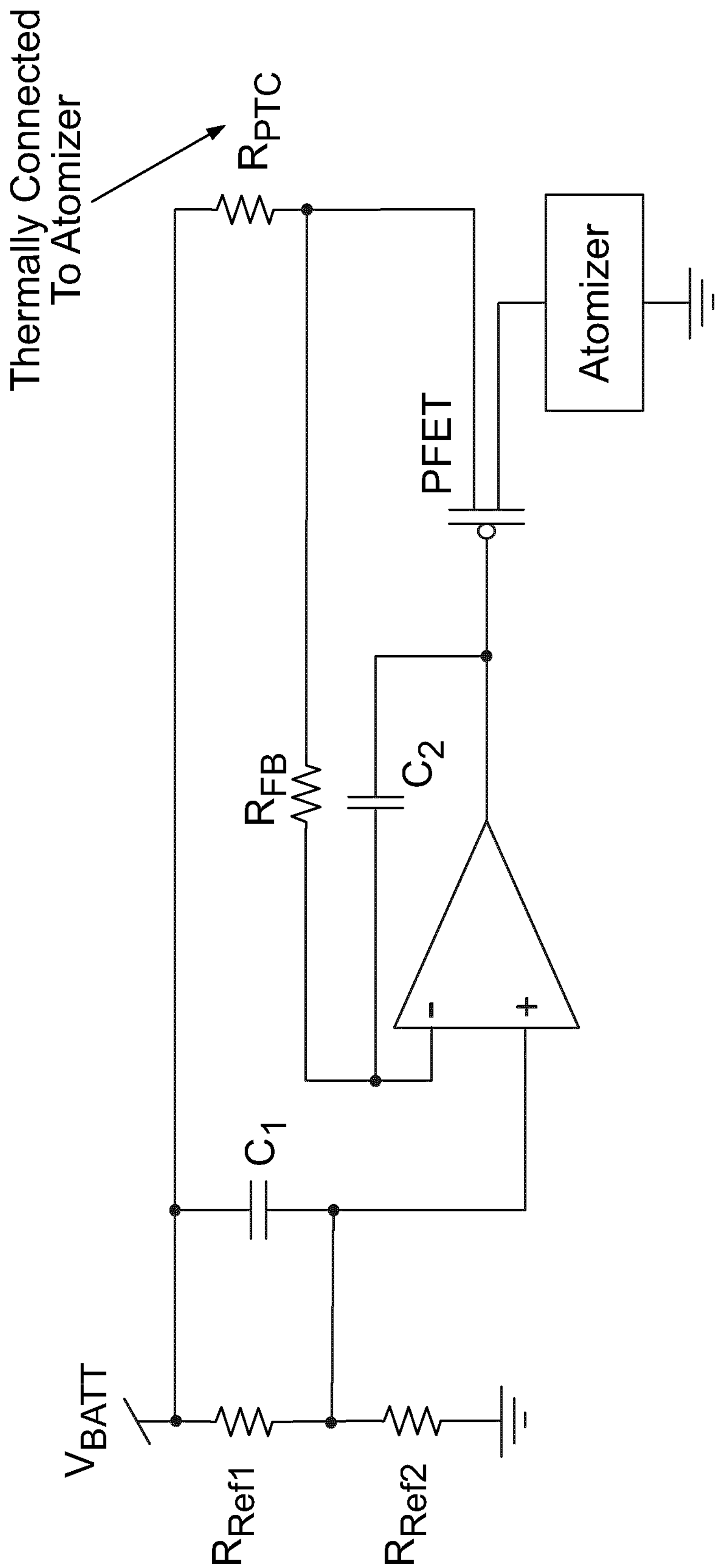

Thermally Connected To Atomizer
R_{PTC}
Atomizer
PFET
R_{FB}
C_2
-
+
C_1
V_{BATT}
R_{Ref1}
R_{Ref2}

FIG. 44

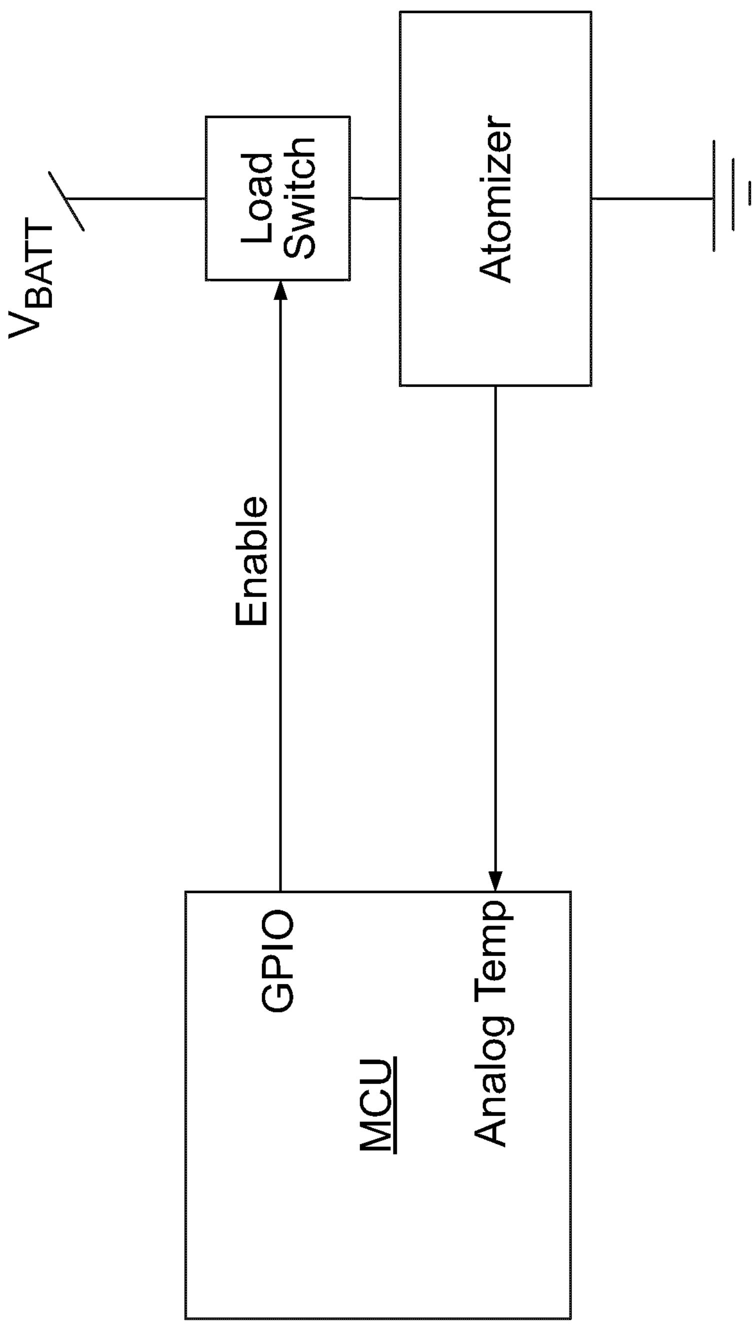


FIG. 45

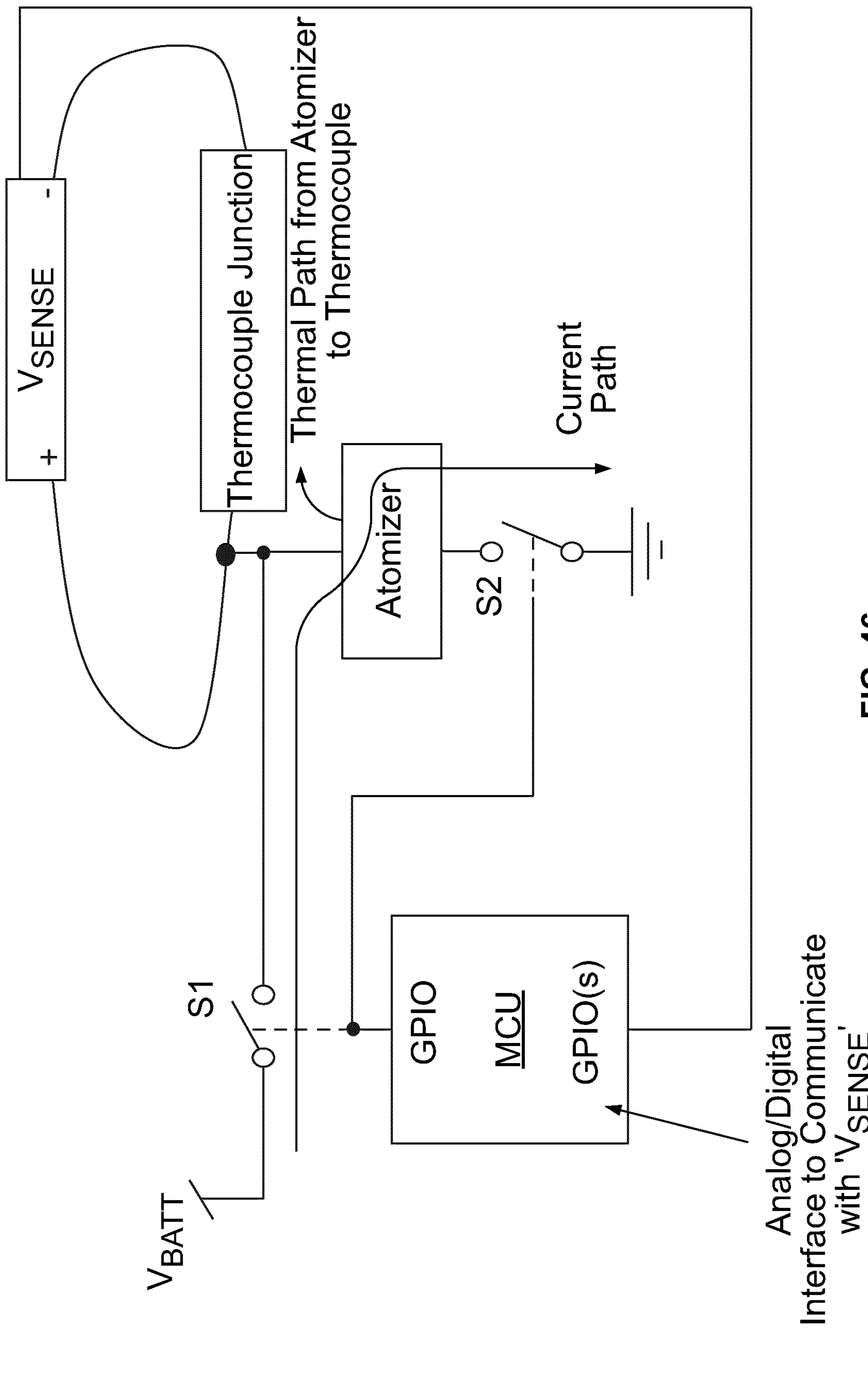

V_{SENSE}
+
-
Thermocouple Junction
Thermal Path from Atomizer to Thermocouple
Atomizer
Current Path
S2
S1
V_{BATT}
GPIO
MCU
GPIO(s)
Analog/Digital Interface to Communicate with 'V_{SENSE}'

FIG. 46

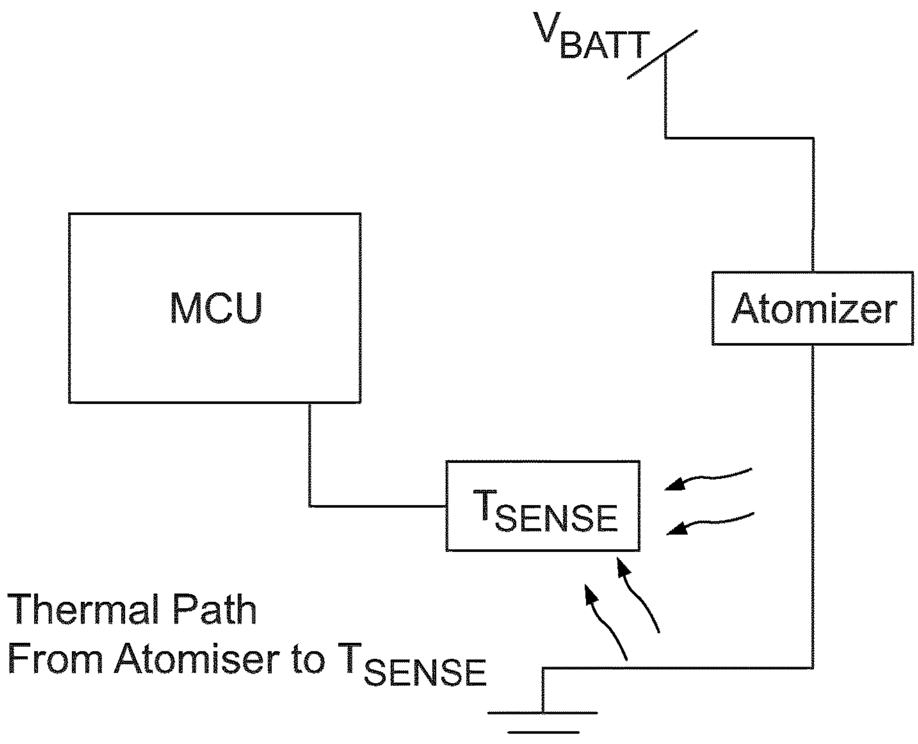

V_{BATT}
MCU
Atomizer
T_{SENSE}
Thermal Path
From Atomiser to T_{SENSE}

FIG. 47

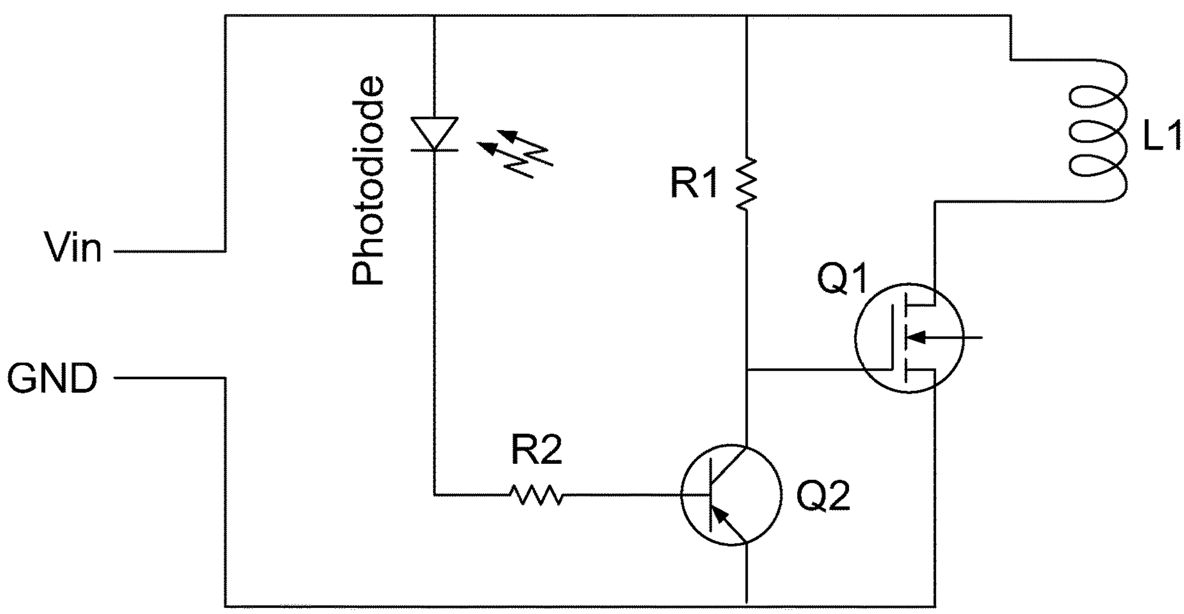
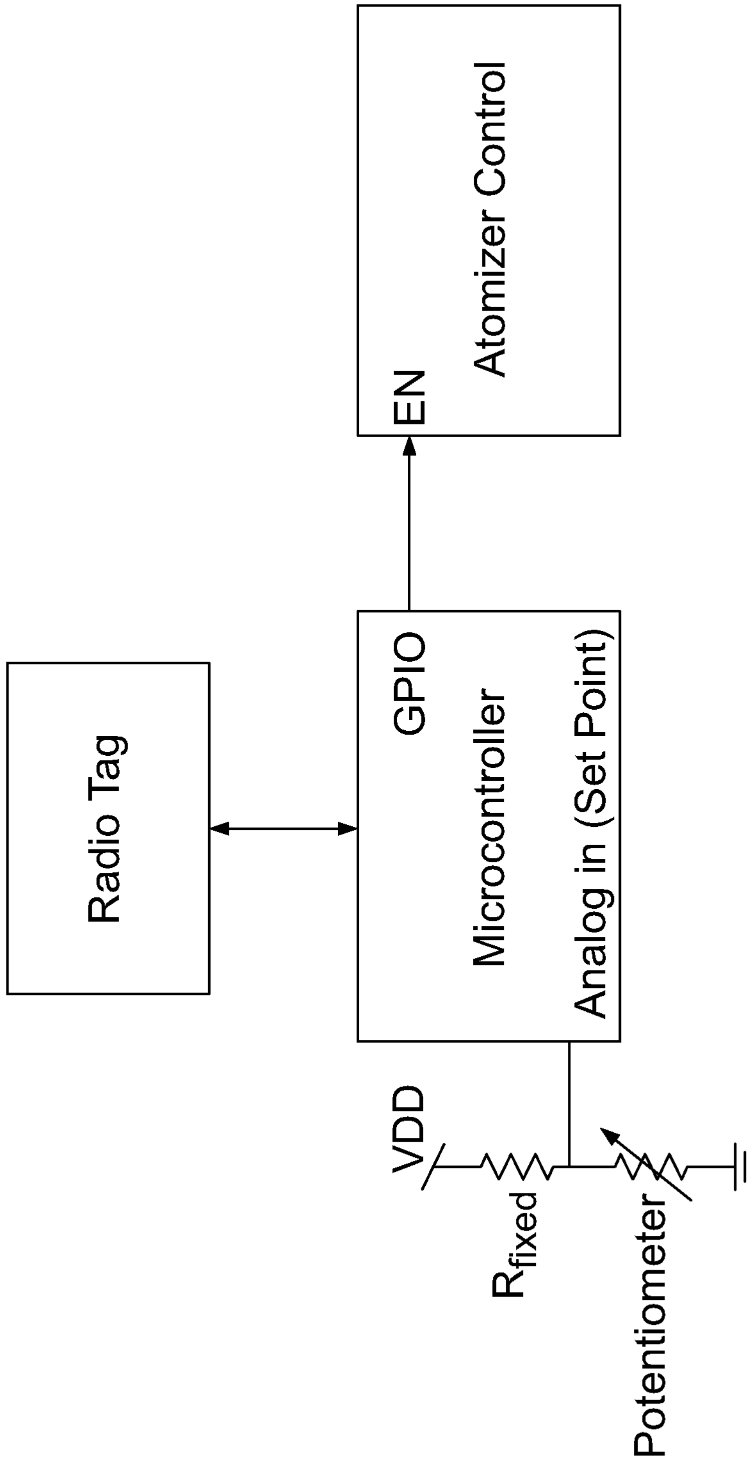

Photodiode
L1
R1
Vin
Q1
GND
R2
Q2

FIG. 48



Atomizer Control
EN
GPIO
Microcontroller
Analog in (Set Point)
Radio Tag
VDD
R_{fixed}
Potentiometer

FIG. 49

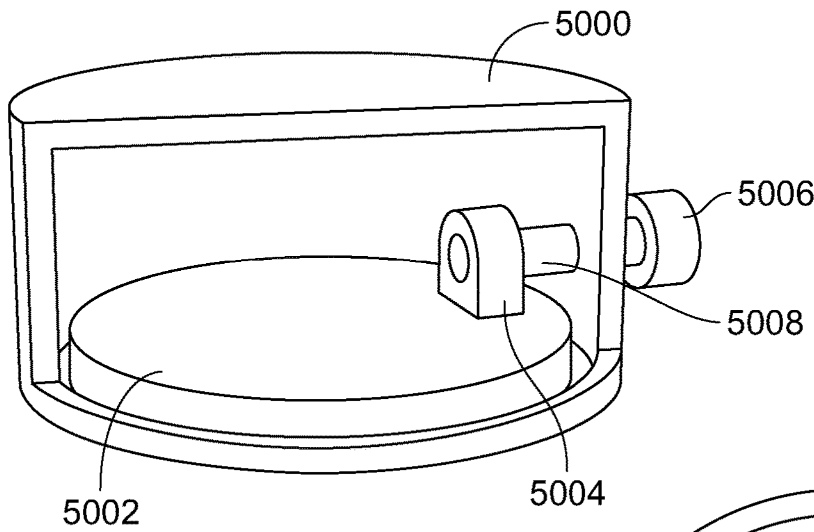


FIG. 50

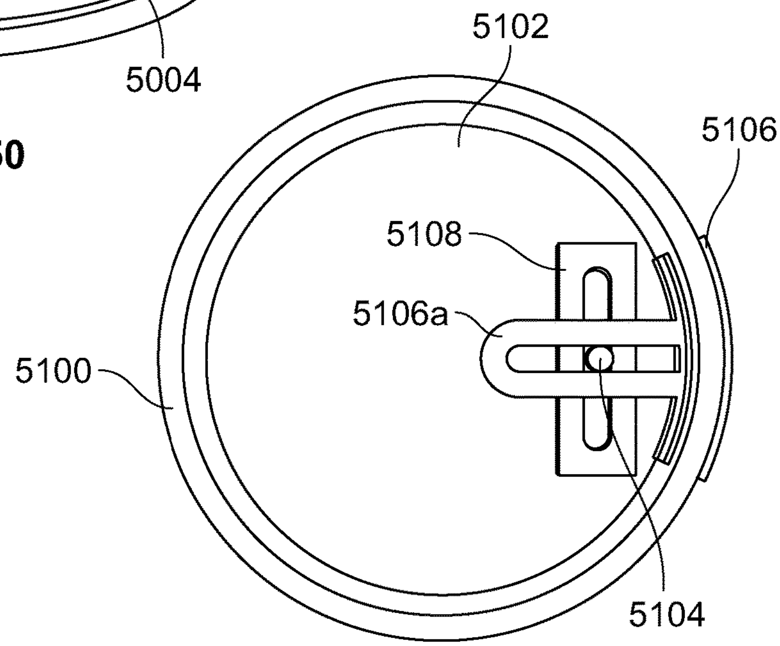


FIG. 51

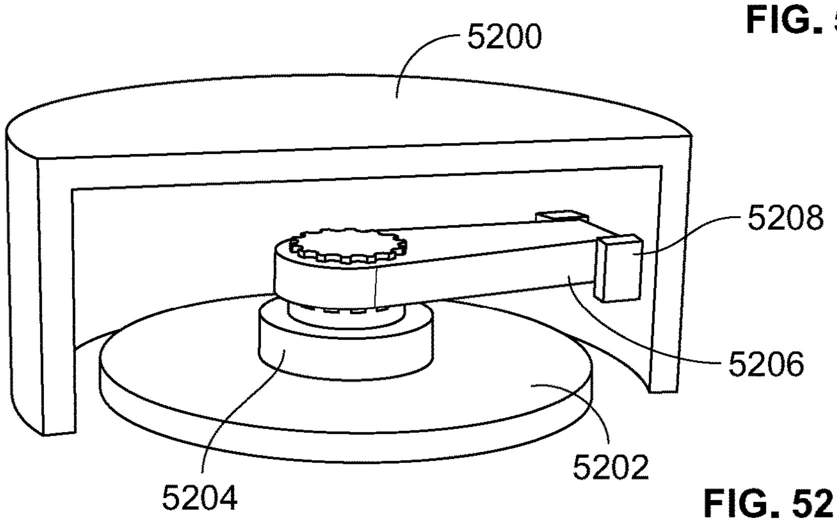


FIG. 52

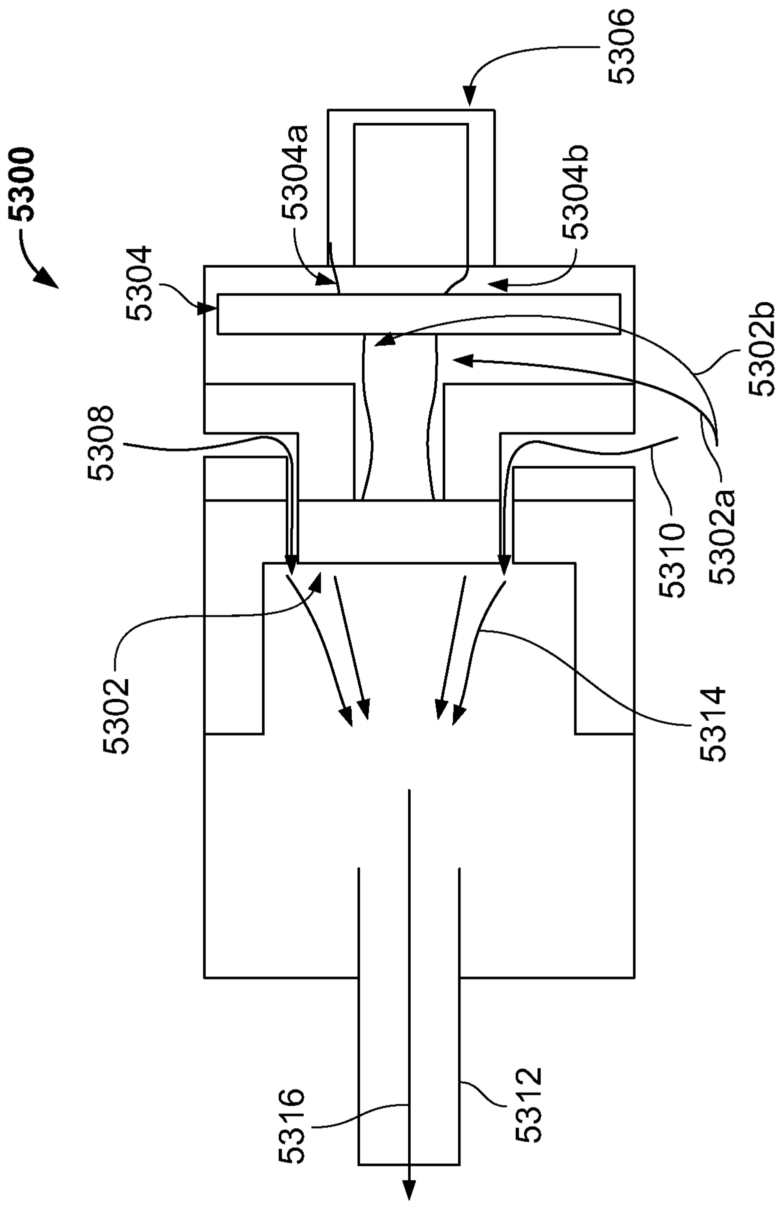

5300
5306
5304a
5304b
5304
5302b
5308
5302a
5310
5302
5314
5316
5312

FIG. 53

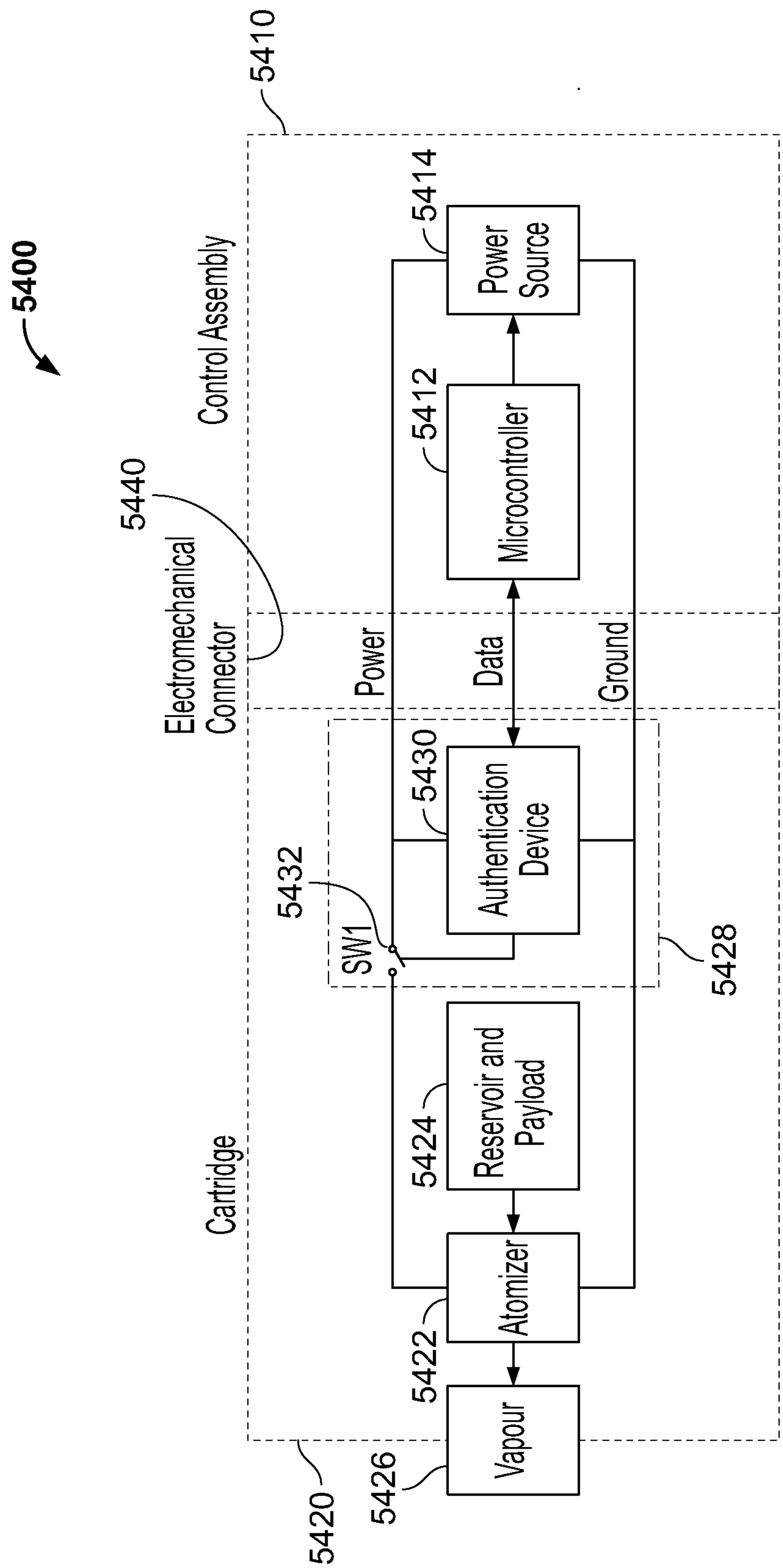

5400
5410
Control Assembly
5414
Power Source
5412
Microcontroller
5440
Electromechanical Connector
Power
Data
Ground
5430
Authentication Device
5432
SW1
5428
Reservoir and Payload
5424
Cartridge
Atomizer
5422
Vapour
5426
5420

FIG. 54

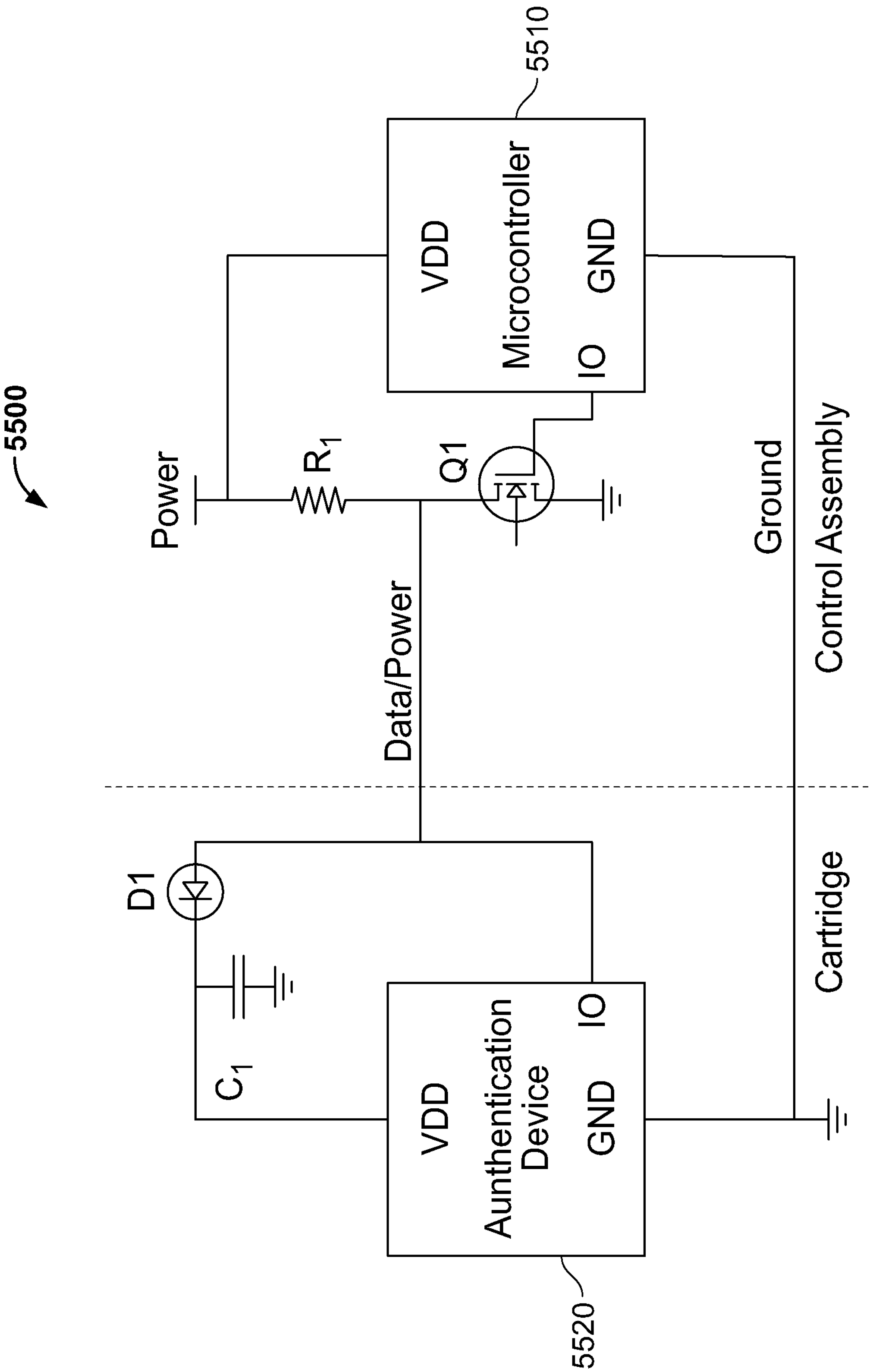

5500
5510
VDD
Microcontroller
GND
IO
Power
R1
Q1
Data/Power
Ground
Control Assembly
D1
C1
VDD
Aunthentication Device
GND
IO
Cartridge
5520

FIG. 55

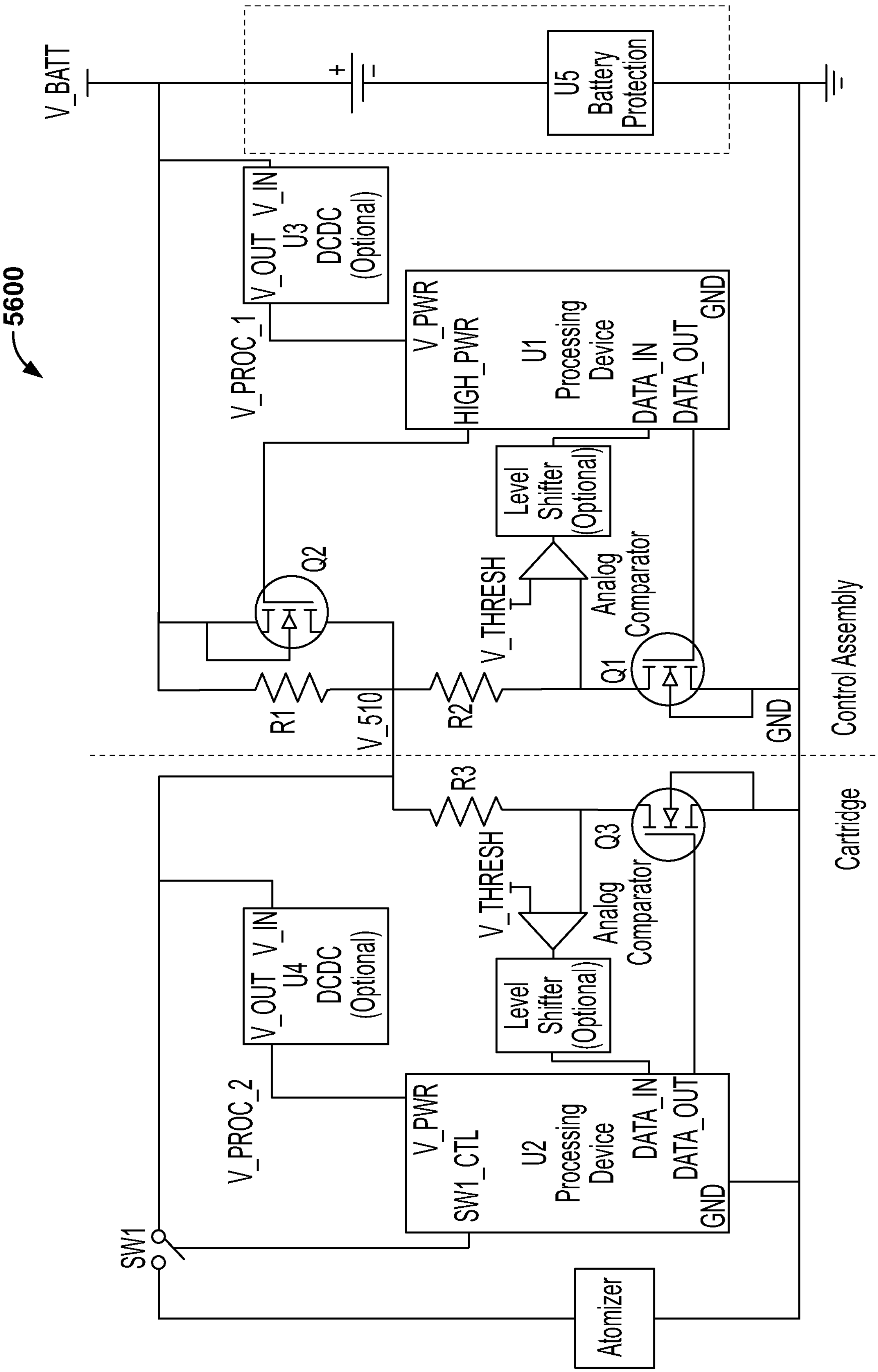

5600
V_BATT
U5
Battery
Protection
V_OUT V_IN
U3
DCDC
(Optional)
V_PROC_1
V_PWR
HIGH_PWR
U1
Processing
Device
DATA_IN
DATA_OUT
GND
Level
Shifter
(Optional)
Q2
V_THRESH
Analog
Comparator
Q1
R1
R2
V_510
GND
Control Assembly
R3
Q3
V_THRESH
Analog
Comparator
Cartridge
V_OUT V_IN
U4
DCDC
(Optional)
Level
Shifter
(Optional)
V_PROC_2
V_PWR
SW1_CTL
U2
Processing
Device
DATA_IN
DATA_OUT
GND
SW1
Atomizer

FIG. 56

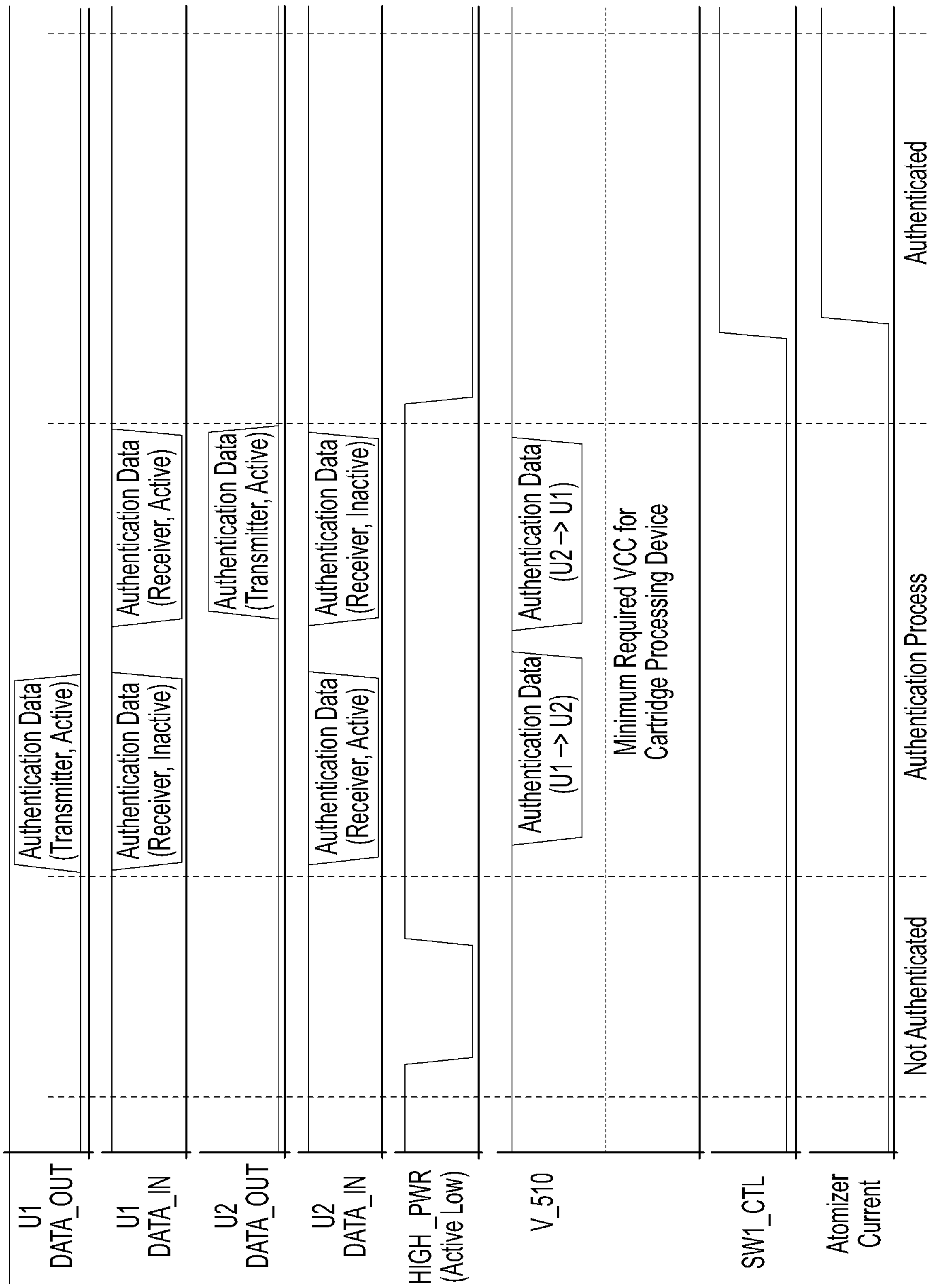

U1 DATA_OUT
U1 DATA_IN
U2 DATA_OUT
U2 DATA_IN
HIGH_PWR (Active Low)
V_510
SW1_CTL
Atomizer Current
Authentication Data (Transmitter, Active)
Authentication Data (Receiver, Inactive)
Authentication Data (Receiver, Active)
Authentication Data (Transmitter, Active)
Authentication Data (Receiver, Active)
Authentication Data (Receiver, Inactive)
Authentication Data (U1 -> U2)
Authentication Data (U2 -> U1)
Minimum Required VCC for Cartridge Processing Device
Not Authenticated
Authentication Process
Authenticated

FIG. 57

VAPE DEVICES, INCLUDING CARTRIDGES, TABLETS, SENSORS, AND CONTROLS FOR VAPE DEVICES, AND METHODS FOR MAKING AND USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority to U.S. patent application Ser. No. 15/921,144, filed on Mar. 14, 2018, U.S. Provisional Application Ser. No. 62/642,805, filed on Mar. 14, 2018, U.S. Provisional Application Ser. No. 62/642,825, filed on Mar. 14, 2018, U.S. Provisional Application Ser. No. 62/661,306, filed on Apr. 23, 2018, U.S. Provisional Application Ser. No. 62/668,380, filed on May 8, 2018, U.S. Provisional Application Ser. No. 62/680,057, filed on Jun. 4, 2018, U.S. Provisional Application Ser. No. 62/696,930, filed on Jul. 12, 2018, U.S. Provisional Application Ser. No. 62/696,937, filed on Jul. 12, 2018, U.S. Provisional Application Ser. No. 62/696,943, filed on Jul. 12, 2018, U.S. Provisional Application Ser. No. 62/733,286 filed on Sep. 19, 2018, and U.S. Provisional Application Ser. No. 62/797,694 filed on Jan. 28, 2019 each of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present disclosure is related to the field of personal vaporizer devices or "vape devices," and in particular, methods and systems for controlling the operation of vape devices and cartridges, tablets, sensors, and controls for vape devices.

2. Description of Related Art

[0003] The use of personal vaporizers or vape devices for consuming tobacco products, as well as cannabis for medical and recreational purposes, has grown significantly. Many of the vape devices merely contain an atomizer for heating and vaporizing liquids or oils to be inhaled. In a basic form, vape devices can be simple devices consisting of a heating element, a battery, a switch for connecting the battery to the heating element, and an amount of liquid or oil to be vaporized by the heating element. Controlling the vape device merely entails closing the switch to heat the liquid or oil to produce vapor to be inhaled. Conventional vape devices such as these provide: no control as to the ramping up and/or down of power applied to the heating element; no control as to the metering of how much vapor is produced when the switch is closed; no control as to how particular fluids or oils are to be heated to produce vapor; and no control to prevent unauthorized use of the vape device by anyone other than the user of the vape device.

[0004] Conventional vape devices and cartridges for use with vape devices (e.g., a cartridge with a 510 threaded connector) are typically designed for use with nicotine "e-juice" that has a relatively low viscosity. When conventional vape devices and cartridges are used with an oil having a higher viscosity (e.g., oils extracted from a cannabis plant), the oil must be diluted with fluids such as vegetable glycerine (VG), propylene glycol (PG) and polyethylene glycol (PEG) in order to attain a viscosity that is compatible with the wicking material that allows the fluid payload to transfer from the payload reservoir to the heating element. Many conventional vape devices or cartridges also need to be stored in a particular orientation (e.g., a vertical orientation) when used with a viscous fluid, and/or substances such as VG, PG, or PEG must be added, so that the viscous fluid reliably makes contact with the heating element or atomizer. Some users, however, prefer not to vape fluids containing additives, such as VG, PG, or PEG, that may adulterate the substance desired to be vaped. Further, storing the vape device or cartridge in a particular orientation can be cumbersome.

[0005] Many conventional vape devices and cartridges further include a bottom air flow design with an air intake positioned on one side of an atomizer and the outlet positioned on the other side of the atomizer. The fluid payload may seep through the atomizer and accumulate on an inner surface of the atomizer. When the atomizer heats the fluid, the fluid may leak through the air intake path out of the cartridge or vape device. Further, if the user inhales before the fluid is vaporized, the user may inhale spurts of oil droplets. Some conventional vape devices and cartridges include a cotton barrier wrapped around the atomizer to prevent leaking and spurting. However, this introduces a fibrous material to the vape device or cartridge that can burn and be contaminated in the production environment. The process of wrapping the atomizer with a layer of cotton is fine detailed work that requires such a high degree of manual dexterity that the factory workers use their bare fingers to perform the procedure, which is unhygienic.

[0006] With conventional vape devices and cartridges, the fluid entry points from the payload reservoir into the atomizer are often only one or two small circular openings (e.g., openings with a diameter of 1-2 mm). These small circular openings trap air bubbles that prevent flow of the fluid to the atomizer, which is commonly known as "air-lock." The positioning of the circular openings also frequently leads to oil waste within the cartridge or vape device.

[0007] While most conventional vape devices are configured to vaporize fluids, some individuals prefer to smoke or vape dry material. Smoking or vaping dry material may affect an individual in a different manner than vaping a fluid. In particular, there may be differences in thermally induced chemical reactions or metabolic transformations between the vaping of dry material and the vaping of fluid that may affect the user in a different manner.

[0008] The conventional method of vaping or smoking dry material includes weighing and grinding the material, removing any undesirable components, such as stems, and packing the ground material into a vaping chamber or bowl of the vaping or smoking device. This process is relatively cumbersome and inconvenient for the user and often leads to loss of material through spillage and/or sticking to the grinder. Further, if the dry material is cannabis, it is difficult to control the dose of active compounds consumed due to variations of the cannabinoid profile from strain to strain, batch to batch, and based on the location where the plant is grown.

[0009] While there are a few conventional vape devices that attempt to determine the dosage of a vaporized payload, they use inaccurate methods that offer poor dose metering performance, e.g., using the known volume and strain of the payload being vaporized to assume the dosage. As such, medicinal patients are unsure of the dosage that they have taken at any given time, which limits the repeatability and efficacy of the drug's effects. Also, recreational users may experience different effects (desirable and undesirable) depending on dosage.

[0010] Conventional cartridges for use with vape devices are typically pre-filled with a substance for vaporization. When a cartridge is purchased from a dispensary, the purchaser may receive documentation with certain cartridge information printed on the packaging. However, this documentation is easily separated from the cartridge and is likely to be discarded, lost, or potentially even tampered with. If the user possesses multiple cartridges, it is possible that he or she will misidentify the cartridges and may not get the expected experience from a particular cartridge. Further, a medical user may not receive the desired relief of his or her symptoms with a particular cartridge.

[0011] Due to the commonality of the connectors used on vape devices, a conventional cartridge (containing a heating element and payload) can be installed on or connected to many different types of control assemblies (that supply power to the heating element) with different capabilities. If a conventional cartridge is installed on a control assembly capable of supplying too much power, there is the possibility of the cartridge being damaged, the payload being burnt, or the user being injured.

[0012] Conventional vape devices that use a two-pin connector to join a cartridge and control assembly are not able to control the atomizer temperature across all operating modes (e.g., low to high airflow, low to high ambient temperature, battery voltage, etc.). Some vape devices include a control assembly that allows a user to select one or more operating parameters, such as the coil resistance, coil material, power, current, voltage, and desired temperature. Using these parameters, a rudimentary form of temperature control can be achieved, but it is very limited in accuracy. In particular, there is generally no accounting for air flow, ambient temperature, and/or current atomizer temperature, which can dramatically impact the atomizer temperature when in use.

[0013] The issue of localized atomizer temperature is particularly problematic with dried cannabis products because the atomizer surface area in contact with the payload is large in comparison to liquid payloads. Further exacerbating the problem is the fact that not all of the cannabis payload is directly in contact with the atomizer due to the volume of cannabis used (typically on the order of 1 cubic centimeter). In this case, it is likely that the payload in direct contact with the atomizer may begin to burn while the payload farther from the atomizer will remain in an area of low heat and potentially not vaporize. This leads to smoke and wasted product, neither of which is desired. An alternative method of heating used with dried cannabis products is convection heating, i.e., using a heating element to heat air that comes into contact with the payload. If the air is not hot enough, no vaporization will occur. If the air is too hot, the payload will burn. If the temperature of the air is just right, the payload will vaporize without combustion.

[0014] Many conventional vape devices comprise a control assembly (e.g., a battery unit) that may be used with multiple disposable cartridges. Each cartridge comprises a payload reservoir that contains a payload and an atomizer for heating and vaporizing the payload. Some vape devices utilize rudimentary methods for preventing unauthorized use of the device. For example, a user may be able to lock and unlock a vape device by depressing a button on the control assembly using a fixed number of clicks in rapid succession (e.g., three clicks to turn on the device and three clicks to turn off the device). In addition, a user may be able to unlock a vape device by placing a finger on a fingerprint scanner provided on the control assembly. However, these methods are limited with respect to the level of authentication and access control that may be desired for a vape device.

BRIEF SUMMARY OF THE INVENTION

[0015] The invention described herein includes: vape devices; cartridges, tablets, sensors, communication systems and control systems for use with vape devices; and methods for making and using the vape devices, cartridge, tablets, sensors, communication systems and control systems.

[0016] A vape device in accordance with one exemplary embodiment of the invention described herein comprises a payload reservoir configured to hold a payload for vaporization; a heating element configured to heat the payload; a power source coupled to the heating element; a sensor that is configured to sense an operational condition of the vape device as vapor is generated by the vape device; a processor; a memory device; and a set of instructions stored in the memory device and executable by the processor to: receive the operational condition from the sensor; and adjust power provided to the heating element by the power source based on the sensed operational condition. The vape device preferably continuously adjusts power provided to the heating element as vapor is generated by the vape device to maintain a temperature of the heating element within a desired range for a particular payload.

[0017] A system for determining a heating profile for a vape device in accordance with another exemplary embodiment of the invention described herein comprises: a processor; a memory device; and a set of instructions stored in the memory device and executable by the processor to: receive a sensed plurality of draw strengths and a sensed plurality of draw lengths, wherein each draw strength and each draw length are associated with an instance of a user drawing vapor from the vape device; determine a historical draw strength from the sensed plurality of draw strengths; determine a historical draw length from the sensed plurality of draw lengths; and generate a heating profile for a heating element of the vape device based on the historical draw strength and the historical draw length, wherein the heating profile corresponds with power provided to the heating element over time. The system may be used with any of the vape devices described herein. The system preferably learns how a particular user uses a vape device to optimize a heating profile for the vape device in accordance with the user's preferred usage.

[0018] A method for operating a vape device in accordance with another exemplary embodiment of the invention described herein comprises: sensing an operational condition of the vape device as vapor is generated by the vape device; and adjusting a power provided to a heating element of the vape device based on the sensed operational condition. The method may be used in connection with any of the vape devices and cartridges disclosed herein.

[0019] A method for operating a vape device in accordance with another exemplary embodiment of the invention described herein comprises: sensing a plurality of draw strengths and a plurality of draw lengths, wherein each draw strength and each draw length are associated with an instance of a user drawing vapor from the vape device;

determining a historical draw strength from the sensed plurality of draw strengths; determining a historical draw length from the sensed plurality of draw lengths; determining a heating profile for a heating element of the vape device based on the historical draw strength and the historical draw length; and adjusting a power provided to the heating element in accordance with the heating profile. The method may be used in connection with any of the vape devices and cartridges disclosed herein. The method preferably allows the vape device to learn how a particular user uses the vape device so that the vape device is optimized to operate in accordance with the user's preferred usage.

[0020] A vape device in accordance with another exemplary embodiment of the invention described herein comprises a payload reservoir configured to hold a payload for vaporization; a heating element configured to heat the payload; a power source coupled to the heating element; a sensor that is configured to sense an operational condition of the vape device as vapor is generated by the vape device; and a processor that is configured to receive the operational condition from the sensor and adjust a power provided to the heating element by the power source based on the sensed operational condition.

[0021] Another exemplary embodiment of the invention described herein includes a cartridge for vaporizing a payload comprising dry material. The cartridge comprises a housing that defines an interior chamber. The housing comprises an inlet and an outlet. The interior chamber is accessible through an opening in the housing. At least a portion of the housing is configured to movably cover and uncover the opening. The cartridge comprises a heating element positioned within the interior chamber.

[0022] Another exemplary embodiment of the invention described herein includes a tablet for use with a cartridge for vaporizing dry material. The tablet comprises dry material pressed into a shape comprising at least a first surface and a second surface positioned opposite the first surface. At least one recess is formed in at least one of the first surface and the second surface. The tablet may be used with any of the cartridges for vaporizing a payload comprising dry material described herein. The recesses preferably allow a greater surface area of the tablet to be in contact with heated air passing over and through the tablet to improve the vaporization of the tablet.

[0023] Another exemplary embodiment of tablet for use with a cartridge for vaporizing dry material comprises dry material pressed into a shape comprising at least a first surface and a second surface positioned opposite the first surface. A heating element is coupled to the dry material. The tablet may be used with any of the cartridges for vaporizing a payload comprising dry material described herein.

[0024] A method of using a vape device to vaporize a tablet of pressed, dry material in accordance with another exemplary embodiment of the invention described herein comprises: inserting the tablet through an opening in the vape device into an interior chamber of the vape device; activating a heating element of the vape device to vaporize a portion of the tablet into tablet vapor; and inhaling at least a portion of the tablet vapor. The method may be used in connection with any of the vape devices and cartridges disclosed herein that are configurable for vaporizing dry material.

[0025] A method of making a tablet for use with a cartridge for vaporizing dry material in accordance with another exemplary embodiment of the invention described herein comprises: providing a dry material; measuring a percentage of a component of the dry material; determining a desired amount of the component; determining a desired thickness that corresponds with the desired amount of the component; and pressing the dry material into a tablet of the desired thickness to include the desired amount of the component. The invention also encompasses a tablet made in accordance with the method. The method may be used to make any of the tablets described herein. The tablet preferably assists in dosage control because a user of the tablet knows how much of the component is present in the tablet.

[0026] A method of making a tablet for use with a cartridge for vaporizing dry material in accordance with another exemplary embodiment of the invention described herein comprises: providing a first dry material; measuring a first percentage of a first component of the first dry material; providing a second dry material; measuring a second percentage of a second component of the second dry material; determining a desired ratio of the first percentage to the second percentage; and forming a tablet that contains the desired ratio of the first percentage to the second percentage. The invention also encompasses a tablet made in accordance with the method. The method may be used to make any of the tablets described herein.

[0027] Another exemplary embodiment of the invention described herein is a cartridge for a vape device. The cartridge comprises a housing defining a payload reservoir, an inlet, an outlet, and an air flow chamber positioned between the inlet and the outlet; an atomizer positioned within the housing, wherein the atomizer is in fluid communication with the payload reservoir; and a deflector positioned in the air flow chamber between the atomizer and the outlet, wherein the deflector comprises a plurality of holes. The invention also encompasses a vape device including the cartridge. The deflector preferably prevents or reduces the likelihood that unvaporized spurts of payload will exit the outlet.

[0028] Another exemplary embodiment of cartridge for a vape device comprises: a housing comprising a first end and a second end, wherein the housing defines a payload reservoir, an inlet positioned adjacent the first end, an outlet positioned adjacent the first end, and an air flow chamber positioned between the inlet and the outlet; and an atomizer positioned within the housing, wherein the atomizer is in fluid communication with the payload reservoir and the air flow chamber. The invention also encompasses a vape device including the cartridge. Positioning both the inlet and the outlet adjacent the first end preferably reduces the likelihood that unvaporized payload will leak out of the vape device or cartridge.

[0029] A cartridge for a vape device in accordance with another exemplary embodiment of the invention described herein comprises: a housing comprising an outer side wall and an inner side wall spaced apart from the outer side wall; and an atomizer positioned within a chamber defined by the inner side wall. The housing defines a payload reservoir positioned between the inner side wall and the outer side wall. A plurality of elongated slots are formed in the inner side wall. The housing defines an inlet, an outlet, and an air flow chamber positioned between the inlet and the outlet. The plurality of elongated slots place the atomizer in fluid communication with the payload reservoir, and the atomizer is in fluid communication with the air flow chamber. The invention also encompasses a vape device including the cartridge. The elongated slots preferably prevent or reduce the likelihood that air bubbles will form within the slots and prevent the payload from reaching the atomizer.

[0030] A cartridge for a vape device in accordance with another exemplary embodiment of the invention described herein comprises: a housing defining a payload reservoir; an atomizer positioned within the housing; and a pressurizer positioned within the housing, wherein the pressurizer is configured to apply pressure to a fluid payload within the payload reservoir to force the fluid payload into contact with the atomizer. The invention also encompasses a vape device including the cartridge. Applying pressure to the fluid payload preferably provides a consistent flow of payload to the atomizer when desired.

[0031] A vape device in accordance with another exemplary embodiment of the invention described herein comprises a housing, an atomizer positioned in the housing, and a payload reservoir positioned in the housing. The housing comprises a first end and a second end, wherein a longitudinal axis of the housing extends between the first end and the second end. The payload reservoir is defined at least in part by a reservoir side wall comprising a first end positioned adjacent the atomizer and a second end. The reservoir side wall slopes toward the atomizer from the second end of the reservoir side wall to the first end of the reservoir side wall when the housing is positioned so that the longitudinal axis is generally horizontal. The reservoir side wall preferably improves the flow of payload to the atomizer to keep the atomizer bathed in the payload and reduce the amount of payload that is wasted in the reservoir.

[0032] A vape device in accordance with another exemplary embodiment of the invention described herein comprises a housing comprising a first end and a second end. A longitudinal axis of the housing extends between the first end and the second end. The vape device is configured so that the housing orients itself in a predetermined position when the housing is placed on a generally horizontal surface and the longitudinal axis is generally horizontal. The housing preferably is able to orient itself in a predetermined position so that a payload within the housing is able to flow into contact with an atomizer to keep the atomizer bathed in the payload and reduce the amount of payload that is wasted in the reservoir.

[0033] A vape device in accordance with another exemplary embodiment of the invention described herein comprises a housing, a tray that is positioned in the housing, an atomizer positioned in the housing, and a flexible circuit board. The housing comprises a first end and a second end. A longitudinal axis of the housing extends between the first end and the second end. The housing defines an inlet, an outlet positioned adjacent the second end of the housing, and an air flow chamber positioned between the inlet and the outlet. The tray comprises a first section that defines a recess and a second section that defines a payload reservoir positioned adjacent the second end of the housing. The tray comprises a first side positioned adjacent the housing and a second side. The atomizer is in fluid communication with the payload reservoir. A flexible circuit board is positioned adjacent the second side of the tray in the recess defined by the tray. The flexible circuit board and tray preferably make manufacturing of the vape device more efficient and consistent.

[0034] A vape device in accordance with another exemplary embodiment of the invention described herein comprises: a housing defining an inlet, an outlet, and an air flow chamber positioned between the inlet and the outlet; an atomizer positioned in the air flow chamber; a capacitive sensor positioned in the air flow chamber between the atomizer and the outlet; and a sensor measurement circuit connected to the capacitive sensor. The atomizer is configured to heat and vaporize a payload to generate a vaporized payload. The capacitive sensor defines a measurement cavity within the air flow chamber. The sensor measurement circuit is configured to directly or indirectly measure a capacitance of the capacitive sensor when the vaporized payload passes through the measurement cavity. The vape device is preferably configured to accurately determine the dosage based on a measured capacitance of vaporized payload in a measurement cavity of the vape device. This vapor measurement system is beneficial to both medicinal patients and recreational users because they will be able to accurately measure their dosage to obtain desired effects in a repeatable fashion.

[0035] A method of determining a capacitance of a capacitive sensor in accordance with another exemplary embodiment of the invention described herein comprises: heating and vaporizing a payload to generate a vaporized payload; passing the vaporized payload through a measurement cavity defined by the capacitive sensor; and measuring a capacitance of the capacitive sensor when the vaporized payload passes through the measurement cavity. The method may be used in connection with any of the vape devices and cartridges disclosed herein.

[0036] A vapor measurement system for a vape device in accordance with another exemplary embodiment of the invention described herein comprises a capacitive sensor that defines a measurement cavity, and a sensor measurement circuit connected to the capacitive sensor. The sensor measurement circuit is configured to directly or indirectly measure a capacitance of the capacitive sensor when a vaporized payload passes through the measurement cavity. The vapor measurement system may be used in connection with any of the vape devices and cartridges disclosed herein.

[0037] A vape device in accordance with another exemplary embodiment of the invention described herein comprises: a control assembly comprising a power source and a reader; a cartridge comprising a heating element and an electronic memory configured to store data; and a two-conductor electrical interface configured to (a) transmit a power signal from the power source to the heating element and (b) transmit a data signal from the electronic memory to the reader. The vape device preferably enables cartridge data to be provided in a secure electronic memory within the cartridge and transmitted to the control assembly. The cartridge data cannot be tampered with, discarded or lost and, thus, a user can be assured that the data is legitimate and not a forgery.

[0038] A method of transmitting a plurality of signals over a two-conductor electrical interface between a control assembly and a cartridge of a vape device in accordance with another exemplary embodiment of the invention described herein comprises: transmitting a power signal from a power source of the control assembly over the two-conductor electrical interface to a heating element of the cartridge; and transmitting a data signal from an electronic memory of the cartridge over the two-conductor electrical interface to a reader of the control assembly. The method may be used in connection with any of the vape devices and cartridges disclosed herein.

[0039] A two-lead communication system for a vape device in accordance with another exemplary embodiment of the invention described herein comprises: a control assembly; a cartridge; and an electromechanical connection comprising a first connector coupled to a second connector. The first connector is provided as part of the control assembly. The second connector is provided as part of the cartridge. The electromechanical connection provides a two-conductor electrical interface that enables the communication of a plurality of electrical signals between the control assembly and the cartridge. The two-lead communication system may be used in connection with any of the vape devices and cartridges disclosed herein.

[0040] A vape device in accordance with another exemplary embodiment of the invention described herein comprises: a control assembly comprising a radio frequency identification (RFID) reader; a cartridge comprising an RFID tag; and a two-conductor electrical interface configured to transmit cartridge data from the RFID reader to the RFID tag to thereby program the cartridge data into the RFID tag.

[0041] A vape device in accordance with another exemplary embodiment of the invention described herein comprises: a control assembly comprising a power source; and a cartridge releasably connected to the control assembly. The cartridge comprises: a payload reservoir configured to hold a payload for vaporization; a heating element configured to heat the payload in the payload reservoir; and a temperature control circuit configured to regulate a power provided to the heating element by the power source based on a temperature sensed within the cartridge and a desired temperature set point. The cartridge preferably has localized temperature control to prevent under or over heating of the payload within the cartridge.

[0042] A method of controlling power provided to a heating element housed within a cartridge of a vape device in accordance with another exemplary embodiment of the invention described herein comprises: sensing a temperature within the cartridge; and regulating a power provided to the heating element based on the temperature sensed within the cartridge and a desired temperature set point. The method may be used in connection with any of the vape devices and cartridges disclosed herein.

[0043] A temperature control system for a cartridge of a vape device in accordance with another exemplary embodiment of the invention described herein comprises: a heating element configured to heat a payload; a temperature sensor configured to sense the temperature within the cartridge; and a temperature control circuit incorporating the temperature sensor. The temperature control circuit is configured to regulate a power provided to the heating element based on the temperature sensed within the cartridge and a desired temperature set point. The temperature control system may be used in connection with any of the vape devices and cartridges disclosed herein.

[0044] A vape device in accordance with another exemplary embodiment of the invention described herein comprises: a control assembly comprising a microcontroller and a power source; a cartridge comprising an atomizer, a payload reservoir, and an authentication device; and an electromechanical connector comprising a first connector releasably coupled to a second connector, wherein the first connector is provided as part of the control assembly and the second connector is provided as part of the cartridge. The microcontroller is configured to control the power source so as to generate a power signal. The authentication device is configured to (a) implement an authentication protocol to determine whether the cartridge is authentic and (b) control transmission of the power signal from the power source to the atomizer based on an outcome of the authentication protocol.

[0045] Another exemplary embodiment of the invention described herein includes a cartridge for a vape device that comprises: a payload reservoir; an atomizer configured to heat a payload contained in the payload reservoir; and an authentication device configured to (a) implement an authentication protocol to determine whether the cartridge is authentic and (b) control transmission of a power signal to the atomizer based on an outcome of the authentication protocol.

[0046] A method of authenticating a cartridge of a vape device in accordance with another exemplary embodiment of the invention described herein comprises: storing authentication data in an authentication device within the cartridge; implementing an authentication protocol that uses the authentication data to determine whether the cartridge is authentic; and controlling transmission of a power signal an atomizer of the cartridge based on an outcome of the authentication protocol. The method may be used in connection with any of the vape devices and cartridges disclosed herein.

[0047] A system for authenticating users of vape devices in accordance with another exemplary embodiment of the invention includes a vape device and an application configured to be installed on a personal computing device. The vape device is configured to store a unique payload identifier that identifies the payload reservoir and transmit the unique payload identifier to the personal computing device. The application is configured to enable the personal computing device to (a) receive user authentication information input by a user, (b) receive the unique payload identifier from the vape device, (c) retrieve authentication information stored in association with the unique payload identifier in a database, (d) compare the user authentication information with the authentication information stored in the database, (e) generate, based on the comparison, a security setting indicating whether the user who input the user authentication information is authorized to use a payload reservoir identified by the unique payload identifier, and (f) transmit the security setting to the vape device.

[0048] A system for determining whether payload reservoirs of vape devices are depleted in accordance with another exemplary embodiment of the invention includes a vape device and an application configured to be installed on a personal computing device. The vape device is configured to store a unique payload identifier that identifies the payload reservoir and transmit the unique payload identifier to the personal computing device. The application is configured to enable the personal computing device to (a) receive the unique payload identifier from the vape device, (b) retrieve payload information stored in association with the unique payload identifier in a database, wherein the payload information comprises an original volume of the payload contained within the payload reservoir, (c) retrieve historical payload reservoir usage information stored in association with the unique payload identifier in the database, (d) analyze the payload information stored in the database and the historical payload reservoir usage information stored in the database, (e) generate, based on the analysis, a security setting indicating whether he payload reservoir is depleted, and (f) transmit the security setting to the vape device, wherein operation of the vape device is prevented if the security setting indicates that the payload reservoir is depleted.

[0049] A system for determining whether payload reservoirs of vape devices have been returned to a return center in accordance with another exemplary embodiment of the invention includes a vape device and an application configured to be installed on a personal computing device. The vape device is configured to store a unique payload identifier that identifies the payload reservoir and transmit the unique payload identifier to the personal computing device. The application is configured to enable the personal computing device to (a) receive the unique payload identifier from the vape device, (b) determine whether the payload reservoir identified by the unique payload identifier has been returned, (c) generate a security setting indicating whether he payload reservoir has been returned, and (d) transmit the security setting to the vape device, wherein operation of the vape device is prevented if the security setting indicates that the payload reservoir has been returned.

[0050] A system for determining whether payload reservoirs of vape devices have been recalled in accordance with another exemplary embodiment of the invention includes a vape device and an application configured to be installed on a personal computing device. The vape device is configured to store a unique payload identifier that identifies the payload reservoir and transmit the unique payload identifier to the personal computing device. The application is configured to enable the personal computing device to (a) receive the unique payload identifier from the vape device, (b) determine whether the payload reservoir identified by the unique payload identifier has been recalled, (c) generate a security setting indicating whether he payload reservoir has been recalled, and (d) transmit the security setting to the vape device, wherein operation of the vape device is prevented if the security setting indicates that the payload reservoir has been recalled.

[0051] A system for determining whether control assemblies are authorized for use with cartridges of vape devices in accordance with another exemplary embodiment of the invention includes a vape device and an application configured to be installed on a personal computing device. The vape device comprises a control assembly and a cartridge. The control assembly is configured to store a control assembly identifier, and the cartridge is configured to store a unique payload identifier that identifies the payload reservoir of the cartridge. The vape device is configured to transmit the control assembly identifier and the unique payload identifier to a personal computing device. The application is configured to enable the personal computing device to (a) receive the control assembly identifier and the unique payload identifier from the vape device, (b) identify a list of one or more control assembly identifiers for control assemblies that are authorized for use with the payload reservoir identified by the unique identifier, (c) compare the control assembly identifier with the list of control assembly identifiers, (d) generate, based on the comparison, a security setting indicating whether the control assembly identified by the control assembly identifier is authorized for use with the payload reservoir identified by the unique payload identifier, and (e) transmit the security setting to the vape device.

[0052] Additional aspects of the invention, together with the advantages and novel features appurtenant thereto, will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned from the practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053] FIG. **1** is a schematic diagram of one embodiment of vape device in accordance with the invention described herein.

[0054] FIG. **2** is a schematic diagram of another embodiment of vape device in accordance with the invention described herein.

[0055] FIG. **3** is a schematic diagram of a vape device system that includes the vape device of FIG. **1** in wireless communication with a computing device.

[0056] FIG. **4** is a flow diagram showing the steps of one exemplary method for using the vape device system of FIG. **3**.

[0057] FIG. **5** is a graph showing a representative vape session of a user, which includes predicted draw (or puff) lengths, draw strengths, and time intervals between draws. Evan Gregg, Thierry Bachmann, Ryuji Bito, Xavier Cahours, Michael McEwan, Paul Nelson, Krishna Prasad, Gerhard Scherer, & Mitchell Stiles, *Assessing Smoking Behaviour and Tobacco Smoke Exposure: Definitions and Methods,* 25 Beiträge zur Tabakforschung International/ Contributions to Tobacco Research, 685-99 (December 2013), available at https://doi.org/10.2478/cttr-2013-0945.

[0058] FIG. **6**A is an interval plot showing the mean and 95% confidence intervals calculated based on measurements of the draw length (or puff duration) of multiple draws from a vape device for each of twenty-two different vape device users (or subjects). Risa Robinson, Edward Hensel, & P. N. Morabito, & K. A. Roundtree, *Electronic Cigarette Topography in the Natural Environment*, PLOS ONE 10(6): e0129296 (2015), available at https://doi.org/10.1371/journal.pone.0129296.

[0059] FIG. **6**B is an interval plot showing the mean and 95% confidence intervals calculated based on measurements of the draw strength (or puff flow) of multiple draws from a vape device for each of twenty-two different vape device users (or subjects).

[0060] FIG. **6**C is an interval plot showing the mean and 95% confidence intervals calculated based on measurements of the draw volume (or puff volume) of multiple draws from a vape device for each of twenty-two different vape device users (or subjects).

[0061] FIG. **6**D is an interval plot showing the mean and 95% confidence intervals calculated based on measurements of the time span between draws (or puff interval) of multiple draws from a vape device for each of twenty-two different vape device users (or subjects).

[0062] FIGS. **7**A-B are flow diagrams of exemplary methods of optimizing vaporization in accordance with the invention described herein.

[0063] FIG. **8**A is a graph showing the approximate time for decarboxylation of THCA to THC at different temperatures. Kerstin Iffland, Michael Carus, & Dr. med. Franjo Grotenhermen, nova-Institut GmbH, Wirth (Germany), *Decarboxylation of Tetrahydrocannabinolic Acid* (*THCA*) *to Active THC*, European Industrial Hemp Association (EIHA) (October 2016), available at http://eiha.org/media/2014/08/16-10-25-Decarboxylation-of-THCA-to-active-THC.pdf.

[0064] FIG. **8**B is a graph showing the THC content in cannabis over time at different temperatures. T. Veress, J. I. Szanto, & L. Leisztner, *Determination of cannabinoid acids by high-performance liquid chromatography of their neutral derivatives formed by thermal decarboxylation: I. Study of the decarboxylation process in open reactors,* 520 Journal of Chromatography A 339-47 (Nov. 9, 1990), available at https://doi.org/10.1016/0021-9673(90)85118-F.

[0065] FIG. **9**A is a perspective view of a conduction-based cartridge for vaporizing dry material in accordance with one embodiment of the invention described herein.

[0066] FIG. **9**B is a cross-sectional view of the cartridge of FIG. **9**A.

[0067] FIG. **9**C is an exploded view of the cartridge of FIG. **9**A.

[0068] FIG. **10**A is a perspective view of a convection-based cartridge for vaporizing dry material in accordance with one embodiment of the invention described herein.

[0069] FIG. **10**B is a cross-sectional view of the cartridge of FIG. **10**A.

[0070] FIG. **10**C is an exploded view of the cartridge of FIG. **10**A.

[0071] FIG. **11**A is a perspective view of another conduction-based cartridge for vaporizing dry material in accordance with one embodiment of the invention described herein.

[0072] FIG. **11**B is an exploded view of the cartridge of FIG. **11**A.

[0073] FIG. **11**C is a partial cross-sectional view of the cartridge of FIG. **11**A.

[0074] FIG. **11**D is a cross-sectional view of the cartridge of FIG. **11**A.

[0075] FIG. **12** is a schematic view of a heating element for use with a cartridge or vape device for vaporizing dry material.

[0076] FIGS. **13**A-C are perspective views of tablets for use with a cartridge or vape device for vaporizing dry material.

[0077] FIG. **14**A is a top plan view of an exemplary embodiment of a tablet in accordance with the invention described herein.

[0078] FIG. **14**B is a right side elevational view of the tablet of FIG. **14**A.

[0079] FIG. **14**C is a front elevational view of the tablet of FIG. **14**A.

[0080] FIG. **14**D is a cross-sectional view taken through the line **14**D-**14**D in FIG. **14**A.

[0081] FIG. **15** is a cross-sectional view showing two of the tablets of FIG. **14**A joined together or placed back-to-back.

[0082] FIG. **16**A is a top plan view of an exemplary embodiment of a tablet that includes a heating element in accordance with the invention described herein.

[0083] FIG. **16**B is a right side elevational view of the tablet of FIG. **16**A.

[0084] FIG. **16**C is a front elevational view of the tablet of FIG. **16**A.

[0085] FIG. **17** is a front elevational view of another exemplary embodiment of tablet that includes a heating element in accordance with the invention described herein.

[0086] FIG. **18** is a schematic view of a tablet storage and dispensing device.

[0087] FIG. **19**A is a perspective view of an exemplary embodiment of a cartridge for vaporizing a fluid payload in accordance with the invention described herein.

[0088] FIG. **19**B is a cross-sectional view of the cartridge of FIG. **19**A.

[0089] FIG. **19**C is an exploded view of the cartridge of FIG. **19**A.

[0090] FIG. **19**D is a partially exploded view of the cartridge of FIG. **19**A.

[0091] FIG. **20** is a schematic view of the air flow within the cartridge of FIG. **19**A.

[0092] FIG. **21** is a perspective view of an alternative embodiment of a cartridge for vaporizing a fluid payload in accordance with the invention described herein.

[0093] FIG. **22** is a cross-sectional view of the cartridge of FIG. **21**.

[0094] FIG. **23**A is a perspective cross-sectional view of the cartridge of FIG. **21**.

[0095] FIG. **23**B is a cross-sectional view of an atomizer of the cartridge of FIG. **21**.

[0096] FIG. **23**C is a top plan view of the atomizer of FIG. **23**B.

[0097] FIG. **23**D is a bottom plan view of the atomizer of FIG. **23**B.

[0098] FIG. **24** is a schematic view of an alternative air flow path for a cartridge for vaporizing a fluid payload in accordance with the invention described herein.

[0099] FIG. **25**A is a perspective view of another alternative embodiment of a cartridge for vaporizing a fluid payload in accordance with the invention described herein.

[0100] FIG. **25**B is a cross-sectional view of the cartridge of FIG. **25**A.

[0101] FIG. **26**A is a perspective view of another alternative embodiment of a cartridge for vaporizing a fluid payload in accordance with the invention described herein.

[0102] FIG. **26**B is a cross-sectional view of the cartridge of FIG. **26**A.

[0103] FIG. **26**C is an exploded view of the cartridge of FIG. **26**A.

[0104] FIG. **26**D is a cross-sectional view of an alternative embodiment of a cartridge for vaporizing a fluid payload that is similar to the cartridge shown in FIG. **26**A.

[0105] FIG. **27** is a schematic view of the air flow within the cartridge of FIG. **25**.

[0106] FIG. **28**A is a perspective view of a vape device in accordance with the invention described herein.

[0107] FIG. **28**B is a cross-sectional view of the vape device of FIG. **28**A.

[0108] FIG. **28**C is a cross-sectional view taken through the line **28**C-**28**C in FIG. **28**B.

[0109] FIG. **28**D is an exploded view of the vape device of FIG. **28**A.

[0110] FIG. **28**E is a perspective view of one end of the vape device of FIG. **28**A showing a view port.

[0111] FIG. **28**F is a perspective view of the end of the vape device shown in FIG. **28**E showing an outlet.

[0112] FIG. **28**G is a perspective view of the other end of the vape device of FIG. **28**A.

[0113] FIG. **29**A is a cross-sectional view of an alternative configuration of a payload reservoir that may be used with the vape device of FIG. **28**A.

[0114] FIG. **29**B is a cross-sectional view of an alternative placement of an atomizer that may be used with the vape device of FIG. **28**A.

[0115] FIG. **29**C is a cross-sectional view of another alternative configuration of a payload reservoir that may be used with the vape device of FIG. **28**A.

[0116] FIG. **29**D is a cross-sectional view of an alternative embodiment of vape device with an alternative inlet configuration.

[0117] FIG. **29**E is a cross-sectional view of an alternative embodiment of vape device with another alternative inlet configuration.

[0118] FIG. **29**F is a partial sectional view of an alternative configuration of a payload reservoir that may be used with the vape device of FIG. **28**A.

[0119] FIG. **29**G is a cross-sectional view of the payload reservoir shown in FIG. **29**F.

[0120] FIG. **30** is a flow diagram showing the steps of one exemplary method for using the vape devices of FIGS. **28**A-**29**G.

[0121] FIG. **31** is a schematic diagram of a cartridge in which a parallel plate capacitor is used as a capacitive sensor of a vapor measurement system in accordance with one embodiment of the invention described herein.

[0122] FIG. **32** is a circuit diagram of a charge pump circuit configured to charge the electrical conductors of a capacitive sensor of a vapor measurement system to enable measurement of the capacitance of the sensor.

[0123] FIG. **33** is a circuit diagram of a resistive voltage divider circuit in which a capacitive sensor of a vapor measurement system is included within a switched-capacitor resistor to enable measurement of the capacitance of the sensor.

[0124] FIG. **34** is a circuit diagram of a phase locked loop circuit in which a capacitive sensor of a vapor measurement system is included within a voltage-controlled oscillator to enable measurement of the capacitance of the sensor.

[0125] FIG. **35** is a circuit diagram of an active low-pass filter circuit connected to a rectifier circuit in which a capacitive sensor of a vapor measurement system is included within the low-pass filter circuit to enable measurement of the capacitance of the sensor.

[0126] FIG. **36** is a bode plot of the active low-pass filter circuit shown in FIG. **35**.

[0127] FIG. **37** is a circuit diagram of a crystal oscillator circuit used to provide a reference signal to a phase locked loop circuit, wherein the crystal oscillator circuit is loaded with a capacitive sensor of a vapor measurement system to enable measurement of the capacitance of the sensor.

[0128] FIG. **38**A is a front elevational view of a rolled capacitor that may be used as a capacitive sensor of a vapor measurement system.

[0129] FIG. **38**B is a front elevational view of the rolled capacitor shown in FIG. **38**A with arrows indicating the direction of air flow in a plane parallel to the front face of the rolled capacitor.

[0130] FIG. **38**C is a perspective view of the rolled capacitor shown in FIG. **38**A with arrows indicating the direction of air flow in a plane perpendicular to the front face of the rolled capacitor.

[0131] FIG. **39**A is a front elevational view of an interdigitated capacitor that may be used as a capacitive sensor of a vapor measurement system.

[0132] FIG. **39**B is a front elevational view of the interdigitated capacitor shown in FIG. **39**A with arrows indicating the direction of air flow in a plane parallel to the front face of the interdigitated capacitor.

[0133] FIG. **39**C is a front elevational view of the interdigitated capacitor shown in FIG. **39**A with arrows indicating the direction of air flow in a plane perpendicular to the front face of the interdigitated capacitor.

[0134] FIG. **40** is a schematic diagram of a vape device that includes a two-lead communication system in accordance with one embodiment of the invention described herein.

[0135] FIG. **41**A is a perspective view of a female two-pin connector that may be used as part of the two-lead communication system shown in FIG. **40**.

[0136] FIG. **41**B is a perspective view of a male two-pin connector that may be used as part of the two-lead communication system shown in FIG. **40**.

[0137] FIG. **42** is a schematic diagram of a vape device that includes a cartridge with an integrated temperature control system in accordance with one embodiment of the invention described herein.

[0138] FIG. **43** is a circuit diagram of a temperature control circuit configured to modify the direct current (DC) voltage applied to a heating element in response to a change in the resistance of a thermistor, which may be incorporated into the cartridge shown in FIG. **42**.

[0139] FIG. **44** is a circuit diagram of a temperature control circuit configured to modify the direct current transmitted to a heating element in response to a change in the resistance of a thermistor, which may be incorporated into the cartridge shown in FIG. **42**.

[0140] FIG. **45** is a circuit diagram of a temperature control circuit configured to modify the pulse width of a pulsed direct current transmitted to a heating element in response to a change in a temperature detected by an analog temperature sensor, which may be incorporated into the cartridge shown in FIG. **42**.

[0141] FIG. **46** is a circuit diagram of a temperature control circuit configured to modify the pulse width of a pulsed direct current transmitted to a heating element in response to a change in the voltage of a thermocouple, which may be incorporated into the cartridge shown in FIG. **42**.

[0142] FIG. **47** is a circuit diagram of a temperature control circuit configured to modify the pulse width of a pulsed direct current transmitted to a heating element in response to a change in the resistance of a thermistor or a change in the voltage of a bandgap temperature sensor, which may be incorporated into the cartridge shown in FIG. **42**.

[0143] FIG. **48** is a circuit diagram of a temperature control circuit configured to interrupt a direct current applied to a heating element in response to detection of light by a light sensor, which may be incorporated into the cartridge shown in FIG. **42**.

[0144] FIG. **49** is a circuit diagram of a temperature control circuit with a potentiometer that enables modification of the temperature set point, which may be incorporated into the cartridge shown in FIG. **42**.

[0145] FIG. **50** is a cross-sectional view of a cartridge housing with a dial connected to the potentiometer shown in FIG. **49** that may be used to modify the variable resistance of the potentiometer.

[0146] FIG. **51** is a cross-sectional view of a cartridge housing with a slider switch connected to the potentiometer shown in FIG. **49** that may be used to modify the variable resistance of the potentiometer.

[0147] FIG. **52** is a cross-sectional view of a rotatable cartridge housing with a rotary arm connected to the potentiometer shown in FIG. **49** that may be used to modify the variable resistance of the potentiometer.

[0148] FIG. **53** is a cross-sectional view of a cartridge with an integrated temperature control system in accordance with one embodiment of the invention described herein.

[0149] FIG. **54** is a schematic diagram of a vape device that includes a smart cartridge with authenticated access control in accordance with one embodiment of the invention described herein.

[0150] FIG. **55** is a circuit diagram of one implementation of the vape device shown in FIG. **54** in which the power and data signals are transmitted between the control assembly and cartridge over a two-conductor electrical interface using a time division multiplexing scheme.

[0151] FIG. **56** is a circuit diagram of another implementation of the vape device shown in FIG. **54** in which the power and data signals are transmitted between the control assembly and cartridge over a two-conductor electrical interface using a voltage level multiplexing scheme.

[0152] FIG. **57** is a graph of an exemplary data transfer protocol that may be used by the vape device shown in FIG. **56**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0153] In this description, references to "one embodiment," "an embodiment," or "embodiments" mean that the feature or features being referred to are included in at least one embodiment of the technology. Separate references to "one embodiment," "an embodiment," or "embodiments" in this description do not necessarily refer to the same embodiment and are also not mutually exclusive unless so stated and/or except as will be readily apparent to those skilled in the art from the description. For example, a feature, structure, acts, etc. described in one embodiment may also be included in other embodiments, but is not necessarily included. Thus, the present technology can include a variety of combinations and/or integrations of the embodiments described herein.

Vape Device

[0154] In some embodiments, vape devices **10** and **100** described herein are high-quality, best-in-class rechargeable vape devices that are simple, intuitive, and appeal instantly to the "cannabis-naive" customer, whether medical or recreational. In some embodiments, vape devices **10** and **100** can communicate with personal computing device **72** and work interactively with an application **74** or "app" operating on the personal computing device **72** to provide additional functions and features that can meet the demands and needs of the most sophisticated connoisseur or medical patient. For the purposes of this description and the claims that follow, the term "personal computing device" is defined as including personal computers, laptop computers, personal digital assistants, personal computing tablets (such as those made by Apple® and Samsung®, and by others as well known to those skilled in the art), smart phones (such as those running on iOS® and Android® operating systems, and others as well known to those skilled in the art), smart watches, fitness tracking wristbands, wearable devices, smart glasses, and any other electronic computing device that comprises means for communications (wireless or wired) with other electronic devices, and with a global telecommunications or computing network.

[0155] Referring to FIG. **1**, one embodiment of vape device **10** is shown. Vape device **10** includes a mouthpiece assembly **12**, an atomizer assembly **19**, a payload assembly **24**, and a control assembly **14**. Any of mouthpiece assembly **12**, atomizer assembly **19**, payload assembly **24**, and control assembly **14** may be formed integrally together and included within a common housing suitable for grasping by a user. Further, any of mouthpiece assembly **12**, atomizer assembly **19**, payload assembly **24**, and control assembly **14** may be formed in separate housings that are releasably connected to each other via connecting means **15**, which can comprise, for example, one or more of pressure or friction fit connection means, twist mechanical lock means, magnetic connection means and any other connecting means as well known to those skilled in the art. The connecting means **15** may include a female 510 threaded connector on the control assembly **14** that releasably engages a male 510 threaded connector on the atomizer assembly **19** or payload assembly **24**. A 510 threaded connector, as is known in the art, is a M7-0.5×5 threaded connector, i.e., a threaded connector with a nominal diameter of 7 mm, a pitch of 0.5 mm, and a length of 5 mm. Connecting means **15** may include threaded connectors of other sizes. The connecting means **15** may be a threaded connector configured to operate in accordance with the two lead communication system described below in connection with vape device **4000**. By way of example, mouthpiece assembly **12** may be releasably connected to atomizer assembly **19**, payload assembly **24** and control assembly **14**, which are either formed integrally together or in separate housings that are releasably connected to each other. Mouthpiece assembly **12** and atomizer assembly **19** may be formed integrally together and releasably connected to payload assembly **24** and control assembly **14**, which are either formed integrally together or in separate housings that are releasably connected to each other. Further, mouthpiece assembly **12**, atomizer assembly **19**, and payload assembly **24** may be formed integrally together and releasably connected to control assembly **14**. The combination of the mouthpiece assembly **12**, atomizer assembly **19**, and payload assembly **24** may be referred to as a cartridge herein, and substituted for any of the cartridges **900**, **1000**, **1100**, **1900**, **2100**, **2400**, **2500**, and **2600** described below. It is also within the scope of the invention for the mouthpiece assembly **12** to be omitted and for the vaporized payload to exit the atomizer assembly **19** directly for inhalation.

[0156] In some embodiments, mouthpiece assembly **12** is operatively coupled to control assembly **14** via connecting means **15**. In some embodiments, a heater or atomizer **20** is disposed in atomizer assembly **19**, with atomizer **20** further comprising a heating element **22** disposed therein for heating and vaporizing a payload that may comprise liquids, oils, other fluids, or tablets. Heating element **22** may be a heating coil. Atomizer **20** can comprise an inlet **21** and an outlet **23**, wherein inlet **21** can be in communication, via fluid connector **46**, with payload reservoir **26** disposed in payload assembly **24**, wherein payload reservoir **26** can contain a payload for vaporization or atomization. The payload may be for example, liquids, oils, other fluids, or tablets. The payload may comprise cannabis oil or nicotine oil or be any of the tablets **940**, **1002**, **1102**, **1202**, **1300**, **1302**, **1400**, **1500**, **1600**, and **1700** described below if vape device **10** is modified to vaporize a tablet of dry material. Outlet **23** can be in communication with a user mouthpiece **16** of mouthpiece assembly **12** via a conduit **17**. In some embodiments, payload assembly **24** can comprise an identifier ("ID") tag **28**, which can further comprise a unique payload identifier that identifies payload reservoir **26**, and also optionally, secondary data as described below. The unique payload identifier of ID tag **28** may be a serial number or tracking number for payload reservoir **26** as a means to identify what payload is contained in payload reservoir **26** so as to obtain information as to the specific parameters of operation of atomizer **20**, or operational settings, that are optimal for vaporizing the specific payload contained in payload reservoir **26**. For example, the payload identifier may be compared to a database that includes the payload identifiers from a plurality of payload reservoirs. The database may include specific operational settings and secondary data for each of the payload identifiers, as described below. When cartridges **900**, **1000**, **1100**, **1900**, **2100**, **2400**, **2500**, and **2600** are used with vape device **10** or **100**, the cartridges preferably have an ID tag **28** that contain a unique payload identifier, as described below.

[0157] ID tag **28** may be any type of device that includes memory or storage capable of storing payload identifier and, optionally, secondary data, and means for allowing that payload identifier and/or secondary data to be retrieved by another device, such as microcontroller **31** and/or RF transceiver circuit **36**, for processing and/or further transmission. For example, ID tag **28** may be an RFID tag or non-volatile memory. ID tag **28** may be configured for use with NFC or a UHF RFID communication system. Vape device **10** may be configured to include the two lead communication system described below in connection with vape device **4000** so that data from ID tag **28** is transmitted to microcontroller **31** via connecting means **15** and so that power is transmitted from the control assembly **14** to the atomizer **20** via connecting means **15**.

[0158] For the purposes of this specification, the term "electrical connection" shall include any form of electrical connection via a wired or wireless connection, such as electrical conductors or wires suitable for the transmission of alternating or direct current power, analog or digital electrical signals or radio frequency signals, as the case may be and as well-known to those skilled in the art.

[0159] In some embodiments, mouthpiece assembly **12** can comprise a draw sensor **18** operatively coupled to atomizer **20** via an electrical connection **44**, wherein draw sensor **18** can cause electric current from battery **42** to flow through heating element **22**. In some embodiments, draw sensor **18** comprises a sensor, such as a mass air flow sensor, that can produce an electrical signal in response to when a user inhales or draws on mouthpiece **16**, wherein the electrical signal can cause electric current from battery **42** to flow through heating element **22**. In some embodiments, draw sensor **18** can be used as a simple "switch" as a means to turn on atomizer **20** to vaporize payload drawn into atomizer **20** from payload reservoir **26** as the user draws on mouthpiece **16**. In some embodiments, draw sensor **18** can be configured to monitor how much payload is being vaporized or how much volume of vapor is being inhaled by the user. Draw sensor **18** is one type of activation mechanism that may be used to activate atomizer **20**. Draw sensor **18** may be replaced with or used in connection with another type of activation mechanism that receives an input to switch it from an off position, in which atomizer **20** is not activated, and a on position, in which atomizer **20** is activated. For example, draw sensor **18** may be replaced with or used in connection with any of the following types of activation mechanisms: a button, switch, draw sensor, pressure transducer, proximity sensor, touch sensor, voice recognition sensor, haptic control, saliva and breath biosensor, and the like.

[0160] In some embodiments, mouthpiece **16** and draw sensor **18** can be part of a single-piece mouthpiece assembly **12**, or can be disposed in a separate mouthpiece section **13** that forms part of mouthpiece assembly **12**.

[0161] In some embodiments, atomizer **20** can be disposed in atomizer assembly **19** that can either be integral to mouthpiece assembly **12**, or a physically separate enclosure that can couple to mouthpiece assembly **12**. Instead of or in addition to including a heating element **22** as disclosed herein, atomizer **20** may include any other structure capable of vaporizing or atomizing a payload in a suitable form for inhalation. For example, atomizer **20** may include a jet nebulizer, an ultrasonic nebulizer, or a mesh nebulizer.

[0162] In some embodiments, payload reservoir **26** and ID tag **28** can be disposed in payload assembly **24** that can either be integral to mouthpiece assembly **12** and/or atomizer assembly **19**, or a physically separate enclosure that can couple to mouthpiece assembly **12** and/or atomizer assembly **19**, which can include one or more of connecting means **15** described above. Preferably, ID tag **28** is physically coupled to payload reservoir **26** either directly or indirectly (e.g., ID tag **28** and payload reservoir **26** are included in a common housing of payload assembly **24**) in a tamper resistant manner.

[0163] In some embodiments, control assembly **14** can comprise one or more antennas **40**, a battery **42** and a circuit board **30** that can further comprise a microcontroller **31** configured for carrying out one or more electronic functions in respect of the operation of vape device **10**. Having more than one antenna **40** can enable the ability for diversity wireless communications of RF signals, as well known to those skilled in the art. In some embodiments, circuit board **30** can comprise a charger circuit **32** configured for charging battery **42**. Charger circuit **32** can be integral to circuit board **30** or can be disposed on a separate circuit board operatively connected to circuit board **30** and to battery **42** via electrical connection **54**. Charger circuit **32** can be configured to be operatively connected to an external source of power, either via a shared or dedicated electrical connector **35** operatively coupled to circuit board **30** with internal connection to charger circuit **32**, or a wireless connection for power transfer, as well known to those skilled in the art.

[0164] In some embodiments, circuit board **30** can comprise user input interface circuit **34** and output interface circuit **38**. Either or both of input interface circuit **34** and output interface circuit **38** can be integral to circuit board **30**

or can be disposed on a separate circuit board operatively connected to circuit board **30**. In some embodiments, input interface circuit **34** can provide the electrical interface between user controls and activation mechanisms disposed on vape device **10**, such as buttons, switches, draw sensors, pressure transducers, proximity sensors, touch sensors, voice recognition sensors, haptic controls, saliva and breath biosensors, and the like, and microcontroller **31** and, thus, can provide the means to relay user input commands from the user controls as instructions to microcontroller **31** to operate vape device **10**. For example, input interface circuit **34** may be electrically coupled to draw sensor **18** for receiving an on signal from draw sensor **18** when a user draws on mouthpiece **16**. When input interface circuit **34** receives the on signal from draw sensor **18**, it may send instructions to microcontroller **31** to activate atomizer **20**, provided that any other conditions necessary to activate atomizer **20** have been met, as described below. In some embodiments, output interface circuit **38** can provided the electrical interface between microcontroller **31** and output display devices, such as indicator lights, alphanumeric display screens, audio speakers, surface heaters, vibration devices, and any other forms of tactile feedback devices as well known to those skilled in the art, and, thus, can provide the means to relay information relating to the operation of vape device **10** from microcontroller **31** to the user.

[0165] In some embodiments, circuit board **30** can comprise radio frequency ("RF") transceiver circuit **36** to provide the means for wireless communication of data between vape device **10** and a personal computing device, such as computing device **72** as shown in FIG. **3**. In some embodiments, RF transceiver circuit **36** can be integral to circuit board **30** or can be disposed on a separate circuit board operatively connected to circuit board **30**. RF transceiver circuit **36** can be connected to one or more antennas **40** via electrical connection **52**, as well known to those skilled in the art. RF transceiver circuit **36** and the one or more antennas **40** comprise a wireless transceiver of vape device **10**.

[0166] In some embodiments, microcontroller **31** can comprise a microprocessor (which for purposes of this disclosure also incorporates any type of processor) having a central processing unit as well known to those skilled in the art, wherein the microprocessor can further comprise a memory configured for storing a series of instructions for operating the microprocessor in addition for storing data collected from sensors disposed on vape device **10** or data received by vape device **10** to control its operation, such as operational settings. Microcontroller **31** is in electrical communication with charger circuit **32**, user input interface circuit **34**, output interface circuit **38**, and RF transceiver circuit **36** for receiving instructions and/or data from and/or transmitting instructions and/or data to charger circuit **32**, user input interface circuit **34**, output interface circuit **38**, and RF transceiver circuit **36**. In some embodiments, atomizer **20** can be operatively and electrically connected to circuit board **30** via electrical connection **48**, which can provide the means to activate atomizer **20** (e.g., deliver electrical current from battery **42** to heating element **22**) when an activation mechanism such as draw sensor **18** sends an on signal to microcontroller **31**, as well as receiving data signals from draw sensor **18** and/or atomizer **20**. In this manner, the activation mechanism (i.e., draw sensor **18**) is coupled to the atomizer **20** indirectly through microcontroller **31**, and a direct connection between the activation mechanism and atomizer **20** is not required (i.e., activation mechanism sends a signal to microcontroller **31** that sends a signal to activate atomizer **20**). In one embodiment, draw sensor **18** may be electrically connected to connecting means **15**, which may operate in accordance with the two lead communication system described below in connection with vape device **4000**, so that signals from draw sensor **18** may be sent to microcontroller **31** through the two lead communication system. In addition to controlling operation of atomizer **20** based on a signal received from the activation mechanism, microcontroller **31** also controls operation of atomizer **20** based on the operational settings as described herein. In some embodiments, microcontroller **31** can be operatively connected to ID tag **28** via electrical connection **50**, which may be either a wired or wireless connection.

[0167] The operational settings referred to herein include any type of setting or instruction that instructs the vape device **10** or certain components of the vape device **10** to operate or not operate in a particular manner. Specifically, operational settings of the vape device **10** include a duty cycle setting, a temperature setting, an operational time duration, a dosage setting, and a security setting. The duty cycle setting preferably corresponds to a pulse width modulation instruction transmitted from microcontroller **31** to battery **42** to send electrical current to heating element **22** in a particular desired manner. The temperature setting preferably corresponds to a temperature instruction transmitted from microcontroller **31** to battery **42** to send electrical current to heating element **22** to maintain heating element **22** at a desired temperature or range of temperatures. A temperature sensor may be coupled to microcontroller **31** to measure the actual temperature of heating element **22** and transmit that information to microcontroller **31** for determination on the amount and duration of electrical current that needs to be sent to heating element **22** to maintain a particular temperature or range of temperatures. Any portion of the cartridge, including mouthpiece assembly **12**, atomizer assembly **19**, and payload assembly **24**, may also include the integrated temperature control system described below in connection with vape device **4200** to regulate the temperature of heating element **22**. The operational time duration preferably corresponds to a time instruction transmitted from microcontroller **31** to battery **42** to maintain heating element **22** at a temperature suitable for vaporization of the contents of payload reservoir **26** for a desired time. The dosage setting preferably corresponds to a dosage instruction transmitted from microcontroller **31** to battery **42** that powers down heating element **22** when a desired volume of vapor passes through atomizer **20**. A vapor metering device may measure the volume of vapor passing through atomizer **20** and transmit that information to microcontroller **31**, which compares the actual volume passed through atomizer **20** to the dosage setting to determine when to shut off heating element **22**. The vapor metering device may be positioned between the atomizer **20** and the mouthpiece **16** to measure the vaporized payload exiting mouthpiece **16**. The vapor metering device may incorporate the capacitive vapor measurement system described below in connection with vape device **3100**. The security setting preferably corresponds to a security instruction that causes microcontroller **31** to prevent operation of atomizer **20** when an event has or has not occurred. Security settings described herein that would prevent operation of atomizer **20** include a payload reservoir **26** that is tampered with or stolen, a payload reservoir **26** that has been returned to a return center (e.g., to recycle payload reservoir **26** and/or its associated cartridge), a payload reservoir **26** that has been recalled, a payload reservoir **26** that has been depleted, a control assembly that is not authorized for use with payload reservoir **26**, an unauthorized user (e.g., a user who does not have a valid prescription for the substance within payload reservoir **26**, or a user who is not identified as owning or having valid rights to use payload reservoir **26**), a user that is in a location that does not permit use of vape device **10**, a user that is traveling in a vehicle, a user that has exceeded his/her permitted usage of the substance in payload reservoir **26** within a particular time frame, and any other security setting described herein or reason why vape device **10** is rendered inoperable as described herein.

[0168] In some embodiments, ID tag **28** and/or microcontroller **31**, along with appropriate sensors, can also be used as part of a system for gathering data relating to the use of vape device **10** by the user by monitoring that can include, without limitation, historical vape device usage information, such as how many times vape device **10** is used during a given period of time (hour, day, week, etc.), the duration of each use of vape device **10**, how many draws the user takes on vape device **10**, the strength of those draws, the amount of payload consumed during each use of vape device **10**, and other information as described herein. The historical vape device usage information is stored in a database in association with the payload identifier, as described below. In some embodiments, the historical vape device usage information can be used as clinical data for determining whether the user is consuming the right amount of medicine to be vaporized and inhaled and at the right times of day. The information can be used to provide feedback to the user in terms of whether the user should consume medicine more frequently or less frequently throughout the day and/or to increase or decrease the amount of medicine consumed per usage overall or per usage at particular times of the day. In some embodiments, the information collected about the user's consumption of a cannabis liquid or oil payload with vape device **10** can be used to estimate the user's intoxication or impairment based on the user's physical characteristics and the amount of cannabis liquid or oil payload consumed. This estimation can be relayed to the user as a means to inform the user as to whether the user is too intoxicated or impaired to operate a motor vehicle or to operate tools or machinery, as an example.

Second Embodiment of Vape Device

[0169] Referring to FIG. **2**, another embodiment of vape device **100** is shown. In some embodiments, vape device **100** can comprise control assembly **14**, atomizer assembly **79** and mouthpiece assembly **88** operatively coupled together in that order using mechanical connection means **56** to join the subassemblies together. Mechanical connection means **56** can comprise one or more of threaded connection means, magnetic connection means and friction or press-fit connection means, and any of the connection means **15** described above, including 510 threaded connectors. In some embodiments, mouthpiece assembly **88** can comprise a mouthpiece **58** in communication with the outlet of atomizer **20** via conduit **60**. Mouthpiece assembly **88** can further comprise a payload reservoir **62** that can be filled with a payload **64** that may be liquid or oil. The payload **64** can flow from payload reservoir **62** to inlet **21** of atomizer **20** via one or more valves **68**. In some embodiments, mouthpiece assembly **88** can comprise ID tag **28** and an oil gauge **66**, which can be configured to monitor the volume of payload **64** in payload reservoir **62** and relay that information to microcontroller **31**. In this embodiment, mouthpiece assembly **88** can be a consumable element that can be replaced as a complete subassembly once depleted, or simply interchanged with another mouthpiece assembly **88** containing a different payload **64** for consumption, depending on the needs and wants of the user. In some embodiments, oil gauge **66** can simply be a sight glass disposed on mouthpiece assembly **88** to provide a visual indicator to the user as to the amount of payload remaining therein. Atomizer assembly **79** is preferably configured to prevent air-lock and/or clogging with thick, undiluted payloads.

[0170] In some embodiments, atomizer assembly **79** can also be a replaceable subcomponent of vape device **100** if and when atomizer **20** becomes damaged or simply ceases to work any further. In some embodiments, control assembly **14** can comprise sensors **70** electrically coupled to input interface circuit **34** along with user input buttons and controls (not shown) disposed on vape device **10** in addition to draw sensor **18**, as described above and shown in FIG. **1**. The sensors **70** may include the capacitive vapor measurement system, or portions thereof, described below in connection with vape device **3100** and/or the integrated temperature control system described below in connection with vape device **4200** and may be positioned anywhere in vape device **10**.

[0171] Control assembly **14** of vape device **100** is preferably substantially similar to control assembly **14** of vape device **10**. Atomizer **20** of vape device **100** is preferably substantially similar to atomizer **20** of vape device **10**, and may include alternative means for vaporizing a payload other than a heating element as described above in connection with vape device **10**. It is within the scope of the invention for atomizer assembly **79** and mouthpiece assembly **88** to be formed integrally within a common housing that is releasably connected to control assembly **14**. Further, it is within the scope of the invention for control assembly **14** and atomizer assembly **79** to be formed integrally within a common housing that is releasably connected to mouthpiece assembly **88**. It is also within the scope of the invention for atomizer assembly **79**, mouthpiece assembly **88**, and control assembly **14** to be formed integrally within a common housing.

Vape Device Application

[0172] Referring to FIG. **3**, a vape device system **102** includes vape device **10** and computing device **72** running application **74** thereon. It is understood that computing device **72** includes a processor **94** that runs application **74**, and that references herein to computing device **72** include its processor **94**. Vape device **100** and vape device **2800** (described below) may also be operated with computing device **72** in the same manner as described below with respect to vape device **10**. In some embodiments, vape device **10** can wirelessly communicate with computing device **72** and application **74** via RF communications link **73**. In some embodiments, RF communications link **73** can comprise one or more of Bluetooth™ communications protocol, Wi-Fi™ IEEE 802 communications protocol, Zigbee IEEE 802.15.4-based protocol, and any other RF, short-range, and long-range communications protocol as well known to those skilled in the art. Vape device **10** may also communicate with computing device **72** via a wired connection established for example between electrical connector **35** of vape device **10** and a communications connector (not shown) of computing device **72**.

[0173] In some embodiments, application **74** can present a visual "dashboard" **75** comprising visual information and controls that can be operated by a user. In some embodiments, dashboard **75** can comprise user information window **76** for displaying information regarding the operation of vape device **10** in addition to general information. This general information can include general news as well as information on available updates for vape device **10** or the application **74** from the manufacturer or supplier of the same.

[0174] In some embodiments, dashboard **75** can comprise a locate button **78** as a means for the user to determine the location of vape device **10** should the user misplace it. By pressing locate button **78**, computing device **72** can send a signal wirelessly to vape device **10** to operate an audible signal from an audio speaker or buzzer or other like device disposed thereon to assist the user in finding vape device **10**. In other embodiments, pressing locate button **78** can assist the user to determine his or her geographic location (using geographic location capabilities of computing device **72**) and whether cannabis products can be consumed using vape device **10** in that location (e.g., whether there are any governmental regulations, laws, or rules applicable to or enforceable in the geographic area where vape device **10** is located that may subject the user of vape device **10** to criminal or administrative penalties, fines, or enforcement actions). In some embodiments, dashboard **75** can comprise heat swipe button **80** as a means for the user to manually control the heat used to vaporize payload **64**, wherein the signal transmitted by application **74** to vape device **10** to control the heat can be included in the operational settings. In some embodiments, dashboard **75** can comprise lock indicator **82**, unlock indicator **84** and swipe button **86** as a means to enable and disable vape device **10** by the user swiping swipe button **86** right or left, respectively.

[0175] In some embodiments, the application **74** can access an online source of data to update the database (described below) or otherwise process information, which can be done periodically and/or automatically, or manually by the user prompting the application to update the data, or a combination of both processes. As described below, the online source of data may include operational settings for a plurality of vape devices **10** and substances contained with payload reservoirs **26**. The online source of data may also include a list of payload identifiers that have been stolen, a list of payload identifiers that have been recalled, and/or a list of payload identifiers that have been returned to a return center (e.g., for recycling). In addition, the online source of data may include a list of control assemblies that are authorized for use with each payload reservoir **26**. In one embodiment, each control assembly is identified by a control assembly identifier, and the online source of data comprises a list of control assembly identifiers for control assemblies that are authorized for use with each payload reservoir **26**.

Database

[0176] In some embodiments, a database is provided that stores the unique payload identifiers for a plurality of payload reservoirs and associates each of the unique payload identifiers with specific operational settings and/or secondary data. The secondary data may comprise, for example, user information, authentication information, prescription information, payload information, historical usage information (including historical vape device usage information and historical payload reservoir information), recall information, return information, and control assembly information, as described below. Of course, it should be understood that the database may store any combination of operational settings and secondary data as required for a particular application.

[0177] User information can include, but is not limited to, various physiological characteristics, such as a user's height, weight, age, gender, medical record and histories, and medical conditions.

[0178] User information can also include demographic information, such as a user's employer, employment history, educational history, criminal history, and the like. Not only can such user information be used for controlling operational settings of the vape device **10**, but demographic information can be used to display targeted content, advertisements, and material on the dashboard **75** and/or user information window **76**.

[0179] User information can be retrieved from, for example, third-party health, fitness, and social networking software applications on the computing device **72**, such as Facebook®, LinkedIn®, Snapchat®, Twitter®, and/or Fitbit®. In addition, user information can be retrieved by application **74** or a remote computing device from third-party databases, such as health information databases, medical records databases, health insurance company databases, crime databases, legal and court databases, and the like. Further, user information can be entered into the application **74** and/or vape device **10** (via, e.g., user input devices coupled to user input interface circuit **34**) by the user.

[0180] Authentication information can include a password or passcode, a fingerprint scan, a facial recognition scan, a retinal scan, or any other type of biometric information that can be used to identify a user. Authentication information can be entered into the application **74** and/or vape device **10** (via, e.g., user input devices coupled to user input interface circuit **34**) by the user.

[0181] Prescription information can be retrieved from, for example, pharmacy and dispensary databases, as well as from physicians, pharmacists, and others licensed to write and/or manage prescriptions. The prescription information preferably includes whether a particular user has a valid, unexpired prescription to use the substance within payload reservoir **26**.

[0182] Payload information may include an identification of the particular substance located within a payload reservoir **26** and the original volume of the substance located within payload reservoir **26**.

[0183] Historical usage information may include information associated with use of the vape device **10** (historical vape device usage information) and/or information associated with use of the payload reservoir **26** (historical payload reservoir information). The historical vape device usage information can include, but is not limited to, the number of prior sessions during which the vape device **10** was used, user information related to prior sessions, durations of prior sessions, operational settings of prior sessions, metering and dose information of prior sessions, and the like. The historical payload reservoir information can include details related to the payload reservoir **26**, such as the original payload contents, remaining contents, used contents, content usage by session, and the like.

[0184] Recall information may include information indicating that payload reservoir **26** has been recalled. Return information may include information indicating that payload reservoir **26** has been returned to a return center (e.g., for recycling). Control assembly information may include information on control assemblies that are authorized for use with payload reservoir **26**. In one embodiment, each control assembly is identified by a control assembly identifier, and the control assembly information comprises a list of control assembly identifiers for control assemblies that are authorized for use with payload reservoir **26**.

[0185] It should be understood that the database may be maintained in memory of computing device **72** that is accessible by application **74**, in memory of microcontroller **31**, and/or in an external memory remote from vape device **10** and computing device **72** that is accessible via a global telecommunications network **92**. Any type of relational database software may be used to maintain the data in the applicable memory, such as the Microsoft Access® software sold by Microsoft Corporation, the Oracle® software sold by Oracle Corporation, or the SQL software sold by Sybase, Inc. Of course, other database software may also be used as is known to those skilled in the art.

Method of Using Vape Device

[0186] Referring to FIG. **4**, steps in accordance with one exemplary method for operating and controlling vape device **10** and **100** are shown. Although the method is described below in connection with vape device **10**, the method may also be used with vape device **100** and vape device **2800** (described below). When used in accordance with the method described herein, vape device **2800** preferably includes an ID tag **28** with a unique payload identifier. The method may be carried out by vape device **10** in connection with application **74** running on computing device **72**, shown in FIG. **3**. The method may start at step **402** with vape device **10** in a default, locked state, meaning, it cannot be operated. When a user gains access to their computing device **72** at step **404**, the computing device **72** can confirm the user's identification (e.g., by the user entering a password, passcode, or biometric authentication) so as to be able to move to step **406**, where the computing device **72** can open the application **74** and then communicate with vape device **10** to poll for the unique payload identifier of ID tag **28**. The application **74** may also be used to authenticate the user prior to transmission of the payload identifier to the computing device **72**. At step **408**, vape device **10** can, upon being polled by the computing device **72**, read ID tag **28** and then transmit the payload identifier to the computing device **72**. Specifically, in one embodiment, microcontroller **31** of vape device **10** receives the payload identifier from ID tag **28**, transmits the payload identifier to the wireless transceiver (i.e., RF transceiver circuit **36** and antenna(s) **40**), and the antenna(s) **40** transmit the payload identifier to computing device **72**.

[0187] In step **410**, the application **74** can utilize the payload identifier of ID tag **28**, and optionally, secondary data, to determine the vaporizing or operational settings associated with the payload identifier of ID tag **28**, and optionally, as well as in light of the secondary data. As described above, computing device **72** can alternatively transmit the unique payload identifier to a remote computing device at a central server or in the cloud. The remote computing device may maintain a database of operational settings that are associated with each unique payload identifier and tailored to the particular substance located in the payload reservoir **26** and the particular user using the payload reservoir **26**. The remote computing device may then send the operational settings and identification of the specific substance within the payload reservoir **26** back to the computing device **72**. In some embodiments, the application **74** proceeds to step **412** and transmits the operational settings to vape device **10**. Specifically, in one embodiment, a wireless transceiver of computing device **72** transmits the operational settings to the antenna(s) **40** and RF transceiver circuit **36** of vape device, which transmits the operational settings to the microprocessor of microcontroller **31**. In step **414**, the microcontroller **31** in the vape device **10** then operates and controls the vape device **10** based on the operational settings.

[0188] In other embodiments, the application **74** proceeds to step **416** instead of step **414**, whereupon the application **74** can confirm whether the user is authorized to use vape device **10**. Application **74** can utilize any combination of secondary data (e.g., user information, prescription information, location information, payload information, historical vape device usage information, and historical payload reservoir information) and the payload identifier in order to determine if the user is authorized to use the vape device **10**. For example, application **74** can use secondary data such as prescription information, as well as payload information indicating the contents of the payload reservoir **26**, to determine if the prescription associated with the prescription information allows the user to access the payload contents within payload reservoir **26**. In yet another example, application **74** can utilize user information such as gender, age, and weight, as well as historical vape device usage information, to determine an appropriate dosage and/or metering of the vape device **10**.

[0189] If the user is so authorized, the application **74** can further determine whether payload reservoir **26** (in FIG. **1**) or mouthpiece assembly **88** (in FIG. **2**) is genuine and not a counterfeit or, optionally, whether it is stolen or otherwise not authorized for use by the user (e.g., the application **74** may compare the payload identifier to payload information that indicates whether the payload reservoir **26** or mouthpiece assembly **88** has been reported as tampered with or stolen). If genuine and not stolen, then the application **74** can proceed to step **412** where the operational settings can be transmitted to vape device **10** and the user is subsequently allowed to operate vape device **10** in step **414**. If not genuine or stolen, the application **74** can lock vape device **10** to prevent its use.

[0190] In other embodiments, the application **74** proceeds from step **416** to step **418**, instead of proceeding to step **414**. In step **418**, the application **74** can determine the geographic location of vape device **10** and whether the payload in vape device **10** can be consumed in that location by comparing the geographic location to location information obtained by the application **74**. If the payload in vape device **10** can be consumed in the location of vape device **10**, the application **74** can proceed to step **412** where the operational settings can be transmitted to vape device **10**, and the user is subsequently allowed to operate vape device **10** in step **414**.

If the payload in vape device **10** cannot be consumed in the location of vape device **10**, the application **74** can lock vape device **10** to prevent its use.

[0191] In other embodiments, the application **74** proceeds to step **420** where a permitted duration of time that the vape device **10** can be used is determined. The permitted duration of time can be determined based on any combination of secondary data (e.g., user information, prescription information, location information, payload information, historical vape device usage information, and historical payload reservoir information) and/or the payload identifier. The permitted duration of time can be transmitted to the vape device as an operational setting in step **412**. Once the operational settings are received by vape device **10** at step **414**, vape device **10** can implement these operational settings to vaporize the payload contained therein accordingly. In this embodiment, vape device **10** can unlock for use by the user in accordance with the received operational settings. In addition, the vape device **10** can be locked in step **402** after the permitted duration of time or usage has expired.

[0192] In addition, after the vape device **10** is operated in step **414**, vape device **10**, either via the microcontroller **31** and/or the application **74**, can be locked in step **402** after use, after a predetermined duration, after being deactivated by the user, after the payload reservoir **26** is deemed or calculated to be empty or used, after a new user has been detected, and/or for any other reason that vape device **10** may be locked as described herein.

[0193] In one embodiment, the method shown in FIG. **4** may be carried out by vape device **10** running application **74**, or an application similar thereto, on the microprocessor of microcontroller **31** without use of computing device **72**. In such an embodiment, step **402** remains the same as described above. Step **404** may be modified so that user information is inputted into vape device **10** to determine whether the user is an approved user of vape device **10** and the contents of payload reservoir **26**. Steps **406** and **408** may be omitted, or optionally, step **408** may comprise the microprocessor of microcontroller **31** receiving the payload identifier from ID tag **28**. In step **410**, operational settings are determined based on the payload identifier and/or the secondary data as described above but they are determined by the microprocessor of microcontroller **31** of vape device **10**. Step **412** is omitted as the operational settings are already contained on vape device **10**. Step **414** proceeds as described above. Optional steps **416**, **418**, and **420** may proceed as described above but with an application running on the microprocessor of microcontroller **31** carrying out the steps. The method may also include operating the vape devices **10** and **100** in accordance with the system and method for optimizing vaporization described below.

[0194] In yet another embodiment, the computing device **72** is integrated within, or physically coupled to, the vape device **10**. In this embodiment, the payload identifier can be transmitted to the computing device **72** via an electrical connection between the payload reservoir **26** and the integral computing device **72**. Similarly, the computing device **72** can transmit the operational settings via the electrical connection to the microcontroller **31**. In yet another embodiment, the integral computing device **72** can include a wireless transceiver, or an optical transceiver, and can operate as in the remote computing device embodiments described herein.

[0195] In some embodiments, vape devices **10** and **100** can comprise security settings to prevent unauthorized use of the vape devices by anyone other than the owner of the vape devices who has a prescription for medical marijuana. In some embodiments, the security settings can prevent the use of the vape devices in regions or jurisdictions, even by the rightful owner of the vape devices, where the consumption of medical marijuana is not authorized or legal. These security settings can be implemented to appease government or law enforcement for unauthorized use of the vape devices in the consumption of cannabis products, for medical purposes or otherwise.

[0196] In another embodiment, application **74** and/or vape device **10** can utilize acceleration, motion, altitude, and/or velocity sensors to determine if the user is within, for example, a moving vehicle or airplane. Such information can be used by application **74** and/or vape device **10** to restrict access to, or lock, the vape device **10**. Sensors **70** such as accelerometers, altimeters, gyroscopes, and velocity sensors may be integrated with the vape device **10** and/or the computing device **72**.

[0197] Of course, it should be understood that the invention is not limited to the exemplary method for operating and controlling a vape device as described above in connection with FIG. **4**, and that other steps and combinations of steps for operating and controlling a vape device using a computing device running application **74** may be used.

[0198] In some embodiments, computing device **72** runs an application **74** comprising a set of instructions stored in the memory of computing device **72** and executable by the processor of computing device **72** to perform the processes described herein. Application **74** causes computing device **72** to retrieve the unique payload identifier, wherein the unique payload identifier and any combination of operational settings and secondary data stored in the database in association with the unique payload identifier, as described above, are used to modify, determine, adjust, or otherwise control the operational settings of, and access to, the vape device. In these embodiments, the database may be maintained in memory of computing device **72** that is accessible by application **74** and/or in an external memory remote from the vape device and computing device **72** that is accessible via a global telecommunications network **92**.

[0199] In other embodiments, computing device **72** can retrieve the unique payload identifier from the vape device and transmit the unique payload identifier to a remote computing device via global telecommunications network **92**, such as a computing device located at a central server or in the cloud. The remote computing device runs an application comprising a set of instructions stored in the memory of the remote computing device and executable by the processor of the remote computing device to perform the processes described herein. The remote computing device utilizes the unique payload identifier and any combination of operational settings and secondary data stored in the database in association with the unique payload identifier, as described above, in order to determine the operational and/or security settings for the vape device and transmit the operational and/or security settings back to computing device **72**.

[0200] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine the operational settings of the vape device. In one embodiment, upon receipt of the unique payload identifier, the application can retrieve operational settings stored in association with the unique payload identifier in the database. The operational settings comprise operational settings for the vape device to vaporize the specific payload contained in the payload reservoir identified by the unique payload identifier as per the recommended settings from the manufacturer of the payload and/or vape device. In another embodiment, upon receipt of the unique payload identifier, the application can retrieve payload information stored in association with the unique payload identifier in the database. The payload information can include an identification of the substance contained in the payload reservoir identified by the unique payload identifier, and the application can access the operational settings associated with that substance via a connection to an online source of data. In another embodiment, the application can access the online source of data to update the operational settings stored in the database, which can be done periodically and automatically, or manually by the user prompting the application to update the data, or a combination of both processes. The operational settings (whether stored in the database or accessed via a connection to an online source of data) may be updated by the manufacturer or provider of the payload reservoir or vape device when new information is learned about the specific substance.

[0201] Once the operational settings have been determined as described above, the application causes transmission of the operational settings to the vape device whereby the vape device operates in accordance with the operational settings. Preferably, the vape device checks for new operational settings each time a user uses the vape device so that if the operational settings have been updated, the vape device operates in accordance with the updated operational settings. In this manner, a manufacturer or provider of the payload reservoir or vape device may update operational settings for a specific substance and specific payload reservoirs and be ensured that they will take effect for any future usage of the particular substance and payload reservoirs affected.

[0202] In some embodiments, application **74** running on computing device **72** can use the unique payload identifier as a means to determine if the person in possession of the vape device and computing device **72** is an authorized user.

[0203] In one embodiment, application **74** can request the user to input user authentication information, such as a password, a fingerprint scan, a facial recognition scan, a retinal scan, or other biometric information. Upon receipt of the unique payload identifier, application **74** can retrieve authentication information stored in association with the unique payload identifier in the database. Application **74** can then compare the user authentication information input by the user with the authentication information stored in the database and generate, based on the comparison, a security setting indicating whether the user who input the user authentication information is authorized to use the payload reservoir identified by the unique payload identifier. Application **74** can then cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the user who input the user authentication information is not authorized to use the payload reservoir identified by the unique payload identifier. However, operation of the vape device is allowed if the security setting indicates that the user who input the user authentication information is authorized to use the payload reservoir identified by the unique payload identifier.

[0204] In another embodiment, the vape device can be unlocked when the user opens his/her personal computing device **72** and satisfies the device's general security settings, that is, by the user entering his/her security access code or password into the personal computing device, or by using a fingerprint scanner disposed on the personal computing device, or by using a camera disposed on the device for facial or retinal scans of the user, as well known to those skilled in the art. If the person in possession of computing device **72** and the vape device is permitted to open up applications on computing device **72** and, thus, access application **74**, application **74** can send an enable signal to the vape device to poll for the unique payload identifier and allow the vape device to operate, provided that all other factors or conditions to allow operation of the vape device have been met. When computing device **72** "goes to sleep," is turned off or powers down due to a low battery charge condition, as well known to those skilled in the art, application **74** can send a disable signal to the vape device, to prevent the vape device from operating. Also, when the vape device and computing device **72** are separated by a predetermined physical distance, the vape device can turn off or become disabled until it receives an enable signal from computing device **72**. In some embodiments, application **74** can require the input of a password by the user, in addition to any password to be entered or other security measure required by computing device **72**, to open up and enable operation of application **74** and, thus, operation of the vape device. If the user can enter the correct password into application **74**, then application **74** can send an enable signal to the vape device to poll for the unique payload identifier. Otherwise, while application **74** is closed, application **74** can send a disable signal to the vape device to disable it.

[0205] In yet another embodiment, application **74** can compare user information associated with the unique payload identifier (e.g., one or more particular users that can or cannot use the substance within the payload reservoir) with application user information that a user provides to application **74** to determine whether the user of application **74** is permitted to operate the vape device and use the particular payload reservoir.

[0206] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine if the payload can be consumed in the geographic region, location, country, state, or municipality where the user is located. In these embodiments, the application can access the global positioning system ("GPS") features that computing device **72** can possess to determine the physical location of computing device **72** and, thus, of its user. In other embodiments, computing device **72** can use cell tower triangulation techniques or other cell phone location techniques, as well known to those skilled in the art, to determine its geographical location.

[0207] Upon receipt of the unique payload identifier, the application can retrieve payload information stored in association with the unique payload identifier in the database. The application can then determine if the substance identified in the payload information can be legally consumed in the location of the user (i.e., the location of computing device **72**). In one embodiment, this determination is made by comparing the geographic location of computing device **72** with a database of location information (that may be stored on computing device **72** or a remote computing device) to determine whether the user may legally consume the substance in that location. The application can then generate, based on the comparison, a security setting indicating whether the substance identified by the unique payload identifier can be legally consumed in the location of computing device **72**. The application can then cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the substance identified by the unique payload identifier cannot be legally consumed in the location of computing device **72** (because its usage would violate laws or regulations or for any other reason). However, operation of the vape device is allowed if the security setting indicates that the substance identified by the unique payload identifier can be legally consumed in the location of computing device **72**.

[0208] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine if a payload reservoir has been recalled, e.g., if a recall has been issued for the substance contained in the payload reservoir. In one embodiment, the application makes this determination by retrieving recall information stored in association with the unique payload identifier in the database, wherein the recall information indicates whether the payload reservoir has been recalled. In another embodiment, the application makes this determination by accessing an online source of data that identifies the payload reservoirs that have been recalled (or alternatively, the substances that have been recalled, which can be compared to the payload information stored in association with the unique payload identifier in the database). The application can then generate a security setting indicating whether the payload reservoir has been recalled and cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the payload reservoir has been recalled. However, operation of the vape device is allowed if the security setting indicates that the payload reservoir has not been recalled. This security feature also enables the display of a recall message and/or the sounding of an audible recall message on computing device **72** and/or the vape device itself. Of course, these recall messages would not be required if the payload reservoir was depleted, as described below.

[0209] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine if a payload reservoir has been returned to a return center, e.g., for recycling of a cartridge or payload reservoir. In one embodiment, the application makes this determination by retrieving return information stored in association with the unique payload identifier in the database, wherein the return information indicates whether the payload reservoir has been returned. In another embodiment, the application makes this determination by accessing an online source of data that identifies the payload reservoirs that have been returned. The application can then generate a security setting indicating whether the payload reservoir has been returned and cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the payload reservoir has been returned. However, operation of the vape device is allowed if the security setting indicates that the payload reservoir has not been returned.

[0210] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine if a payload reservoir has been stolen. In one embodiment, the application makes this determination by retrieving information stored in association with the unique payload identifier in the database, wherein the information indicates whether the payload reservoir has been stolen. In another embodiment, the application makes this determination by accessing an online source of data that identifies the payload reservoirs that have been stolen. The application can then generate a security setting indicating whether the payload reservoir has been stolen and cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the payload reservoir has been stolen. However, operation of the vape device is allowed if the security setting indicates that the payload reservoir has not been stolen.

[0211] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine if a control assembly of the vape device is authorized for use with the payload reservoir contained in a cartridge of the vape device. In one embodiment, the application makes this determination by receiving a control assembly identifier for the control assembly of the vape device (which may be stored in the microcontroller of the control assembly and transmitted to the computing device **72** along with the unique payload identifier). In one embodiment, the control assembly identifier comprises a unique control assembly identifier, but this is optional and not required. The application then identifies a list of one or more control assembly identifiers for control assemblies that are authorized for use with the payload reservoir identified by the unique identifier. The application then compares the received control assembly identifier with the list of control assembly identifiers and, based on this comparison, generates a security setting indicating whether the control assembly identified by the received control assembly identifier is authorized for use with the payload reservoir identified by the received unique payload identifier. The application can then cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the control assembly identified by the control assembly identifier is not authorized for use with the payload reservoir identified by the unique payload identifier. However, operation of the vape device is allowed if the security setting indicates that if the security setting indicates that the control assembly identified by the control assembly identifier is authorized for use with the payload reservoir identified by the unique payload identifier.

[0212] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine whether the user of the vape device has a prescription for vaporizing the payload contained in the payload reservoir. In one embodiment, the application makes this determination by retrieving and analyzing user information and/or prescription information stored in association with the unique payload identifier in the database. The application can then generate a security setting indicating whether the user has a valid prescription for vaporizing the payload contained in the payload reservoir and cause transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the user does not have a valid prescription for vaporizing the payload contained in the payload reservoir. However, operation of the vape device is allowed if the security setting indicates that the user has a valid prescription for vaporizing the payload contained in the payload reservoir. Preferably, the prescription information is updated in the database when a user's prescription has changed.

[0213] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine whether the payload reservoir is depleted. In one embodiment, the application makes this determination by retrieving and analyzing payload information and historical payload reservoir usage information stored in association with the unique payload identifier in the database. The payload information includes the original volume of payload contained within the payload reservoir. The historical payload reservoir usage information is updated based on payload reservoir usage information obtained from the vape device, as described above. The application analyzes the payload information and the historical payload reservoir usage information to determine if the payload reservoir is depleted, e.g., if the current calculated volume of payload is below a predetermined threshold. The application then generates a security setting indicating whether the payload reservoir is depleted and causes transmission of the security setting (e.g., an enable or disable control signal) to the vape device. Operation of the vape device is prevented if the security setting indicates that the payload reservoir is depleted. However, operation of the vape device is allowed if the security setting indicates that the payload reservoir is not depleted. This security feature prevents the operation of vape devices with counterfeit payload reservoirs (e.g., a payload reservoir with the same unique identifier as a valid payload reservoir) or vape devices in which the payload reservoirs have been refilled without authorization. This security feature also prevents a user from dry vaping (i.e., inhaling without any payload in the payload reservoir), which provides improved consumer health.

[0214] In some embodiments, the application (whether application **74** running on computing device **72** or an application running on the remote computing device) can use the unique payload identifier as a means to determine when the payload reservoir is nearly empty of payload. In one embodiment, the application makes this determination by retrieving and analyzing payload information and historical payload reservoir usage information stored in association with the unique payload identifier in the database. The payload information includes the original volume of payload contained within the payload reservoir. The historical payload reservoir usage information is updated based on payload reservoir usage information obtained from the vape device, as described above. The application analyzes the payload information and the historical payload reservoir usage information to determine when the payload reservoir is nearly empty of payload. When this occurs, the application can alert the user to replace or order a new cartridge and/or automatically order a replacement cartridge.

[0215] In some embodiments, vape devices **10** and **100** can comprise a disposable or single-use version with reduced functionality but adapted from higher quality embodiments thereof.

[0216] In some embodiments, vape devices **10** and **100** can comprise a traditional "cigarette appearance" while other embodiments can comprise a non-cigarette appearance.

[0217] In some embodiments, vape devices **10** and **100** can comprise a light to emulate the ember of a cigarette when vapor is being inhaled.

[0218] In some embodiments, vape devices **10** and **100**, in combination with application **74** running on personal computing device **72**, can control the temperature and/or duty cycle of vaporization to optimize for flavor or vapor quantity for any given type of payload to be vaporized for inhalation. In some embodiments, the application **74** can be used to improve the efficiency of the operation of the vape devices **10** and **100** and to maximize the longevity of a fluid or oil-filled cartridge or payload reservoir **26** used in the vape devices.

[0219] In some embodiments, the application **74** can include features to customize a user's vape device **10** or **100**, such as naming the vape device, selecting its color and controlling a vibrating device disposed in the vape device. In some embodiments, the application **74** can include security settings to control access to the vape devices **10** and **100**, and to lock them when not in use.

[0220] In some embodiments, vape devices **10** and **100** can comprise a processor (i.e., such as included within microcontroller **31**) operating on firmware disposed thereon. Connectivity between the vape devices **10** and **100** and the application **74** disposed on the personal computing device **72** can enable means for updating the firmware on the vape devices to keep them operating on the most current firmware. In some embodiments, the vape devices can comprise a physical configuration that can be adapted to display an OEM brand or sub-brand depending on the brand, the sales channel for the branded vape device, and the vape devices' anticipated end use such as medical, recreational, etc.

[0221] In some embodiments, vape devices **10** and **100** will be used with high quality oil products that cannot leak from the vape devices. The vape devices will avoid producing stale vapor by precise temperature control, quick cooling and providing a fast path for vapor to be inhaled from the vape devices.

[0222] In some embodiments, vape devices **10** and **100** can comprise a battery **42** as a power source for vaporizing a payload. The battery **42** can comprise a lithium ion power cell although other battery technologies can be used, as well known to those skilled in the art. As the vape devices are personal use devices, the battery **42** can comprise technology that prevents the advent of an explosion should the battery fail.

[0223] In some embodiments, vape devices **10** and **100** can be configured not to contain or use propylene glycol

("PG") or other non-essential chemicals anywhere, whether in the oils used in the vape devices or on materials used in the manufacture thereof.

[0224] In some embodiments, vape devices **10** and **100** can comprise means for preventing them from overheating.

[0225] In some embodiments, vape devices **10** and **100** can comprise means for preventing them from producing latent odors or smells. Vape devices **10** and **100** can further be configured to produce vapor that can be seen when it is exhaled by a user.

[0226] In some embodiments, vape devices **10** and **100** can be configured to enable viewing of the payload in a cartridge or payload reservoir **26** when it is inserted or attached to the vape devices. In other embodiments, the vape devices can be configured so that the payload in the cartridge is not visible when the cartridge is inserted into the vape devices.

[0227] In some embodiments, vape devices **10** and **100** can be configured to be water-resistant or water-proof.

[0228] In some embodiments, cartridges for use with the vape devices **10** and **100** can be separated from the vape devices, and can be available in various sizes in terms of the amount of payload they can contain.

[0229] In some embodiments, vape devices **10** and **100** can comprise means for acquiring data on a cartridge based on the serial number of the cartridge that can be used to control the operation of the vape device. For example, the vape device can acquire certain data specific to the payload in the cartridge to know the manufacturer-recommended temperature and/or duty cycle for heating the payload in order to achieve optimum vaporization. In some embodiments, the vape devices can comprise means for enabling the user to alter one or more operational settings of the vape devices to suit the user's personal preferences. In some embodiments, the vape devices can comprise means for tracking of data relating to the operation of the vape devices and their use by a user. In some embodiments, the vape devices can be configured to provide warnings in the advent of certain conditions of the vape devices, such as when the cartridge is almost empty, when the battery is nearly depleted, when the heating element is overheating or non-functioning to name but a few. In some embodiments, the vape devices can comprise means for monitoring and collecting data on how the vape devices are being used by a user, and to provide information and assessments about the way the user uses the vape devices in addition to being able to provide advice to the user on how to improve or optimize their use of the vape devices based on the user's current use of the vape devices.

[0230] In some embodiments, vape devices **10** and **100** can be configured for exchanging data with other personal computing devices **72** that a user may use or possess, such as a smart phone or device (like an iPhone® or Apple® Watch®) or a fitness tracking wristband (like a Fitbit®) to provide the user with further information on their life and habits.

[0231] In some embodiments, vape devices **10** and **100** can comprise means for locating them should they become lost. This can include means for communicating with a smart phone or device to provide similar functionality as the Find iPhone™ app as used on Apple® iPhones® and iPads®.

[0232] In some embodiments, vape devices **10** and **100** can be configured for communicating with an application **74** running on a smart phone or personal computing device **72**, wherein the app can comprise the ability to adjust the temperature and/or duty cycle the heating element **22** operates at, as well as being able to control the operation of the vape devices for users of various experience. As an example, the application **74** can enable an anti-cough setting on the vape devices for a novice user.

[0233] Vape devices **10** and **100** can preferably communicate with smart phones or devices and operate in conjunction with applications running thereon to control and monitor the use of the vape devices by a user, as described above. In some embodiments, the application **74** can be configured to acquire specific information on the payload being vaporized based on the serial number of the cartridge. This information can then be used to control or meter the dose of vapor inhaled by the user.

[0234] In some embodiments, vape devices **10** and **100** can be locked and unlocked by the user with their personal computing device **72**. In some embodiments, the vape devices can be configured to be child-resistant, as well as prevent use by an unauthorized user. In some embodiments, the vape devices can be configured to lock inherently when not connected to the application **74** for regulatory purposes. In some embodiments, the vape devices can further comprise means for identifying an authorized user when connectivity with the user's smart phone or device is lost, such as when the user does not have their smart phone or device, or when the battery in the smart phone or device becomes depleted. Such means can include a fingerprint sensor disposed on each vape device itself, wherein the vape devices can retain personal data on the user such as one or more fingerprint scan data stored in a memory on the vape devices in order to determine whether a fingerprint scan taken by the fingerprint sensor matches the fingerprint scan data stored in the memory to confirm the identity of the person attempting to use the vape devices is an authorized user.

[0235] Broadly stated, in some embodiments, vape devices **10** and **100** may comprise: an atomizer comprising a heating element, the atomizer further comprising an inlet and an outlet; a mouthpiece operatively coupled to the outlet; and a payload reservoir operatively coupled to the inlet, the payload reservoir comprising an identifier ("ID") tag comprising a unique identifier for the payload reservoir, the payload reservoir configured to hold a payload that can be drawn into the atomizer to be vaporized when the user draws on the mouthpiece.

[0236] Broadly stated, in some embodiments, the vape device can further comprise a radio frequency transceiver or wireless transceiver and at least one antenna operatively coupled to the transceiver, the combination of the transceiver and the antenna configured for enabling the wireless transmission of data between the vape device and a personal computing device.

[0237] Broadly stated, in some embodiments, an improved vape device system can be provided, the system comprising a vape device comprising: an atomizer comprising a heating element, the atomizer further comprising an inlet and an outlet, a mouthpiece operatively coupled to the outlet, a payload reservoir operatively coupled to the inlet, the payload reservoir comprising an identifier ("ID") tag comprising a unique identifier for the payload reservoir, the payload reservoir configured to hold a payload that can be drawn into the atomizer to be vaporized when the user draws on the mouthpiece, and a radio frequency transceiver and at least one antenna operatively coupled to the transceiver, the combination of the transceiver and the at least one antenna configured for wirelessly transmitting and receiving data; and a personal computing device configured for the wireless transmission of the data to and from the vape device.

[0238] Broadly stated, in some embodiments, the vape device can further comprise a switch or a draw sensor operatively coupled to the mouthpiece, the switch or the draw sensor configured to cause electrical current to flow through the heating element when the switch is operated or when the user draws on the mouthpiece.

[0239] Broadly stated, in some embodiments, the vape device can further comprise a battery configured to provide the electrical current.

[0240] Broadly stated, in some embodiments, the vape device can further comprise a battery charger configured for charging the battery.

[0241] Broadly stated, in some embodiments, the personal computing device can comprise a software application running thereon, wherein the combination of the vape device and the personal computing device can be configured for wireless control of the vape device using the personal computing device.

[0242] Broadly stated, in some embodiments, the software application can be further configured for carrying out the steps of: interpreting the ID tag via first data transmitted to the personal computing device from the vape device, the first data comprising the unique payload identifier; using the unique identifier to determine what payload is in the payload reservoir; and transmitting an operational setting to the vape device from the personal computing device, the operational setting comprising instructions to the vape device to either enable operation of the vape device if the user is authorized to use the vape device or to disable operation of the vape device if the user is not authorized to use the vape device.

[0243] Broadly stated, in some embodiments, the operational setting can further comprise instructions to the vape device to either enable operation of the vape device if the user is located in a geographic region where the payload can be vaporized by the user and to disable operation of the vape device if the user is located in a geographic region where the payload cannot be vaporized by the user.

[0244] Broadly stated, in some embodiments, the vape device can further comprise a microcontroller operatively coupled to the atomizer and to the ID tag, the microcontroller configured to control the operation of the vape device.

[0245] Broadly stated, in some embodiments, the vape device can further comprise a user interface operatively coupled to the microcontroller.

[0246] Broadly stated, in some embodiments, the user interface can comprise one or more user input control devices operatively coupled to the microcontroller, the input control devices configured for controlling the operation of the vape device when operated by the user.

[0247] Broadly stated, in some embodiments, the user interface can further comprise one or more user output indicating devices operatively coupled to the microcontroller, the output indicating devices configured for relaying information on the operation of the vape device to the user.

[0248] Broadly stated, in some embodiments, the atomizer can be disposed in an atomizer assembly; the mouthpiece and the payload reservoir can be both disposed in a mouthpiece assembly; and the microcontroller can be disposed in a control assembly, wherein the atomizer assembly can be disposed between the mouthpiece assembly and the control assembly.

Optimizing Vaporization

[0249] In addition to operating as described above, vape devices **10** and **100**, vape device system **102**, and vape device **2800** (described below) may be configured to optimize vaporization for a particular user by using sensors and microcontrollers to monitor, analyze, and store a user's draw profile. The information obtained may be used to adapt the heat profile of the vape device **10**, **100**, **2800** and vape device system **102**. Optimizing vaporization in accordance with the system and method described below results in a more efficient vape device and a better user experience.

[0250] As described above, vape devices **10** and **100** include an atomizer **20** that is used to vaporize a payload, such as but not limited to, a fluid, oil, or tablet containing nicotine or cannabis (in dry, oil, wax, crystalline, or shatter form). Although the description below refers to the vape devices **10** and **100**, it is within the scope of the invention to configure cartridges **900**, **1000**, **1100**, **1900**, **2100**, **2400**, **2500**, and **2600** and vape device **2800** to operate in a similar manner. When atomizer **20** includes a heating element such as heating element **22** to vaporize the payload, different compounds of the payload may be vaporized at different temperatures. For example, the table below lists the temperature at which different compounds of a payload may vaporize.

Compound	Boiling/Vaporization Temperature
Δ-9-tetrahydrocannabinol (THC)	157° C.
Cannabidiol (CBD)	160-180° C.
Cannabinol (CBN)	185° C.
Cannabichromene (CBC)	220° C.
4-8-tetrahydrocannabinol (Δ-8-THC)	175-178° C.
tetrahydrocannabivarin (THCV)	<220° C.
Nicotine	247° C.

[0251] The various compounds within the payload may have different effects on the user when vaped, and thus the user may desire to control the temperature of heating element **22** so that it releases certain compounds from the payload and not others, which may not provide a desired effect or be harmful. In order to ensure that desired compounds from the payload are released when heating element **22** heats the payload, it is desirable for the temperature of heating element **22** to be as accurate and consistent as possible. The temperature of the heating element **22** can vary based on a number of different factors, including the air flow through the mouthpiece **16** and atomizer **20** caused by a user drawing vaporized payload and air through the vape device **10**, the composition of the payload within payload reservoir **26**, and the thermal conductivity of the vape device **10**. The temperature of heating element **22** can also be adjusted by regulating the amount of power provided to the heating element **22** from battery **42**. Microcontroller **31** has the ability to adjust the level of power (by either current or voltage control) provided to the heating element **22** from battery **42**.

[0252] A vape device user often uses a vape device in a similar manner from one vape session to the next. For example, FIGS. **6A-6D** are charts showing the mean and

95% confidence intervals calculated based on multiple measurements of draws or puffs from a vape device for twenty-two different vape device users. FIG. **6**A shows the mean and 95% confidence intervals for the users' measured puff duration, or draw length, in seconds. FIG. **6**B shows the mean and 95% confidence intervals for the users' measured puff flow, or draw strength, in milliliters/second. FIG. **6**C shows the mean and 95% confidence intervals for the users' measured puff or draw volume in milliliters. FIG. **6**D shows the mean and 95% confidence intervals for the users' measured puff interval, or time span between puffs/draws, in seconds. From the charts, it can be seen that the majority of the vape device users had relatively narrow confidence intervals for puff duration (FIG. **6**A), puff flow (FIG. **6**B), and puff volume (FIG. **6**C). Many of the users also had relatively narrow confidence intervals for puff interval (FIG. **6**D). The narrow confidence intervals are an indication that each user has a similar draw length and draw strength in each of multiple draws from the vape device.

[0253] By measuring a user's draw length, draw strength, and other operational conditions of the vape device over time, the user's preferred draw length, draw strength, and other operational conditions can be predicted for future vaping sessions and used to optimize operational settings of the vape device to correspond to that particular user. The measured operational conditions can also be used to predict a user's typical vape session, which may constitute a plurality of draws from the vape device of different draw lengths and draw strengths with time intervals between each draw. By way of example, a typical session for a user that includes multiple draws may follow the pattern of: five total draws; each draw having a draw length of approximately three seconds; each draw consisting of two seconds of a relatively high draw strength with the draw strength decreasing for the last second; and a time interval of fifteen seconds between each draw.

[0254] FIG. **5** shows one example of a typical representative vape session of a user based on measured draw lengths, draw strengths, and time intervals between draws. The representative vape session shown in FIG. **5** includes a first puff/draw, a second puff/draw, and a final (nth) puff/draw. The representative vape session may be used by any of the vape devices and cartridges described herein to power the heating element of the vape devices and cartridges an appropriate amount at appropriate times. For example, the power sent to heating element **22** may be variable based on the representative vape session with more power sent to heating element **22** at times of peak draw strength (shown in FIG. **5** as a higher flow in ml/s) and less power sent to heating element **22** as the draw begins and ends. Between draws, no power or a minimal amount of power may be sent to heating element **22**. The level of power sent to heating element **22** may also vary based on real-time measurements of the draw strength and draw length that may vary from the representative vape session profile, which is based on historical draw strength and historical draw length measurements, the type of payload being heated, preferred heating modes selected by the user (as described below), and desired temperatures associated with the payload and preferred selected heating mode. The representative vape session profile may be updated with each vape session so that it changes when a user's manner of vaping changes.

[0255] A preferred vape device for use in accordance with the system and methods of optimizing vaporization described herein is described below in connection with vape device **10**; however, any of the vape devices and cartridges described herein, and other types of vape devices and cartridges may be used in connection with this system and method. When used in connection with the system and method of optimizing vaporization described herein, the payload reservoir **26** of vape device **10** is preferably configured to hold a payload or substance for vaporization. Heating element **22**, or any other type of heating element, is configured to heat the payload within the payload reservoir **26**. The heating element **22** may be placed in direct contact with the payload, or heat the payload by convection or another manner as described herein. Battery **42**, or any other type of power source, is electrically coupled to heating element **22**. At least one sensor, such as draw sensor **18** or sensors **70** (which may be one or more of a mass air flow sensor, air pressure sensor, air temperature sensor, payload temperature sensor, atomizer ambient temperature sensor, a heating element temperature sensor, a dose measurement sensor and/or any other type of suitable sensor), is configured to sense an operational condition of vape device **10** as a user draws vapor from vape device **10** or as vapor is generated by the vape device **10**. The sensors used may include the capacitive vapor measurement system described below in connection with vape device **3100** and/or the integrated temperature control system described below in connection with vape device **4200**. A processor, such as included within microcontroller **31**, is configured to execute a set of instructions stored in a memory device allowing it to receive the operational condition from the sensor and adjust power provided to the heating element **22** by the battery **42** based on the sensed operational condition. When the at least one sensor includes an air pressure sensor or an air flow sensor, the sensed operational condition is an air pressure and/or a draw strength (i.e. air flow measured in, for example, ml/s). When the at least one sensor includes a temperature sensor, the temperature sensor is preferably configured to sense at least one of a temperature of the heating element **22**, a temperature of the payload in the payload reservoir **26**, or a temperature of a vaporized portion of the payload after it is vaporized by the heating element **22**. The processor in microcontroller **31** is configured to operate the vape device **10** and vape device system **102** in accordance with any of the methods described below.

[0256] A first method for optimizing vaporization with vape device **10** and vape device system **102** (or any of the vape devices and cartridges described herein) includes sensing an operational condition of vape device **10** as a user draws vapor from vape device **10** or, more broadly, as vapor is generated by the vape device **10**, and adjusting a power provided to heating element **22** based on the sensed operational condition. The operational condition includes at least one of a draw strength, a draw length, a payload temperature, an air temperature, an air pressure, an atomizer ambient temperature, an air flow, a heating element temperature, and a dose measurement. The operational condition(s) of the vape device **10** are sensed by draw sensor **18** and/or sensors **70** in real time and adjustments are made to the power provided to heating element **22** to maintain during the user's draw or generation of vapor by the vape device **10**: the heating element **22** at a desired heating element temperature (or range of temperatures); the payload that is in contact with and/or being heated by the heating element (not necessarily the payload positioned within the payload reservoir **26** and not being heated for vaporization) at a desired payload temperature (or range of payload temperatures); and/or a sensed air temperature (e.g., a sensed air temperature adjacent an outlet of atomizer **20**) at a desired air temperature (or range of air temperatures). The desired range for the payload temperature preferably corresponds to a user selected cannabinoid. For example, the user may select one of the cannabinoids from the table above, and the desired temperature range correlates with the temperature listed in the table for the selected cannabinoid. Preferably, the operational condition(s) of the vape device **10** are continuously sensed by draw sensor **18** or sensors **70** during a user's draw of vapor from vape device **10** and during a vape session, and the microcontroller **31** continuously adjusts the power provided to heating element **22** to maintain the heating element **22** and payload at a desired temperature or within a range of desired temperatures.

[0257] When the operational condition is an air pressure and/or a draw strength, the power provided to heating element **22** is increased to raise the temperature of the heating element **22** when the sensed outlet air pressure decreases relative to inlet air pressure (or inlet air pressure increases relative to outlet air pressure) or the sensed draw strength increases. The power provided to heating element **22** is decreased to lower the temperature of heating element **22** when the sensed outlet air pressure increases relative to inlet air pressure (or inlet air pressure decreases relative to outlet air pressure) or the sensed draw strength decreases.

[0258] Because the draw strength and corresponding air flow rate impacts the temperature of the heating element **22**, an air pressure sensor or an air flow sensor can be used to quantify the volume of the air flow going through the heating element **22**. A stronger draw (more air flow) will cool the element and the payload at a much faster rate, which can result in a suboptimal temperature for vaporization (the temperature might become too low for vaporization). A weaker draw (less air flow) will lead to a higher temperature, which can result in the vaporization of undesirable compounds or burning of the payload. By measuring the air flow (either using an air flow sensor or an air pressure sensor), the power is dynamically adjusted (by either current or voltage control) to the heating element **22** in real time. FIGS. **7**A and **7**B show flow diagrams of this first method of optimizing vaporization. As shown in FIG. **7**A, the heating element power is increased based on an increase in a desired temperature of the payload and heating element **22** and based on an increase in an air flow measurement taken by an air flow sensor. The heating element power increases the heating element temperature and the air flow decreases the heating element temperature. Thus, the air flow measurement is used to increase the heating element power to take into account the decrease in heating element temperature caused by the air flow.

[0259] FIG. **7**B shows a flow diagram that is the same as FIG. **7**A with the addition that the process in FIG. **7**B includes using the heating element temperature, as measured by a temperature sensor, to adjust the heating element power. The integrated temperature control system described below in connection with vape device **4200** may be used to sense the temperature and adjust the heating element power. For example, if the heating element temperature rises above the desired temperature, the heating element power may be decreased to lower the heating element temperature back to the desired temperature.

[0260] A second method for optimizing vaporization with vape device **10** and vape device system **102** (or any of the vape devices and cartridges described herein) includes sensing a plurality of draw strengths and a plurality of draw lengths with the draw sensor **18** and/or sensors **70** on the vape device **10** (preferably either an air pressure sensor or an air flow sensor). Each draw strength and each draw length is associated with an instance of a user drawing vapor from the vape device **10**. A historical draw strength is determined from the sensed plurality of draw strengths, and a historical draw length is determined from the sensed plurality of draw lengths. A heating profile for heating element **22** is determined based on the historical draw strength and the historical draw length. Microcontroller **31** adjusts the power provided to the heating element **22** by battery **42** in accordance with the heating profile.

[0261] Using the historical draw strength and historical draw length, the heating profile can be pre-defined so that the heating element **22** is heated to a temperature that is appropriate for how the user typically uses the vape device **10**.

[0262] The historical draw strength and the historical draw length may be determined by averaging all measured draw strengths and draw lengths, respectively, over time as the user uses vape device **10**. The historical draw strength and the historical draw length may be determined by microcontroller **31** based on individual draw strengths and draw lengths that are stored in memory on vape device **10**, in memory on computing device **72**, or in memory remote from vape device **10** and computing device **72**. The historical draw strength and the historical draw length may alternatively be determined by processor **94** of computing device **72**, which is separate from vape device **10**, that executes a set of instructions (e.g., as provided with application **74**) stored in memory of computing device **72**. Processor **94** may determine the historical draw strength and draw length based on individual draw strengths and draw lengths that are sent by vape device **10** to computing device **72** and stored in memory of computing device **72**. Further, the historical draw strength and the historical draw length may be determined by processor **94** executing application **74** based on individual draw strengths and draw lengths that are sent by vape device **10** to computing device **72** and sent by computing device **72** via global telecommunications network **92** to a database or remote computing device that is remote and separate from the vape device **10** and the computing device **72**. The individual draw strengths and draw lengths may be stored in the remote database and accessed by computing device **72** for determining the historical draw strength and the historical draw length, or a processor remote from computing device **72** may access the individual draw strengths and individual draw lengths on the remote database, determine the historical draw strength and the historical draw length, and send them to computing device **72**. The historical draw strength and the historical draw length may be stored: in the database that is remote from vape device **10** and computing device **72**; in memory on computing device **72**; and/or in memory on vape device **10**.

[0263] The heating profile corresponds to the amount of power that needs to be provided to the heating element **22** over time to maintain the heating element **22** and payload at a desired temperature over time. The amount of power within the heating profile is preferably variable over time taking into account the historical draw strength and the historical draw length, and how the power provided to heating element **22** needs to be varied based on the cooling effect of a draw to maintain the temperature of the heating element **22** and payload within a desired range of temperatures. The heating profile may be determined by any of microcontroller **31**, processor **94** of computing device **72** executing application **74**, or a processor remote from vape device **10** and computing device **72**, and stored in memory of vape device **10**, computing device **72**, or a database remote from vape device **10** and computing device **72**. If the heating profile is determined and stored remotely from vape device **10**, it is preferably sent to the microcontroller **31** of vape device **10** so that the microcontroller **31** can adjust the power provided to heating element **22** in accordance with the heating profile. The historical draw strength, historical draw length, and heating profile are preferably updated with each draw from the user so that over time the vape device **10** learns the user's vaping profile.

[0264] Microcontroller **31** may begin powering heating element **22** in accordance with the heating profile, and then adjust the heating profile in real-time as vapor is generated by the vape device **10** in accordance with the first method of optimizing vaporization described above. For example, operational conditions, such as draw strength, draw length, payload temperature, air temperature, air pressure, atomizer ambient temperature, air flow, heating element temperature, and dose measurement, can be measured in real-time as the vapor is generated by the vape device **10**, and the heating profile based on the historical draw length and historical draw strength can be modified in real-time as vapor is generated by the vape device to adjust the power provided to heating element **22** based on the sensed operational conditions.

[0265] In addition to being determined based on the historical draw strength and the historical draw length, the heating profile is also preferably determined based on the particular payload being heated and desired compounds or cannabinoids that a user selects. For example, different payloads and different desired compounds or cannabinoids require different temperatures for optimal vaporization. The heating profile may also be determined based on operational settings that vape device **10**, processor **94** of computing device **72**, or a central processor remote from vape device **10** and computing device **72** determine based on the unique payload identifier for payload reservoir **26** described above. For example, the unique payload identifier may be transmitted from the vape device **10** to the computing device **72**, which uses the unique payload identifier to determine the specific compound(s) within the payload reservoir **26**. The computing device **72** may send the unique payload identifier to a remote central processor and database using global telecommunications network **92**, where the unique payload identifier is associated with the specific compound(s) within the payload reservoir **26** and with preferred operational settings for the specific compound. Those operational settings may be transmitted back to computing device **72** and vape device **10** and used to develop the heating profile. If the vape device **10** is not connected to a computing device **72**, the vape device **10** may have the ability to independently determine the operational settings and heating profile(s), the vape device **10** may operate with default operational settings and heating profile(s) stored on the vape device **10**, and/or the vape device **10** may operate with the last set of operational settings and heating profile(s) received from a computing device **72**.

[0266] The heating profile is also preferably determined in accordance with a heating mode selected by the user for vape device **10**. For example, the user may use user input buttons or controls of control assembly **14** or application **74** to select a desired heating mode for the vape device **10**. Exemplary heating modes may include a potency mode, an efficiency mode, and a decarb mode, each of which are described below.

[0267] When the potency mode is the selected heating mode for vape device **10**, power is provided to heating element **22** when the sensed draw strength indicates that the user is drawing vapor from vape device **10**, and power is not provided to heating element **22** when the sensed draw strength indicates that the user has stopped drawing vapor from vape device **10**. Thus, the heating element **22** is powered throughout a user's entire draw of vapor from vape device **10**. This results in vapor production throughout the entire length of the draw. The amount of power provided to heating element **22** for the potency mode may be determined based on the heating profile (i.e., the historical draw strength, historical draw length, particular payload, and desired compounds or cannabinoids that a user selects). At the end of the draw, the heating element **22** and payload will still be at the vaporizing temperature for the particular compounds desired for vaporization, which may cause some of the payload to vaporize and be lost after the user has completed drawing vapor from the device.

[0268] When the efficiency mode is the selected heating mode for vape device **10**, power is provided to heating element **22** for no longer than an efficiency time period that is determined based on the user's historical draw length such that the efficiency time period is shorter than the historical draw length. The efficiency time period begins when the sensed draw strength indicates that the user is drawing vapor from vape device **10** and preferably ends before the user stops drawing vapor from vape device **10** unless the user stops drawing vapor before the end of the efficiency time period. By turning off the heating element **22** before the end of the draw, the user is able to inhale all of the residual vapor that is generated as the heating element **22** and payload cool down, without substantial loss of vaporized payload. As an alternative to turning off the heating element **22** entirely before the end of the draw, power to the heating element **22** may be reduced gradually or in steps before the end of the user's historical draw length. The reduction of power may be determined based on the user's historical draw strength. If the actual draw length is shorter than the efficiency time period, vape device **10** may sense that the draw has ended and turn off the heating element **22** at the end of the draw even though the efficiency time period has not fully ended. In this manner, the efficiency time period is a maximum time for powering the heating element **22**, but not a minimum time. Further, when in the efficiency mode, the vape device **10** has more time to begin cooling down, which reduces the residual heat that is transferred to the user's hand, pocket or purse.

[0269] When the decarb mode is the selected heating mode for vape device **10**, the heating profile corresponds to a decarb temperature and a decarb time duration that allows decarboxylation of the payload of the vape device. The decarb time duration may be selected by the user or based on the user's historical draw length, and the decarb temperature may be calculated based on the decarb time duration. The decarb time duration may optionally be shortened based on an actual draw length if an actual draw is shorter than the preset decarb time duration. For example, FIG. **8**A shows the approximate time for decarboxylation of THCA to THC at different temperatures, and FIG. **8**B shows the THC content in cannabis over time at different temperatures. The times and temperatures shown in FIGS. **8**A and **8**B may be used to set the heating profile for the decarb mode.

[0270] In addition, or as an alternative, to determining historical draw strength and historical draw length of a user, the method of optimizing vaporization may include determining a vape session profile of a user. The vape session profile is based on a plurality of vape sessions undertaken by the user, where each vape session includes a plurality of draws that are separated by a relatively short period of time. The vape session profile may include a historical number of draws during a user's typical vape session. For each of the draws, the vape session profile may include a historical draw length and a historical draw strength. For example, the vape session profile may include a first historical draw strength and a first historical draw length that are determined based on a first plurality of draw strengths and a first plurality of draw lengths, respectively, each corresponding to a first draw of vapor from vape device **10** during the plurality of vape sessions. The vape session profile may include a second historical draw strength and a second historical draw length that are determined based on a second plurality of draw strengths and a second plurality of draw lengths, respectively, each corresponding to a second draw of vapor from vape device **10** during the plurality of vape sessions. The vape session profile may further include additional historical draw strengths and additional historical draw lengths for each of the historical number of draws during a user's typical vape session.

[0271] Further, each of the historical number of draws during a user's typical vape session may include its own heating profile that is based on the historical draw strength and the historical draw length of the particular draw in the sequence of the historical number of draws. For example, the vape session profile may include a first heating profile that is determined based on the first historical draw strength and the first historical draw length, a second heating profile that is determined based on the second historical draw strength and the second historical draw length, and additional heating profiles each determined based on the additional historical draw strengths and additional historical draw lengths. Each of the heating profiles may be determined as described above and used to adjust the power provided to the heating element **22** during a user's vape session, such that each draw in sequence of a user's vape session has its own predefined heating profile in accordance with how the user typically draws vapor during a vape session or generated vapor with the vape device. For example, during a first draw of a new vape session, power is provided to heating element **22** in accordance with the first heating profile, during a second draw of a new vape session, power is provided to heating element **22** in accordance with the second heating profile, and during additional draws of a new vape session, power is provided to heating element **22** in accordance with the additional heating profiles.

[0272] The first heating profile, the second heating profile, and the additional heating profiles may each be determined in accordance with one of the exemplary heating modes described above (i.e., the potency mode, the efficiency mode, and the decarb mode). The user may select different heating modes for each of the first heating profile, the second heating profile, and the additional heating profiles such that during a new vape session, different heating modes may be used for each draw of vapor from vape device **10**. For example, if a user's typical vape session includes five draws, the user's vape session profile may be set up so that the heating mode for the first three draws is set to the potency mode, and the heating mode for the last two draws is set to the efficiency mode. Because the user will take additional draws after each of the first three draws, there is less worry about losing vaporized material, and thus the potency mode can be used during those first three draws. The last two draws are set to the efficiency mode so that little vapor is lost and the vape device has time to cool down before it is stowed away in a user's pocket, purse, or other desired location.

[0273] Alternatively, a heating profile for a user may be defined to have multiple heating modes that each operate for a set period of time. For example, the heating profile may have a first heating mode and a second heating mode that are each selected to be one of the potency mode, the efficiency mode, or the decarb mode. The heating profile may cause the vape device **10** to operate in the first heating mode for a first time period of the heating profile and in the second heating mode for a second time period of the heating profile following the first time period. Additional heating modes operating for additional time periods may follow the second time period. The overall time period for the heating mode may correspond to the overall length of a user's historical vape session as determined based on the lengths of a plurality of vape sessions. For example, if a user's historical vape session length is 390 seconds, the first 300 seconds of a new vape session may be set to operate in the potency mode, and the last 90 seconds (or more depending on how long the new vape session lasts) may be set to operate in the efficiency mode.

[0274] The user may set the heating modes on user controls of vape device **10** or using application **74** or another computing device that can send information to vape device **10** directly or through another computing device. Further, the user may view the measured operational conditions (e.g., draw strength, draw length, payload temperature, air temperature, air pressure, atomizer ambient temperature, air flow, heating element temperature, and dose measurement), historical draw strength, historical draw length, vape session profile, heating profile, power levels, cannabinoid selections and/or specific compound(s) within the payload on an output display of vape device **10** or on computing device **72** or another computing device that can receive information from vape device **10** directly or through another computing device. The user can preferably alter or fine tune the vape session profile, heating profile, and power levels to desired settings using vape device **10** or computing device **72**. Further, the user can preferably set up multiple vape session profiles, heating profiles, and power levels, and for new vape sessions select one of the multiple predefined vape session profiles, heating profiles, and power levels, as desired.

Vape Devices and Cartridges for Use with Dry Tablets

[0275] Additional embodiments of the invention described herein include a vape device that is designed to heat a payload comprising dry material, such as cannabis, such that the active components in the dry material are vaporized for inhalation, a cartridge portion of the vape device that receives the dry material, a tablet formed from dry material for use with the vape device and cartridge, methods of using the vape device and cartridge to vaporize the tablet, and methods of making the tablet. The tablets may be formed from dry material that is pressed into a shape. The tablets may be heated by conduction, when they are in direct contact with a heating element, by convection, when heated air is drawn over or through the tablets, or by a combination of conduction and convection. The term "dry material" when used herein is not limited to material that is completely devoid of any fluid. Rather, the term is used to denote material that is capable of being pressed together to form a solid or semi-solid tablet for insertion into a vape device or cartridge.

[0276] A cartridge for vaporizing dry material in accordance with one embodiment of the invention described herein is identified generally as **900** in FIG. **9**A. Cartridge **900** heats a tablet **940** (FIG. **9**B) by conduction with the tablet **940** being in direct contact with a heating element **942**. Although cartridge **900** is shown and described herein as being used with a tablet **940**, it is within the scope of the invention for cartridge **900** to be used in connection with a payload comprising dry material that is not necessarily pressed into tablet form. If tablet **940** has internal holes or flow passageways (as described below), heated air may flow through tablet **940** to also heat tablet **940** by convection. Cartridge **900** includes a housing formed from an outer side wall **902** and end caps **904** and **906** each removably threaded into engagement with internal threads of the outer side wall **902**. Outer side wall **902** is preferably clear, but may be any color. End cap **904** includes a first end wall **908** of cartridge **900**, and end cap **906** includes a second end wall **910** of cartridge **900**. End cap **904** further includes a first cylindrical tube **912** (FIG. **9**B) integral with and extending from first end wall **908**, and a second cylindrical tube **914** integral with and extending from first cylindrical tube **912**. The outer surface of second cylindrical tube **914** has a diameter that is less than the diameter of the outer surface of first cylindrical tube **912**. The inner surface of second cylindrical tube **914** has a diameter that is substantially the same as the diameter of the inner surface of first cylindrical tube **912**. External threads are formed on the outer surfaces of first cylindrical tube **912** and second cylindrical tube **914**. The external threads on first cylindrical tube **912** removably engage internal threads of outer side wall **902**. End cap **906** further includes a cylindrical tube **916** integral with and extending from second end wall **910**. External threads formed on the outer surface of cylindrical tube **916** removably engage internal threads of outer side wall **902**.

[0277] A tubular threaded connector **918** is integral with first end wall **908** and extends outward from first end wall **908** in a direction opposite to first cylindrical tube **912**. Threaded connector **918** includes external threads on its outer surface. Preferably, the threaded connector **918** is configured for coupling the cartridge **900** to a control assembly, such as the control assembly **14** described above and shown in FIG. **1**. Threaded connector **918** may be a 510 threaded connector. Further, threaded connector **918** may be configured to operate in accordance with the two lead communication system described below in connection with vape device **4000**. A central opening **920** extends through first end wall **908** and threaded connector **918**. A plurality of radial openings **922** (FIG. **9**A) extend through first end wall **908**. The central opening **920** and radial openings **922** comprise an inlet of first end wall **908**. The inlet of first end wall **908** may be any opening through first end wall **908** that is in fluid communication with the interior chamber **932** of cartridge **900** described below.

[0278] A tube **924** is integral with second end wall **910** and extends outward from second end wall **910** in a direction opposite to cylindrical tube **916**. A central opening **926** extends through second end wall **910** and tube **924**. Central opening **926** comprises an outlet of the second end wall **910**. The outlet of second end wall **910** may be any opening through second end wall **910** that is in fluid communication with the interior chamber **932** of cartridge **900** described below. A tubular spring retainer **928** is integral with second end wall **910** and extends outward from second end wall **910** in the same direction as cylindrical tube **916**. Spring retainer **928** is concentric with cylindrical tube **916**. Central opening **926** extends through spring retainer **928**.

[0279] Cartridge **900** includes an interior side wall **930** with internal threads that removably engage the external threads of second cylindrical tube **914**. Interior side wall **930** has an external surface that is spaced apart from outer side wall **902** to form a gap between interior side wall **930** and outer side wall **902**.

[0280] Outer side wall **902**, first end wall **908**, and second end wall **910** define and surround an interior chamber **932** of cartridge **900**. The interior chamber **932** includes an inlet chamber **934** that is positioned between outer side wall **902** and interior side wall **930**, a vaporization chamber **936** defined by and positioned within interior side wall **930**, and a mixing chamber **938** defined by and positioned within outer side wall **902**. Inlet chamber **934** is in fluid communication with the inlet (i.e., central opening **920** and radial openings **922**) for receiving ambient air when a user draws air through cartridge **900**. Vaporization chamber **936** receives vaporized material from a tablet **940** heated within vaporization chamber **936**. Mixing chamber **938** is in fluid communication with inlet chamber **934**, vaporization chamber **936**, and the outlet (i.e., central opening **926**). Mixing chamber **938** receives ambient air from inlet chamber **934** and vaporized material from vaporization chamber **936** when a user draws air through cartridge **900**. The mixed ambient air and vaporized material exit mixing chamber **938** through central opening **926** for inhalation by the user.

[0281] Cartridge **900** further includes a heating element **942** that is positioned within vaporization chamber **936**. Heating element **942** is retained in place between interior side wall **930** and end cap **904** when interior side wall **930** threadably engages end cap **904**. Wires (not shown) preferably electrically couple heating element **942** to threaded connector **918** for receiving electrical current or an electrical signal from a control assembly joined to threaded connector **918** that causes heating element **942** to power on or begin generating heat. Heating element **942** extends across the vaporization chamber **936** and includes a payload retention surface **944** (FIG. **9**C) facing end cap **906**. Payload retention surface **944** may be a tablet retention surface when a tablet is used with vape device **900**.

[0282] A spring **946** positioned within interior chamber **932** has a first end that is positioned around spring retainer **928** and a second end that is positioned around a tablet engager **948**. Tablet engager **948** engages tablet **940** and spring **946** presses tablet **940** into vaporization chamber **936** and into direct engagement with the payload retention surface **944** of heating element **942**. Heating element **942** heats tablet **940** by conduction to heat tablet **940** until desired compounds of tablet vaporize. As tablet **940** is vaporized and reduces in volume, spring **946** maintains tablet **940** in direct connection with heating element **942**. Other types of biasing mechanisms may be used instead of spring **946** to maintain tablet **940** in engagement with heating element **942**. Interior side wall **930** is preferably sized so that the internal diameter of interior side wall **930** is slightly larger than the exterior diameter of tablet **940**.

[0283] A mouthpiece (not shown) is preferably coupled to end cap **906** and includes an interior channel that is in fluid communication with central opening **926**. The mouthpiece is preferably configured for partial placement within a user's mouth so that the user can draw air through the mouthpiece and mixing chamber **938** to receive the vaporized material from tablet **940**.

[0284] Tablet **940** may be placed within vaporization chamber **936** by unscrewing end cap **906** from outer side wall **902** so that vaporization chamber **936** may be accessed by a user. After placing tablet **940** within vaporization chamber **936**, end cap **906** is screwed back into engagement with outer side wall **902**. Alternatively, end cap **904** may be unscrewed from outer side wall **902** to place tablet **940** within vaporization chamber **936**. Alternatively, another type of opening may be formed in cartridge **900** for allowing placement of tablet **940** within vaporization chamber **936**. The opening is preferably closeable after tablet **940** is placed within vaporization chamber **936** to prevent the leaking of vaporized material from the chamber. When the tablet **940** is spent, any remnants thereof are removed before a new tablet **940** is placed within the cartridge **900**.

[0285] Cartridge **900** may be formed integral with a control assembly (e.g., control assembly **14**) that is operable to power heating element **942**, or cartridge **900** may be screwable into a control assembly using threaded connector **918** as shown. Threaded connector **918** is preferably a 510 threaded connector that allows cartridge **900** to be used with compatible 510 threaded control assemblies or vape devices.

[0286] A cartridge for vaporizing dry material in accordance with another embodiment of the invention described herein is identified generally as **1000** in FIG. **10**A. Cartridge **1000** heats a tablet **1002** by convection as hot air heated by a heating element **1004** is drawn over and/or through the tablet **1002**. Although cartridge **1000** is shown and described herein as being used with a tablet **1002**, it is within the scope of the invention for cartridge **1000** to be used in connection with a payload comprising dry material that is not necessarily pressed into tablet form. Cartridge **1000** includes an outer side wall **1006** and end caps **1008** and **1010** each removably threaded into engagement with internal threads of the outer side wall **1006**. Outer side wall **1006** is preferably clear, but may be any color. End cap **1008** includes a first end wall **1012** of cartridge **1000**, and end cap **1010** includes a second end wall **1014** of cartridge **1000**. Referring to FIG. **10**B, end cap **1008** further includes a first cylindrical tube **1016** integral with and extending from first end wall **1012**, and a second cylindrical tube **1018** integral with and extending from first cylindrical tube **1016**. The outer surface of second cylindrical tube **1018** has a diameter that is less than the diameter of the outer surface of first cylindrical tube **1016**. The inner surface of second cylindrical tube **1018** has a diameter that is substantially the same as the diameter of the inner surface of first cylindrical tube **1016**. External threads are formed on the outer surfaces of first cylindrical tube **1016** and second cylindrical tube **1018**. The external threads on first cylindrical tube **1016** removably engage internal threads of outer side wall **1006**. End cap **1010** further includes a cylindrical tube **1020** integral with and extending from second end wall **1014**. External threads formed on the outer surface of cylindrical tube **1020** removably engage internal threads of outer side wall **1006**.

[0287] A tubular threaded connector **1022** is integral with first end wall **1012** and extends outward from first end wall **1012** in a direction opposite to first cylindrical tube **1016**. Threaded connector **1022** includes external threads on its outer surface. Preferably, the threaded connector **1022** is configured for coupling the cartridge **1000** to a control assembly, such as the control assembly **14** described above and shown in FIG. **1**. Threaded connector **1022** may be a 510 threaded connector. Further, threaded connector **1022** may be configured to operate in accordance with the two lead communication system described below in connection with vape device **4000**. A central opening **1024** extends through first end wall **1012** and threaded connector **1022**. A plurality of openings **1026** radially spaced from central opening **1024** extend through first end wall **1012**. The central opening **1024** and openings **1026** comprise an inlet of first end wall **1012**. The inlet of first end wall **1012** may be any opening through first end wall **1012** that is in fluid communication with the interior chamber **1040** of cartridge **1000** described below.

[0288] A tube **1028** is integral with second end wall **1014** and extends outward from second end wall **1014** in a direction opposite to cylindrical tube **1020**. A central opening **1030** extends through second end wall **1014** and tube **1028**. Central opening **1030** comprises an outlet of the second end wall **1014**. The outlet of second end wall **1014** may be any opening through second end wall **1014** that is in fluid communication with the interior chamber **1040** of cartridge **1000** described below. A tubular spring retainer **1032** is integral with second end wall **1014** and extends outward from second end wall **1014** in the same direction as cylindrical tube **1020**. Spring retainer **1032** is concentric with cylindrical tube **1020**. Central opening **1030** extends through spring retainer **1032**.

[0289] Cartridge **1000** includes a divider **1034** that is coupled to end cap **1008** and positioned within outer side wall **1006**. Divider **1034** includes an interior side wall **1036** that is cylindrical and concentric with outer side wall **1006**. Interior side wall **1036** is spaced apart from outer side wall **1006** to define a gap between the interior side wall **1036** and outer side wall **1006**. Interior side wall **1036** extends from adjacent first end wall **1012** to adjacent second end wall **1014**. Divider **1034** further includes a dividing panel **1038** that is integral with an interior surface of interior side wall **1036** and extends across interior side wall **1036** to divide the interior of divider **1034** into two compartments.

[0290] Outer side wall **1006**, first end wall **1012**, and second end wall **1014** define and surround an interior chamber **1040** of cartridge **1000**. The interior chamber **1040** includes an outer chamber **1042** that is positioned between outer side wall **1006** and interior side wall **1036**, an inlet chamber **1044** defined by and positioned within interior side wall **1036** on the side of dividing panel **1038** facing end cap **1008**, and a vaporization chamber **1046** defined by and positioned within interior side wall **1036** on the side of dividing panel **1038** facing end cap **1010**. Dividing panel

1038 divides inlet chamber **1044** from vaporization chamber **1046**. Inlet chamber **1044** is in fluid communication with the inlet (i.e., central opening **1024** and openings **1026**) for receiving ambient air when a user draws air through cartridge **1000**.

[0291] A spiral flow guide **1048** is positioned within inlet chamber **1044** along with heating element **1004**. Wires (not shown) preferably electrically couple heating element **1004** to threaded connector **1022** for receiving electrical current or an electrical signal from a control assembly joined to threaded connector **1022** that causes heating element **1004** to power on or begin generating heat. Spiral flow guide **1048** is positioned between central opening **1024** and heating element **1004**, which is in contact with dividing panel **1038**. Spiral flow guide **1048** includes a continuous groove **1050** formed in its outer surface that spirals to direct air from adjacent central opening **1024** to heating element **1004** adjacent dividing panel **1038**. The outer surface of spiral flow guide **1048** has a diameter that is substantially the same as the diameter of the inner surface of interior side wall **1036** so that air entering central opening **1024** is directed through the groove **1050** as a user draws air through cartridge **1000**. Heating element **1004** heats the spiral flow guide **1048** and air within inlet chamber **1044**. The spiral flow guide **1048** provides a relatively large, heated surface area to enhance heating of the air passing through inlet chamber **1044**, and causes the incoming air to remain in inlet chamber **1044** for a length of time that is sufficient to heat it to a desired temperature.

[0292] Interior side wall **1036** includes a first set of openings **1052** (FIG. **10**C) that place the outer chamber **1042** in fluid communication with inlet chamber **1044** adjacent heating element **1004**. Air flowing through inlet chamber **1044** passes through the openings **1052** into outer chamber **1042** after being heated by heating element **1004** and spiral flow guide **1048**. Interior side wall **1036** includes a second set of openings or slots **1054** that place the outer chamber **1042** in fluid communication with vaporization chamber **1046** adjacent tablet **1002**. The heated air from inlet chamber **1044** and outer chamber **1042** flows through openings **1054** into vaporization chamber **1046** as a user draws air through cartridge **1000**. The heated air makes contact with tablet **1002** heating tablet **1002** via convection. Tablet **1002** may also be heated via conduction in as much as heating element **1004** heats divider **1034**, which heats tablet **1002**.

[0293] As tablet **1002** is heated, compounds and material vaporize from tablet **1002** and mix with the heated air within vaporization chamber **1046**. Vaporization chamber **1046** is in fluid communication with the outlet (i.e., central opening **1030**). The mixed heated air and vaporized material from tablet **1002** exit vaporization chamber **1046** through central opening **1030** for inhalation by the user.

[0294] A spring **1056** positioned within vaporization chamber **1046** has a first end that is positioned around spring retainer **1032** and a second end that is positioned around a tablet engager **1058**. Tablet engager **1058** engages tablet **1002** and spring **1056** presses tablet **1002** into vaporization chamber **1046** and into direct engagement with a payload retention surface **1060** of divider **1034**. As tablet **1002** is vaporized and reduces in volume, spring **1056** maintains tablet **1002** in place within vaporization chamber **1046** to maximize contact between the heated air and tablet **1002**. Other types of biasing mechanisms may be used instead of spring **1056** to maintain tablet **1002** in place. Interior side wall **1036** is preferably sized so that the internal diameter of interior side wall **1036** is slightly larger than the exterior diameter of tablet **1002**.

[0295] A mouthpiece (not shown) is preferably coupled to end cap **1010** and includes an interior channel that is in fluid communication with central opening **1030**. The mouthpiece is preferably configured for partial placement within a user's mouth so that the user can draw air through the mouthpiece and vaporization chamber **1046** to receive the vaporized material from tablet **1002**.

[0296] Tablet **1002** may be placed within vaporization chamber **1046** by unscrewing end cap **1010** from outer side wall **1006** so that vaporization chamber **1046** may be accessed by a user. After placing tablet **1002** within vaporization chamber **1046**, end cap **1010** is screwed back into engagement with outer side wall **1006**. Alternatively, end cap **1008** may be unscrewed from outer side wall **1006** to place tablet **1002** within vaporization chamber **1046**. Alternatively, another type of opening may be formed in cartridge **1000** for allowing placement of tablet **1002** within vaporization chamber **1046**. The opening is preferably closeable after tablet **1002** is placed within vaporization chamber **1046** to prevent the leaking of vaporized material from the chamber. When the tablet **1002** is spent, any remnants thereof are removed before a new tablet **1002** is placed within the cartridge **1000**.

[0297] Cartridge **1000** may be formed integral with a control assembly (e.g., control assembly **14**) that is operable to power heating element **1004**, or cartridge **1000** may be screwable into a control assembly using threaded connector **1022** as shown. Threaded connector **1022** is preferably a 510 threaded connector that allows cartridge **1000** to be used with compatible 510 threaded control assemblies or vape devices.

[0298] FIGS. **11**A-D show another alternative embodiment of a cartridge **1100** for vaporizing dry material. Like cartridge **900**, cartridge **1100** heats a tablet **1102** (or other dry material not pressed into tablet form) by conduction with the tablet **1102** being in direct contact with a heating element **1104**. If tablet **1102** has internal holes or flow passageways (as described below), heated air may flow through tablet **1102** to also heat tablet **1102** by convection. Cartridge **1100** includes an outer side wall **1106** and an end cap **1108** coupled to one end of outer side wall **1106**. Outer side wall **1106** is preferably clear, but may be any color. End cap **1108** includes a first end wall **1110** of cartridge **1100**, and a second end wall **1112** is integral with outer side wall **1106** on the opposite end of cartridge **1100**. End cap **1108** further includes a cylindrical protrusion **1114** integral with and extending from first end wall **1110**. External threads may be formed on the outer surface of cylindrical protrusion **1114** to removably engage internal threads of outer side wall **1106**.

[0299] A tubular threaded connector **1116** is integral with first end wall **1110** and extends outward from first end wall **1110** in a direction opposite to first cylindrical protrusion **1114**. Threaded connector **1116** includes external threads on its outer surface. Preferably, the threaded connector **1116** is configured for coupling the cartridge **1100** to a control assembly, such as the control assembly **14** described above and shown in FIG. **1**. Threaded connector **1116** may be a 510 threaded connector. Further, threaded connector **1116** may be configured to operate in accordance with the two lead communication system described below in connection with vape device **4000**. A central opening **1118** extends through first end wall **1110** and threaded connector **1116**. A plurality of openings **1120** radially spaced from central opening **1118** extend through first end wall **1110**. The openings **1120** comprise an inlet of first end wall **1110**. The inlet of first end wall **1110** may be any opening through first end wall **1110** that is in fluid communication with the interior chamber **1125** of cartridge **1100** described below.

[0300] A tube **1122** (FIG. **11**C) is integral with second end wall **1112** and extends outward from second end wall **1112** in a direction opposite to first end wall **1110**. A central opening **1124** extends through second end wall **1112** and tube **1122**. Central opening **1124** comprises an outlet of the second end wall **1112**. The outlet of second end wall **1112** may be any opening through second end wall **1112** that is in fluid communication with the interior chamber **1125** of cartridge **1100** described below.

[0301] Outer side wall **1106**, first end wall **1110**, and second end wall **1112** define and surround an interior chamber **1125** (FIG. **11**D) of cartridge **1100**. Heating element **1104** is positioned within interior chamber **1125** and includes a heater **1126** and a cap **1128** that covers the heater **1126**. Wires (not shown) preferably electrically couple heating element **1104** to threaded connector **1116** for receiving electrical current or an electrical signal from a control assembly joined to threaded connector **1116** that causes heating element **1104** to power on or begin generating heat. A spring **1130** presses tablet **1102** against the cap **1128**. One end of spring **1130** engages second end wall **1112**, and the other end of spring **1130** engages a tablet retention plate **1132** that abuts tablet **1102**. Holes are formed through tablet retention plate **1132** to allow vaporized material from tablet **1102** to travel through central opening **1124**. Holes are also preferably formed in tablet **1102** (as described below) so that when a user draws air through cartridge **1100**, the air enters cartridge **1100** through openings **1120** and then flows through tablet **1102**, tablet retention plate **1132**, and central opening **1124**.

[0302] FIG. **11**A shows one embodiment of a mouthpiece **1136** that is coupled to second end wall **1112** (FIG. **11**C) and tube **1122**. Mouthpiece **1136** includes an interior channel that is in fluid communication with central opening **1124** through tube **1122**. Mouthpiece **1136** is configured for partial placement within a user's mouth so that the user can draw air through the mouthpiece **1136** to receive the vaporized material from tablet **1102**. FIGS. **11**B-**11**D show an alternative embodiment of mouthpiece **1138** that is also coupled to second end wall **1112** and tube **1122**, and that has an interior channel in fluid communication with central opening **1124**.

[0303] Tablet **1102** may be placed within cartridge **1100** by uncoupling end cap **1108** from outer side wall **1106**. After placing tablet **1102** within cartridge **1100**, end cap **1108** is coupled back into engagement with outer side wall **1106**. Alternatively, another type of opening may be formed in cartridge **1100** for allowing placement of tablet **1102** within cartridge **1100**. The opening is preferably closeable after tablet **1102** is placed within cartridge **1100** to prevent the leaking of vaporized material from the cartridge.

[0304] Cartridge **1100** may be formed integral with a control assembly (e.g., control assembly **14**) that is operable to power heating element **1104**, or cartridge **1100** may be screwable into a control assembly using threaded connector **1116** as shown. Threaded connector **1116** is preferably a 510 threaded connector that allows cartridge **1100** to be used with compatible 510 threaded control assemblies or vape devices.

[0305] FIG. **12** shows an alternative embodiment of heating element **1200** that may be used in connection with any of the cartridges **900**, **1000**, and **1100** described herein. Heating element **1200** is configured to heat a tablet **1202** (or other dry material not pressed into tablet form) by conduction and also preferably by convection as described below. Heating element **1200** includes a first wall **1204** and a second wall **1206** that define a heating chamber **1208** positioned between the first wall **1204** and the second wall **1206**. The heating chamber **1208** is accessible through a first opening **1210** in a side wall **1212** and through a second opening **1214** in a side wall **1216**.

[0306] Ventilation holes (not shown) may be provided through the first wall **1204** and the second wall **1206** to allow air flow through the walls into heating chamber **1208**. The use of ventilation holes allows for convection heating of tablet **1202** and also reduces the thermal mass that must be heated when tablet **1202** is solely heated by conduction. The use of ventilation holes also provides an efficient way of allowing vapor to be released for inhalation.

[0307] The first wall **1204** and the second wall **1206** may also include grooves or patterns (not shown) that are formed in the walls adjacent heating chamber **1208**. The use of grooves or patterns preferably increases air turbulence and maximizes heat transfer from heating element **1200** to the air proximate tablet **1202** if contact is not perfect between heating element **1200** and tablet **1202**. The first wall **1204** and the second wall **1206** of the heating element **1200** may be constructed from any suitable material, including ceramic, aluminum, and stainless steel. First wall **1204** and second wall **1206** may also include metal heating coils that are encased in a material, such as ceramic. The metal heating coils may be implemented as single or multi-strand elements in serial or parallel arrangement, among other configurations.

[0308] Heating chamber **1208** may be configured to receive tablets of different sizes and configurations. For example, heating chamber **1208** may be configured to accept circular tablets, such as tablet **1300** shown in FIG. **13**A and/or rectangular tablets, such as tablet **1302** shown in FIG. **13**B. Any of the tablets described herein may also be toroidal, such as tablet **1304** shown in FIG. **13**C. With heating chamber **1208** being open at both ends, a tablet may be inserted through first opening **1210**, and once the tablet is spent, the remaining debris from the tablet can be pushed through heating chamber **1208** out through second opening **1214**. A cleaning tool **1218** may be used to push the tablet debris out through second opening **1214**. Cleaning tool **1218** includes a handle **1220** for grasping by a user and a ram **1222** that is shaped to be received by first opening **1210** and push tablet debris through and out of heating chamber **1208**.

Tablets

[0309] The tablets and methods for making and using the tablets described herein provide a more convenient way to vape or smoke dry material. The composition, potency and physical characteristics of the tablets may be controlled in such a manner that they provide for a convenient and repeatable vaping or smoking experience.

[0310] Referring to FIGS. **14**A-D, an exemplary embodiment of tablet for use with a cartridge for vaporizing dry material is identified as **1400**. Tablet **1400** may be used with any of the cartridges **900**, **1000**, and **1100** described above and in heating element **1200**. Tablet **1400** includes dry material that is pressed into a relatively flat cylindrical shape; although other shapes are within the scope of the present invention. Tablet **1400** may be formed from any suitable dry material, such as cannabis, tobacco, hemp, or cannabinoid. It is within the scope of the invention for the dry material to be mixed with other materials, solids, semi-solids, or liquids, that assist in retaining the dry material in a tablet shape.

[0311] Tablet **1400** includes a first surface **1402** and a second surface **1404** (FIG. **14**C) positioned opposite the first surface **1402**. Each of the first and second surfaces **1402** and **1404** are circular. An annular side wall **1406** extends between the first and second surfaces **1402** and **1404**. A recess **1408** is formed in first surface **1402**. Recess **1408** is spiral shaped, but may be shaped in any desirable manner. A hole **1410** extends through tablet **1400** from first surface **1402** to second surface **1404**. Hole **1410** is positioned at one end of recess **1408** such that the hole **1410** is in fluid communication with the recess **1408**. Another recess **1412** (shown in dashed lines in FIG. **14**A) is formed in second surface **1404**. Recess **1412** is also preferably spiral shaped, but extends across a different portion of tablet **1400**. Recess **1408** on first surface **1402** begins at the center of tablet **1400**, winds around 180 degrees in a fairly tight spiral, and then winds another 180 degrees in a spiral of larger radius until it terminates at hole **1410** adjacent a peripheral edge of tablet **1400**. From hole **1410**, recess **1412** winds 270 degrees around a peripheral edge of tablet **1400** and then bends 90 degrees toward hole **1410**.

[0312] While tablet **1400** includes a recess on both first surface **1402** and second surface **1404**, it is within the scope of the invention for only one of first and second surfaces **1402**, **1404** to include a recess.

[0313] As shown in FIG. **14**D, side walls **1414** and **1416** are adjacent and define recess **1408**. It is within the scope of the invention for the side walls **1414** and **1416** to include protrusions, ribs, or further recesses or patterns to increase the surface area of the tablet **1400** that is exposed to heated air flowing through the recess **1408**. The side walls **1414**, **1416** of recess **1412** may also include protrusions, ribs, or further recesses or patterns (e.g., the protrusion **1417** shown in FIG. **14**D).

[0314] The recesses **1408** and **1412** and hole **1410** improve the convective heating of tablet by allowing heated air to reach portions of the tablet **1400** that would be inaccessible if tablet **1400** was solid. Recesses **1408** and **1412** and hole **1410** increase the overall surface area of tablet **1400** that is exposed to heated air within a vape device or cartridge. Thus, tablet **1400** is preferably desirable for use with a vape device or cartridge that heats the tablet **1400** with convection heating. Tablet **1400** may also be used with vape devices or cartridges that use conduction heating by itself or in connection with convection heating. The recesses **1408** and **1412** may be implemented as a part of a logo or image of the manufacturer of the tablet **1400**. The addition of surface discontinuities on the side walls **1414**, **1416** that define the recesses **1408**, **1412** (e.g., protrusions, ribs, further recesses or patterns) can further improve heat transfer by causing turbulence as the air flows through the recesses.

[0315] A tablet with recesses and holes, such as tablet **1400**, may also be formed by laminating, or otherwise joining, two separate tablets together to form a combined, laminated tablet. FIG. **15** shows one exemplary embodiment of a laminated tablet **1500**. Laminated tablet **1500** is formed from two tablets **1502** and **1504** that are laminated together to permanently join the tablets **1502** and **1504** together. Each of tablets **1502** and **1504** is substantially similar to tablet **1400** described above. Tablet **1502** has a first surface **1506** and a second surface **1508**, and tablet **1504** has a first surface **1510** and a second surface **1512**. The second surface **1508** of tablet **1502** is laminated to the second surface of **1512**. Tablet **1502** has a hole **1514** extending through it, and tablet **1504** has a hole **1516** extending through it. The tablets **1502** and **1504** are oriented so that the holes **1514** and **1516** are on opposite sides of the laminated tablet **1500**. The orientation of the tablets **1502** and **1504** creates a serpentine flow path where heated air flows through the tablet from a recess **1518** on first surface **1510**, through hole **1516**, through a recess **1520** on second surface **1512**, through a recess **1522** on second surface **1508**, through hole **1514**, and through a recess **1524** on first surface **1506**. In lieu of laminating tablets **1502** and **1504** permanently together, a user may simply insert tablets **1502** and **1504** into a vape device or cartridge back-to-back as shown in FIG. **15** to obtain substantially the same effect.

[0316] FIGS. **16**A-C show another exemplary embodiment of tablet **1600** that includes a heating element **1602**, which is coupled to the dry material that is pressed into the generally rectangular shape of the tablet **1600**. The heating element **1602** helps to achieve a uniform vaporization and consumption of the tablet material by heating a relatively large surface area of the tablet **1600**. Heating element **1602** may also be used in connection with convection heating and with the recesses and holes of the tablet **1400** described above.

[0317] Tablet **1600** includes dry material, such as cannabis, tobacco, hemp, or cannabinoid, that is pressed into a generally rectangular shape having a first surface **1604** and a second surface **1606** positioned opposite the first surface **1604**. An annular side wall **1608** extends between the first and second surfaces **1604** and **1606**. Heating element **1602** is coupled to the first surface **1604** and to side wall **1608**. The contacts of heating element **1602** are designed and positioned to contact electrical terminals of a vape device or cartridge to allow electrical current to flow through heating element **1602**. The contacts are positioned on the side wall **1608**, 180 degrees apart from each other on opposite sides of tablet **1600**. Heating element **1602** is preferably a resistive heating element. Heating element **1602** is preferably pressed into or onto the tablet **1600** as a part of the pressing process for forming the dry material into tablet **1600**.

[0318] Tablet **1600** preferably has a shape that only allows it to be inserted into a vape device or cartridge in one particular orientation to ensure that the contacts of heating element **1602** are in solid electrical contact with the electrical terminals of the vape device or cartridge. For example, tablet **1600** may have an alignment structure that is configured to align the tablet **1600** in a particular orientation within a cartridge so that heating element **1602** is in proper electrical contact with electrical terminals of the cartridge. The vape device or cartridge may have a mating alignment structure that receives or engages the alignment structure of tablet **1600** to ensure the tablet **1600** is correctly oriented when inserted into the vape device or cartridge. The alignment structures of tablet **1600** and the vape device may include alignment notches on one of tablet **1600** and the vape device and alignment protrusions on the other of tablet **1600** and the vape device. The alignment structures of tablet **1600** and the vape device may also include pogo contact pins.

[0319] FIG. **17** shows an exemplary embodiment of laminated tablet **1700** that is formed from three separate tablets **1702**, **1704**, and **1706**, which are laminated together with portions of a heating element **1708** laminated and positioned between the adjacent tablets **1702**, **1704**, and **1706**. Each of tablets **1702**, **1704**, and **1706** may be formed from dry material that is pressed together. The tablets **1702**, **1704**, and **1706** may then be positioned so that a first portion **1710** of heating element **1708** is between tablets **1702** and **1704**, and a second portion **1712** of heating element **1708** is between tablets **1704** and **1706**. Heating element **1708** also includes side portions **1714** and **1716** on the sides of laminated tablet **1700**. As an alternative to being formed from three separate tablets **1702**, **1704**, and **1706**, tablet **1700** may be formed in a single pressing operation. Integrating the heating element **1708** within the tablet **1700** improves the heating of tablet **1700** by conductively heating inner areas of tablet **1700** and increasing the surface area of tablet **1700** that is exposed to conductive heating. Tablet **1700** may also include holes or recesses as described above in connection with tablet **1400** to improve the convective heating of tablet **1700**.

[0320] Any of the tablets **940**, **1002**, **1102**, **1202**, **1300**, **1302**, **1400**, **1500**, **1600**, and **1700** described above may be made in accordance with the dose control methods described below. One dose control method is to simply vary the thickness of tablets that have a predefined cross-sectional area so that there are a plurality of different thicknesses of different doses for a user to choose from. Further, any of the tablets **940**, **1002**, **1102**, **1202**, **1300**, **1302**, **1400**, **1500**, **1600**, and **1700** described above may be formed in any shape including a cylindrical shape, which may, for example, have a circular or elliptical cross-section, or a toroidal shape.

[0321] In accordance with another method, first, a quantity of loose, preferably relatively dry material, such as dry cannabis buds, is provided. A percentage of a component of the dry material, by weight or volume, may be measured. For example, the dry material may be analyzed to determine the percentage weight of a particular compound or compounds of the dry material. If the dry material is cannabis, the component measured may be one of the cannabinoid compounds listed in the table above under the heading Optimizing Vaporization. Once the percentage weight of the particular component is known for the type of plant or plants from which the dry material is derived, that type of plant or plants may be grown in known, repeatable conditions to yield a consistent cannabinoid profile. This can reduce or eliminate the need to test future dry material produced from the type of plant or plants because the percentages of particular cannabinoids within that type of plant or plants are already known.

[0322] Next, a desired amount of the component by weight or volume may be determined (e.g., 0.2 g). A desired volume of the tablet may be determined that corresponds with the desired amount of the component. Alternatively, if the tablet has a predefined cross-sectional area, then a desired thickness of the tablet may be determined that corresponds with the desired amount of the component. A tablet pressing machine may be modified to press the tablet into the desired volume or thickness. The dry material is then pressed into a tablet of the desired thickness, which includes the desired amount of the component.

[0323] To provide an additional level of control on the dosage, the tablet's thickness can be increased or decreased from production lot to lot (using the same production tooling), based on sample measurements taken of the raw material to be pressed into tablet form, in order to adjust the content as necessary. This degree of freedom, to adjust the tablet's volume, is highly desirable as the relative concentrations of cannabinoids can vary from crop to crop despite the crops being from the same genetic strain.

[0324] This method of making a tablet assists a user of the tablet in dosage control by ensuring that the tablet includes a known, desired amount of the target component so that a user of the tablet knows how much of the target component they are inhaling. By following this method, a consistent and specified amount of cannabinoids can be delivered reliably from tablet to tablet. For example, the method may be used to make tablets that a doctor would prescribe to a patient so that the doctor and patient know exactly how much of the target component is within each tablet. Tablets made in accordance with the method would also assist a recreational user of the tablets in determining how much of the target component they are inhaling.

[0325] Any of the tablets described above may also be made to include multiple types of dry material that are pressed together into a single tablet. For example, two or more types of loose, relatively dry material may be provided. A percentage, by weight or volume, of a target component of one or more of the types of dry material may be measured. Desired ratios between the target components may be determined. For example, if two types of dry material are used to make the tablet, a desired ratio of a first percentage of a target component of the first type of dry material to a second percentage of a target component of the second type of dry material may be determined. The two types of dry material are mixed together to form a combined dry material so that the combined dry material includes the desired ratio of the first percentage to the second percentage. The combined dry material is then pressed into a tablet of a desired thickness. The desired thickness may be determined as described above by determining a desired amount of the first and/or second component within the tablet and determining the desired thickness that corresponds to that amount before pressing the tablet into the desired thickness. For example, a tablet may be produced in accordance with this method to include a 1:1 ratio of THC to CBD and a desired amount by weight or volume of THC and/or CBD.

[0326] When it is desired to vaporize two or more types of dry material, the different types of dry material may each be pressed into separate tablets. The separate tablets may be combined by lamination, by heating and pressing the tablets together, adhesive, or any suitable method. Alternatively, a user of the tablets may use the two or more tablets together by inserting them back-to-back within a vape device or cartridge. Each of the tablets may be produced in accordance with the method described above so that the tablet is formed to have a desired thickness that corresponds to a desired amount of a component present within the tablet. The tablets may also be produced so that when combined, a desired ratio of components within the separate tablets is achieved. For example, the separate tablets may be produced to have a desired ratio between a weight or volume of a first component within a first tablet and a weight or volume of a second component within a second tablet. The separate tablets may be combined or simply used together.

[0327] Any of the cartridges **900**, **1000**, and **1100** and heating element **1200** described above may be used with any of the tablets **940**, **1002**, **1102**, **1202**, **1300**, **1302**, **1400**, **1500**, **1600**, and **1700** described above to vaporize desired components of the tablets for inhalation. With reference to cartridge **900** and tablet **940**, end cap **906** is removed from engagement with outer side wall **902**, and tablet **940** is inserted through the opening at the end of outer side wall **902**. The tablet **940** is inserted into the interior chamber **932** adjacent heating element **942**. Heating element **942** is activated to vaporize a portion of tablet **940** into tablet vapor. The user inserts a mouthpiece of the cartridge **900** into his or her mouth and draws air and the tablet vapor into his or her mouth for inhalation. The cartridge **900** heats the tablet by conduction, but may also heat the tablet by convection as described above. Further, as described above with respect to cartridge **1000**, the tablet may be heated primarily or solely by convection by heating air that is drawn into contact with the tablet.

[0328] Any of the cartridges **900**, **1000**, and **1100** described above may be formed integral with a control assembly (e.g., control assembly **14**) to form a vape device that is operable to power the heating elements of the cartridges upon demand by a user by supplying a controlled current or voltage to the atomizer. The cartridges **900**, **1000**, and **1100** may also be screwable into a control assembly using their threaded connectors or may have snap clips or some other structure that joins them to a control assembly. The control assembly **14** is configured to cause the cartridges **900**, **1000**, and **1100** to provide vapor through the outlet in response to a user's input by supplying a controlled current or voltage to the heating element, as described above. Any of the cartridges **900**, **1000**, and **1100** may be operated to heat a tablet in accordance with the methods described above for vape devices **10** and **100** and vape device system **102**, including in accordance with the system and method for optimizing vaporization described above. The cartridges **900**, **1000**, and **1100** or tablets placed within the cartridges may have an ID tag **28** that includes a unique payload identifier, which identifies the particular tablet. The cartridges **900**, **1000**, and **1100** may also include sensors to measure operational conditions of the cartridges. For example, the cartridges **900**, **1000**, and **1100** may include the integrated temperature control system described below in connection with vape device **4200** to regulate the temperature of the heating elements and the capacitive vapor measurement system described below in connection with vape device **3100**. Conductive plates of the capacitive vapor measurement system, such as the conductive plates **3114** and **3116** shown in FIG. **31**, may be positioned anywhere between the heating element and outlet of the cartridges. For example, the conductive plates may be position in the mixing chamber **938** or the tube **924** of cartridge **900**, in the tube **1028** of cartridge **1000**, or in the tube **1122** of cartridge **1100**. Data from the sensors may be transmitted to a control assembly via a threaded connector that operates in accordance with the two lead communication system described below in connection with vape device **4000** such that power is also provided to the cartridge via the threaded connector.

[0329] A tablet storage and dispensing device **1800**, shown in FIG. **18**, may be used to facilitate easier tablet transport, and/or loading of tablets into a cartridge or vape device. The tablet storage and dispensing device **1800** includes a side wall **1802** that surrounds an interior cavity **1804**. An end wall **1806** is coupled to one end of side wall **1802** and an opening **1808** is at the other end of side wall **1802**. A plurality of tablets **1810** are positioned within the interior cavity **1804**. The tablets **1810** may be either preloaded at point of manufacture or loaded by the end-user. A spring **1812** engages end wall **1806** and the tablets **1810** to force the tablets **1810** upward toward opening **1808**. A retention device **1814** engages the uppermost tablet **1810** and positions it to have an edge slightly angled upward for easy grasping by a user or by a loading mechanism on a vape device or cartridge with which tablet storage and dispensing device **1800** is engaged. Tablet storage and dispensing device **1800** may be designed for single use or it may be reusable. Tablet storage and dispensing device **1800** may be loaded into or engaged with a vape device or cartridge to enable a user to use the vape device with multiple tablets without individually loading each tablet into the vape device. A mechanism may be incorporated into the tablet storage and dispensing device **1800** or vape device to expel waste from a spent tablet either simultaneous with or before loading the next tablet.

[0330] Any of the tablets described above and shown herein may be formed from a dry material that is milled or ground and then pressed in a specially designed tableting press. In one aspect, the dry material is milled using a Comil conical mill, Model 194 manufactured by Quadro Engineering Corp. of Waterloo, Ontario, Canada. The dry material may be milled to have an average particle size of <1000 mesh. The dry material may be milled so that >95% of the particle sizes of the milled dry material are between 100 and 200 μm.

[0331] The dry material may be milled at a temperature below 0° C., below −5° C., below −10° C., below −15° C., below −20° C., below −25° C., below −30° C., below −35° C., below −40° C., below −45° C., below −50° C., below −55° C., below −60° C., below −65° C., below −70° C., below −75° C., below −100° C., below −150° C., or below −190° C.

[0332] The table below identifies variables and results of six dry material milling tests. The dry material used in the tablets disclosed herein may be milled in accordance with any of the variables identified below.

Test Number:	1.0	2.0	3.0	4.0	5.0	6.0
Comil Model:	197	197	197	197	197	197
Screen:	024R	018R Bonded	018R Bonded	024R	024R	045R

-continued

Impeller:	1607	1607	1601	1601	1601	1601
RPM:	4800	4800	3600	3600	3600	3600
Process Time (secs.):	—	—	25	22	33	—
Product Out Weight (kg):	—	—	0.145	0.161	0.133	—
Capacity (kg/hr):	—	—	21	26	15	—
Capacity (lbs/hr):	—	—	46	58	32	—
Other:	Pre-frozen with nitrogen Action zone temperature maintained low via cryo ring Pre-milled material (to ~4 mm) and heated for 2 hrs @ 120 C.	Pre frozen with nitrogen Pre-milled material to ~4 mm Less dry than Test 1 material	Pre-frozen with nitrogen Pre-milled material (to ~4 mm) and heated for 2 hrs @ 120 C.	Pre-frozen with nitrogen (~700 g to ~230 g of material) Pre-milled material (to ~4 mm) and heated for 2 hrs @ 120 C.	Pre-frozen with nitrogen (~238 g to 238 g of material) Pre-milled material (to ~4 mm) and heated for 2 hrs @ 120C.	Pre-frozen with nitrogen (~150 g to 59 g of material) Pre-milled material (to ~4 mm) Less dry than Test 1 material

[0333] The tableting press used to form a tablet from the milled dry material may use a pressing force of less than 10 tons to form the tablet. The tableting press may be a NP400 rotary tablet press manufactured by Natoli Engineering of St. Charles, Mo. The tablets can be pressed into any shape, including but not limited to, a cylindrical shape, which may, for example, have a circular or elliptical cross section, or a toroidal shape.

[0334] The dry material may be pressed into its final tablet shape at a temperature below 0° C., below −5° C., below −10° C., below −15° C., below −20° C., below −25° C., below −30° C., below −35° C., below −40° C., below −45° C., below −50° C., below −55° C., below −60° C., below −65° C., below −70° C., below −75° C., below −100° C., below −150° C., or below −190° C.

[0335] The dry material used to form any of the tablets described above and shown herein may be a cannabis composition having a variation of +/−5% in the percentage by weight (wt. %) of a specified cannabinoid, cannabinoids or other phytoconstituents.

[0336] The dry material used to form any of the tablets described above and shown herein may be specially processed cannabis derived plant material. The specially processed cannabis derived plant material may have a moisture content of about 0 wt. %, about 1 wt. %, about 2 wt. %, about 3 wt. %, about 4 wt. %, or about 5 wt. % moisture. The specially processed cannabis derived plant material may have no material added to the cannabis whatsoever. The specially processed cannabis derived plant material may have only glidants as added material to the cannabis. The specially processed cannabis derived plant material may have only terpenes as added material to the cannabis. The specially processed cannabis derived plant material may have only humectants e.g., glycerine or propylene glycol, as added material to the cannabis. The specially processed cannabis derived plant material may have only glidants and humectants as added materials to the cannabis. The specially processed cannabis derived plant material may have only glidants and terpenes as added materials to the cannabis. The specially processed cannabis derived plant material may have only terpenes and humectants as added materials to the cannabis. The specially processed cannabis derived plant material may have only glidants, terpenes and humectants as added material to the cannabis. The specially processed cannabis derived plant material may be enriched in its trichome component. The specially processed cannabis derived plant material may comprise plant material derived from a single strain of cannabis. The specially processed cannabis derived plant material may be derived from two or more different strains of cannabis. The specially processed cannabis derived plant material may comprise a blend of batches of cannabis chosen to provide a homogenous material with a defined phytochemical profile. The specially processed cannabis derived plant material may comprise cannabis leaves that have been trimmed off of the cannabis plant in the process of harvesting manicured whole flowers and cannabis extracts. The specially processed cannabis derived plant material may be prepared by combining cannabis leaf material with cannabis extracts in a ribbon blender.

[0337] When the dry material is specially processed cannabis derived plant material that is trichrome enriched, the material may be subjected to a first pressing and micropelletizing step to provide a granulated material with a higher density than the original trichome enriched cannabis material. The granulated material is then pressed into the final tablet shape by the tableting press.

[0338] The specially processed cannabis derived plant material may be decarboxylated in a vacuum at about 50° C. at any point during the tablet making processes described above.

Fluid Cartridges

[0339] Other aspects of the invention described herein include cartridges and vape devices designed to vaporize a payload comprising fluids and oils for inhalation, and preferably cartridges and vape devices designed to vaporize cannabis oil or other viscous oils for inhalation of a vapor stream. The cartridges are an improvement to a commonly used cartridge in the personal vaporizer market, the vaporizer cartridge (or cartomizer) with two-conductor electromechanical connectors (often referred to as 510 threaded connectors). The cartridge technology described herein may also be incorporated into a self-contained vape device, for example, a one piece disposable vape device or a one piece refillable and rechargeable vape device, such as the vape device **2800** described below.

[0340] The cartridges described herein are designed for use with highly-viscous oils like those extracted from the cannabis plant. The cartridges described herein are also configured to prevent oil leakage from fouling the area where the cartridge attaches to the control assembly, which includes the battery and control unit.

[0341] One embodiment of a cartridge for a vape device in accordance with the invention described herein is identified generally as **1900** in FIG. **19**A. Cartridge **1900** includes a first section **1902** (FIG. **19**D) and a second section **1904** that removably engages the first section **1902** via threads as described below. The first section **1902** and second section **1904** in combination form a housing **1906** of cartridge **1900**. Referring to FIG. **19**B, an atomizer **1908**, deflectors **1910** and **1912**, and power connector **1914** are positioned within housing **1906**.

[0342] Housing **1906** has a first end **1916** and a second end **1918**. A longitudinal axis of housing **1906** extends from first end **1916** to second end **1918**. At second end **1918**, housing **1906** includes a threaded connector **1920** that is configured for coupling the housing **1906** to a control assembly, such as the control assembly **14** described above and shown in FIG. **1**. Threaded connector **1920** may be a 510 threaded connector. Further, threaded connector **1920** may be configured to operate in accordance with the two lead communication system described below in connection with vape device **4000**. Housing **1906** includes an outer side wall **1922** and an inner side wall **1924** that is spaced apart from outer side wall **1922**. The outer side wall **1922** includes a first section **1922*a*** that is a part of first section **1902** of housing **1906** and a second section **1922*b*** that is a part of second section **1904**. When the first section **1902** and second section **1904** of housing **1906** are joined together, a seal **1926** seals between the first and second sections **1922*a-b*** of outer side wall **1922** to prevent leakage of the fluid payload from cartridge **1900**. The first section **1922*a*** is preferably formed from a clear material, such as glass or a polymer. For example, first section **1922*a*** may be formed from a heat resistant glass such as a borosilicate glass, a glass ceramic, synthetic sapphire, or quartz. The first section **1922*a*** may also be sheathed in a metal sleeve positioned on the exterior surface of outer side wall **1922**.

[0343] Housing **1906** includes a first end wall **1928** at first end **1916** and a second end wall **1930** at second end **1918**. First end wall **1928** is preferably formed integrally with the second section **1922*b*** of outer side wall **1922** to form a generally cylindrical mouthpiece **1929** (FIG. **19**C). Second end wall **1930** is part of an end cap **1932** that includes a cylindrical tube **1934** that extends into a portion of the first section **1922*a*** of outer side wall **1922**. Seals **1936*a-b*** are positioned between cylindrical tube **1934** and outer side wall **1922** to prevent leakage of the fluid payload from cartridge **1900**. Threaded connector **1920** extends outward from second end wall **1930** away from the remainder of cartridge **1900**. Power connector **1914** extends through a central opening **1938** in threaded connector **1920** and second end wall **1930**. Seal **1940*a*** is positioned between power connector **1914** and end cap **1932** to prevent leakage of the fluid payload from cartridge **1900**. Threads **1942** are formed on an interior surface of cylindrical tube **1934** for removably joining the first and second sections **1902** and **1904** of cartridge **1900**. Cylindrical tube **1934** forms a part of the inner side wall **1924** of cartridge **1900** along with a portion of second section **1904** as described below.

[0344] Second section **1904** includes the mouthpiece **1929** and a central post **1944** that is coupled to and extends away from an end wall **1946** of mouthpiece **1929** in a direction opposite first end **1916**. Central post **1944** may be coupled to mouthpiece **1929** in any suitable manner, including a threaded or press-fit connection, or central post **1944** may be formed integrally with mouthpiece **1929**. Central post **1944** is a generally cylindrical tube that includes external threads **1948** at an end of central post **1944** opposite mouthpiece **1929**. Threads **1948** on central post **1944** are configured to removably engage the threads **1942** on cylindrical tube **1934** for joining the first and second sections **1902** and **1904** of cartridge **1900**. Cartridge **1900** is formed in first and second sections **1902** and **1904** to allow refilling and cleaning of cartridge **1900**. Central post **1944** forms the inner side wall **1924** of cartridge **1900** along with cylindrical tube **1934**. Central post **1944** includes an enlarged diameter portion **1944*a*** (FIG. **19**D) that contains atomizer **1908** and deflector **1910** near the second end **1918** of cartridge **1900** and a reduced diameter portion **1944*b*** that extends from mouthpiece **1929**. As the atomizer **1908** and deflector **1910** cannot fit within the reduced diameter portion **1944*b***, the reduced diameter portion **1944*b*** retains the atomizer **1908** and deflector **1910** in place within central post **1944**.

[0345] A power connector **1950** is partially inserted into the end of central post **1944** adjacent atomizer **1908**. Seal **1940*b*** seals between power connector **1950** and central post **1944** to prevent fluid payload leakage. Power connector **1950** is electrically coupled with atomizer **1908** to provide power to atomizer **1908**. Power connector **1950** is also in electrical connection with power connector **1914** when first and second sections **1902** and **1904** of cartridge **1900** are joined together. Power connector **1914** receives power from a control assembly when threaded connector **1920** joins cartridge **1900** to a control assembly.

[0346] Housing **1906** defines a payload reservoir **1952** (FIG. **19**A) positioned between outer side wall **1922** and inner side wall **1924**. Payload reservoir **1952** preferably contains a fluid payload that may include substances such as nicotine, cannabis, or cannabinoid for vaporization and inhalation by a user. Payload reservoir **1952** may also contain propylene glycol, polyethylene glycol, or vegetable glycerin. Payload reservoir **1952** is accessible for refilling when first and second sections **1902** and **1904** (FIG. **19**D) are separated. For refilling cartridge **1900**, the fluid payload may be poured into the first section **1902** and then second section **1904** may be threadably coupled with first section **1902**. Seals **1926**, **1936*a***, **1936*b***, **1940*a***, and **1940*b*** prevent the fluid payload from leaking out of cartridge **1900**.

[0347] Referring to FIG. **19**B, housing **1906** defines an air flow chamber **1953** that extends through mouthpiece **1929** and central post **1944**. A divider **1954** is positioned within the air flow chamber **1953** to divide the air flow chamber **1953** into an inlet flow chamber **1956** and an outlet flow chamber **1958**. Divider **1954** is a cylindrical tube that is positioned within the central post **1944** and spaced apart from the interior surface of the central post **1944** to form inlet flow chamber **1956**. The inlet flow chamber **1956** is concentric with the outlet flow chamber **1958**.

[0348] An inlet **1960** is positioned adjacent the first end **1916** of cartridge **1900**, and an outlet **1962** is positioned adjacent the first end **1916** of cartridge **1900**. The air flow chamber **1953** is positioned between inlet **1960** and outlet **1962** such that air entering inlet **1960** travels through the air flow chamber **1953** to outlet **1962**. Inlet **1960** consists of two holes that extend through outer side wall **1922** of mouth-piece **1929**. Inlet **1960** is in fluid communication with the inlet flow chamber **1956**. Divider **1954** engages an interior surface of mouthpiece adjacent inlet **1960** to seal inlet flow chamber **1956** from outlet flow chamber **1958**. Outlet **1962** is an opening formed in first end wall **1928** and is in fluid communication with outlet flow chamber **1958** through the center of divider **1954**.

[0349] FIG. **20** shows a schematic view of the air flow within cartridge **1900** from inlet **1960** to outlet **1962**. When a user inserts mouthpiece **1929** in his or her mouth and draws air through outlet **1962**, fresh air from external to cartridge **1900** enters inlet **1960** and travels through inlet flow chamber **1956** toward atomizer **1908**. The divider **1954** is spaced apart from a first end **1964** of atomizer **1908** to place the inlet flow chamber **1956** in fluid communication with outlet flow chamber **1958** adjacent the first end **1964** of atomizer **1908** in the space between divider **1954** and atomizer **1908**. Air from inlet flow chamber **1956** combines with vaporized payload from atomizer **1908** and enters outlet flow chamber **1958**. The air and vaporized payload is drawn through outlet flow chamber **1958** through outlet **1962** into the user's mouth. The inlet air passing through inlet flow chamber **1956** can cool the vaporized payload and air flowing through the outlet flow chamber **1958** to prevent the user's mouth or lips from being burned. Alternatively, cartridge **1900** may be formed with an air flow path as shown in FIG. **23**A and described below.

[0350] Inner side wall **1924** is positioned around at least a portion of atomizer **1908** and air flow chamber **1953**, including inlet flow chamber **1956** and outlet flow chamber **1958**. A plurality of openings **1966** are formed in inner side wall **1924** adjacent atomizer **1908** to place atomizer **1908** in fluid communication with payload reservoir **1952**. Referring to FIG. **19**A, each of the openings **1966** is an elongated slot that extends in a direction aligned with the longitudinal axis of housing **1906**, which extends from first end **1916** to second end **1918**. The openings **1966** are spaced approximately equidistant from each other around a circumference of inner side wall **1924**. Any suitable number of openings **1966** may be formed in inner side wall **1924**. For example, there may be 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 openings **1966**. The openings **1966** are rectangular-shaped slots with rounded vertices. Each of the openings **1966** is defined by a pair of linear side edges **1968***a-b* that are spaced apart from each other and a pair of rounded end edges **1970***a-b* that are each positioned at one end of the opening **1966**. The linear side edges **1968***a-b* extend in a direction that is aligned with the longitudinal axis of housing **1906**. The end edge **1970***b* is positioned near the cylindrical tube **1934** of end cap **1932**. The end edge **1970***b* may be positioned directly adjacent to and abut the cylindrical tube **1934** so that when cartridge **1900** is oriented with first end **1916** facing up and second end **1918** facing down, the payload within payload reservoir **1952** is in fluid communication with the openings **1966** even when very little payload remains in payload reservoir **1952**. Further, the openings **1966** may be configured to be at the bottom of the payload reservoir **1952** when the cartridge **1900** is oriented with first end **1916** facing up and second end **1918** facing down. The linear side edges **1968***a-b* and the rounded end edges **1970***a-b* (including the surfaces surrounding the openings **1966** and extending radially from the side edges **1968***a-b*, **1970***a-b* to atomizer **1908**) may be coated with an oleophobic, a hydrophobic, hydrophilic, or low surface energy coating to facilitate flow of the payload within payload reservoir **1952** through the openings **1966**. Further, the linear side edges **1968***a-b* and the rounded end edges **1970***a-b* (including the surfaces surrounding the openings **1966** and extending radially from the side edges **1968***a-b*, **1970***a-b* to atomizer **1908**) may be micro-patterned to promote flow of the payload through the openings **1966**. The micro-patterns may comprise ridges and/or dimples.

[0351] The openings **1966** are preferably sized and configured to prevent air bubbles from blocking the openings **1966** and preventing the flow of the fluid payload into the atomizer **1908**. If air bubbles form in any of the openings **1966**, the shape of the openings allows any air bubbles to channel up the elongated slot and release to unblock the opening. Including openings **1966** spaced circumferentially around the inner side wall **1924** allows the fluid payload within payload reservoir **1952** to be in contact with atomizer **1908** through an opening **1966** no matter how the cartridge **1900** is oriented rotationally around its longitudinal axis (i.e., one of the openings **1966** will always be at or near the bottom of cartridge **1900** no matter how it is rotated).

[0352] Preferably, the openings **1966** are all of equal size and shape; however it is within the scope of the invention for the openings **1966** to have different sizes and shapes. In an alternative embodiment, the openings **1966** may be oval shaped. Further, the end edges **1970***a-b* may be linear so that the openings **1966** are rectangular shaped. The openings **1966** may additionally be any type of suitable shape such as triangular or square. In an alternative embodiment, the openings **1966** may be elongated around the circumference of housing **1906** such that the side edges **1968***a-b* are perpendicular to the longitudinal axis of the housing **1906**.

[0353] The openings **1966** may have the same shape on the outer surface of inner side wall **1924** as on the inner surface of inner side wall **1924** that abuts atomizer **1908**. Alternatively, the openings **1966** may taper to expand or decrease in size as they move from the outer surface of inner side wall **1924** to the inner surface of inner side wall **1924**. The openings **1966** may be spaced equidistant from each other so they are symmetrically distributed around the inner side wall **1924**. Alternatively, the openings **1966** may be distributed asymmetrically around the inner side wall **1924** with varying distances between adjacent openings **1966**. Each of the openings **1966** may be filled with a wicking filler, which may be, for example, porous ceramic, metal mesh, metal fibers, fiberglass, porous or sintered plastic, or porous or sintered metal.

[0354] In one aspect, each of the openings **1966** may have a surface area of about 0.25 mm^2, 0.5 mm^2, 1.0 mm^2, 1.5 mm^2, 2 mm^2, 3 mm^2, 4 mm^2, 5 mm^2, 6 mm^2, 7 mm^2, 8 mm^2, 9 mm^2, 10 mm^2, 11 mm^2, 12 mm^2, 13 mm^2, 14 mm^2, 15 mm^2, 16 mm^2, 17 mm^2, 18 mm^2, 19 mm^2, 20 mm^2, 21 mm^2, 22 mm^2, 23 mm^2, 24 mm^2, or 25 mm^2.

[0355] In one aspect, the aspect ratio of the length (i.e., distance between end edges **1970***a-b*) and width (i.e., distance between side edges **1968***a-b*) of the one or more of the openings **1966** may be about 1.1:1, 1.2:1, 1.3:1, 1.4:1, 1.5:1, 1.6:1, 1.7:1, 1.8:1, 1.9:1, 2:1, 2.1:1, 2.2:1, 2.3:1, 2.4:1, 2.5:1, 2.6:1, 2.7:1, 2.8:1, 2.9:1, 3:1, 3.2:1, 3.4:1, 3.6:1, 3.8:1, 4:1, 4.2:1, 4.4:1, 4.6:1, 4.8:1 or 5:1.

[0356] Atomizer **1908** is positioned within housing **1906** adjacent the second end **1918** of the housing **1906**. The atomizer **1908** is in fluid communication with both the payload reservoir **1952** and the air flow chamber **1953**, as described above. Atomizer **1908** is a generally cylindrical tube that includes an outer side wall **1972** and an inner side wall **1974**, which defines a cylindrical atomizer chamber **1976**. Atomizer **1908** has a first end **1964** facing the first end **1916** of housing **1906** and a second end **1978** facing the second end **1918** of housing **1906**.

[0357] Atomizer **1908** is preferably formed from a porous ceramic material (e.g., a non-fibrous material such as Japanese alumina ceramic or black porous ceramic such as Al_2O_3 or black Al_2O_3) that surrounds a heating element positioned between the outer side wall **1972** and the inner side wall **1974**. The heating element is electrically connected to power connector **1950**. The heating element may be a coil that is encased in a porous ceramic material. The heating element may be a resistive or inductive heating element and may comprise SS316L surgical stainless steel or a titanium alloy. In one embodiment, the heating element has an electrical resistance of less than 2 ohm, less than 1.5 ohm, less than 1.3 ohm or less than 1 ohm. In one embodiment, the heating element and atomizer **1908** does not include nichrome or kanthal. The heating element may also be applied to the inner side wall **1974** of atomizer **1908**. The outer side wall **1972** may be coated with an oleophobic, a hydrophobic, hydrophilic, or low surface energy coating to facilitate flow of the payload through openings **1966**. The outer side wall **1972** may also be micro-patterned to facilitate flow of the payload through openings **1966**. The micro-patterns may comprise ridges and/or dimples.

[0358] The payload within payload reservoir **1952** is in contact with the outer side wall **1972** through openings **1966**. The payload travels through the porous atomizer **1908** from outer side wall **1972** to the atomizer chamber **1976**. The heating element heats and vaporizes the payload as it passes through the atomizer **1908** to the atomizer chamber **1976**. The vaporized payload within the atomizer chamber **1976** is drawn into the outlet flow chamber **1958** where it is mixed with air from inlet flow chamber **1956**, as described above.

[0359] Deflectors **1910** and **1912** are positioned in the air flow chamber **1953** between the atomizer **1908** and the outlet **1962** for the purpose of preventing unvaporized fluid payload from leaking out of cartridge **1900**. Deflector **1910** includes a side wall **1980** with a cylindrical portion that is positioned within the atomizer chamber **1976**. The side wall **1980** defines a hollow deflector chamber **1982**. The end of side wall **1980** facing first end **1916** of housing **1906** flares outwardly into a section **1980***a* of side wall **1980** that has a larger diameter than the cylindrical portion of side wall **1980**. The outwardly flared section **1980***a* is shaped as a truncated cone and is positioned outside of atomizer chamber **1976**. The truncated cone shape of the section **1980***a* expands in diameter as it extends away from the cylindrical portion of the side wall **1980** toward first end **1916**.

[0360] In one aspect, the largest diameter portion at the end of the flared section **1980***a* has a diameter that is about 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, or 2 times the diameter of the cylindrical portion of the deflector **1910**. In one aspect, the length of the flared section **1980***a* (i.e., the distance from the cylindrical portion of side wall **1980** to the end of deflector **1910**) is about 0.1, 0.2, 0.3, 0.4, or 0.5 times the length of the cylindrical portion of deflector **1910**.

[0361] Deflector **1910** is perforated with a plurality of holes. Each of the holes may have a diameter that is between about 0.1 mm to about 0.5 mm, between about 0.5 mm to about 1 mm, between about 1 mm to about 2 mm, or between about 2 mm to about 5 mm. In one aspect, each of the holes may have a diameter that is about 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, 1.4 mm, 1.5 mm, 1.6 mm, 1.7 mm, 1.8 mm, 1.9 mm, or 2.0 mm.

[0362] Deflector **1910** may also be formed from a hollow cylindrical mesh including a plurality of openings. In one aspect, the longest distance across each of the openings of the hollow cylindrical mesh may be from about 0.1 mm to about 0.5 mm, about 0.5 mm to about 1 mm, about 1 mm to about 2 mm, or about 2 mm to about 5 mm. In one aspect, the longest distance across each of the openings may be about 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, 1.4 mm, 1.5 mm, 1.6 mm, 1.7 mm, 1.8 mm, 1.9 mm, or 2.0 mm.

[0363] Deflector **1912** is positioned downstream of deflector **1910** within the outlet flow chamber **1958** near outlet **1962**. Deflector **1912** is a generally planar, perforated disc with a plurality of holes formed therein that allow air to flow through deflector **1912**. Each of deflectors **1910** and **1912** may comprise an oleophobic, a hydrophobic, a hydrophilic, or a low surface energy coating. The deflectors **1910** and **1912** may comprise a micro-patterned surface configured to be hydrophobic and/or oleophobic. Deflectors **1910** and **1912** are optional and may be omitted from cartridge **1900**. Further, cartridge **1900** may include one of deflectors **1910** or **1912** and not the other.

[0364] In one aspect, each of the holes of deflector **1912** may have a diameter that is between about 0.1 mm to about 0.5 mm, between about 0.5 mm to about 1 mm, between about 1 mm to about 2 mm, or between about 2 mm to about 5 mm. In one aspect, each of the holes of deflector **1912** may have a diameter that is about 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, 1.4 mm, 1.5 mm, 1.6 mm, 1.7 mm, 1.8 mm, 1.9 mm, or 2.0 mm.

[0365] Deflector **1912** may be formed from mesh or a screen. In one aspect, the longest distance across each of the openings of the mesh may be from about 0.1 mm to about 0.5 mm, about 0.5 mm to about 1 mm, about 1 mm to about 2 mm, or about 2 mm to about 5 mm. In one aspect, the longest distance across each of the openings may be about 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, 1.4 mm, 1.5 mm, 1.6 mm, 1.7 mm, 1.8 mm, 1.9 mm, or 2.0 mm.

[0366] Deflectors **1910** and **1912** preferably catch or deflect unvaporized fluid payload within outlet flow chamber **1958** to prevent heated fluid payload from entering a user's mouth through outlet **1962**. Deflectors **1910** and **1912** may inhibit any unvaporized payload from exiting outlet **1962** by limiting droplet accumulation with a micro-patterned surface configured to be hydrophobic and/or oleophobic. In another embodiment, inhibiting the droplets from exiting outlet **1962** comprises entrapping droplets on a micro-patterned surface. Deflectors **1910** and **1912** could be positioned anywhere between the atomizer **1908** and outlet **1962**.

[0367] Deflectors **1910** and **1912** may be made of a metal or metal alloy such as stainless steel, aluminum, titanium or another metal or metal alloy. Preferably, deflectors **1910** and **1912** are made from SS316L surgical grade stainless steel or a titanium alloy. Alternatively, deflectors **1910** and **1912** may be made of a suitable polymer material that has sufficient heat resistance to maintain its shape and not outgas volatiles at the typical operating temperatures of the cartridge **1900**.

[0368] In one embodiment, the mouthpiece **1929**, end cap **1932**, and central post **1944** of cartridge **1900** may be made of a metal or metal alloy such as stainless steel, aluminum, titanium or another metal or metal alloy.

[0369] Cartridge **1900** may also include a valve to regulate the size of the openings **1966** that place payload reservoir **1952** in fluid communication with atomizer **1908**. For example, the valve may be a rotating sleeve positioned between the atomizer **1908** and inner side wall **1924**. The rotating sleeve may have a plurality of spaced apart openings that are similar to the openings **1966** in inner side wall **1924**. The rotating sleeve can be rotated into a fully open position, in which the openings in the rotating sleeve are aligned with the openings **1966**, a plurality of partially open positions, in which the openings in the rotating sleeve are partially aligned with the openings **1966** and a solid portion of the rotating sleeve blocks fluid flow through a portion of the openings, or a closed position, in which the openings in the rotating sleeve are not aligned with the openings **1966** and a solid portion of the rotating sleeve completely blocks the openings **1966**.

[0370] FIGS. **21**-**23**D show a portion of an alternative embodiment of cartridge **2100** that is similar to cartridge **1900** except that cartridge **2100** has an inlet flow chamber **2102** that extends through channels **2104** in the atomizer **2106**. Because cartridge **2100** is similar to cartridge **1900**, only the differences between cartridges **2100** and **1900** are described in detail herein. Referring to FIG. **22**, cartridge **2100** has a divider **2108** that divides the air flow chamber **2110** within inner side wall **2112** into inlet flow chamber **2102** and outlet flow chamber **2114**. Air enters inlet flow chamber **2102** through inlets in a similar manner as described above with respect to cartridge **1900**. Divider **2108** abuts atomizer **2106** so that air within inlet flow chamber **2102** is directed through channels **2104** in atomizer **2106**. Atomizer **2106** includes a first end **2116** facing the first end **2117** of cartridge **2100** and a second end **2118** facing the second end **2119** of cartridge **2100**. Atomizer **2106** includes an outer side wall **2120** and an inner side wall **2122**. Channels **2104** are positioned between outer side wall **2120** and inner side wall **2122** and extend through atomizer **2106** from first end **2116** to second end **2118**. The channels **2104** form part of the inlet flow chamber **2102** extending through cartridge **2100** so that the inlet flow chamber **2102** extends from the inlet past the first end **2116** of the atomizer **2106** to the second end **2118** of the atomizer **2106**.

[0371] The inner side wall **2122** of atomizer **2106** defines an atomizer chamber **2124**. As shown in FIG. **23**B, a recess **2126** is formed in the second end **2118** of atomizer **2106** to place channels **2104** and thus inlet flow chamber **2102** in fluid communication with atomizer chamber **2124** adjacent the second end **2118** of atomizer **2106**. The atomizer chamber **2124** is in fluid communication with outlet flow chamber **2114** adjacent the first end **2116** of atomizer **2106**, as shown in FIG. **22**. The elongated slots **2128** (FIG. **21**) formed in the inner side wall **2112** are preferably offset circumferentially from the channels **2104** through atomizer **2106** to allow fluid payload from payload reservoir **2130** to more easily pass through atomizer **2106** into atomizer chamber **2124** and prevent the fluid payload from entering the channels **2104**. The surfaces of atomizer **2106** surrounding the channels **2104** may also be formed from, coated with, or covered with a non-porous material to prevent the fluid payload in payload reservoir **2130** from entering the channels **2104**. For example, while the atomizer **2106** may be formed from a porous material such as porous ceramic, the surfaces surrounding the channels **2104** may be coated or glazed with a non-porous material, covered with a sheet of non-porous material, or heat treated to render the surfaces non-porous.

[0372] The inner side wall **2112** is positioned within a housing **2132** to define payload reservoir **2130** between the inner side wall **2112** and housing **2132**. A seal or gasket **2134** is positioned between the inner side wall **2112** and an end wall **2136** of the housing **2132** to prevent fluid payload from leaking out of payload reservoir **2130** and to prevent air from entering the cartridge **2100**. The inner side wall **2112** may be joined to end wall **2136**. For example, the inner side wall **2112** may be joined to end wall **2136** by fusing, swaging or gluing them together. The seal **2134** can also be eliminated if the inner side wall **2112** and end wall **2136** are joined in a manner that prevents fluid payload from leaking between the inner side wall **2112** and end wall **2136**. Alternatively, the inner side wall **2112** may be part of a central post that removably screws into an end cap, like with the cartridge **1900** described above. The elongated slots **2128** may extend to end wall **2136** so that fluid payload is in communication with the elongated slots **2128** when cartridge **2100** is oriented with first end **2117** positioned above second end **2119** and very little fluid payload is left in cartridge **2100**.

[0373] In an alternative embodiment, the channels **2104** of cartridge **2100** may be positioned between the atomizer **2106** and the inner side wall **2112**. For example, a plurality of circumferentially spaced recesses may be formed in the outer side wall **2120** of atomizer **2106** to form the channels between the atomizer **2106** and the inner side wall **2112**. The recesses are preferably circumferentially offset from the elongated slots **2128** that place the payload reservoir **2130** in fluid communication with atomizer **2106**. Surfaces surrounding the recesses may be formed from, coated with, or covered with a non-porous material to prevent the fluid payload in payload reservoir **2130** from entering the channels.

[0374] Extending the inlet flow chamber **2102** through or adjacent to the atomizer **2106** improves the performance of cartridge **2100**. As the inlet air flows through or adjacent to the atomizer **2106**, the atomizer **2106** pre-heats the inlet air, which allows the concentration of vaporized payload to be more easily optimized with respect to the wattage supplied to the heating element of atomizer **2106**. Pre-heating the inlet air also allows for a more even temperature profile that prevents undesired thermolysis of the payload as it is vaporized. In another aspect, the inlet air can cool the vaporized payload and air flowing through the outlet flow chamber **2114** to prevent the user's mouth or lips from being burned.

[0375] In one embodiment, the ceramic material of the atomizer **2106** could be replaced with a sintered metal or a high-heat resistant plastic. The divider **2108**, inner side wall **2112**, and housing **2132** may be formed from metal, plastic, wood, a composite material or ceramic. The cartridge **2100** may include deflectors **1910** and **1912** (described above) with deflector **1910** being modified to remove the flared section **1980***a* so that divider **2108** can abut atomizer **2106**.

[0376] Cartridge **2100** may have a rotating sleeve valve that is structured similar to the rotating sleeve valve described above for cartridge **1900** to regulate the fluid flow through elongated slots **2128**.

[0377] FIG. **24** is a schematic view of an alternative embodiment of cartridge **2400** with a different air flow path than the cartridges **1900** and **2100**. The air flow path of cartridge **2400** may be used in cartridge **1900** along with the elongated slot openings **1966** and deflectors **1910** and **1912**. Cartridge **2400** has a first end **2402** and a second end **2404**. The inlet **2406** is adjacent the second end **2404** of the cartridge **2400** and the outlet **2408** is adjacent the first end **2402**. The inlet flow chamber **2410** extends from the inlet **2406** to the atomizer **2412** and the atomizer chamber **2414**. The outlet flow chamber **2416** extends from the atomizer chamber **2414** to the outlet **2408**. As a user draws air through a mouthpiece adjacent outlet **2408**, air enters inlet **2406**, the air mixes with vaporized payload within atomizer chamber **2414**, and the air and vaporized payload exit outlet **2408**.

[0378] Any of the cartridges **1900**, **2100**, and **2400** described above may be formed integral with a control assembly (e.g., control assembly **14**) to form a vape device that is operable to power the atomizers **1908**, **2106**, and **2412** upon demand by a user by supplying a controlled current or voltage to the atomizer. The cartridges **1900**, **2100**, and **2400** may also be screwable into a control assembly using threaded connector **1920** as shown or may have snap clips or some other structure that joins them to a control assembly. The control assembly **14** is configured to cause the cartridges **1900**, **2100**, and **2400** to provide vapor through the outlet in response to a user's input by supplying a controlled current or voltage to the atomizer **1908**, **2106**, or **2412**, as described above. Threaded connector **1920** is preferably a 510 threaded connector that allows cartridges **1900**, **2100**, and **2400** to be used with compatible 510 threaded control subassemblies or vape devices. Any of the cartridges **1900**, **2100**, and **2400** may be operated to vaporize a fluid payload within the payload reservoir in accordance with the methods described above for vape devices **10** and **100** and vape device system **102**, including in accordance with the system and method for optimizing vaporization described above. The cartridges **1900**, **2100**, and **2400** may have an ID tag **28** that includes a unique payload identifier, which identifies the cartridges **1900**, **2100**, and **2400**. The cartridges **1900**, **2100**, and **2400** may also include sensors to measure operational conditions of the cartridges. For example, the cartridges **1900**, **2100**, and **2400** may include the integrated temperature control system described below in connection with vape device **4200** to regulate the temperature of the atomizers and the capacitive vapor measurement system described below in connection with vape device **3100**. Conductive plates of the capacitive vapor measurement system, such as the conductive plates **3114** and **3116** shown in FIG. **31**, may be positioned anywhere between the atomizer and outlet of the cartridges. For example, the conductive plates may be position in the outlet flow chamber **1958** of cartridge **1900**, in the outlet flow chamber **2114** of cartridge **2100**, or in the outlet flow chamber **2416** of cartridge **2400**. Data from the sensors may be transmitted to a control assembly via a threaded connector that operates in accordance with the two lead communication system described below in connection with vape device **4000** such that power is also provided to the cartridge via the threaded connector.

Cartridge with Pressurized Fluid Reservoir

[0379] In addition to the cartridges **1900**, **2100**, and **2400** described above, another aspect of the invention described herein that relates to a cartridge for use with a fluid payload is a cartridge that pressurizes a fluid payload within a payload reservoir. Pressurizing the fluid payload allows the fluid payload to reliably flow into the atomizer without the formation of air bubbles in the opening or channel between the payload reservoir and the atomizer. This is particularly advantageous when the fluid payload is a highly-viscous oil or fluid like those extracted from the cannabis plant. Further, pressurizing the fluid payload ensures that substantially all of the fluid payload is available for vaporization and that no substantial amount of fluid payload is leftover in the payload reservoir after use.

[0380] One embodiment of cartridge with a pressurized fluid reservoir is identified generally as **2500** in FIG. **25**A. Cartridge **2500** includes a housing **2502**, an atomizer **2504** (FIG. **25**B), a pressurizer **2506**, a stopper **2508**, a dose ring **2510**, and a spring **2512**. Atomizer **2504**, pressurizer **2506**, stopper **2508**, and spring **2512** are positioned within an interior chamber **2513** defined by housing **2502**. The spring **2512** biases the pressurizer **2506** toward a payload reservoir **2514** of the housing **2502** to apply pressure to a fluid payload within the payload reservoir **2514**, which forces the fluid payload into contact with atomizer **2504**. Dose ring **2510** threadably engages stopper **2508** and allows a user to move stopper **2508** to regulate the amount of fluid payload forced into contact with atomizer **2504**. Payload reservoir **2514** preferably contains a fluid payload that includes nicotine, cannabis, or cannabinoid for vaporization and inhalation by a user. Payload reservoir **2514** may also contain propylene glycol, polyethylene glycol, or vegetable glycerin.

[0381] As shown in FIG. **25**A, housing **2502** includes a mouthpiece **2516**, an end cap **2518**, and a cylindrical tube **2520** coupled to end cap **2518**. Dose ring **2510** is positioned between and joined to cylindrical tube **2520** and mouthpiece **2516** in a manner that permits rotation of dose ring **2510**. End cap **2518** forms a first end wall **2522** of housing **2502**, and mouthpiece **2516** forms a second end wall **2524**. An outer side wall **2526** is formed by the combination of cylindrical tube **2520** and mouthpiece **2516**. End cap **2518** includes a threaded connector **2528** that is configured for coupling the housing **2502** to a control assembly, such as the control assembly **14** described above and shown in FIG. **1**. An inlet **2530** is formed in the outer side wall **2526** adjacent the second end wall **2524**, and an outlet **2532** is formed in the second end wall **2524**. The inlet **2530** preferably comprises a plurality of holes that extend through outer side wall **2526** into a chamber **2533** of housing **2502**. End cap **2518** may be permanently coupled to cylindrical tube **2520** or removably coupled to cylindrical tube **2520** for refilling payload reservoir **2514**.

[0382] Pressurizer **2506** includes a circular pressure plate **2534**, a cylindrical tube **2536** coupled to and extending from pressure plate **2534** toward second end wall **2524**, and a flange **2538** coupled to the end of tube **2536** and extending generally perpendicular outward from the tube **2536**. Pressure plate **2534** has a first side **2534***a* positioned adjacent payload reservoir **2514** and a second side **2534***b* positioned adjacent atomizer **2504**. Payload reservoir **2514** is positioned between and defined by the pressure plate **2534**, outer side wall **2526**, and first end wall **2522**. The outer peripheral edge of pressure plate **2534** sealingly engages outer side wall **2526**. The pressurizer **2506** moves within the housing **2502** in a direction that is aligned with a longitudinal axis of the housing **2502** (i.e., an axis extending between first end wall **2522** and second end wall **2524**). Movement of pressurizer **2506** within the housing **2502** reduces or expands the size of the payload reservoir **2514**.

[0383] Pressure plate **2534** includes a central opening **2540** that places atomizer **2504** in fluid communication with payload reservoir **2514**. The opening **2540** is preferably sized based on the viscosity of the fluid payload contained within the payload reservoir **2514**, the force exerted by spring **2512** on pressurizer **2506**, and the desired flow rate of fluid payload through opening **2540**. Tube **2536** extends through a central opening of dose ring **2510** into chamber **2533** adjacent inlet **2530**. A valve may be positioned adjacent central opening **2540** to regulate the size of the opening **2540** and the amount of fluid that can flow therethrough. For example, the valve **2540** may slide to unblock opening **2540**, partially block opening **2540**, or completely block opening **2540**.

[0384] Atomizer **2504** is positioned within pressurizer tube **2536** adjacent the second side **2534***b* of pressure plate **2534**. Atomizer **2504** preferably comprises porous ceramic that surrounds a heating element. Atomizer **2504** may be formed from any of the materials, and may operate in the same manner, as described above in connection with atomizer **1908**. Atomizer **2504** is cylindrical and includes a central atomizer channel **2542** that is aligned with the opening **2540** in pressure plate **2534** for allowing fluid payload to flow from payload reservoir **2514** through the opening **2540** and into atomizer channel **2542**.

[0385] A divider **2544** extends from chamber **2533** into tube **2536**. The divider **2544** is a cylindrical tube that divides the chamber **2533** and interior chamber of tube **2536** into an inlet flow chamber **2546**, positioned between an outer surface of divider **2544** and an inner surface of tube **2536**, and an outlet flow chamber **2548**, positioned within divider **2544**. Inlet **2530** is in fluid communication with the inlet flow chamber **2546**, and outlet **2532** is in fluid communication with the outlet flow chamber **2548**. The end of divider **2544** within tube **2536** is spaced from atomizer **2504** to place inlet flow chamber **2546** in fluid communication with outlet flow chamber **2548** adjacent atomizer **2504**. When a user draws air through outlet **2532**, air enters inlet **2530** and travels through inlet flow chamber **2546**. Vaporized fluid payload from atomizer **2504** mixes with the air from inlet flow chamber **2546** and travels through outlet flow chamber **2548** into the user's mouth for inhalation. FIG. **27** shows a schematic view of the air flow path through cartridge **2500**.

[0386] Stopper **2508** is a cylindrical tube that is positioned around the tube **2536** of pressurizer **2506**. Stopper **2508** is positioned between the flange **2538** and pressure plate **2534** of pressurizer **2506**. The length of stopper **2508** is less than the distance between flange **2538** and pressure plate **2534** so that the stopper **2508** can move relative to pressurizer **2506** in a direction that is aligned with the longitudinal axis of housing **2502**. The outer surface of stopper **2508** is threaded and engages threads on an inner surface of dose ring **2510**. Stopper **2508** engages a portion of tube **2536** or housing **2502** in a manner that prevents rotational movement of the stopper **2508** around the tube **2536** but that allows stopper **2508** to move in a direction that is aligned with the longitudinal axis of housing **2502**.

[0387] Dose ring **2510** includes an outer surface that is generally aligned with the outer surface of outer side wall **2526** and an inner surface with threads that engage the threads on stopper **2508**. Dose ring **2510** is rotatable with respect to housing **2502**.

[0388] Spring **2512** is positioned between dose ring **2510** and pressure plate **2534**. Spring **2512** biases the pressure plate **2534** toward the payload reservoir **2514** and first end wall **2522** when stopper **2508** does not prevent movement of pressurizer **2506**. Spring **2512** also biases flange **2538** toward stopper **2508**. It is within the scope of the invention to use other types of biasing mechanisms that have the capability to exert force on pressurizer **2506** instead of spring **2512**.

[0389] When a user desires to use cartridge **2500** to vaporize a fluid payload within payload reservoir **2514**, the user connects the cartridge **2500** to a control assembly, such as control assembly **14** described above. The control assembly may operate to power a heating element of atomizer **2504** in accordance with the methods of operation described above for the vape devices **10** and **100** and vape device system **102**. Before use, stopper **2508** is in a closed position in which it engages flange **2538** to prevent spring **2512** from moving pressurizer **2506** toward payload reservoir **2514**. This prevents the pressurizer **2506** from pressurizing the fluid payload within payload reservoir **2514** to an extent that the fluid payload will flow through the opening **2540** in pressure plate **2534**. To allow fluid payload to flow through the opening **2540**, the user rotates dose ring **2510** in a direction that causes stopper **2508** to move away from engagement with flange **2538**. Alternatively, a motor may be used to rotate the dose ring **2510** and may be controlled manually by the user or by a processor that sends a signal to turn the motor on and off. Because rotational movement of stopper **2508** is blocked, rotation of dose ring **2510** causes longitudinal movement of stopper **2508** away from flange **2538**. Once stopper **2508** is moved away from flange **2538**, spring **2512** and pressure plate **2534** exert pressure on the fluid payload within payload reservoir **2514** causing the fluid payload to move through the opening **2540** in pressure plate **2534** and into contact with atomizer **2504**.

[0390] Dose ring **2510** and housing **2502** preferably include a dose indicator that corresponds with a particular amount of fluid payload contained within payload reservoir **2514**. For example, the dose indicator may be a line or set of lines on dose ring **2510** and a line or set of lines on the outer side wall **2526** adjacent dose ring **2510**. The user may rotate dose ring **2510** so that a line on dose ring moves from alignment with a first line on outer side wall **2526** to a second line on outer side wall **2526**. The dose ring **2510** may also move axially with respect to housing **2502** as it rotates. Alternatively, if a first line on dose ring **2510** is aligned with a line on outer side wall **2526**, the user may rotate the dose ring **2510** until a second line on dose ring **2510** is aligned with the line on outer side wall **2526**. The spacing between adjacent lines on dose ring **2510** or outer side wall **2526** corresponds with an angular degree of movement of dose ring **2510**, which corresponds with a longitudinal movement of stopper **2508**. The longitudinal movement of stopper **2508** toward payload reservoir **2514** corresponds with a volume reduction of payload reservoir **2514** and a volume of the fluid payload within payload reservoir **2514** that is forced through opening **2540** into atomizer **2504** for vaporization. Thus, the user can use the dose indicator on dose ring **2510** and housing **2502** to select the volume of the fluid payload, or dose, that the user wants to vaporize. Other types of dose indicators may be used with cartridge **2500** instead of lines. For example, a detent mechanism can be used with a spring loaded ball or pin on either dose ring **2510** or housing **2502** engaging one of a series of holes or recesses on the other of dose ring **2510** or housing **2502**. The use of a detent mechanism may provide the user with tactile or audible feedback so that the user knows when the dose ring has rotated from one position to the next, which each instance of rotation from one position to the next corresponding with a dose of the fluid payload that will be forced through opening **2540**.

[0391] After the dose is selected with dose ring **2510**, the user causes power to be supplied to the atomizer **2504** by, for example, pressing a button on the control assembly connected to cartridge **2500**, beginning to draw air through outlet **2532**, or any of the other methods described above with respect to vape devices **10** and **100**. As the atomizer **2504** heats the fluid payload, the fluid payload vaporizes, is mixed with air from inlet **2530**, and exits through outlet **2532** for inhalation. As the fluid payload passes through opening **2540** and vaporizes, spring **2512** causes pressurizer **2506** to move toward payload reservoir **2514**, which also causes the flange **2538** of pressurizer **2506** to move toward stopper **2508**. When flange **2538** engages stopper **2508**, pressurizer **2506** can no longer move toward payload reservoir **2514**, which causes the fluid payload to stop flowing through opening **2540** and vaporizing. To vaporize the fluid payload again, the user turns dose ring **2510** as described above.

[0392] Opening **2540** is preferably sized so that the fluid payload within payload reservoir **2514** does not leak through the opening **2540** when stopper **2508** engages flange **2538**. The viscosity of the fluid payload combined with the size of the opening **2540** prevents leakage through the opening **2540**.

[0393] A heater may be positioned in or adjacent payload reservoir **2514** to heat the fluid payload within payload reservoir **2514** to a temperature that is below the vaporization temperature of the fluid payload, but that reduces the viscosity of the fluid payload allowing it to flow in a desired manner through the opening **2540** of pressurizer **2506**.

[0394] In an alternative embodiment, the inlet flow chamber **2546** may extend from the inlet **2530** through a channel in the pressurizer **2506**. The channel may be blocked by the stopper **2508** when the flange **2538** engages stopper **2508** to prevent a user from drawing air through the cartridge **2500** when the stopper **2508** prevents spring **2512** and pressurizer **2506** from forcing fluid payload into contact with atomizer **2504**. Blocking air flow from the inlet **2530** and inlet flow chamber **2546** can prevent the user from heating the atomizer **2504** when fluid payload is not in contact with the atomizer **2504** for vaporization, which is advantageous because heating the atomizer **2504** without it being in contact with the fluid payload can potentially damage the atomizer **2504**. If the cartridge **2500** has a pressure activation switch, as described above in connection with vape devices **10** and **100**, that senses a decrease in pressure before activating atomizer **2504**, blocking air flow through inlet flow chamber **2546** will prevent activation of the pressure activation switch and atomizer **2504**.

[0395] Another embodiment of cartridge with a pressurized fluid reservoir is identified generally as **2600** in FIG. 26A. Cartridge **2600** includes a housing **2602**, an atomizer **2604** (FIG. 26B), a pressurizer **2606**, a stopper **2608**, a dose ring **2610**, and a spring **2612**. Atomizer **2604**, pressurizer **2606**, stopper **2608**, and spring **2612** are positioned within an interior chamber **2613** defined by housing **2602**. The spring **2612** biases the pressurizer **2606** toward a payload reservoir **2614** of the housing **2602** to apply pressure to a fluid payload within the payload reservoir **2614**, which forces the fluid payload into contact with atomizer **2604**. Dose ring **2610**, pressurizer **2606**, and stopper **2608** allow a user to move stopper **2608** to regulate the amount of fluid payload forced into contact with atomizer **2604**, as described below. Payload reservoir **2614** preferably contains a fluid payload that includes nicotine, cannabis, or cannabinoid for vaporization and inhalation by a user. Payload reservoir **2614** may also contain propylene glycol, polyethylene glycol, or vegetable glycerin.

[0396] Housing **2602** includes a mouthpiece **2616**, an end cap **2618**, and a cylindrical tube **2620** coupled to end cap **2618**. Dose ring **2610** is positioned between and joined to cylindrical tube **2620** and mouthpiece **2616** in a manner that permits rotation of dose ring **2610**. End cap **2618** forms a first end wall **2622** of housing **2602**, and mouthpiece **2616** forms a second end wall **2624**. An outer side wall **2626** is formed by the combination of cylindrical tube **2620** and mouthpiece **2616**. End cap **2618** may include a threaded connector that is configured for coupling the housing **2602** to a control assembly, such as the control assembly **14** described above and shown in FIG. **1**. An inlet **2630** is formed in the outer side wall **2626** adjacent the second end wall **2624**, and an outlet **2632** is formed in the second end wall **2624**. The inlet **2630** preferably comprises a plurality of holes that extend through outer side wall **2626**. End cap **2618** may be permanently coupled to cylindrical tube **2620** or removably coupled to cylindrical tube **2620** for refilling payload reservoir **2614**.

[0397] A central post **2631** is integrally formed with mouthpiece **2616** and extends from mouthpiece **2616** to payload reservoir **2614** adjacent first end wall **2622**. Central post **2631** is positioned within the interior chamber **2613** defined by housing **2602**. A channel **2633** extends through central post **2631** and has an opening **2635** adjacent first end wall **2622**. Atomizer **2604** is positioned within the channel **2633** at the end of central post **2631** adjacent first end wall **2622**. The end of central post **2631** is spaced apart from the first end wall **2622** so that fluid payload in payload reservoir **2614** can flow through opening **2635** into atomizer **2604** when stopper **2608** is spaced apart from first end wall **2622**. Central post **2631** may also be attached to first end wall **2622** with, for example, threads or clips, in which case at least one opening would extend through central post **2631** to place atomizer **2604** in fluid communication with payload reservoir **2614** when the opening is not covered by stopper **2608**.

[0398] Pressurizer **2606** includes an annular pressure plate **2634** and a cylindrical tube **2636** coupled to and extending from pressure plate **2634** toward second end wall **2624**. Payload reservoir **2614** is positioned between and defined by the pressure plate **2634**, outer side wall **2626**, and first end wall **2622**. The outer peripheral edge of pressure plate **2634** sealingly engages outer side wall **2626**. Pressurizer **2606** includes an interior surface **2638** that is threaded and surrounds an interior chamber extending through the pressurizer **2606**. The threaded interior surface **2638** engages a threaded outer surface **2640** of stopper **2608**. The pressurizer **2606** moves within the housing **2602** in a direction that is aligned with a longitudinal axis of the housing **2602** (i.e., an axis extending between first end wall **2622** and second end wall **2624**). Movement of pressurizer **2606** within the housing **2602** reduces or expands the size of the payload reservoir **2614**.

[0399] Pressurizer **2606** includes at least one flute **2642** that is positioned within a recess of dose ring **2610**. The engagement between the flute **2642** and recess of dose ring **2610** allows pressurizer **2606** to rotate with rotation of dose ring **2610** and also allows pressurizer **2606** to move axially with respect to dose ring **2610** in a direction aligned with the longitudinal direction of housing **2602**. It is within the scope of the invention to use other types of structures besides a flute and recess as long as the pressurizer **2606** is rotationally fixed to dose ring **2610** and the pressurizer **2606** can move axially with respect to dose ring **2610**.

[0400] Atomizer **2604** preferably comprises porous ceramic that surrounds a heating element. Atomizer **2604** may be formed from any of the materials, and may operate in the same manner, as described above in connection with atomizer **1908**. Atomizer **2604** is cylindrical and includes a central atomizer channel **2643** that is in fluid communication with payload reservoir **2614** when stopper **2608** does not engage first end wall **2622** for allowing fluid payload to travel from payload reservoir **2514** into atomizer channel **2643**.

[0401] Housing **2602** includes a divider **2644** that is positioned within the channel **2633** of central post **2631**. The divider **2644** is a cylindrical tube that divides the channel **2633** into an inlet flow chamber **2646**, positioned between an outer surface of divider **2644** and an inner surface of central post **2631**, and an outlet flow chamber **2648**, positioned within divider **2644**. Inlet **2630** is in fluid communication with the inlet flow chamber **2646**, and outlet **2632** is in fluid communication with the outlet flow chamber **2648**. The end of divider **2644** within central post **2631** is spaced from atomizer **2604** to place inlet flow chamber **2646** in fluid communication with outlet flow chamber **2648** adjacent atomizer **2604**. When a user draws air through outlet **2632**, air enters inlet **2630** and travels through inlet flow chamber **2646**. Vaporized fluid payload from atomizer **2604** mixes with the air from inlet flow chamber **2646** and travels through outlet flow chamber **2648** into the user's mouth for inhalation.

[0402] Stopper **2608** is a cylindrical tube that is positioned around the central post **2631**. A portion of stopper **2608** engages housing **2602**, which may include central post **2631**, so that stopper **2608** cannot rotate around central post **2631**, but the engagement allows stopper **2608** to move with respect to central post **2631** in a direction aligned with the longitudinal axis of housing **2602**. Stopper **2608** is positioned between first end wall **2622** and an interior wall **2650** of housing **2602**. The length of stopper **2608** is less than the distance between first end wall **2622** and interior wall **2650** so that the stopper **2608** can move relative to pressurizer **2606** and central post **2631** in a direction that is aligned with the longitudinal axis of housing **2602**. The outer surface **2640** of stopper **2608** includes threads that engage threads on the interior surface **2638** of pressurizer **2606**.

[0403] Stopper **2608** has an end surface **2652** adjacent first end wall **2622**. End surface **2652** surrounds a central opening **2654** (FIG. **26**C) that extends through stopper **2608**. Central post **2631** is positioned within the opening **2654** of stopper **2608**. End surface **2652** is configured to sealingly engage first end wall **2622**, when spring **2612** forces stopper **2608** into engagement with first end wall **2622**, which prevents fluid payload within payload reservoir **2614** from flowing through opening **2654** and into contact with atomizer **2604**. When stopper **2608** is spaced apart from first end wall **2622**, fluid payload within payload reservoir **2614** may flow through opening **2654** into contact with atomizer **2604** for vaporization.

[0404] Dose ring **2610** includes an outer surface that is generally aligned with the outer surface of outer side wall **2626** and an inner surface that engages pressurizer **2606** in a manner that rotationally fixes pressurizer **2606** to dose ring **2610** but that allows pressurizer **2606** to move axially with respect to dose ring **2610**. Dose ring **2610** is rotatable with respect to housing **2602**.

[0405] Spring **2612** is positioned between dose ring **2610** and pressure plate **2634**. Spring **2612** biases the pressure plate **2634** toward the payload reservoir **2614** and first end wall **2622**. Spring **2612** also biases the stopper **2608** toward the first end wall **2622** by virtue of the threaded engagement between stopper **2608** and pressurizer **2606**. It is within the scope of the invention to use other types of biasing mechanisms that have the capability to exert force on pressurizer **2606** and stopper **2608** instead of spring **2612**.

[0406] When a user desires to use cartridge **2600** to vaporize a fluid payload within payload reservoir **2614**, the user connects the cartridge **2600** to a control assembly, such as control assembly **14** described above. The control assembly may operate to power a heating element of atomizer **2604** in accordance with the methods of operation described above for the vape devices **10** and **100** and vape device system **102**. Before use, stopper **2608** is biased by spring **2612** to a closed position in which it engages first end wall **2622** to prevent fluid payload within payload reservoir **2614** from entering the opening **2654** in stopper **2608** and making contact with atomizer **2604**. To allow fluid payload to flow through the opening **2654**, the user rotates dose ring **2610** in a direction that causes stopper **2608** to move away from engagement with first end wall **2622**. Alternatively, a motor may be used to rotate the dose ring **2610** and may be controlled manually by the user or by a processor that sends a signal to turn the motor on and off. As dose ring **2610** rotates, pressurizer **2606** rotates in the same direction. Because stopper **2608** engages housing **2602** in a manner that blocks rotational movement of stopper **2608** and the fluid payload within payload reservoir **2614** prevents pressurizer **2606** from moving toward first end wall **2622**, rotation of pressurizer **2606** causes longitudinal movement of stopper **2608** away from first end wall **2622**. Once stopper **2608** is moved away from first end wall **2622**, the pressure exerted on the fluid payload within payload reservoir **2614** by spring **2612** and pressure plate **2634** causes the fluid payload to move through the opening **2654** in stopper **2608** and into contact with atomizer **2604**.

[0407] Dose ring **2610** and housing **2602** preferably include a dose indicator that is substantially similar to the dose indicator described above for cartridge **2500** so that a user can select a desired dose of the fluid payload within payload reservoir **2614** by rotating dose ring **2610** a certain amount.

[0408] After the dose is selected with dose ring **2610**, the user causes power to be supplied to the atomizer **2604** by, for example, pressing a button on the control assembly connected to cartridge **2600**, beginning to draw air through outlet **2632**, or any of the other methods described above with respect to vape devices **10** and **100**. As the atomizer **2604** heats the fluid payload, the fluid payload vaporizes, is mixed with air from inlet **2630**, and exits through outlet **2632** for inhalation. As the fluid payload passes through opening **2654** and vaporizes, spring **2612** causes pressurizer **2606** and stopper **2608** to move toward first end wall **2622**. When the selected dose has moved through opening **2654** and vaporized, stopper **2608** sealingly engages first end wall **2622** to prevent the further flow of fluid payload into atomizer **2604**. With the stopper **2608** sealingly engaging first end wall **2622**, the fluid payload within payload reservoir **2614** is blocked from leaking out of cartridge **2600**. To vaporize the fluid payload again, the user turns dose ring **2610** as described above.

[0409] Cartridge **2600** may also include an optional heater that is positioned in or adjacent payload reservoir **2614** to heat the fluid payload within payload reservoir **2614** to a temperature that is below the vaporization temperature of the fluid payload, but that reduces the viscosity of the fluid payload allowing it to flow in a desired manner through the opening **2654**. The inlet **2630** of cartridge **2600** may also be positioned adjacent first end wall **2618**, in which case the divider **2644** would not be necessary as the incoming air would flow from near first end wall **2618** through or by the atomizer **2604** before exiting through outlet **2632**.

[0410] FIG. **26**D shows another cartridge **2656** that is similar to cartridge **2600** except for the configuration of atomizer **2658** and center post **2660**. Center post **2660** extends from near second end wall **2662** to atomizer **2658**. There is a gap between center post **2660** and atomizer **2658**. Stopper **2664** is movable in the same manner as the stopper **2608** described above to block the gap and stop the flow of fluid payload from payload reservoir **2666** to atomizer **2658** or open the gap to allow the flow of fluid payload from payload reservoir **2666** to atomizer **2658**. Atomizer **2658** is positioned adjacent first end wall **2668** where it is in electrical communication with power connector **2670**. Cartridge **2656** includes a threaded connector **2672** for joining the cartridge to a control assembly that can power atomizer **2658** in the same manner as described above with respect to the other cartridges described herein.

[0411] Any of the cartridges **2500** and **2600** described above may be formed integral with a control assembly (e.g., control assembly **14**) to form a vape device that is operable to power the atomizers **2504**, **2604** upon demand by a user by supplying a controlled current or voltage to the atomizer. The cartridges **2500** and **2600** may also be screwable into a control assembly using threaded connector **2528** or may have snap clips or some other structure that joins them to a control assembly. The control assembly **14** is configured to cause the cartridges **2500**, **2600** to provide vapor through the outlet in response to a user's input by supplying a controlled current or voltage to the atomizer **2504**, **2604**, as described above. Threaded connector **2528** is preferably a 510 threaded connector that allows cartridges **2500**, **2600** to be used with compatible 510 threaded control subassemblies or vape devices. Any of the cartridges **2500**, **2600** may be operated to vaporize a fluid payload within the payload reservoir in accordance with the methods described above for vape devices **10** and **100** and vape device system **102**, including in accordance with the system and method for optimizing vaporization described above. The cartridges **2500**, **2600** may have an ID tag **28** that includes a unique payload identifier, which identifies the cartridges **2500**, **2600**. The cartridges **2500**, **2600** may also include sensors to measure operational conditions of the cartridges. For example, the cartridges **2500**, **2600** may include the integrated temperature control system described below in connection with vape device **4200** to regulate the temperature of the atomizers and the capacitive vapor measurement system described below in connection with vape device **3100**. Conductive plates of the capacitive vapor measurement system, such as the conductive plates **3114** and **3116** shown in FIG. **31**, may be positioned anywhere between the atomizer and outlet of the cartridges. For example, the conductive plates may be position in the outlet flow chamber **2548** of cartridge **2500**, or in the outlet flow chamber **2648** of cartridge **2600**. Data from the sensors may be transmitted to a control assembly via a threaded connector that operates in accordance with the two lead communication system described below in connection with vape device **4000** such that power is also provided to the cartridge via the threaded connector.

[0412] The components of cartridges **2500** and **2600** may be made from any of the materials described above in connection with cartridge **1900**.

Tamper Resistant Vape Device with Improved Atomizer/Fluid Contact

[0413] An additional embodiment of the invention described herein is a vape device or cartridge with the ability to keep the atomizer continuously bathed in a viscous payload fluid when the vape device or cartridge is generally horizontal and even when there is very little payload remaining. The vape device or cartridge in accordance with the invention described herein does not need to be stored vertically or used with a viscosity modifier that adulterates the payload fluid. The vape device or cartridge may have the ability to orient itself in a predetermined position that keeps the atomizer continuously bathed in the payload fluid when the vape device or cartridge is placed on a horizontal surface. The vape device or cartridge is also preferably tamper resistant. The vape device may also be pre-charged and pre-filled.

[0414] A vape device in accordance with the invention described herein is identified generally as **2800** in FIG. **28**A. Referring to FIGS. **28**A, B, and D, vape device **2800** includes a housing **2802** and the following that are all positioned within an interior chamber defined by the housing: a tray **2804**, a flexible circuit board **2806**, a battery **2808**, a pressure sensor **2810**, a haptic motor **2812**, an atomizer **2814**, a seal **2816**, and a button **2818**.

[0415] As shown in FIG. **28**D, housing **2802** may be formed from first and second sections **2802*a*** and **2802*b*** that are joined together to form a side wall **2820**, a first end wall **2822** at a first end of housing **2802**, a second end wall **2824** at a second end of housing **2802**, and a generally planar surface **2826**. A longitudinal axis of housing **2802** extends between the first end wall **2822** and the second end wall **2824**. Side wall **2820** and generally planar surface **2826** extend from the first end wall **2822** to the second end wall

2824 in the same direction as the longitudinal axis. Generally planar surface **2826** has a first side edge **2826***a* (FIG. **28**C) and a second side edge **2826***b*, and side wall **2820** extends around the housing **2802** from first side edge **2826***a* to second side edge **2826***b*. Side wall **2820** has a cross-section, as shown in FIG. **28**C, that is generally oval-shaped with a major axis of the oval being parallel to and spaced apart from generally planar surface **2826** and a minor axis of the oval being perpendicular to generally planar surface **2826**. It is within the scope of the invention for the cross-section of side wall **2820** to be any suitable shape, such as circular, triangular, or polygonal. Housing **2802** is generally shaped as an elongated, elliptical cylindrical tube with closed ends and a flat bottom.

[0416] Due to the oval-shaped side wall **2820** and generally planar surface **2826**, vape device **2800** is configured so that housing **2802** orients itself in a predetermined position (i.e., a position in which generally planar surface **2826** faces downward) when housing **2802** is placed on a generally horizontal surface and the longitudinal axis of housing **2802** is generally horizontal. In this predetermined position, generally planar surface **2826** faces downward and abuts the generally horizontal surface on which housing **2802** is placed. Vape device **2800** assumes this predetermined position because if side wall **2820** is placed on the generally horizontal surface, the oval-shape of side wall **2820** will cause vape device **2800** to roll over until generally planar surface **2826** faces downward and abuts the generally horizontal surface. As described above, housing **2802** may be formed to have other shapes, other than an oval-shaped side wall **2820** and generally planar surface **2826**, that are capable of orienting vape device **2800** in a predetermined position when it is placed on a generally horizontal surface. Further, in addition to, or in lieu of, having a housing **2802** that is shaped to orient vape device **2800** in a predetermined position, the weight and center of mass of vape device **2800** may be configured to cause the vape device **2800** to orient itself in a predetermined position when the housing **2802** is placed on a generally horizontal surface or a generally planar surface. For example, housing **2802** may have a side wall with a circular or oval-shaped cross-section and the housing **2802** may not include a generally planar surface so that the entire outer surface of the housing **2802** is cylindrical or curved. The weight and center of mass of the vape device **2800** may be configured so that when the side wall is placed on a generally horizontal surface, the vape device **2800** rolls to its predetermined position no matter how the side wall is originally placed on the generally horizontal surface. The approximately cylindrical shape of housing **2802** is preferably easily distinguished from round or polygonal pens, lipstick containers, pencils or penlights.

[0417] Preferably, when vape device **2800** is in the predetermined position, a payload reservoir **2856** (FIG. **28**B) is oriented so that a fluid payload within the payload reservoir **2856** forms a pool that bathes the atomizer **2814** when the reservoir is at least about 1% to 5% full, about 5% to 10% full, or about 10% to 15% full.

[0418] Referring to FIG. **28**A, an inlet **2828** of housing **2802** is positioned adjacent first end wall **2822**. Inlet **2828** generally consists of six openings extending through side wall **2820** to an interior chamber surrounded by housing **2802**. Three of the openings are positioned on one side of housing **2802**, and three of the openings are positioned on the opposite side of housing **2802**. An outlet **2830** of housing **2802** (FIG. **28**F) extends through a center of second end wall **2824**. Housing **2802** also includes a view port **2832** (FIG. **28**E) that is positioned adjacent second end wall **2824**. The view port **2832** is positioned adjacent payload reservoir **2856** of vape device **2800** (described below) so that a user of vape device **2800** may look through view port **2832** to determine how much payload remains in the payload reservoir **2856**. As shown in FIG. **28**E, view port **2832** may include an opening formed through side wall **2820** and a clear sheet of material, such as glass or a polymeric material, that covers the opening to generally seal the interior chamber of housing **2802**. View port **2832** is positioned on side wall **2820** opposite generally planar surface **2826**, approximately 180 degrees around housing **2802** from generally planar surface **2826**. It is within the scope of the invention for view port **2832** to be placed in alternate locations, such as approximately 90 degrees around housing **2802** from view port **2832** on either side of vape device **2800**. There may also be two or more view ports **2832**, one on each side of housing **2802**. If the payload reservoir **2856** cannot be fully filled, the view port **2832** may include a max fill line that indicates when the payload reservoir **2856** is full when vape device **2800** is in the predetermined position described above.

[0419] Referring to FIG. **28**B, tray **2804** is positioned in housing **2802** and extends nearly the entire length of housing **2802** from first end wall **2822** to second end wall **2824**. As shown in FIG. **28**D, tray **2804** has a first section **2804***a* and a second section **2804***b* formed integrally with first section **2804***a*. It is also within the scope of the invention for the first and second sections **2804***a* and **2804***b* to be separate components that are joined together or merely placed adjacent each other within housing **2802**. First section **2804***a* has curved side walls **2834***a-b* (FIG. **28**C) that are shaped to abut the side wall **2820** of housing **2802**. First section **2804***a* has a generally planar bottom **2836** that is shaped to abut the generally planar surface **2826** of housing **2802**. Side walls **2834***a-b* each extend upward from one side of generally planar bottom **2836** and terminate at a location that is at approximately half the overall height of housing **2802**. As shown in FIG. **28**D, side walls **2834***a-b* and generally planar bottom **2836** define a semi-cylindrical recess **2838**. Side walls **2834***a-b* have flat sections **2840***a-b* (FIG. **28**C), respectively, adjacent and perpendicular to the major axis of the oval-shaped side wall **2820**. Flat sections **2840***a-b* cause enclosed channels **2842***a-b* to be formed between side walls **2834***a-b*, respectively, and side wall **2820** of housing **2802**. Enclosed channels **2842***a-b* form a part of an inlet flow chamber of vape device **2800**, as described below. As shown in FIG. **28**D, openings **2844***a-b* are formed in side walls **2834***a-b*. Openings **2844***a-b* are positioned adjacent atomizer **2814** and place channels **2842***a-b* and inlet **2828** in fluid communication with atomizer **2814**. Tray **2804** has a first side that is positioned adjacent housing **2802** and a second side adjacent recess **2838**. The openings **2844***a-b* extend through tray **2804** from the first side to the second side.

[0420] As shown in FIG. **28**B, second section **2804***b* of tray **2804** has an outer side wall **2846** with an outer surface that is generally cylindrical and that includes a flat bottom **2848** to match the generally planar surface **2826** of housing **2802**. An interior surface of outer side wall **2846** forms a reservoir side wall **2850**. First and second reservoir end walls **2852** and **2854** are coupled to and integral with outer side wall **2846** and reservoir side wall **2850**. Reservoir side wall **2850** and first and second reservoir end walls **2852** and **2854** define and enclose payload reservoir **2856**, which is positioned adjacent the second end wall **2824** of housing **2802**. A reservoir opening **2858** extends through the second reservoir end wall **2854**. Reservoir opening **2858** is spaced from outlet **2830** in a direction that is generally perpendicular to the longitudinal axis of housing **2802**. Spacing reservoir opening **2858** from outlet **2830** makes it more difficult to access reservoir opening **2858** through outlet **2830**, which is advantageous to prevent tampering with the payload positioned in payload reservoir **2856** and to prevent the unauthorized refilling of payload reservoir **2856** after the original payload is depleted. For authorized refilling, the asymmetrical design of housing **2802** allows a refilling machine to properly orient vape device **2800** before filling payload reservoir **2856** if payload reservoir **2856** is designed in a manner that allows it to be refilled. A plug, such as the plug **2910** shown in FIG. **29**C or the plug **2966** shown in FIGS. **29**F-G, is preferably inserted in the reservoir opening **2858** after it is filled. The plug may be tamper-resistant as described below with respect to plug **2910**, and/or designed to equalize the pressure within payload reservoir **2856** as described below with respect to plug **2966**. First reservoir end wall **2852** includes a plurality of openings **2860** to place the payload reservoir **2856** in fluid communication with atomizer **2814**. Payload reservoir **2856** is preferably inserted in housing **2802** after it is filled.

[0421] Tray **2804** is advantageous during manufacturing of vape device **2800** because it allows the flexible circuit board **2806**, battery **2808**, pressure sensor **2810**, haptic motor **2812**, atomizer **2814**, seal **2816**, and button **2818**, to be preassembled on tray **2804** before being slid into first section **2802***a* of housing **2802**. Second section **2802***b* of housing **2802** may then be joined with first section **2802***a*. Payload reservoir **2856** may also be filled before tray **2804** is slid into housing **2802** for final assembly.

[0422] Referring to FIG. **28**B, reservoir side wall **2850** is shaped as a truncated oblique cone and has a first end **2862** positioned adjacent atomizer **2814** and a second end **2864** positioned adjacent second end wall **2824**. The truncated portion of the oblique cone is at the second end **2864**. The apex of the cone is also positioned at the second end **2864** and is positioned at a height above the bottom of vape device **2800** that is about three-fourths of the total height of vape device **2800**. When the vape device **2800** is oriented in the predetermined position described above and as shown in FIG. **28**B (i.e., with generally planar surface **2826** of housing **2802** facing downward and vape device **2800** positioned so that the longitudinal axis of housing **2802** is generally horizontal), reservoir side wall **2850** slopes downward toward atomizer **2814** from the second end **2864** to the first end **2862**. In this predetermined position, the second end **2864** of reservoir side wall **2850** is positioned just beneath the reservoir opening **2858** at a height above the bottom of vape device **2800** that is about two-thirds of the total height of vape device **2800**. In this predetermined position, the first end **2862** of reservoir side wall **2850** is positioned near the bottom of vape device **2800**. The reservoir side wall **2850** angles upwardly from first end **2862** to second end **2864** at an angle X formed between reservoir side wall **2850** and the bottom of vape device **2800**. The angle X is preferably determined by the viscosity of the payload and the tendency of the payload to stick to the reservoir side wall **2850**. For example, the angle X may be increased for more viscous payloads and for payloads that have a greater tendency to stick to the reservoir side wall **2850**. The angle X is preferably optimized for the viscosity or other physical or chemical properties of the payload to improve flow of the payload toward atomizer **2814**. Reservoir side wall **2850** may be made from any suitable material including plastic, metal, ceramic, and/or glass.

[0423] Atomizer **2814** is positioned in the housing **2802** adjacent first reservoir end wall **2852**. Atomizer **2814** is positioned approximately 1-2 mm above the bottom of vape device **2800**. It is within the scope of the invention for atomizer **2814** to be at a different height within vape device **2800**, and preferably the position of atomizer **2814** is optimized based on the characteristics of the payload, e.g., the viscosity or other physical or chemical properties, within payload reservoir **2856** and the configuration of payload reservoir **2856**. Atomizer **2814** is in fluid communication with payload reservoir **2856** through the openings **2860** in first reservoir end wall **2852**. Payload reservoir **2856** preferably contains a fluid payload that may include substances such as nicotine, cannabis, or cannabinoid for vaporization and inhalation by a user. Payload reservoir **2856** may also contain propylene glycol, polyethylene glycol, or vegetable glycerin. Atomizer **2814** is configured to heat and vaporize the payload to generate a vaporized payload. A valve is preferably positioned between payload reservoir **2856** and atomizer **2814** to regulate flow of the payload from payload reservoir **2856** to atomizer **2814**. The valve may be mechanically operated by a user, or electromechanically operated with instructions received from the processor described below. In one embodiment, a polyethylene terephthalate (PET) pad may be positioned between payload reservoir **2856** and atomizer **2814** instead of a valve. The payload within payload reservoir **2856** preferably does not contain glycerine or propylene glycol as a solvent. The payload within payload reservoir **2856** may be a water-based payload. The payload is preferably substantially free from particulates.

[0424] Atomizer **2814** may be configured as any one of a pancake ceramic, coil wrapped wick, coil wrapped ceramic rod, or coil wrapped quartz rod. Further, atomizer **2814** may include titanium, stainless, nichrome, kanthal, and/or nickel wicks.

[0425] Referring to FIG. **28**D, flexible circuit board **2806** is positioned within the recess **2838** of tray **2804**. Flexible circuit board **2806** includes a middle section **2866**, a front section **2868** extending away from middle section **2866** toward first end wall **2822**, and a rear section **2870** extending away from middle section **2866** toward second end wall **2824**. Middle section **2866** is semi-cylindrical and defines a battery recess **2872** that receives battery **2808** to place flexible circuit board **2806** between the battery **2808** and tray **2804**. Front section **2868** is shaped as an inverted-U and is connected to a bottom portion of middle section **2866** with a tab **2874**. Rear section **2870** is also shaped as an inverted-U and is connected to a bottom portion of middle section **2866** with a tab **2876**. Battery **2808** may be any type of suitable battery including a lithium ion battery, a LiPo battery, a NiMH battery, an alkaline battery, or an air-zinc battery.

[0426] As shown in FIG. **28**B, front section **2868** includes lights **2878***a-b*, preferably LEDs. Lights **2878***a-b* are positioned adjacent first end wall **2822**. At least a portion of first end wall **2822** is preferably clear or opaque so that lights **2878***a-b* are visible to a user of vape device **2800**. Lights

2878*a-b* preferably illuminate according to a status of vape device **2800**. For example, lights **2878***a-b* may turn on when atomizer **2814** is activated, the intensity of lights **2878***a-b* may increase throughout the length of a user's draw, and lights **2878***a-b* may blink at certain preset time intervals throughout a draw. Lights **2878***a-b* may also change colors at different times throughout the length of a draw.

[0427] Flexible circuit board **2806** contains circuit components for controlling vape device **2800**, which may be positioned in rear section **2870** or other locations on flexible circuit board **2806**. For example, flexible circuit board **2806** may contain the circuit components described above in connection with vape device **10**, including microcontroller **31**, charger circuit **30** configured for charging battery **2808**, input interface circuit **34**, RF transceiver circuit **36**, output interface circuit **38**, antenna(s) **40**, and electrical connector **35**, all of which may operate as described above in connection with vape device **10**. Antenna(s) **40** may include an NFC antenna and a Bluetooth antenna. The use of flexible circuit board **2806** provides a relatively large surface area for placement of the antenna(s) **40**. For example, the antenna(s) **40** may be placed in the middle section **2866** of flexible circuit board **2806** extending the length of the middle section **2866**. Microcontroller **31** includes a microprocessor or processor that is configured to receive signals from the pressure sensor **2810**, pressure sensor **2880**, and other sensors or controls of vape device **2800** and activate haptic motor **2812**, lights **2878***a-b*, and atomizer **2814** as described below.

[0428] Pressure sensor **2810** is positioned adjacent the rear section **2870** of flexible circuit board **2806** between the battery **2808** and payload reservoir **2856**. Pressure sensor **2810** is electrically connected to flexible circuit board **2806**. Pressure sensor **2810** preferably senses the air pressure within an air flow chamber **2882** (FIG. **28**B) that is described in more detail below. Haptic motor **2812** is positioned underneath the rear section **2870** of flexible circuit board **2806** at a location that is approximately one-third of the total length of vape device **2800** from second end wall **2824**, which is where a thumb of a typical user would be placed during use. Haptic motor **2812** is electrically connected with flexible circuit board **2806**. The processor of vape device **2800** may be programmed to activate the haptic motor **2812** when a pressure sensed by the pressure sensor **2810** drops below a pressure threshold for a predetermined amount of time.

[0429] A seal **2816** is positioned within the housing **2802** between the atomizer **2814** and flexible circuit board **2806**. Seal **2816** may be a silicone gasket. The seal **2816** separates an electronics recess **2884** within the interior of housing **2802** from the air flow chamber **2882**, atomizer **2814**, and payload reservoir **2856**. The electronics recess **2884** is positioned between the seal **2816**, first end wall **2822**, and tray **2804**. The electronics recess **2884** is preferably not in fluid communication with the air flow chamber **2882**. The seal **2816** seals the flexible circuit board **2806** and battery **2808** within electronics recess **2884** from air flow chamber **2882** and atomizer **2814** so that the air entering vape device **2800** and vaporized payload exiting vape device **2800** do not contact the components of flexible circuit board **2806**. Pressure sensor **2810** is positioned within an opening in seal **2816**. A portion of atomizer **2814** extends through the seal **2816** so that the atomizer **2814** is electrically connected to flexible circuit board **2806**.

[0430] Air flow chamber **2882** is positioned within housing **2802** between the inlet **2828** and the outlet **2830**. Air flow chamber **2882** includes an inlet flow chamber, which is formed by enclosed channels **2842***a-b* (FIG. **28**C), and an outlet flow chamber **2886**. The inlet flow chamber extends from inlet **2828** through the enclosed channels **2842***a-b* to the openings **2844***a-b* (FIG. **28**D). The outlet flow chamber **2886** extends from atomizer **2814** to outlet **2830** around a gap formed between the second section **2804***b* of tray **2804** and housing **2802**. The inlet flow chamber is in fluid communication with the inlet **2828** and atomizer **2814** through openings **2844***a-b*. The outlet flow chamber **2886** is in fluid communication with atomizer **2814** and outlet **2830**. When a user places his/her mouth on outlet **2830** and draws air through vape device **2800**, air enters inlet **2828** and travels through enclosed channels **2842***a-b* to openings **2844***a-b*. The air makes contact with atomizer **2814** through openings **2844***a-b* and mixes with vaporized payload from atomizer **2814**. The air and vaporized payload then travels through outlet flow chamber **2886** to outlet **2830** for inhalation by the user.

[0431] Vape device **2800** may include a vapor measurement system, such as the capacitive vapor measurement system of vape device **3100** described below, that is configured to determine a dosage of the vaporized payload that passes through outlet flow chamber **2886**. The vapor measurement system may measure dosage per unit time. Conductive plates, such as the conductive plates **3114** and **3116** of vape device **3100**, may be positioned within the outlet flow chamber **2886**. Flexible circuit board **2806** may include any of the sensor measurement circuits described in connection with vape device **3100**, and the microcontroller **31** of vape device **2800** may determine the dosage of the vaporized payload. RF transceiver circuit **36** and antenna **40** may transmit the dosage to a separate computing device, which may be used to determine operational settings of the vape device **2800** in accordance with the systems and methods described above in connection with vape devices **10** and **100** and vape device system **102**. The separate computing device, e.g., a mobile device such as a smartphone, tablet, or watch, may run a software application accessible by the user (e.g., as shown in FIG. **3**). The application can record the doses that the user has inhaled and record the user's dosage experience. This information can be analyzed by the application to track and optimize the user's experience with the substance inhaled. To help improve analysis, the user may enter personal information such as ailments, pains, weight and food intake. The information recorded can be used to accurately monitor a user's intake details and may be submitted to a doctor for review and/or improvement.

[0432] The application may also preferably connect with other users via the internet, which may be used to share experiences, receive recommendations, and network with a community of users. The application may also be used as an e-commerce platform to purchase dosage capsules, or vaporizer equipment. The platform may offer specific substances based on a user's rated experience. Another enhanced use might be finding other users within geographic locations that may allow for social interactions and meetings. These enhanced services may be integrated with others over the internet.

[0433] Vape device **2800** may also preferably be locked by the user via the application. This may be used as a safety feature against undesired use (by children or others). The application may include a customizable lock setting to enhance safety or limit usage for those with low self-control.

[0434] An ID tag associated with the payload in payload reservoir **2856** may also be positioned in housing **2802**. The ID tag may be configured in a similar manner as ID tag **28** described above and may store a unique payload identifier that is used as described above in connection with vape devices **10** and **100** and vape device system **102**. The ID tag may be an RFID tag and may use NFC, any other type of RFID communication system, including UHF RFID, or any other type of suitable communication system to communicate with other devices. The ID tag may be updated when the payload reservoir **2856** is filled or refilled to include a unique payload identifier associated with the payload. The ID tag may simplify Bluetooth enrollment by allowing the enrollment to be done automatically without pressing a button.

[0435] FIG. **29**A shows an alternative configuration of payload reservoir **2900** that may be used with vape device **2800**. Payload reservoir **2900** is defined by a reservoir side wall **2902** with a first section **2902***a* shaped as a truncated oblique cone and a second section **2902***b* that is cylindrical. First section **2902***a* is positioned adjacent reservoir opening **2904** and second section **2902***b* is positioned adjacent atomizer **2814**.

[0436] FIG. **29**B shows an alternative placement of atomizer **2814** within vape device **2800**. In FIG. **29**B, atomizer **2814** is positioned approximately 3-4 mm above the bottom of vape device **2800**.

[0437] FIG. **29**C shows another alternative configuration of payload reservoir **2906** that may be used with vape device **2800**. A reservoir opening **2908** receives a solid plug **2910**, which is inserted after payload reservoir **2906** is filled with a payload. FIG. **29**C also shows an alternative configuration of second end wall **2912** and tray **2914** that may be used with vape device **2800**. Second end wall **2912** is formed from an end cap that is separate from side wall **2916** and that is coupled to side wall **2916** (e.g., the end cap may snap into the side wall **2916**). Plug **2910** may be coupled to second end wall **2912** and configured in a tamper-resistant manner so that the plug **2910** breaks from second end wall **2912** near the reservoir opening **2908** if second end wall **2912** is pried off of side wall **2916** without the use of special tools. Thus, if the second end wall **2912** is pried off by a user for the purpose of refilling payload reservoir **2906** or tampering with the payload therein, the plug **2910** breaks off within reservoir opening **2908** preventing the user from accessing payload reservoir **2906**. Tray **2914** includes an outlet flow chamber **2917** that extends through a channel formed in tray **2914** to an outlet **2918**. A seal **2920** is positioned between an outer surface of tray **2914** and side wall **2916**.

[0438] FIG. **29**D shows an alternative configuration of vape device **2922** that is similar to vape device **2800**. Vape device **2922** includes an air flow chamber that extends from an inlet **2924** to an outlet **2926** through a housing **2928** of the vape device **2922**. The inlet **2924** is positioned on top of vape device **2922** adjacent a first end of vape device **2922**. The air flow chamber includes an inlet flow chamber **2930** that extends from inlet **2924** underneath a tray **2932** holding a battery **2934**. The inlet flow chamber **2930** flows around a circuit board **2936** and haptic motor **2938** to a chamber **2940** holding an atomizer. The air flow chamber includes an outlet flow chamber **2942** that extends from the chamber **2940** above a payload reservoir **2944** to outlet **2926**. The payload reservoir **2944** is also cylindrical in shape. Other than as described herein vape device **2922** may be substantially similar to vape device **2800**. Vape device **2800** may be modified to include the air flow chamber configuration and payload reservoir configuration of vape device **2922**.

[0439] FIG. **29**E shows another alternative configuration of vape device **2946** that is similar to vape device **2800**. Vape device **2946** includes an air flow chamber that extends from an inlet **2948** to an outlet **2950**. Inlet **2948** is positioned adjacent the second end **2952** of the housing **2954** along with the outlet **2950**. Inlet **2948** is positioned directly above the atomizer chamber **2956**. The inlet flow chamber extends straight down from the inlet **2948** to the atomizer chamber **2956**, and the outlet flow chamber **2957** extends from the atomizer chamber **2956** around the payload reservoir **2959** to the outlet **2950**. The payload reservoir **2959** is configured substantially the same as shown in FIG. **29**C. In this embodiment, the flexible circuit board **2958** is modified to position a haptic motor **2960** between the battery **2962** and first end **2964** of the housing **2954**. The battery **2962** and flexible circuit board **2958** are preferably sealed from the atomizer chamber **2956** with a seal **2965**. Other than as described herein vape device **2946** may be substantially similar to vape device **2800**. Vape device **2800** may be modified to include the air flow chamber configuration, flexible circuit board **2958**, and haptic motor **2960** placement of vape device **2946**.

[0440] FIGS. **29**F and **29**G show a plug **2966** placed within a reservoir opening **2968**. Plug **2966** includes a vent hole **2970** and an air permeable membrane **2972**. Air permeable membrane **2972** prevents a fluid payload within payload reservoir **2974** from leaking through vent hole **2970**. Air permeable membrane **2972** and vent hole **2970** allow pressure to equalize within payload reservoir **2974**. For example, as payload reservoir **2974** is depleted (i.e., the fluid therein is vaporized), air permeable membrane **2972** and vent hole **2970** allow air to enter payload reservoir **2974**. Further, when there is an increase in ambient temperature or a decrease in external atmospheric pressure, air permeable membrane **2972** and vent hole **2970** allow air to exit payload reservoir **2974**. Plug **2966** preferably ensures that a fluid payload within payload reservoir **2974** does not leak out in response to air pressure, temperature, or altitude changes. Plug **2966** may be used with vape device **2800** described above. Plug **2966** may be made from a self-healing material such as silicone.

[0441] FIG. **30** shows a method of operating vape device **2800** that may also be used with the other vape devices and cartridges disclosed herein. The processor of microcontroller **31** (as incorporated into the circuit components of vape device **2800**) may be programmed to perform the process described herein. In accordance with the method of FIG. **30**, at step **3002** vape device **2800** is unlocked and unused. At step **3004**, vape device **2800** determines whether the time period of inactivity of vape device **2800** is greater than a predetermined amount of time. If the time period of inactivity is less than the predetermined amount of time, vape device **2800** remains unlocked. If the time period of inactivity is greater than the predetermined amount of time, vape device **2800** locks at step **3006** and remains in a locked state **3008**. To unlock vape device **2800**, the user must provide an application running on a separate computing device, e.g., a phone, tablet, or watch, with a PIN code associated with the user or the device. If the PIN code is provided, the computing device instructs the vape device **2800** to return to the unlocked state at step **3002**. Vape device **2800** may also be manually locked at step **3010** via the user providing manual lock instructions to the application, regardless of the time period of inactivity. Vape device **2800** may also be locked and unlocked for use in accordance with any of the systems and methods described above for vape device **10**.

[0442] From the unlocked state, step **3002**, the atomizer **2814** of vape device **2800** is activated at step **3012** when a user draws air through outlet **2830**. Pressure sensor **2810** senses the pressure decrease caused by the user drawing air and sends a signal to the processor of vape device **2800**, which causes electrical current to be provided from battery **2808** to atomizer **2814**. Vape device **2800** may also be activated when a user presses button **2818**. At step **3012**, lights **2878***a-b* are also turned on to a relatively low intensity. The method of operating vape device **2800** then proceeds to a series of steps that detect the elapsed time of the user's draw and activate lights **2878***a-b* and haptic motor **2812** based on the elapsed time of the draw. At step **3014**, the method waits for one second before proceeding to step **3016**, where the elapsed time of the draw is determined. If the elapsed time is three seconds, six seconds, or nine seconds, the method proceeds to steps **3018**, **3020**, or **3022**, respectively. If the elapsed time is three seconds, at step **3018** lights **2878***a-b* flash one time and then remain on with an increased intensity of 30% of the maximum intensity of the lights **2878***a-b*. Haptic motor **2812** is also turned on to vibrate one time with a relatively short time duration. If the elapsed time is six seconds, at step **3020** lights **2878***a-b* flash twice and then remain on with an increased intensity of 60% of the maximum intensity of the lights **2878***a-b*. Haptic motor **2812** is also turned on to vibrate two times each with a relatively short time duration. If the elapsed time is nine seconds, the intensity of lights **2878***a-b* is increased to 100% of the maximum intensity of the lights **2878***a-b*. Haptic motor **2812** is also turned on to vibrate one time with a relatively long time duration. From step **3022**, the method proceeds to step **3024**, at which the processor locks the atomizer **2814** to turn it off and prevent it from vaporizing the payload.

[0443] If the elapsed time is other than three seconds, six seconds, or nine seconds at step **3016**, and after each of steps **3018**, **3020**, and **3024**, the method proceeds to step **3026**, where the elapsed time counted by the processor is increased by one second. The method then proceeds to step **3028** (if the atomizer is not locked at step **3024**) where the processor of vape device **2800** determines whether the user is still drawing air through the vape device **2800**. If the user is still drawing air, the method proceeds back to step **3014**, which repeats the loop of steps **3014**, **3016**, **3026**, and **3028**, and one of steps **3018**, **3020**, and **3022**, if applicable. If the atomizer is locked after step **3026**, or if the user is not still drawing air through the vape device at step **3028**, the method proceeds to step **3030** at which the atomizer **2814** is deactivated and the lights **2878***a-b* are turned off. The method then proceeds back to the start at step **3002**.

[0444] The three seconds and six seconds triggers for steps **3018** and **3020** are preferably configurable by the user to be any other value less than nine. The nine seconds represents a max elapsed draw time that is not user configurable. Thus, after a draw of nine seconds, the atomizer is turned off and the method returns to step **3002**. Preferably, the user can also select another trigger point, such as five seconds, where the intensity of lights **2878***a-b* is between the intensities set at steps **3018** and **3020**. The user can also preferably change how the lights **2878***a-b* and haptic motor **2812** are operated at each of the trigger points.

[0445] Vape device **2800** may be formed from two separate pieces, a cartridge and a control assembly, that are coupled together by the user. For example, 510 threaded connectors may be used on the cartridge and control assembly to couple the separate pieces together. A bayonet, magnetic, or socket connection may also be used to join the cartridge and control assembly. The cartridge may include the payload reservoir **2856** and atomizer **2814**, and the control assembly may include the flexible circuit board **2806**, battery **2808**, and haptic motor **2812**. The air flow chamber may be altered so that the inlet is positioned in the cartridge, as shown in FIG. **29**E. Data from sensors in the cartridge (e.g., the capacitive vapor measurement system of vape device **3100** described below) may be transmitted to the processor on flexible circuit board **2806** via a threaded connector that operates in accordance with the two lead communication system of vape device **400** described below such that power is also provided to the cartridge via the threaded connector. Vape device **2800** may be operated to vaporize a fluid payload within the payload reservoir **2856** in accordance with the methods described above for vape devices **10** and **100** and vape device system **102**, including in accordance with the system and method for optimizing vaporization described above, which may include minimizing the chemical decomposition or transformation of the payload components. Vape device **2800** may also include sensors, other than pressure sensor **2810** and the capacitive vapor measurement system of vape device **3100**, to measure operational conditions of the vape device **2800**. For example, vape device **2800** may include the integrated temperature control system described below in connection with vape device **4200** to regulate the temperature of atomizer **2814**.

[0446] In one aspect of the invention, a kit is provided that comprises the vape device **2800** and a payload comprising a cannabinoid. In one aspect of the invention, a kit is provided that comprises the vape device **2800** and a payload comprising a terpene. In one aspect of the invention, a kit is provided that comprises vape device **2800** and a diary for recording user experiences. In one aspect of the invention, a kit is provided that comprises vape device **2800** and a payload comprising a cannabinoid, a terpene, and a diary for recording user experiences.

Capacitive Vapor Measurement System

[0447] In some embodiments, the vape device includes a capacitive vapor measurement system to accurately gauge the concentration of a vaporized payload in a measurement cavity of the vape device so that the dosage of the vaporized payload can be accurately determined. The vapor measurement system includes a capacitive sensor (which may comprise a parallel plate capacitor, a rolled capacitor, a digitated capacitor, or other types of capacitors known in the art) in combination with a sensor measurement circuit configured to measure the capacitance of the capacitive sensor. The vapor measurement system also includes a processor programmed to determine the dosage of the vaporized payload based on the measured capacitance of the capacitive sensor. Various embodiments of the vapor measurement system are described below.

[0448] Referring to FIG. **31**, one embodiment of a vape device **3100** is shown that utilizes a capacitive sensor in the form of a parallel plate capacitor. Vape device **3100** includes a housing **3102** that defines an inlet **3104** and an outlet **3106** with an air flow chamber **3108** that extends therebetween. An atomizer **3110** is positioned in air flow chamber **3108** and, as described above, atomizer **3110** is in fluid communication with a payload reservoir (not shown). Atomizer **3110** is configured to heat and vaporize the payload so as to output a vaporized payload **3112**.

[0449] A first conductive plate **3114** and a second conductive plate **3116** are positioned in air flow chamber **3108** between atomizer **3110** and outlet **3106**. Conductive plates **3114** and **3116** each comprise a generally square or rectangular plate that may be formed of metal or any other conductive material, such as copper, stainless steel, silicon (which may be doped), gold, or titanium. Conductive plates **3114** and **3116** are mounted or otherwise attached to the inner surface of housing **3102** using a non-conductive mechanical support (not shown). Conductive plates **3114** and **3116** are spaced apart in a generally parallel relationship so as to define a measurement cavity **3118** therebetween. As such, conductive plates **3114** and **3116** form a parallel plate capacitor that is used as the capacitive sensor of the vapor measurement system. When vaporized payload **3112** passes from atomizer **3110** to outlet **3106**, it passes through measurement cavity **3118** such that vaporized payload **3112** effectively functions as the dielectric of the parallel plate capacitor formed by conductive plates **3114** and **3116**.

[0450] It should be understood that the components shown in FIG. **31** may be provided as part of an atomizer assembly of a vape device, may be provided as part of a replaceable cartridge of a vape device, or may be provided as part of an integrated vape device. Further, it should be understood that measurement cavity **3118** may be placed at any position between the atomizer and the mouthpiece of a vape device.

[0451] The capacitance of the parallel plate capacitor formed by conductive plates **3114** and **3116** is expressed by the following equation:

$$c = \frac{\varepsilon_r \times \varepsilon_0 \times A}{d} \tag{1}$$

where

[0452] C=capacitance of parallel plate capacitor in farads

[0453] ε_r=relative dielectric constant of material between plates

[0454] ε_0=permittivity of free space (8.854×10^{-12} farad/meter)

[0455] A=area of plates in meters^2

[0456] d=distance between plates in meters.

[0457] Because the relative dielectric constant of air is about 1 (ε_r=1.00059), any material with a dielectric constant greater than that of air that passes through measurement cavity **3118** between conductive plates **3114** and **3116** will increase the capacitance of the parallel plate capacitor in a measurable manner. For example, the dielectric constant of vaporized payload **3112** will typically be in the range of 2 to 10). This same principle applies to other types of capacitors that include first and second electrical conductors to form a capacitive sensor, as described below.

[0458] In one embodiment, the electrical conductors of the capacitive sensor (e.g., conductive plates **3114** and **3116**) are coated with a protective film to maintain the integrity of the conductors (i.e., protect them from degradation due to a chemical reaction) and reduce the likelihood of a change in capacitance due to a buildup of condensate, which will change the dielectric constant of the material between the conductors.

[0459] In another embodiment, measurement cavity **3118** is isolated within air flow chamber **3108** by placing a guard on the side of measurement cavity **3118** adjacent outlet **3106**. The guard is comprised of a conductor that is maintained at the same voltage as measurement cavity **3118**. When voltage is applied to conductive plates **3114** and **3116**, a separate circuit applies the exact same voltage to the guard. Because there is no voltage difference between measurement cavity **3118** and the guard, there is no electric field between them. Any conductors behind the guard will form an electric field with the guard instead of measurement cavity **3118**. Only the unguarded side of measurement cavity **3118** adjacent atomizer **3110** is allowed to form an electric field with vaporized payload **3112**. This guarding technique enables a more accurate measurement of the capacitance of the capacitive sensor.

[0460] There are many different electrical circuits that can be used to measure the capacitance of the capacitive sensor, both directly and indirectly. In some embodiments, the sensor measurement circuit is configured to measure the absolute capacitance of the capacitive sensor when vaporized payload **3112** passes through measurement cavity **3118**. In other embodiments, the sensor measurement circuit is configured to measure a capacitance shift, i.e., a change in capacitance of the capacitive sensor. In all of these embodiments, the measurement of the sensor's capacitance enables the dosage of the vapor's constituent parts to be accurately determined.

[0461] Various examples of sensor measurement circuits that can be used to measure the capacitance of the capacitive sensor will now be described. It should be understood that the invention is not limited to the use of these particular circuits and that other types of electrical circuits configured to measure the capacitance of the capacitive sensor may also be used in accordance with the invention.

[0462] Referring to FIG. **32**, in one embodiment, the sensor measurement circuit comprises a charge pump circuit configured to charge the electrical conductors of a capacitive sensor (C_{sensor}) of a vapor measurement system. The capacitive sensor (C_{sensor}) may comprise, for example, the parallel plate capacitor shown in FIG. **31**, in which case a first terminal connection (Term 1) is provided on conductive plate **3114** and a second terminal connection (Term 2) is provided on conductive plate **3116**. Of course, other types of capacitive sensors may also be used as described below.

[0463] The charge pump circuit also includes a first current source (I_{S1}) connected to the supply voltage (V_{DD}) and a second current source (I_{S2}) connected to ground. The current sources are separated by a first switch (SW_1) and a second switch (SW_2). A controller (with may include control logic implemented in software) provides the "Up" and "Down" control signals that turn on the first switch (SW_1) and the second switch (SW_2), respectively. When the "Up" control signal is high (Up=1) to turn on the first switch

(SW_1) and the "Down" control signal is low (Down=0) to turn off the second switch (SW_2), then the first current source (I_{S1}) of known current output (I) charges the capacitive sensor (C_{sensor}). By observing the change in output voltage (V_{out}) across the capacitive sensor (C_{sensor}) as a function of time (dV/dt), one can determine the capacitance of the capacitive sensor (C_{sensor}) using the following equation:

$$C = I\frac{dV^{-1}}{dt} \tag{2}$$

where

[0464] C=capacitance of capacitive sensor (C_{sensor}) in farads

[0465] I=current output of first current source (I_{S1}) in amperes

[0466] dV/dt=change in output voltage (V_{out}) as a function of time.

[0467] If the charge pump operates at a known switching frequency and duty cycle, the amount of charge deposited on the electrical conductors of the capacitive sensor (C_{sensor}) with every "Up" current pulse is known. Thus, the capacitance of the capacitive sensor (C_{sensor}) can be determined by any one of the following methods: (1) counting the number of "Up" current pulses required to obtain a desired output voltage (V_{out}); (2) counting the time required to obtain a desired output voltage (V_{out}) while the "Up" current pulses are provided at a fixed frequency and duty cycle; and (3) measuring the output voltage (V_{out}) following a known number of "Up" current pulses. Thus, the charge pump circuit shown in FIG. **32** enables direct measurement of the capacitance of the capacitive sensor (C_{sensor}).

[0468] Alternatively, the output voltage (V_{out}) may be biased to some value (e.g., $V_{DD}/2$) and the first and second switches (SW_1 and SW_2) may be used to carefully measure shifts in the capacitance of the capacitive sensor (C_{sensor}). A large shift in the capacitance of the capacitive sensor (C_{sensor}) requires large asymmetry between the first and second switches (SW_1 and SW_2) for a measurable shift in the output voltage (V_{out}). In contrast, a small shift in the capacitance of the capacitive sensor (C_{sensor}) requires small asymmetry between the first and second switches (SW_1 and SW_2) for a measurable shift in the output voltage (V_{out}) that does not clip.

[0469] It should be understood that all of the components of the charge pump circuit shown in FIG. **32** (with the exception of the capacitive sensor (C_{sensor})) are provided as a sensor measurement circuit with suitable connections to the first terminal connection (Term 1) and the second terminal connection (Term 2) of the capacitive sensor (C_{sensor}). In some embodiments, the sensor measurement circuit is positioned within air flow chamber **3108** of vape device **3100**, preferably near the capacitive sensor (C_{sensor}). In other embodiments, the sensor measurement circuit is positioned outside of air flow chamber **3108**, such as in the control assembly described above.

[0470] Referring to FIG. **33**, in another embodiment, the sensor measurement circuit comprises a resistive voltage divider circuit that includes a first resistor (R_1) connected in series with a second switched-capacitor resistor (R_2). The switched-capacitor resistor (R_2) is comprised of a capacitive sensor (C_{sensor}), a first switch (SW_1) and a second switch (SW_2). A controller (with may include control logic implemented in software) provides the control signals that turn on the first switch (SW_1) and the second switch (SW_2). The capacitive sensor

[0471] (C_{sensor}) may comprise, for example, the parallel plate capacitor shown in FIG. **31**, in which case a first terminal connection (Term 1) is provided on conductive plate **3114** and a second terminal connection (Term 2) is provided on conductive plate **3116**. Of course, other types of capacitive sensors may also be used as described below.

[0472] The equivalent resistance of the switched-capacitor resistor (R_2) is a function of the capacitance of the capacitive sensor (C_{sensor}) and the switching frequency, as shown by the following equation:

$$R_2 = \frac{1}{C \times f} \tag{3}$$

where

[0473] R_2=equivalent resistance of switched-capacitor resistor (R_2) in ohms

[0474] C=capacitance of capacitive sensor (C_{sensor}) in farads

[0475] f=switching frequency in hertz.

[0476] It should be understood that the duty cycle (D) will not have an appreciable effect on the equivalent resistance of the switched-capacitor resistor (R_2) if the period (T) is long enough (i.e., the switching frequency (f) is low enough) to enable the capacitive sensor (C_{sensor}) to fully charge/discharge. With that said, if the duty cycle (D) decreases to the point that the capacitive sensor (C_{sensor}) does not fully charge/discharge, then it will have an effect on the equivalent resistance of the switched-capacitor resistor (R_2). Additionally, as the switching frequency (f) increases to the point that the capacitive sensor (C_{sensor}) does not fully charge/discharge over half of the period (T), then the duty cycle (D) will have an immediate and large effect on the equivalent resistance of the switched-capacitor resistor (R_2). In cases where the duty cycle (D) has an effect, the equivalent resistance of the switched-capacitor resistor (R_2) may be shown by the following equation:

$$R_{eq} = \frac{R}{(1 - D) \times D} \tag{4}$$

where

[0477] R_2=equivalent resistance of switched-capacitor resistor (R_2) in ohms

[0478] R=parasitic resistance in the circuit in ohms

[0479] D=duty cycle

[0480] f=switching frequency in hertz.

[0481] With reference to equation (4), it is possible to add a resistor in order to provide a well-controlled resistance value in the circuit, in which case the duty cycle may be modified to adjust the equivalent resistance of the switched-capacitor resistor (R_2) as a method of control.

[0482] The input supply voltage (V_{DD}) is applied across the series of resistances (R_1 and R_2) and the output voltage (V_{out}) is read across the switched-capacitor resistor (R_2). The output voltage (V_{out}) may thus be expressed by the following equation:

$$V_{out} = \frac{R_2}{R_1 + R_2} V_{DD} \quad (5)$$

where

[0483] V_{DD}=input supply voltage in volts

[0484] V_{out}=output voltage in volts

[0485] R_1=resistance of first resistor (R_1) in ohms

[0486] R_2=equivalent resistance of switched-capacitor resistor (R_2) in ohms.

[0487] Equations (3) and (5) can be combined and rewritten as follows:

$$C = \frac{V_{DD} - V_{out}}{R_1 \times f \times V_{out}} \quad (6)$$

where

[0488] C=capacitance of capacitive sensor (C_{sensor}) in farads

[0489] V_{DD}=input supply voltage in volts

[0490] V_{out}=output voltage in volts

[0491] R_1=resistance of first resistor (R_1) in ohms

[0492] f=switching frequency in hertz.

[0493] With reference to equation (6), it can be appreciated that the input supply voltage (V_{DD}), the resistance of the first resistor (R_1), and the switching frequency are known values. Thus, by reading the output voltage (V_{out}), it is possible to determine the capacitance of the capacitive sensor (C_{sensor}). In some embodiments, the output voltage (V_{out}) may be scaled through a gain stage if the change in voltage is too small to measure directly in a reliable manner. Thus, the resistive voltage divider circuit shown in FIG. **33** enables direct measurement of the capacitance of the capacitive sensor (C_{sensor}).

[0494] It should be understood that all of the components of the resistive voltage divider circuit shown in FIG. **33** (with the exception of the capacitive sensor (C_{sensor})) are provided as a sensor measurement circuit with suitable connections to the first terminal connection (Term 1) and the second terminal connection (Term 2) of the capacitive sensor (C_{sensor}). In some embodiments, the sensor measurement circuit is positioned within air flow chamber **3108** of vape device **3100**, preferably near the capacitive sensor (C_{sensor}). In other embodiments, the sensor measurement circuit is positioned outside of air flow chamber **3108**, such as in the control assembly described above.

[0495] Referring to FIG. **34**, in another embodiment, the sensor measurement circuit comprises a phase locked loop circuit. The phase locked loop circuit generally includes a variable frequency oscillator that generates a reference signal having a reference frequency (f_{ref}), as well as a phase comparator, a loop filter, and a voltage-controlled oscillator (VCO) that operate in a feedback loop. The phase comparator receives the two input periodic signals from the variable frequency oscillator and the feedback loop and generates an output signal representing the phase difference between the two inputs. The loop filter suppresses the higher-frequency components of that output signal and provides the filtered signal to the VCO. The frequency of the periodic signal generated by the VCO is controlled by the control voltage (V_e). Thus, the VCO is a variable frequency oscillator that allows an external voltage, i.e., the control voltage (V_e), to control its frequency of oscillation. An N-Divider may optionally be provided to scale the output frequency of the VCO by a factor of N.

[0496] It can be seen that the capacitive sensor (C_{sensor}) is included as part of the VCO. The capacitive sensor (C_{sensor}) may comprise, for example, the parallel plate capacitor shown in FIG. **31**, in which case a first terminal connection (Term 1) is provided on conductive plate **3114** and a second terminal connection (Term 2) is provided on conductive plate **3116**. Of course, other types of capacitive sensors may also be used as described below. By including the capacitive sensor (C_{sensor}) as part of the VCO, there will be a shift in the output frequency of the VCO whenever the capacitance of the capacitive sensor (C_{sensor}) changes (e.g., when vaporized payload **3112** passes through measurement cavity **3118**). When the circuit corrects for the frequency shift by attempting to realign the phases of the two input periodic signals received by the phase comparator, there will be a measurable change in the control voltage (V_e) provided to the VCO. This change in the control voltage (V_e) is related to the capacitance of the capacitive sensor (C_{sensor}). Thus, the phased lock loop circuit shown in FIG. **34** enables indirect measurement of the capacitance of the capacitive sensor (C_{sensor}).

[0497] It should be understood that all of the components of the phase locked loop circuit shown in FIG. **34** (with the exception of the capacitive sensor (C_{sensor})) are provided as a sensor measurement circuit with suitable connections to the first terminal connection (Term 1) and the second terminal connection (Term 2) of the capacitive sensor (C_{sensor}). In some embodiments, the sensor measurement circuit is positioned within air flow chamber **3108** of vape device **3100**, preferably near the capacitive sensor (C_{sensor}). In other embodiments, the sensor measurement circuit is positioned outside of air flow chamber **3108**, such as in the control assembly described above.

[0498] Referring to FIG. **35**, in another embodiment, the sensor measurement circuit comprises a first order active low-pass filter circuit connected to a rectifier circuit. The low-pass filter circuit includes an operational amplifier in which an input signal in the form of a sine wave is provided through a first resistor (R_1) to the inverting input of the amplifier. Preferably, the input voltage (V_{in}) is chosen close to the 3 dB point of the low-pass filter. A second resistor (R_2) and a capacitive sensor (C_{sensor}) are connected in parallel between the inverting input of the amplifier and the output of the amplifier. The capacitive sensor (C_{sensor}) may comprise, for example, the parallel plate capacitor shown in FIG. **31**, in which case a first terminal connection (Term 1) is provided on conductive plate **3114** and a second terminal connection (Term 2) is provided on conductive plate **3116**. Of course, other types of capacitive sensors may also be used as described below.

[0499] The cut-off frequency (f_c) of the low-pass filter is expressed as follows:

$$f_c = \frac{1}{2\pi R_2 C} \quad (7)$$

where

[0500] f_c=cut-off frequency of low-pass filter in hertz

[0501] R_2=resistance of second resistor (R_2) in ohms

[0502] C=capacitance of capacitive sensor (C_{sensor}) in farads.

[0503] Also, the stop frequency (f_s) of the low-pass filter is expressed as follows:

$$f_s = \frac{1}{2\pi R_1 C} \tag{8}$$

where

[0504] f_s=stop frequency of low-pass filter in hertz

[0505] R_1=resistance of first resistor (R_1) in ohms

[0506] C=capacitance of capacitive sensor (C_{sensor}) in farads.

[0507] At low frequencies, where f<fc, the capacitive sensor (C_{sensor}) is open such that the gain of the amplifier is $-R_2/R_1$. At high frequencies, where $f>f_s$, the capacitive sensor (C_{sensor}) is a short such that the gain of the amplifier goes to zero. At frequencies between f_e and f_s, the gain of the amplifier drops off at −20 dB/decade. The bode plot of the low-pass filter is shown in FIG. **36**.

[0508] Referring again to FIG. **35**, the rectifier circuit is used to convert the alternating current (AC) signal provided at the output of the amplifier to direct current (DC). As such, a DC output voltage (V_{out}) is provided at the output of the circuit.

[0509] It can be appreciated that a change in the capacitance of the capacitive sensor (C_{sensor}) causes a change in the bandwidth of the low-pass filter. An increase or decrease in the bandwidth changes the signal amplitude at the output of the amplifier, which in turn changes the value of the DC output voltage (V_{out}). The value of the DC output voltage (V_{out}) is related to the capacitance of the capacitive sensor (C_{sensor}). Thus, the circuit shown in FIG. **35** enables indirect measurement of the capacitance of the capacitive sensor (C_{sensor}).

[0510] In some embodiments, the DC output voltage (V_{out}) may be scaled through a gain stage if the change in voltage is too small to measure directly in a reliable manner. Also, a higher order filter with a sharper roll-off may alternatively be used to increase the change in the DC output voltage (V_{out}) as the capacitance of the capacitive sensor (C_{sensor}) changes.

[0511] It should be understood that all of the components of the circuit shown in FIG. **35** (with the exception of the capacitive sensor (C_{sensor})) are provided as a sensor measurement circuit with suitable connections to the first terminal connection (Term 1) and the second terminal connection (Term 2) of capacitive sensor (C_{sensor}). In some embodiments, the sensor measurement circuit is positioned within air flow chamber **3108** of vape device **3100**, preferably near the capacitive sensor (C_{sensor}). In other embodiments, the sensor measurement circuit is positioned outside of air flow chamber **3108**, such as in the control assembly described above.

[0512] Referring to FIG. **37**, in another embodiment, the sensor measurement circuit comprises a crystal oscillation circuit that generates a reference signal having a reference frequency (f_{ref}), which functions as the variable frequency oscillator of a phase locked loop circuit. In this embodiment, the crystal oscillation circuit comprises a Colpitts crystal oscillator that includes a quartz crystal (XTAL), a transistor, a first resistor (R_1), a second resistor (R_2), a third resistor (R_3), a first capacitor (C_1), and a second capacitor (C_2), as shown in FIG. **37**. Of course, other types of oscillation circuits may also be used.

[0513] The phase locked loop circuit includes a phase comparator, a loop filter, a VCO, and optionally a divider, as described in greater detail above in connection with the circuit of FIG. **34**. However, in this embodiment, the capacitive sensor (C_{sensor}) is not included within the VCO. Rather, the capacitive sensor (C_{sensor}) is used to load the crystal oscillation circuit. The capacitive sensor (C_{sensor}) may comprise, for example, the parallel plate capacitor shown in FIG. **31**, in which case a first terminal connection (Term 1) is provided on conductive plate **3114** and a second terminal connection (Term 2) is provided on conductive plate **3116**. Of course, other types of capacitive sensors may also be used as described below.

[0514] It can be appreciated that a change in the capacitance of the capacitive sensor (C_{sensor}) causes a change in the reference frequency (fief) of the reference signal provided to the phase locked loop circuit. To compensate for the change in the reference frequency (f_{ref}), the phase locked loop circuit will change the value of the control voltage (V_e) provided to the VCO. The value of the control voltage (V_e) is related to the capacitance of the capacitive sensor (C_{sensor}). Thus, the circuit shown in FIG. **37** enables indirect measurement of the capacitance of the capacitive sensor (C_{sensor}).

[0515] It should be understood that all of the components of the circuit shown in FIG. **37** (with the exception of the capacitive sensor (C_{sensor})) are provided as a sensor measurement circuit with suitable connections to the first terminal connection (Term 1) and the second terminal connection (Term 2) of capacitive sensor (C_{sensor}). In some embodiments, the sensor measurement circuit is positioned within air flow chamber **3108** of vape device **3100**, preferably near the capacitive sensor (C_{sensor}). In other embodiments, the sensor measurement circuit is positioned outside of air flow chamber **3108**, such as in the control assembly described above.

[0516] It can be appreciated that the sensor measurement circuits described above may be required to accommodate very small to large shifts in capacitance. For example, the capacitance of the capacitive sensor (C_{sensor}) will be low when the measurement cavity is filled with air. However, when the measurement cavity is filled with dense vapor, the capacitance of the capacitive sensor (C_{sensor}) will be multiple times larger (potentially 2 or more orders of magnitude higher). As such, in some embodiments, a controller is used to adjust the sensitivity of the sensor measurement circuit (e.g., adjust the gain of the amplifier, charge pump current, or VCO).

[0517] The vapor measurement system of the present invention further includes a processor that is part of the control assembly or, alternatively, may be provided as part of the sensor measurement circuit. The processor is programmed to perform the following steps: (1) correlate the measured capacitance to a change in a dielectric constant; (2) correlate the change in the dielectric constant to a change in a dielectric density, i.e., the density of the vaporized payload; and (3) correlate the change in the dielectric density to a dosage of the vaporized payload. Thus, the measurement of the sensor's capacitance enables the dosage of the vapor's constituent parts to be accurately determined. The dose may be used in a variety of few ways, including:

(1) the dose could be reported to the user after being administered; (2) a dose could be pre-selected by the user and the system could turn off the atomizer once that dose has been administered; or (3) a constant dose could be administered to the user (i.e., the dose is not configurable).

[0518] Because many types of payload (e.g., cannabis oil) are sticky, there will likely be a buildup of residue on the surfaces of conductive plates **3114** and **3116** (or other electrical conductors of a capacitive sensor, as described below) over time. In order to compensate for a capacitance shift due to this residue buildup, some embodiments utilize a calibration step in which the nominal capacitance of the capacitive sensor (C_{sensor}) is measured (i.e., the capacitance when no vaporized payload is present in the measurement cavity) and used as a reference against which one or more subsequent capacitance measurements will be compared. When vaporized payload is passed through the measurement cavity, the capacitance of the capacitive sensor (C_{sensor}) is re-measured. This second capacitance measurement is compared to the reference value and the difference between them is used to determine the concentration of vaporized payload in the measurement cavity. The calibration step may be performed on a periodic basis, e.g., before every capacitance measurement or every group of capacitance measurements. Of course, other calibration schedules will be apparent to one skilled in the art. For example, calibration steps may be performed both before and after the vaporized payload is present in the measurement cavity, in which case any new offset in the latter measurement is subtracted from the dose measured during inhalation insofar as the offset is attributable to new residue buildup on the sensor.

[0519] In some embodiments, the capacitance of the capacitive sensor (C_{sensor}) is sampled at several points during usage of the vape device and used to modulate the atomizer's vaporization profile (i.e., create more or less vaporized payload). For example, if it is known that the heating element of an atomizer is hot but there is no vaporized payload detected, then the power to the atomizer can be reduced to avoid over-heating the element. As another example, if there is too much vaporized payload in the measurement cavity, then the power to the atomizer can be limited to reduce the amount of vaporized payload being created. Of course, other examples of modifications to the atomizer's vaporization profile will be apparent to one skilled in the art.

[0520] With reference again to vape device **3100** shown in FIG. **31**, the vapor measurement system of the present invention is not limited to the use of a capacitive sensor positioned in air flow chamber **3108** between atomizer **3110** and outlet **3106**. In some embodiments, the conductive plates of the capacitive sensor form a part of the atomizer, which enables the use of smaller vape devices that are more convenient to use. For example, one or both of the conductive plates of the capacitive sensor may function as a heating element/coil of the atomizer. In this case, a user can apply an arbitrary amount of payload (e.g., cannabis oil) directly to the conductive plates using various dispensing methods known in the art (e.g., the outlet of the payload reservoir may be positioned directly on the sensor plates/coils). The system can measure the pre-vape and post-vape capacitance of the capacitive sensor (C_{sensor}) and the difference may be used to provide an accurate measurement of the dose administered.

[0521] As noted above, the vapor measurement system of the present invention is not limited to the use of a parallel plate capacitor as the capacitive sensor (C_{sensor}). Other types of capacitors may also be used, such as a rolled capacitor or an interdigitated capacitor. In general, any capacitor may be used that includes a first electrical conductor spaced from a second electrical conductor to define a measurement cavity therebetween.

[0522] FIGS. **38**A-**38**C show an example of a rolled capacitor. As shown in FIG. **38**A, the rolled capacitor includes a first electrical conductor **3800** and a second electrical conductor **3802**. First electrical conductor **3800** comprises a plurality of rolled plates **3800*a*-3800*f*** connected to a common mounting plate **3800*g*** that provides a first terminal connection (Term 1). Second electrical conductor **3802** comprises a plurality of rolled plates **3802*a*-3802*d*** connected to a common mounting plate **3802*e*** that provides a second terminal connection (Term 2). First and second electrical conductors **3800** and **3802** may be formed of metal or any other conductive material, such as copper, stainless steel, silicon (which may be doped), gold, or titanium.

[0523] The rolled capacitor includes an air inlet **3804** and an air outlet **3806**. FIG. **38**B includes arrows indicating the direction of air flow in a plane parallel to the front face of the rolled capacitor. FIG. **38**C includes arrows indicating the direction of air flow in a plane perpendicular to the front face of the rolled capacitor.

[0524] With reference to vape device **3100** shown in FIG. **31**, the rolled capacitor is configured to be positioned in air flow chamber **3108** between atomizer **3110** and outlet **3106** (as an alternative to conductive plates **3114** and **3116**) using a non-conductive mechanical support (not shown). First and second electrical conductors **3800** and **3802** define a measurement cavity between rolled plates **3800*a*-3800*f*** and rolled plates **3802*a*-3802*d***. When vaporized payload **3112** passes from atomizer **3110** to outlet **3106**, it passes through the measurement cavity such that vaporized payload **3112** effectively functions as the dielectric of the rolled capacitor.

[0525] FIGS. **39**A-**39**C show an example of an interdigitated capacitor. As shown in FIG. **39**A, the interdigitated capacitor includes a first electrical conductor **3900** and a second electrical conductor **3902**. First electrical conductor **3900** comprises a plurality of interconnected segments **3900*a*-3900*e*** that provide a first terminal connection (Term 1). Second electrical conductor **3902** comprises a plurality of interconnected segments **3902*a*-3902*e*** that provide a second terminal connection (Term 2). First and second electrical conductors **3900** and **3902** may be formed of metal or any other conductive material, such as copper, stainless steel, silicon (which may be doped), gold, or titanium.

[0526] The interdigitated capacitor includes an air inlet **3904** and an air outlet **3906**. FIG. **39**B includes arrows indicating the direction of air flow in a plane parallel to the front face of the interdigitated capacitor. FIG. **39**C includes arrows indicating the direction of air flow in a plane perpendicular to the front face of the interdigitated capacitor.

[0527] With reference to vape device **3100** shown in FIG. **31**, the interdigitated capacitor is configured to be positioned in air flow chamber **3108** between atomizer **3110** and outlet **3106** (as an alternative to conductive plates **3114** and **3116**) using a non-conductive mechanical support (not shown). First and second electrical conductors **3900** and **3902** define a measurement cavity between segments **3900*a*-3900*e*** and segments **3902*a*-3902*e***. When vaporized payload **3112** passes from atomizer **3110** to outlet **3106**, it passes through the measurement cavity such that vaporized payload **3112** effectively functions as the dielectric of the interdigitated capacitor.

[0528] It should be understood that multiple capacitors could be used in different configurations, including multiple parallel capacitors or multiple series capacitors. Of course, the use of multiple parallel capacitors is preferred because this configuration will increase the overall capacitance of the capacitive sensor and make it easier to detect (the overall capacitance would be reduced and harder to detect with multiple series capacitors).

[0529] In one embodiment, a modified differential interdigitated capacitive sensor design is used in which the electrical conductors of one capacitor are chemically modified and those of the other capacitor are not. The capacitors are positioned adjacent to each other so that substantially the same number of target molecules (e.g., THC and/or CBD molecules) are present within each capacitor. The electrical conductors of the chemically modified capacitor have a coating designed to absorb the target molecules relative to the baseline capacitor. The surface absorption of the target molecules will alter the dielectric constant of the chemically modified capacitor, which may be measured by low noise electronics.

[0530] The capacitive vapor measurement system described above is configured to accurately determine the dosage based on a measured capacitance of vaporized payload in a measurement cavity of the vape device. This vapor measurement system is beneficial to both medicinal patients and recreational users because they will be able to accurately measure their dosage to obtain desired effects in a repeatable fashion.

Two-Lead Communication System

[0531] In some embodiments, the vape device includes a two-lead communication system that utilizes an electromechanical connection in which a first connector provided as part of the control assembly is releasably coupled to a second connector provided as part of the cartridge. The electromechanical connection provides a two-conductor electrical interface that enables the communication of a plurality of electrical signals between the control assembly and the cartridge, such as a power signal and one or more data signals. Various embodiments of the two-lead communication system are described below.

[0532] Referring to FIG. **40**, one embodiment of a vape device **4000** that includes a two-lead communication system is shown. In general, vape device **4000** includes a control assembly **4010** and a cartridge **4020** that are formed in separate housings and releasably connected to each other via an electromechanical connection **4040**. In this embodiment, control assembly **4010** is provided as a re-useable component that can be used with multiple disposable cartridges, such as cartridge **4020**. In other embodiments, control assembly **4010** may be disposable and/or cartridge **4020** may contain a payload reservoir that is accessible for refilling, as described above.

[0533] Control assembly **4010** is shown in FIG. **40** with a microcontroller **4012**, a power source **4014**, a radio frequency identification (RFID) reader **4016** and a switch **4018**, which are the components that form a part of the two-lead communication system. It should be understood that control assembly **4010** may include a number of other components that are not shown in FIG. **40**, as described above in connection with the control assembly **14** of vape device **10**.

[0534] Microcontroller **4012** is configured for carrying out one or more electronic control functions in respect of the operation of vape device **4000**, including control of power source **4014**, control of RFID reader **4016**, and control of switch **4018**. In some embodiments, microcontroller **4012** comprises a microprocessor (which for purposes of this disclosure also incorporates any type of processor) having a central processing unit as known to those skilled in the art. Microcontroller **4012** further comprises a memory configured for storing a series of instructions for operating the microprocessor and storing data collected from RFID tag **4024** (described below) or sensors disposed on vape device **4000** to control its operation, such as operational settings.

[0535] Power source **4014** is configured to generate a power signal that is used to power heating element **4022** of the atomizer. In one embodiment, power source **4014** comprises a battery that generates a direct current. The direct current may be pulsed in accordance with a pulse width modulation (PWM) instruction provided by microcontroller **4012** in order to control the temperature of heating element **4022** in a particular desired manner. Alternatively, the temperature of heating element **4022** may be regulated through current and voltage control. In some embodiments, control assembly **4010** further comprises a draw switch (not shown) that sends an “on” signal to microcontroller **4012**. When microcontroller **4012** receives the “on” signal from the draw switch, it may send instructions to activate heating element **4022** (i.e., deliver electric current from power source **4014** to heating element **4022**), provided that any other conditions necessary to activate heating element **4022** have been met, as described above.

[0536] RFID reader **4016** is configured to read data stored on an RFID tag **4024** (and optionally write data to RFID tag **4024**) in accordance with instructions from microcontroller **4012**. In one embodiment, RFID reader **4016** operates in accordance with the near-field communication (NFC) protocol and RFID tag **4024** comprises an NFC tag. Of course, RFID reader **4016** may communicate with RFID tag **4024** using other RFID-type protocols, such as ultra-high frequency (UHF) RFID, FeliCa, and analog signaling methods known to those skilled in the art.

[0537] Switch **4018** is configured to control the communication of signals between control assembly **4010** and cartridge **4020** over a two-conductor electrical interface provided by electromechanical connection **4040** in accordance with instructions from microcontroller **4012**. In one embodiment, switch **4018** comprises a double-pole, double-throw (DPDT) switch having a first switch position and a second switch position. Movement of the DPDT switch to the first switch position, as shown in FIG. **40**, enables the transmission of a power signal from power source **4014** to heating element **4022**. Movement of the DPDT switch to the second switch position enables the transmission of one or more data signals between RFID reader **4016** and RFID tag **4024**.

[0538] Cartridge **4020** is shown in FIG. **40** with a heating element **4022** of the atomizer, an RFID tag **4024**, capacitors **4026** and **4028**, inductors **4030** and **4032**, a choke **4034**, and electrical terminals **4036** and **4038**, which are the components that form a part of the two-lead communication system. It should be understood that cartridge **4020** may include a number of other components that are not shown in

FIG. **40**, as described above in connection with the control assembly **14** of vape device **10**.

[0539] Heating element **4022** is disposed within the atomizer for heating and vaporizing a payload contained in the payload reservoir (not shown) of cartridge **4020**, as described above. In this embodiment, heating element **4022** comprises a heating coil. Choke **4034** comprises a high-frequency choke that is provided to prevent the low impedance heating element **4022** from loading the analog circuitry (i.e., capacitors **4026** and **4028**, inductors **4030** and **4032**, and RFID tag **4024**). Choke **4034** is self-resonant at the radio frequency of RFID tag **4024** and is thus high impedance at that frequency.

[0540] RFID tag **4024** comprises any type of electronic storage device that includes memory for storing data relating to cartridge **4000**. In one embodiment, RFID tag **4024** comprises an integrated circuit (IC) chip for modulating and demodulating radio frequency signals. For example, RFID tag **4024** may comprise a galvanically isolated NFC tag.

[0541] The data stored in RFID tag **4024** may include a variety of different types of information, such as: (1) information on the specific payload contained in the payload reservoir of cartridge **4000** (e.g., payload volume, payload composition, THC concentration, CBD concentration, terpene profiles); (2) information on the manufacture of cartridge **4000** (e.g., date and lot codes, serial number, MAC address); (3) information on one or more operational settings recommended for use in vaporizing the specific payload contained in the payload reservoir of cartridge **4000** (e.g., a current setting); (4) information to enable verification of the authenticity of cartridge **4000** (e.g., cryptographic key(s)); (5) information on software or hardware contained within cartridge **4000** (e.g., a software revision of a microcontroller of a temperature control circuit, as described below); and/or (6) information on an intended user of cartridge **4000** (e.g., user information and prescription information for a particular individual having a prescription for the payload within the payload reservoir of cartridge **4000**). Of course, those skilled in the art will understand that other types of data may also be stored in RFID tag **4024**.

[0542] RFID tag **4024** can be programmed during production (e.g., during filling of the payload reservoir) to store the desired data in order to personalize cartridge **4020**. This can be accomplished by connecting the two-pin connector provided on cartridge **4020** (discussed below) to a corresponding RFID reader capable of programming RFID tag **4024** with the desired information.

[0543] In one embodiment, RFID tag **4024** operates at a frequency of 13.56 MHz. In another embodiment, RFID tag **4024** operates at a frequency in a range of 860-960 MHz. In other embodiments, RFID tag **4024** operates at a lower frequency (e.g., a frequency in a range of 125-134.2 kHz) or at a higher frequency (e.g., 2.45 GHz). Of course, other frequencies may also be used in accordance with the invention.

[0544] Capacitors **4026** and **4028** comprise DC-blocking capacitors that are provided to isolate RFID tag **4024** from the power signal transmitted from power source **4014** to heating element **4022** over the two-conductor electrical interface. Capacitors **4026** and **4028** are self-resonant at the radio frequency of RFID tag **4024** and are thus low impedance at that frequency.

[0545] Inductor **4030** functions as the antenna of RFID reader **4016**, and inductor **4032** functions as the antenna of RFID tag **4024**. Inductors **4030** and **4032** are positioned to allow magnetic coupling between them and provide wireless transmission over the very short range that separates the inductors. Alternatively, inductors **4030** and **4032** could be replaced with a transformer that serves the same function.

[0546] It should be understood that cartridge **4020** supports two different modes: (1) a DC mode in which a DC voltage is applied across electrical terminals **4036** and **4038** and (2) an AC mode in which the antenna terminals of RFID reader **4016** are connected across electrical terminals **4036** and **4038** so that RFID tag **4024** can be accessed by RFID reader **4016**.

[0547] Electromechanical connection **4040** of vape device **4000** enables the communication of signals (e.g., a power signal and one or more data signals) between control assembly **4010** and cartridge **4020**. Electromechanical connection **4040** comprises a pair of connectors, i.e., a first connector provided at an end of control assembly **4000** and a second connector provided at an end of cartridge **4020**. The first and second connectors are configured to be mechanically and electrically connected together. The mechanical connection may comprise a threaded connection, a pressure or friction fit connection, a twist mechanical lock, a magnetic connection, or any other mechanical connecting means known to those skilled in the art. The electrical connection provides a two-conductor electrical interface that forms a part of the two-lead communication system.

[0548] In one embodiment, the first and second connectors comprise M7×0.5 mm threaded connectors (commonly referred to as "510 threaded connectors"). The first connector (i.e., the connector on control assembly **4010**) comprises a female 510 threaded connector, an example of which is shown in FIG. **41**A. This connector comprises a two-pin electromechanical connector **4100** that uses an outer housing **4104** as the negative electrical terminal and a center pin **4106** as the positive electrical terminal, and an insulator may optionally be provided therebetween. The second connector (i.e., the connector on cartridge **4020**) comprises a male 510 threaded connector, an example of which is shown in FIG. **41**B. This connector comprises a two-pin electromechanical connector **4102** that uses an outer housing **4108** as the negative electrical terminal and a center pin **4110** as the positive electrical terminal, and an insulator may optionally be provided therebetween.

[0549] When the male connector **4102** and female connector **4100** are connected, (1) center pin **4110** contacts center pin **4106** to provide a positive lead that extends between the positive electrical terminal of switch **4018** and positive electrical terminal **4036** of cartridge **4020** and (2) outer housing **4108** contacts outer housing **4104** to provide a negative lead that extends between the negative electrical terminal of switch **4018** and negative electrical terminal **4038** of cartridge **4020**.

[0550] Of course, the invention is not limited to the use of 510 threaded connectors and other types of two-conductor connectors may also be used.

[0551] The two-lead communication system provides a way of allowing at least two functions to share a two-conductor electrical interface: (1) the transmission of a power signal from power source **4014** to heating element **4022** and (2) the transmission one or more data signals between RFID reader **4016** and RFID tag **4024** (e.g., NFC data transmission).

[0552] The first function is provided when switch **4018** is moved to its first switch position. In this case, a power signal (e.g., a direct current or pulsed direct current) is transmitted from power source **4014** through switch **4018** and over the two-conductor electrical interface to electrical terminals **4036** and **4038**. The power signal is then transmitted from electrical terminals **4036** and **4038** to heating element **4022** so as to activate the atomizer.

[0553] The second function is provided when switch **4018** is moved to its second switch position. In this case, the transmission of data signals will depend on whether RFID tag **4024** comprises a passive tag, an active transponder tag, or an active beacon tag.

[0554] If RFID tag **4024** comprises a passive tag, RFID reader **4016** transmits an interrogating signal through switch **4018** and over the two-conductor electrical interface to electrical terminals **4036** and **4038**. The interrogating signal is then coupled from inductor **4030** to inductor **4032**, which draws in energy from the radio frequency waves. This energy moves from inductor **4032** to RFID tag **4024** to power the tag. In response, RFID tag **4024** generates a response signal that encodes the data stored on the tag. The response signal is then coupled from inductor **4032** to inductor **4030** and provided at electrical terminals **4036** and **4038**. The response signal is then transmitted over the two-conductor electrical interface and through switch **4018** to RFID reader **4016**.

[0555] If RFID tag **4024** comprises an active transponder tag, the operation is similar to that of the passive tag with the exception that the active transponder tag is not powered by the interrogating signal. Rather, the active transponder tag has its own internal power source.

[0556] If RFID tag **4024** comprises an active beacon tag, there is no interrogating signal and the active beacon tag has its own power source. In this case, RFID tag **4024** generates a signal that encodes the data stored on the tag. The signal is then coupled from inductor **4032** to inductor **4030** and provided at electrical terminals **4036** and **4038**. The signal is then transmitted over the two-conductor electrical interface and through switch **4018** to RFID reader **4016**.

[0557] In the embodiments described above, the power signal and data signal(s) are transmitted over the two-conductor electrical interface in accordance with a time division multiplexing scheme. Thus, the DC and analog signaling paths require mutually exclusive time slots and cannot be operated simultaneously. In other embodiments, the DC and analog signaling paths (which operate at different frequencies) can be simultaneously provided over the two-conductor electrical interface in accordance with a frequency division multiplexing scheme. This functionality would be incorporated into the RFID reader **4016** so that the transmit and receive functions are operated in parallel at different frequencies, as known to those skilled in the art.

[0558] The two-lead communication system described above enables the cartridge data to be provided in a secure electronic memory within the cartridge. The cartridge data cannot be tampered with, discarded or lost and, thus, a user can be assured that the data is legitimate and not a forgery.

Integrated Temperature Control System

[0559] In some embodiments, the vape device includes a cartridge with an integrated temperature control system. In particular, the cartridge includes a temperature sensor configured to sense or determine the temperature within the cartridge. The temperature sensor may comprise a component configured to sense the temperature within the cartridge, such as a thermistor, a thermocouple, a bandgap temperature sensor, an analog temperature sensor, a digital temperature sensor, or a light sensor. The temperature sensor may also comprise a circuit configured to measure the resistance of the heating element and utilize this measurement to determine the temperature within the cartridge. The temperature sensor is incorporated into a temperature control circuit configured to regulate the power provided to the heating element based on the temperature within the cartridge and a desired temperature set point. Various embodiments of the temperature control circuit are described below.

[0560] Referring to FIG. **42**, one embodiment of a vape device **4200** that includes a cartridge with an integrated temperature control system is shown. In general, vape device **4200** includes a control assembly **4210** and a cartridge **4220** that may be formed in separate housings that are releasably connected to each other via an electromechanical connection **4230**. In this embodiment, control assembly **4210** is provided as a re-useable component that can be used with multiple disposable cartridges, such as cartridge **4220**. In other embodiments, control assembly **4210** may be disposable and/or cartridge **4220** may contain a payload reservoir that is accessible for refilling, as described above.

[0561] Electromechanical connection **4230** is configured to provide a mechanical connection between control assembly **4210** and cartridge **4220**, as well as an electrical connection that enables the routing of power from a power source **4212** in control assembly **4210** to the heater or atomizer **4224** in cartridge **4220**. For example, electromechanical connection **4230** may comprise a female 510 threaded connector on control assembly **4210** that releasably engages a male 510 threaded connector on cartridge **4220**. Of course, the invention is not limited to the use of 510 threaded connectors and other types of two-pin connectors may also be used, such as EGO connectors.

[0562] As shown in FIG. **42**, control assembly **4210** includes a power source **4212**. Of course, it should be understood that control assembly **4210** may include a number of other components and circuits that are not specifically shown in FIG. **42**, as described above in connection with the control assembly **14** of vape device **10**. Power source **4212** is configured to generate a power signal that is used to power the heating element of atomizer **4224**. In one embodiment, power source **4212** comprises a battery that generates a direct current.

[0563] Cartridge **4220** is shown in FIG. **42** with a payload reservoir **4222**, a heater or atomizer **4224**, a temperature sensor **4226**, and a temperature control circuit **4228**. It should be understood that cartridge **4220** may include a number of other components that are not shown in FIG. **42**, as described above in connection with vape devices **10**, **100**, and **2800** and cartridges **900**, **1000**, **1100**, **1900**, **2100**, **2400**, **2500**, and **2600**.

[0564] Payload reservoir **4222** is configured to contain a payload for vaporization or atomization, as described above. The payload may be for example, liquids, oils, other fluids, or tablets. The payload may comprise cannabis oil or nicotine oil or be any of the tablets **940**, **1002**, **1102**, **1202**, **1300**, **1302**, **1400**, **1500**, **1600**, and **1700** described above if vape device **4200** is modified to vaporize a tablet of dry material.

[0565] Heater or atomizer **4224** includes a heating element disposed therein for heating and vaporizing a payload contained in payload reservoir **4222**. In this embodiment, the heating element comprises a heating coil. As described below, the heating element is connected to temperature control circuit **4228**, which is configured to regulate the power provided to the heating element based on the temperature sensed within cartridge **4220** and a desired temperature set point.

[0566] Temperature sensor **4226** may comprise any type of component capable of sensing the temperature within cartridge **4220**. For example, temperature sensor **4226** may comprise a thermistor, a thermocouple, a bandgap temperature sensor, an analog temperature sensor, a digital temperature sensor (e.g., temperature sensors with I2C interface compatibility), or any other type of temperature sensor known to those skilled in the art. The thermal path between the atomizer and the temperature sensor may be implemented with thermal paste, a ceramic thermal bridge (e.g., the Q-Bridge thermal conductor available from American Technical Ceramics), or air and PCB dielectric.

[0567] Temperature sensor **4226** may also comprise a light sensor configured to detect light emitted from a material within cartridge **4220**, wherein the intensity of the emitted light is proportional to the temperature of the material, as is known to those skilled in the art. The light sensor may comprise, for example, a photodiode or phototransistor that detects light emitted by the heating element and/or light emitted by the vaporized payload (which would typically be in the infrared region of 0.7 microns to 20 microns). The light sensor is preferably able to detect the light through different seals or glass so that the light sensor can be isolated from the vaporized payload. The light sensor can be used to trigger when a certain threshold temperature has been reached or can be used to maintain operation within a range of temperatures. As an example, the light sensor can be used to detect when the wick is dry, in which case the heating element will heat much faster and become red. Detecting a dry wick can be used as a way to prevent the inhalation of burned silica and save battery power.

[0568] Temperature sensor **4226** may also comprise a circuit configured to measure the resistance of the heating element and utilize this measurement to determine the temperature within cartridge **4220**. As is known in the art, the resistance of the heating element is directly proportional to the resistivity of the material from which the heating element is made (i.e., the resistance is dependent on the resistivity, length, and cross-sectional area of the heating element). The relationship between the resistivity of the heating element and temperature is shown by the following equation (which is a linear approximation for cases in which the temperature variance is not large):

$$\rho=\rho_0(1+\alpha(T-T_0)) \tag{9}$$

where

[0569] ρ=resistivity of heating element at temperature Tin ohm meters

[0570] ρ_0=resistivity of heating element at temperature T_0 in ohm meters

[0571] α=temperature coefficient of resistivity at T_0

[0572] T=current temperature in ° K

[0573] T_0=fixed reference temperature (e.g., ambient temperature) in ° K.

[0574] It can be seen from equation (9) that the resistivity of the heating element increases with an increase in the current temperature of the heating element. Thus, if the resistance of the heating element is known at any given moment, it is possible to calculate the resistivity of the heating element and, using equation (9), calculate the current temperature of the heating element.

[0575] For example, the following method may be implemented to determine the current temperature of the heating element (and thus the temperature within cartridge **4220**): (a) measure the ambient temperature within cartridge **4220** (the heating element will be approximately the same temperature provided it has not been activated recently); (b) periodically measure the resistance of the heating element while the heating element is being powered; and (c) calculate the current temperature of the heating element based on the measured resistance (or determine a change in the resistance of the heating element to provide the temperature increase above the ambient temperature value). Thus, the resistance of the heating element as a function of temperature can be used to provide an accurate assessment of the temperature within cartridge **4220** at any given moment.

[0576] Temperature control circuit **4228** is configured to regulate the power provided to the heating element of atomizer **4224** based on the temperature sensed by temperature sensor **4226** within cartridge **4220** and a desired temperature set point. Various methods may be used to regulate the power provided to the heating element. In one embodiment, temperature control circuit **4228** is configured to increase or decrease the direct current (DC) voltage applied to the heating element. In another embodiment, temperature control circuit **4228** is configured to increase or decrease the direct current transmitted to the heating element. In another embodiment, temperature control circuit **4228** includes a processing element (e.g., microcontroller) programmed to modify the pulse width of pulsed direct current transmitted to the heating element (i.e., fixed voltage/current implementations). In this embodiment, it is possible to use either pulse width modulation (PWM) (i.e., regular periodic pulsing for several cycles) or irregular pulsing. An example of irregular pulsing is to turn the current on until a set point is reached, and then turn the current off until a hysteresis point is reached, and then turn the current back on). In yet another embodiment, temperature control circuit **4228** is configured to interrupt the flow of direct current to the heating element. Of course, other methods of power regulation will be apparent to those skilled in the art.

[0577] Various examples of temperature control circuits that can be used to regulate the power provided to the heating element of atomizer **4224** will now be described. It should be understood that the invention is not limited to the use of these particular circuits and that other types of electrical circuits configured to regulate the power provided to the heating element of atomizer **4224** may also be used in accordance with the invention.

[0578] Referring to FIG. **43**, in one embodiment, the temperature control circuit includes a DC-DC converter (DCDC) with an input voltage (V_{in}) connected to the voltage of the battery (V_{BATT}) and an output voltage (V_{out}) connected to the voltage of the heating element (V_{COIL}). The DC-DC converter (DCDC) is enabled when a microprocessor, button or other control means applies a control voltage to the enable pin voltage (EN). Alternatively, the DC-DC converter (DCDC) could be enabled when power is present. A resistive feedback divider that includes a fixed resistor (R_{fixed}) and a PTC thermistor (R_{PTC}) is connected to the feedback pin voltage (FB) of the DC-DC converter (DCDC).

The PTC thermistor (R_{PTC}) is thermally connected to the atomizer and has a resistance that increases with an increasing temperature and decreases with a decreasing temperature. As such, the PTC thermistor (R_{PTC}) functions as the temperature sensor of the circuit.

[0579] In operation, when the resistance of the PTC thermistor (R_{PTC}) increases, the DC-DC converter decreases the output voltage (V_{out}) so as to decrease the voltage applied to the heating element (V_{COIL}). Conversely, when the resistance of the PTC thermistor (R_{PTC}) decreases, the DC-DC converter increases the output voltage (V_{out}) so as to increase the voltage applied to the heating element (V_{COIL}). Thus, this circuit regulates the power to the heating element by increasing or decreasing the direct current (DC) voltage applied to the heating element based on the temperature sensed by the PTC thermistor (R_{PTC}).

[0580] Referring to FIG. **44**, in another embodiment, the temperature control circuit includes an operational amplifier in which the non-inverting input is connected to the voltage of the battery (V_{BATT}) through two reference resistors (R_{Ref1} and R_{ReF2}). The output of the operational amplifier is connected to the inverting input through a capacitor (C_2), and the output of the operational amplifier is connected to the non-inverting input through a feedback circuit that includes the capacitor (C_2), an anti-burst fusible resistor (R_{FB}), a PTC thermistor (R_{PTC}), and a capacitor (C_1). The PTC thermistor (R_{PTC}) is thermally connected to the atomizer and has a resistance that increases with an increasing temperature and decreases with a decreasing temperature. As such, PTC thermistor (R_{PTC}) functions as the temperature sensor of the circuit. It can also be seen that the output of the operational amplifier is connected to the heating element through a p-type field effect transistor (PFET) that provides DC current gain.

[0581] In operation, when the resistance of the PTC thermistor (R_{PTC}) increases, the voltage at the non-inverting input of the operational amplifier decreases so as to increase the voltage at the output and, thus, the current transmitted to the heating element through the p-type field effect transistor (PFET) is decreased. Conversely, when the resistance of the PTC thermistor (R_{PTC}) decreases, the voltage at the non-inverting input of the operational amplifier increases so as to decrease the voltage at the output and, thus, the current transmitted to the heating element through the p-type field effect transistor (PFET) is increased. Thus, this circuit regulates the power to the heating element by increasing or decreasing the direct current transmitted to the heating element based on the temperature sensed by the PTC thermistor (R_{PTC}).

[0582] Referring to FIG. **45**, in another embodiment, the temperature control circuit includes a microcontroller unit (MCU) connected through a general purpose input/output pin (GPIO) to a load switch positioned in the current path from the battery. The microcontroller unit (MCU) is programmed to transmit control signals to open and close the load switch and thereby generate a pulsed direct current at the output of the load switch. The microcontroller unit (MCU) also receives a temperature value as feedback from an analog temperature sensor configured to measure the temperature of the atomizer. Of course, any type of temperature sensor could be used to provide feedback to the microcontroller (MCU), such as a digital temperature sensor, a serial bus read sensor, a PWM output sensor, or a sensor that utilizes any type of analog temperature measurement as known to those skilled in the art.

[0583] In operation, when the temperature value received from the analog temperature sensor is above a desired temperature set point, the microcontroller unit (MCU) decreases the pulse width of the pulsed direct current so as to decrease the current transmitted to the heating element. Conversely, when the temperature value received from the analog temperature sensor is below a desired temperature set point, the microcontroller unit (MCU) increases the pulse width of the pulsed direct current so as to increase the current transmitted to the heating element Thus, this circuit regulates the power to the heating element by increasing or decreasing the pulse width of the pulsed direct current transmitted to the heating element based on the temperature value received from the analog temperature sensor.

[0584] Referring to FIG. **46**, in another embodiment, the temperature control circuit includes a microcontroller unit (MCU) connected through a general purpose input/output pin (GPIO) to a first switch (S_1) positioned in the current path from the battery and a second switch (S_2) positioned in the current path to the atomizer. The microcontroller unit (MCU) is programmed to transmit control signals to open and close the first switch (S_1) and thereby generate a pulsed direct current at the output of the first switch (S_1). The microcontroller unit (MCU) also includes a thermocouple in which the thermocouple junction is included as part of the wiring that supplies the atomizer. If the thermocouple junction is positioned outside of the payload area, then the thermal conductivity of the atomizer wiring is sufficient to transfer a temperature to the thermocouple junction that is directly related to the atomizer temperature. The thermocouple voltage (V_{SENSE}) is communicated to another general purpose input/output pin (GPIO) of the microcontroller unit (MCU) and, thus, the thermocouple functions as the temperature sensor of the circuit. The microcontroller circuitry is programmed to implement a brief period of inactivity during which the atomizer is unpowered so that the thermocouple voltage (V_{SENSE}) can be read.

[0585] In operation, when the thermocouple voltage (V_{SENSE}) is above the voltage associated with a desired temperature set point, the microcontroller unit (MCU) decreases the pulse width of the pulsed direct current so as to decrease the current transmitted to the heating element. Conversely, when the thermocouple voltage (V_{SENSE}) is below the voltage associated with a desired temperature set point, the microcontroller unit (MCU) increases the pulse width of the pulsed direct current so as to increase the current transmitted to the heating element. Thus, this circuit regulates the power to the heating element by increasing or decreasing the pulse width of the pulsed direct current transmitted to the heating element based on the sensed thermocouple voltage (V_{SENSE}).

[0586] Referring to FIG. **47**, in another embodiment, the temperature control circuit includes a microcontroller unit (MCU) that includes functionality similar to that described above in connection with FIG. **45**. However, instead of utilizing an analog temperature sensor, the circuit receives feedback from another type of temperature sensor (T_{SENSE}) positioned in the thermal path of the atomizer. The temperature sensor (T_{SENSE}) may comprise, for example, a thermistor, a bandgap temperature sensor, a digital temperature sensor, or any other type of PCB-mounted passive or active temperature sensor.

[0587] In operation, when the sensor value received from the temperature sensor (T_{SENSE}) is above a value associated with a desired temperature set point, the microcontroller unit (MCU) decreases the pulse width of the pulsed direct current so as to decrease the current transmitted to the heating element. Conversely, when the sensor value received from the temperature sensor (T_{SENSE}) is below a value associated with a desired temperature set point, the microcontroller unit (MCU) increases the pulse width of the pulsed direct current so as to increase the current transmitted to the heating element. Thus, this circuit regulates the power to the heating element by increasing or decreasing the pulse width of the pulsed direct current transmitted to the heating element based on the sensor value received from the temperature sensor (T_{SENSE}).

[0588] Referring to FIG. **48**, in another embodiment, the temperature control circuit includes a photodiode (i.e., a light sensor) that turns off the heating element (L**1**) when the temperature reaches an upper temperature limit (e.g., 200° C.). The circuit also includes first and second resistors (R**1** and R**2**) and first and second transistors (Q**1** and Q**2**), as shown, wherein the level of light required to turn off the heating element (L**1**) can be adjusted by changing the value of the first resistor (R**1**) and/or the value of the second resistor (R**2**). It can be appreciated that this circuit ensures consistent and safe performance of the vape device.

[0589] Of course, it can be appreciated that other temperature control circuits may also be used in accordance with the invention. For example, it is possible to use an analog circuit that provides power regulation based on a temperature sensing element (e.g., a thermistor) in a configuration that biases an electronic element capable of providing regulation (e.g., a MOSFET transistor). As another example, it is possible to use a simple thermal fuse that temporarily interrupts the power connection when the temperature of the atomizer or heating element exceeds the desired temperature set point. When the temperature is reduced to a level below the temperature set point, then the thermal fuse would reset so as to provide power to the atomizer or heating element.

[0590] In all of the examples provided above, the desired temperature set point is either determined by the values of the electrical components within the circuit or is programmed into a microcontroller unit (MCU). In other embodiments, the desired temperature set point is user-configurable, i.e., the temperature set point may be modified as desired by a particular user or for a desired temperature profile.

[0591] In some embodiments, the temperature control circuit includes a potentiometer having a variable resistance, and the vape device includes a user-actuated mechanism that enables a user to modify the variable resistance of the potentiometer to thereby modify the temperature set point.

[0592] An example of a temperature control circuit that includes a potentiometer is shown in FIG. **49**. This circuit includes a resistive divider that feeds an "analog in" pin of a microcontroller, wherein the value at the "analog in" pin changes the temperature set point. The resistive divider includes a fixed resistor (R_{fixed}) and a potentiometer. The potentiometer has a variable resistance that can be modified by a user, as described below, so that a change in the value of the resistance of the potentiometer changes the temperature set point. It should be understood that the microcontroller may be used with any of the temperature control circuits described above (e.g., load switch, FET, DCDC, etc.) to regulate the power provided to the atomizer. The microcontroller may optionally be connected to a radio tag, such as radio tag **4024** shown in FIG. **40** of the two-lead communication system described above.

[0593] The temperature control circuit shown in FIG. **49** may be used in combination with a user-actuated mechanism that can translate a mechanical setting to a resistance value of the potentiometer. Various examples of such user-actuated mechanisms are shown in FIGS. **50-52**.

[0594] FIG. **50** shows a portion of a cartridge that includes an outer housing **5000** and a printed circuit board **5002** disposed therein. The printed circuit board includes the components of the temperature control circuit shown in FIG. **49**, including the potentiometer **5004**. A rotary dial **5006** is positioned outside of outer housing **500** so as to be accessible to a user. Dial **5006** is connected to potentiometer **5004** via a rotary connector **5008**. Thus, a user can modify the resistance value of potentiometer **5004** by turning dial **5006**.

[0595] FIG. **51** shows a portion of a cartridge that includes an outer housing **5100** and a printed circuit board **5102** disposed therein. The printed circuit board includes the components of the temperature control circuit shown in FIG. **49**, including the potentiometer **5104**. A slideable tab **5106** is positioned outside of outer housing **500** so as to be accessible to a user. Slideable tab **5106** is integrally connected to an arm **5106***a* that extends into the cartridge and engages potentiometer **5104** that extends through a slider switch **5108**. Thus, a user can modify the resistance value of potentiometer **5104** by sliding tab **5106** along outer housing **5100**.

[0596] FIG. **52** shows a portion of a cartridge that includes an outer housing **5200** and a printed circuit board **5202** disposed therein. The printed circuit board includes the components of the temperature control circuit shown in FIG. **49**, including the potentiometer **5204**. Outer housing is rotatable and is connected to potentiometer **5204** via a rotary arm **5206** that is rigidly mounted to outer housing **5200** via a mount **5208**/. Thus, a user can modify the resistance value of potentiometer **5204** by rotating outer housing **5200**.

[0597] Of course, it should be understood that the invention is not limited to the user-actuated mechanisms shown in FIGS. **50-52** and that other mechanisms may be used in accordance with the invention. Also, instead of using a potentiometer to vary the resistance and thereby modify the temperature set point, the temperature control circuit may incorporate a user interface that enables a user to input a digital value (e.g., based on several bits) to modify the temperature set point.

[0598] It is also possible to "translate" a voltage setting into a temperature setting (e.g., if the voltage output from the control assembly is 3.8 volts, the cartridge temperature is translated to 180° C.; if the voltage output from the control assembly is 4.0 volts, the cartridge temperature is translated to 200° C., etc.). The cartridge is thus able to translate this voltage into an appropriate power setting to create the predetermined temperature setting.

[0599] Cartridges with localized temperature sensing and control provide an additional layer of safety for the end user. Due to the commonality of the connectors used on vape devices, these types of cartridges can be installed on many different types of control assemblies with different capabilities. If a conventional cartridge with no localized temperature control is installed on a control assembly capable of supplying too much power, there is the possibility of the cartridge being damaged, the payload being burnt, or the user being injured. However, if the cartridge includes localized temperature control, then the cartridge, payload, and user are protected from such a control assembly.

[0600] It can be appreciated that the temperature control system described above adds localized temperature control to the cartridge containing the atomizer or heating element so that there is no need to pass additional electrical signals to facilitate temperature control through the electromechanical connector between the cartridge and control assembly. As such, it is possible for the vape device to use existing two-pin connector types while adding a desirable feature, i.e., localized control of the atomizer temperature.

[0601] Of course, the invention may be used with vape devices that utilize multi-pin connectors to enable communication between the control assembly and the cartridge. For example, the control assembly could send a signal that sets the upper temperature limit for a particular strain to the temperature control circuit of the cartridge, whereby one of the user-actuated mechanisms shown in FIGS. **50-52** could be used to lower the temperature from the upper limit. If the cartridge were connected to a control assembly that does not provide this functionality (i.e., does not send a signal with the upper temperature limit), then the temperature control circuit would see the signal as ground and operate in a standalone mode.

[0602] Referring to FIG. **53**, another embodiment of a cartridge **5300** with an integrated temperature control system is shown. In this embodiment, cartridge **5300** includes a heating element **5302** (described above) and a temperature control circuit (described above) provided on a printed circuit board **5304**. Printed circuit board **5304** provides connections **5304***a* and **5304***b* to an electromechanical connector **5306** to enable the transfer of power from a power source of a control assembly (not shown) to the temperature control circuit. Electromechanical connector **5306** may comprise a male 510 threaded connector, although other types of connectors may also be used as described herein. Heating element **5302** provides connections **5302***a* and **5302***b* to printed circuit board **5304** to enable the temperature control circuit to regulate the power provided to heating element **5302**.

[0603] Cartridge **5300** also includes two air inlets **5308** and **5310**. When a user inserts a mouthpiece (not shown) in his or her mouth and draws air through outlet **5312**, fresh air from external to cartridge **5200** enters inlets **5308** and **5310** and travels toward heating element **5302**. This fresh air combines with vaporized payload **5314** from heating element **5302** and enters outlet **5312**. The air and vaporized payload **5316** is drawn through outlet **5312** into the user's mouth.

[0604] In this embodiment, the temperature sensor provided as part of the temperature control circuit on printed circuit board **5304** is positioned in close proximity to heating element **5302** so as to enable measurement of the temperature within the atomizer. In other embodiments, a heat pipe may be used between the temperature sensor and heating element, in which case the temperature control circuit may be positioned a greater distance from the heating element. Thus, one skilled in the art will understand that the invention is not limited to the structural configuration of the cartridge shown in FIG. **53** and that other cartridge configurations may also be used.

[0605] The temperature control system described herein may be used for conduction or convection heating of a payload, which may be a fluid payload or a payload comprising dry material.

Smart Cartridge with Authenticated Access Control

[0606] In some embodiments, the vape device comprises a cartridge that is releasably connected to a control assembly, wherein the cartridge includes an authentication device that permits access to the payload only when the cartridge and/or control assembly are properly authenticated. A cartridge that includes this functionality may be referred to herein as a "smart" cartridge insofar as the cartridge provides authentication and access control independent of the control assembly. Various embodiments of vape devices that include a smart cartridge are described below.

[0607] Referring to FIG. **54**, one embodiment of a vape device **5400** comprises a control assembly **5410** and a smart cartridge **5420** that are formed in separate housings and releasably connected to each other via an electromechanical connector **5440**. In this embodiment, control assembly **5410** is provided as a re-useable component that can be used with multiple disposable cartridges, such as smart cartridge **5420**. In other embodiments, control assembly **5410** may also be disposable.

[0608] As shown in FIG. **54**, control assembly **5410** includes a microcontroller **5412** connected to a power source **5414**. It should be understood that control assembly **5410** may include a number of other components that are not shown in FIG. **54**, as described above in connection with the control assembly **14** of vape device **10**.

[0609] Microcontroller **5412** is configured to carry out one or more electronic control functions with respect to the operation of vape device **5400**, including control of power source **5414**. In some embodiments, microcontroller **5412** comprises a microprocessor (which for purposes of this disclosure also incorporates any type of processor) having a central processing unit as known to those skilled in the art. Microcontroller **5412** further comprises a memory configured to store a series of instructions for operating the microprocessor and also store data collected from one or more sensors disposed on vape device **5400** to control its operation, such as operational settings.

[0610] The memory of microcontroller **5412** may also be configured to store authentication data transmitted from authentication device **5430** of cartridge **5420** to microcontroller **5412**. In addition, the memory may be configured to store a list of valid public/private key pairs that are used for cryptographic authentication purposes, as described below. This list comprises the public/private key pairs associated with the various cartridges that have been manufactured for use with control assembly **5410**. Preferably, this list is periodically updated via communication with a remote server to either add new public/private key pairs or revoke particular public/private key pairs if it is determined that particular cartridges have been compromised.

[0611] Power source **5414** is configured to generate a power signal that is used to power atomizer **5422** of cartridge **5420**. In one embodiment, power source **5414** comprises a battery that generates a direct current. The direct current may be pulsed in accordance with a pulse width modulation (PWM) instruction provided by microcontroller **5412** in order to control the temperature of atomizer **5422** in a particular desired manner. Alternatively, the temperature of atomizer **5422** may be regulated through current and voltage control. In some embodiments, control assembly **5410** further comprises a draw switch (not shown) that sends an "on" signal to microcontroller **5412**. When microcontroller **5412** receives the "on" signal from the draw switch, it may send instructions to power source **5414** to deliver a power signal to atomizer **5422**, provided that any other conditions necessary to activate atomizer **5422** have been met as described above.

[0612] Cartridge **5420** is shown in FIG. **54** with an atomizer **5422**, a payload reservoir **5424**, and an authentication assembly **5428**. Authentication assembly **5428** includes an authentication device **5430** and a power gate **5432** that provide the "smart" capabilities of cartridge **5420**. It should be understood that cartridge **5420** may include a number of other components that are not shown in FIG. **54**, as described above in connection with cartridge **12** of vape device **10**.

[0613] The inlet of atomizer **5422** is in communication with payload reservoir **5424** that contains a payload. The payload may be, for example, liquids, oils, other fluids, or tablets. As described above, atomizer **5422** includes a heating element, such as a heating coil, configured to heat and vaporize the payload contained in payload reservoir **5424** to generate a vaporized payload **5426** provided at the outlet of atomizer **5422**.

[0614] Authentication device **5430** comprises a standard or custom integrated circuit (IC) with a microcontroller unit (MCU) and secure element capable of storing authentication data and performing cryptographic operations, as described below. The secure element may comprise an inaccessible memory (i.e., a memory block that is guaranteed inaccessible from outside the IC), encrypted memory, or other secure elements known to those skilled in the art. The authentication data may include a cryptographic key, such as the public key of a public/private key pair. The authentication data may optionally include an expiry date for the cartridge (or optionally a manufacture date and shelf life for the cartridge from which the expiry date may be determined), a maximum number of puff seconds allowed for operation of the cartridge, a unique identifier (e.g., a unique serial number) for the cartridge, and other authentication data known to those skilled in the art. Because the authentication data is stored in a secure element, the data cannot be tampered with, discarded or lost and, thus, a user can be assured that the data is legitimate and not a forgery.

[0615] Power gate **5432** is configured to control the transmission of a power signal from power source **5414** to atomizer **5422** over electromechanical connector **5440** in accordance with instructions received from authentication device **5430**. In this embodiment, power gate **5432** comprises a single-pole single-throw switch (SW1) having an open position and a closed position. Movement of power gate **5432** to the open position, as shown in FIG. **54**, disables the transmission of a power signal from power source **5414** to atomizer **5422**. In contrast, movement of power gate **5432** to the closed position enables the transmission of a power signal from power source **5414** to atomizer **5422**. As described below, authentication device **5430** is programmed to cause movement of power gate **5432** from the open position to the closed position when cartridge **5420** and/or control assembly **5410** are determined to be authentic.

[0616] Authentication device **5430** and power gate **5432**, as shown in FIG. **54**, are provided as separate discrete components. In other embodiments, authentication device **5430** and power gate **5432** may be integrated into a single component, such as a silicon die, a multiple chip module (MCM), or other components known to those skilled in the art.

[0617] In some embodiments, cartridge **5420** is initially provided in a locked state, i.e., power gate **5432** is in the open position. When cartridge **5420** is coupled to control assembly **5410**, authentication device **5430** is configured to implement an authentication protocol to determine whether cartridge **5420** is authentic. The authentication protocol may comprise one or more different tests that rely on use of the authentication data stored in the secure element of authentication device **5430**, as describe below. Authentication device **5430** then uses the outcome of the authentication protocol to control power gate **5432**, e.g., if cartridge **5420** is authenticated, power gate **5432** is moved from the open position to the closed position to enable operation of vape device **5400**. This feature minimizes the opportunities for accidental or intentional misuse of vape device **5400**.

[0618] In one embodiment, cartridge **5420** is implemented so as to return to its locked state on power loss to enforce strict access control, i.e., power gate **5432** is moved from the closed position back to the open position at the end of a power cycle. As such, authentication must occur on every inhalation. Of course, the act of authentication need not be noticeable by the user such that the cartridge may appear to remain authenticated at the start of a session even though authentication occurs on every inhalation. In another embodiment, cartridge **5420** is maintained in its unlocked state across power cycles to avoid having to authenticate on subsequent inhalations in a session. For example, authentication device **5430** may store the last time stamp of authentication and only require re-authentication if an internally defined timeout (user, factory, or otherwise) has lapsed.

[0619] One test that is part of the authentication protocol comprises a cryptographic handshake (e.g., challenge-response) between microcontroller **5412** and authentication device **5430** to enable authentication of cartridge **5420** and control assembly **5410**. In one embodiment, authentication device **5430** stores a public key and microcontroller **5412** stores a list of valid public key/private key pairs, as described above. The cryptographic handshake may be performed as follows: (1) microcontroller **5412** transmits a message to authentication device **5430**; (2) authentication device **5430** encrypts the message with the stored public key to generate an encrypted message; (3) authentication device **5430** transmits the encrypted message and the public key to microcontroller **5412**; (4) microcontroller **5412** accesses the stored list of public key/private key pairs to identify the private key associated with the public key; (5) microcontroller **5412** decrypts the encrypted message with the private key to generate a decrypted message; (6) microcontroller **5412** determines whether the original message matches the decrypted message and, if so, cartridge **5420** and control assembly **5410** are deemed to be authentic. Of course, other cryptographic authentication protocols known to those skilled in the art may also be used.

[0620] Once the cryptographic handshake is complete, microcontroller **5412** transmits an indication of authenticity to authentication device **5412**. If cartridge **5420** and control assembly **5410** are authentic, authentication device **5430** directly moves power gate **5432** to the closed position to enable the transmission of a power signal from power source **5414** to atomizer **5422**. Alternatively, authentication device

5430 may move power gate **5432** to the closed positon upon receipt of operational instructions from microprocessor **5412**. This may be accomplished by changing an operational setting that is either persistent or not-persistent across a power cycle as experienced by cartridge **5420** or control assembly **5410**.

[0621] It can be appreciated that the cryptographic handshake described above enables the authentication of cartridge **5420** and control assembly **5410** without accessing a remote server. This authentication method is also sufficient to ensure that cartridge **5420** and control assembly **5410** are compatible, which eliminates the potential for pairing a mismatched cartridge and control assembly and potentially exposing the user to danger.

[0622] Another test that may optionally be performed as part of the authentication protocol comprises a test to determine whether cartridge **5420** is expired.

[0623] In one embodiment, the test to determine whether cartridge **5420** is expired may be performed as follows: (1) authentication device **5430** transmits the stored expiry date for cartridge **5420** (or optionally a manufacture date and shelf life from which the expiry date may be determined) to microcontroller **5412**; (2) microcontroller **5412** determines the current date; and (3) microcontroller **5412** determines if the expiry date for cartridge **5420** is after the current date. The data transmitted from authentication device **5430** to microcontroller **5412** may be encrypted data or plaintext data. If cartridge **5420** is deemed not to be authentic, microcontroller **5412** may permanently disable cartridge **5420** via authentication device **5430**.

[0624] In another embodiment, the test to determine whether cartridge **5420** is expired may be performed as follows: (1) microcontroller transmits the current date to authentication device **5430**; (2) authentication device **5430** determines the expiry date for cartridge **5420** (either from a stored expiry date or from a stored manufacture date and shelf life from which the expiry date may be determined); and (3) authentication device **5430** determines if the expiry date for cartridge **5420** is after the current date and, if so, cartridge **5420** is deemed to be authentic. The data transmitted from microcontroller **5412** to authentication device **5430** may be encrypted data or plaintext data.

[0625] Yet another optional test that may be performed as part of the authentication protocol comprises a test to determine whether cartridge **5420** is being used beyond its maximum allowable operational time, i.e., the maximum allowed time for operation of cartridge **5420**. The maximum allowable operational time may be measured in puff seconds. As used herein, a "a puff second" means one second of time during which atomizer **5422** is powered and a portion of the payload in payload reservoir **5424** is being vaporized. In order to perform this test, authentication device **5430** is configured to record user analytics (i.e., number of puffs and puff durations) to enable a determination of the total number of puff seconds elapsed during operation of cartridge **5420**, i.e., the current operational time.

[0626] In one embodiment, the test to determine whether cartridge **5420** is being used beyond its maximum allowable operational time may be performed as follows: (1) authentication device **5430** transmits the stored maximum allowable operational time and the current operational time (or the user analytics from which the current operational time may be determined) to microcontroller **5412**; and (2) microcontroller **5412** compares the maximum allowable operational time with the current operational time to determine whether the current operational time is greater than the maximum allowable operational time. In some cases, microcontroller **5412** may use this comparison result to determine if the maximum allowable operational time has elapsed. If so, microcontroller **5412** may permanently disable cartridge **5420** via authentication device **5430**. Alternatively, microcontroller may transmit the comparison result to authentication device **5430** for recordation in authentication device **5430**. In this case, authentication device **5430** may refuse to power cartridge **5420** if the maximum allowable operational time has elapsed.

[0627] In another embodiment, authentication device **5430** compares the stored maximum allowable operational time with the stored user analytics to determine whether the current operational time is greater than the maximum allowable operational time. In some cases, authentication device **5430** may refuse to power cartridge **5420** if the maximum allowable operational time has elapsed. Alternatively, authentication device **5430** may transmit the comparison result to microcontroller **5412**. If the maximum allowable operational time has elapsed, microcontroller **5412** may permanently disable cartridge **5420** via authentication device **5430**.

[0628] Yet another optional test that may be performed as part of the authentication protocol comprises a test to determine whether cartridge **5420** is a counterfeit. This test may be performed as follows: (a) authentication device **5430** transmits the stored unique identifier for cartridge **5420** to microcontroller **5412**; (2) microcontroller **5412** transmits the unique identifier to a wireless transceiver of control assembly **5410** (such as RF transceiver circuit **36** and antenna(s) **40** of control assembly **14** shown in FIG. **1**); (3) the wireless transceiver transmits the unique identifier to an external computing device (such as computing device **72** shown in FIG. **3**) via an RF communications link (e.g., Bluetooth); (4) the external computing device determines via access to a remote server whether the unique identifier is valid; (5) the external control device transmits a response indicating whether the unique identifier is valid to the wireless transceiver; and (6) the write transceiver transmits the response to microcontroller **5412** and, if the unique identifier is valid, cartridge **5420** is deemed to be authentic. It can be appreciated that once a cartridge with its unique identifier has been registered to the remote server, any other cartridges with the same identifier will be deemed a counterfeit.

[0629] Vape device **5400** may utilize any one or combination of the tests described above as part of its authentication protocol. If cartridge **5420** is deemed to be authentic, vape device **5400** may provide an indication to a user that cartridge **5420** has been authenticated. For example, control assembly **5410** may include a light emitting diode (LED) that turns green if cartridge **5420** has been authenticated. In another example, control assembly **5410** may wirelessly communicate the authentication information to an external computing device (such as computing device **72** shown in FIG. **3**), wherein an application running on the computing device causes the authentication information to be displayed to the user.

[0630] In some embodiments, after cartridge **5420** has been authenticated, an additional key verification step is performed to verify that the operator of vape device **5400** is authorized to use cartridge **5420**. In one embodiment, the owner of cartridge **3420** enters a key (cryptographic or mundane) to lock cartridge **5420**, wherein the key is stored in the secure element of authentication device **5430**. Authentication device **5430** will thereafter ensure that the operator of vape device **5400** is in possession of a smartphone or other RFID-enabled device that stores the key before moving power gate **5432** to the closed position to enable the transmission of a power signal from power source **5414** to atomizer **5422**.

[0631] In one embodiment, multiple keys are allowed to be stored in the secure element of authentication device **5430**. Multiple keys offer the benefit of enabling multiple operators to access the same cartridge without having to share a key. This is particularly beneficial if an owner has multiple applications on his/her smartphone or other RFID-enabled device that are capable of unlocking the cartridge, or, if an owner has multiple accounts on the same application on his/her smartphone or other RFID-enabled device that are capable of unlocking the cartridge. This key verification scheme may be implemented with a single administrator who can add/remove keys, with multiple administrators, or with all shared owners as administrators.

[0632] In another embodiment, the current owner of a cartridge may transfer ownership of the cartridge to a new owner via use of his/her smartphone or other RFID-enabled device to transfer the key. The transfer of cartridge ownership may be implemented permanently or temporarily. Temporary transfer of cartridge ownership use cases include, but are not limited to, number of puff seconds elapsed, dose, date, time of day, location, and others known to those skilled in the art. Also, temporary transfer of cartridge ownership may occur during scheduled times that define known usage windows, such as when a prescribing doctor temporarily transfers cartridge ownership to a patient for a limited dose, puff seconds, etc. before ownership is automatically transferred back to the prescribing doctor. The scheduled transfer of cartridge ownership may also be recurring.

[0633] Referring back to FIG. **54**, electromechanical connector **5440** comprises a pair of connectors, i.e., a first connector provided at an end of control assembly **5410** and a second connector provided at an end of cartridge **5420**. The first and second connectors are configured to be mechanically and electrically connected together. The mechanical connection may comprise a threaded connection, a pressure or friction fit connection, a twist mechanical lock, a magnetic connection, or any other mechanical connecting means known to those skilled in the art. As described below, electromechanical connector **5440** enables (1) the transmission of a power signal from control assembly **5410** to cartridge **5420** and (2) the transfer of one or more data signals between control assembly **5410** and cartridge **5420**. Of course, it should be understood that this same electromechanical connector **5440** is also used to read and write payload information (e.g., strain information, optimal vaping temperature, puff counts, expiry date, etc.), which is used by control assembly **5410** or an external computing device to modify the operational parameters of vape device **5400**.

[0634] In some embodiments, electromechanical connector **5440** provides an electrical interface that includes two conductors. For example, in a common implementation, the first and second connectors comprise M7×0.5 mm threaded connectors which are commonly referred to as "510 threaded connectors." The first connector (i.e., the connector on control assembly **5410**) comprises a female 510 threaded connector and the second connector (i.e., the connector on cartridge **5420**) comprises a male 510 threaded connector, as described above and shown in FIG. **41**A. Of course, the invention is not limited to the use of 510 threaded connectors and other types of two-conductor connectors may also be used.

[0635] The two-conductor electrical interface is typically used in vape devices to provide a power conductor and a ground conductor. In order to accommodate the transfer of one or more data signals between control assembly **5410** and cartridge **5420**, the data signals must also be transmitted over one of these conductors. A variety of different multiplexing schemes may be used to provide this functionality, such as time division multiplexing, frequency division multiplexing, or voltage level multiplexing. Of course, other types of multiplexing schemes may also be used in accordance with the invention.

[0636] In embodiments that use a time division multiplexing scheme, the power signal and the data signals are sequentially transmitted over the same conductor. An example of a circuit that may be used to implement a time division multiplexing scheme is shown in FIG. **55**. Of course, other circuits may be used to implement a time division multiplexing scheme as known to those skilled in the art.

[0637] As shown in FIG. **55**, circuit **5500** includes a microcontroller **5510** of a control assembly and an authentication device **5520** of a cartridge that are connected by a two-conductor electrical interface. The electrical interface includes a first conductor that provides a data/power path (i.e., data and power share the first conductor) and a second conductor that provides a ground path. The data and power require mutually exclusive time slots on the first conductor, i.e., data and power cannot be transmitted simultaneously over the first conductor.

[0638] In circuit **5500**, microcontroller **5510** is connected through an input/output pin (IO) to an NMOS transistor (Q**1**), which is in turn connected across the electrical interface to an IO pin of authentication device **5520**. This provides a data path on the first conductor to enable the transmission of data signals between microcontroller **5510** and authentication device **5520**.

[0639] The control assembly also includes a power source (not shown) that provides a power signal through a resistor (R**1**) having a relatively large resistance value, which is in turn connected across the electrical interface through a diode (D**1**) to an atomizer (not shown) of the cartridge. Of course, a power gate (not shown) will also be provided in the cartridge to control the transmission of the power signal to the atomizer, as described above. This provides a power path on the first conductor to enable the transmission of a power signal from the power source to the atomizer. It can be seen that the power signal also provides the supply voltage (V_{DD}) for both microcontroller **5510** and authentication device **5520**. A capacitor (C**1**) is provided with a capacitance value large enough to hold up the power to authentication device **5520** during the transfer of data signals between microcontroller **5510** and authentication device **5520**. Thus, the first conductor may be used to temporarily transfer data signals between microcontroller **5510** and authentication device **5520** while authentication device **5520** remains powered-up.

[0640] In embodiments that use a frequency division multiplexing scheme, the power signal and the data signals are simultaneously transmitted between the control assembly and the cartridge. In this case, the data is encoded on either the power conductor or the ground conductor using an alternating current (AC) or radio frequency (RF) signal superimposed on that conductor. Frequency division multiplexing can support both full-duplex and half-duplex operations using different uplink and downlink frequencies, as known to those skilled in the art. Filtering is then used to separate the data from the power. This may also be accomplished using amplitude modulation (AM). Digital communication methods such as binary phase shift keying (BPSK), Guassian minimum shift keying (GMSK), and other methods known to those skilled in the art may also be used.

[0641] In embodiments that use a voltage level multiplexing scheme, the power signal and the data signals are simultaneously transmitted between the control assembly and the cartridge. As described below, it is possible to transfer data signals over the same conductor used to transmit the power signal if the logic low used for digital signaling is greater than the minimum required supply voltage of the cartridge's authentication device. An example of a circuit that may be used to implement a voltage level multiplexing scheme is shown in FIG. **56**. Of course, other circuits may be used to implement a voltage level multiplexing scheme as known to those skilled in the art.

[0642] As shown in FIG. **56**, circuit **5600** includes a microcontroller of a control assembly (referenced as processing device U**1**) and an authentication device of a cartridge (referenced as processing device U**2**) that are connected by a two-conductor electrical interface. The electrical interface includes a first conductor that provides a data/power path (i.e., data and power share the first conductor) and a second conductor that provides a ground path.

[0643] As can be seen, processing device (U**1**) is connected through an output pin (DATA_OUT) to an NMOS transistor (Q**1**) and a resistor (R**2**), which is in turn connected across the electrical interface to a resistor (R**3**), an analog comparator, and an optional level shifter to an input pin (DATA_IN) of processing device (U**2**). This provides a data path on the first conductor to enable the transmission of data signals from processing device (U**1**) to processing device (U**2**).

[0644] Similarly, processing device (U**2**) is connected through an output pin (DATA_OUT) to an NMOS transistor (Q**3**) and resistor (R**3**), which is in turn connected across the electrical interface to resistor (R**2**), an analog comparator, and an optional level shifter to an input pin (DATA_IN) of processing device (U**1**). This provides a data path on the first conductor to enable the transmission of data signals from processing device (U**2**) to processing device (U**1**).

[0645] The control assembly also includes a power source with battery protection (U**5**) that provides a power signal through a resistor (R**1**) in parallel with an NMOS transistor (Q**2**) connected to the high power pin (HIGH-PWR) of processing device (U**1**), which is in turn connected across the electrical interface to a power gate (SW**1**). A control pin (SW**1**_CTL) of processing device (U**2**) is connected to the power gate (SW**1**) in order to control the transmission of the power signal to the atomizer of the cartridge, as described above. This provides a power path on the first conductor to enable the transmission of a power signal from the power source to the atomizer. It can be seen that the power signal provides the supply voltage (V_PWR) for processing device (U**1**) through an optional DC-DC converter (U**3**). Similarly, the power signal provides the supply voltage (V_PWR) for processing device (U**2**) through an optional DC-DC converter (U**4**).

[0646] In circuit **5600**, the non-inverting input to each of the analog comparators (V_THRESH) is selected such that it is greater than the minimum required power supply voltage for the processing device (U**2**). Also, resistor (R**1**) is selected to have a small enough resistance value such that the current required to power processing device (U**2**) does not cause too large of a voltage drop. If the resistance value of resistor (R**1**) is selected incorrectly, then processing device (U**2**) may experience voltages below its minimum required power supply voltage.

[0647] It can be appreciated that the logic blocks illustrated in FIG. **56** can be integrated as monolithic integrated circuits, discrete components, or some combination thereof. Preferably, all of the cartridge electronics (excluding the atomizer) are integrated into a single integrated circuit (IC) or module. This is advantageous because the envelope for electronics is extremely small in typical cartridge applications.

[0648] It can be appreciated that there are many alternative configurations for the circuit shown in FIG. **56** that can be used to achieve the same effect, including, but not limited to: (1) open-drain implementation of the level shifter(s); (2) removal of the optional level shifter(s) by integrating or using a compatible process; (3) removal of the optional DC-DC converters by integrating or using a compatible process; (4) inverting the analog comparators to simplify the logic; and (5) addition of a diode and capacitor to assist with holding up the power supply voltage (V_PWR) of processing device (U**2**) (or its corresponding DC-DC converter (U**4**)) in the event that V_510 occasionally drops too far for short periods of time.

[0649] The data transfer protocol used by circuit **5600** may be optimized for many different use cases, including, but not limited to: (1) optimized for data transfer rate; (2) optimized to minimize noise for V_510; and (3) optimized to minimize noise and/or ripple for the power supply voltage (V_PWR) of processing device (U**2**) (or its corresponding DC-DC converter (U**4**)).

[0650] An example of a data transfer protocol used by circuit **5600** is shown in FIG. **57**, which includes a "Not Authenticated" phase, an "Authentication Process" phase, and an "Authenticated" phase. During each of these phases, the logic values are shown for the pins of processing device (U**1**) (i.e., DATA_OUT, DATA_IN, and HIGH_PWR), the pins of processing device U**2** (i.e., DATA_OUT, DATA_IN, and SW**1**_CTL), V_510, and the atomizer current.

[0651] During the "Not Authenticated" phase, the control assembly attempts to heat the atomizer (i.e., the HIGH_PWR pin of processing device (U**1**) is active low), but the processing device (U**2**) in the cartridge has not enabled the control pin (SW**1**_CTL) such that the power gate (SW**1**) remains in the open position. As a result, no current is delivered to the atomizer.

[0652] During the "Authentication Process" phase, the authentication protocol is implemented to authenticate the cartridge and the control assembly. As can be seen, authentication data is initially transmitted from processing device (U**1**) to processing device (U**2**), as shown by the active status of the DATA_OUT pin of processing device (U**1**) and the active status of the DATA_IN pin of processing device (U**2**) (see also V-510). Then, authentication data is transmitted from processing device (U**2**) to processing device (U**1**), as shown by the active status of the DATA_OUT pin of processing device (U**2**) and the active status of the DATA_IN pin of processing device (U**1**) (see also V-510).

[0653] During the "Authenticated" phase (i.e., once the authentication process is complete), the control assembly again attempts to heat the atomizer (i.e., the HIGH_PWR pin of processing device (U**1**) is active low), and the processing device (U**2**) in the cartridge has enabled the control pin (SW**1**_CTL) such that the power gate (SW**1**) is moved to the closed position. As a result, current is delivered to the atomizer to enable heating of the payload.

[0654] In all of the implementations discussed above, it is possible that the power signal comprises a direct current that is pulsed in accordance with a pulse width modulation (PWM) instruction in order to control the temperature of the atomizer in a particular desired manner. In this case, the cartridge must be able to ensure that the authentication device is sufficiently de-coupled to avoid brownouts and resets/power cycles. Another method of ensuring that the authentication device does not lose power is to ensure that the lowest level of the PWM signal is still sufficient to meet the minimum supply voltage requirements of the authentication device.

[0655] In all of the implementations discussed above, it is also possible that the power source uses variable output voltages in order to control the temperature of the atomizer in a particular desired manner. In this case, the authentication device must be sufficiently decoupled and function at low enough voltages to avoid brownouts and resets/power cycles. The cartridge may also include the required circuitry to boost convert (i.e., raise the input voltage to a higher potential) the voltage of the power signal to a voltage that is high enough to meet the minimum supply voltage requirements of the authentication device.

[0656] In some embodiments, electromechanical connector **5440** provides an electrical interface that includes three or more conductors/pins. In this case, it is not necessary to use any of the multiplexing schemes described above. For a three-pin electrical interface, there are separate pins for power, ground, and data. There are also several options for a four-pin interface, such as the Inter Integrated Circuit (I2C) interface. For example, it is possible to transmit data using dedicated signal pins of the ITC interface, such as the SDA (data line) and SCL (clock line) pins. It is also possible to use a multi-conductor connector that is similar to a stereo headphone connector with an integrated microphone. Using this method, it is possible to use a cartridge with a 510-thread that uses more than two electrical connections while being compatible with a control assembly having only two electrical connections (and vice versa).

[0657] In all of the embodiments described above, the smart cartridge is used with a control assembly having the functionality to implement the desired authentication protocol. However, in other embodiments, the smart cartridge may be used with a "dumb" control assembly, e.g., in cases where a user may not care to authenticate the cartridge or may have previously authenticated the cartridge with another control assembly. In these embodiments, the cartridge is defaulted to an unlocked state, i.e., the power gate is in the closed position.

[0658] It is also possible to authenticate a cartridge that is not coupled to a control assembly. For example, the cartridge may be implemented with RFID capabilities so as to enable communication with a smartphone or other RFID-enabled device. In this case, the cartridge can be authenticated wirelessly at the point-of-sale (POS) or by an owner using a smartphone or other RFID enabled device. It can be appreciated that providing authentication and unlocking of the cartridge at the POS is a desirable feature for retailers because it ensures that any stolen cartridges cannot be used.

[0659] Although a few embodiments have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications can be made to these embodiments without changing or departing from their scope, intent or functionality. The terms and expressions used in the preceding specification have been used herein as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding equivalents of the features shown and described or portions thereof, it being recognized that the invention is defined and limited only by the claims that follow. From the foregoing it will be seen that this invention is one well adapted to attain all ends and objectives herein-above set forth, together with the other advantages which are obvious and which are inherent to the invention.

[0660] Since many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matters herein set forth or shown in the accompanying drawings are to be interpreted as illustrative, and not in a limiting sense.

[0661] While specific embodiments have been shown and discussed, various modifications may of course be made, and the invention is not limited to the specific forms or arrangement of parts and steps described herein, except insofar as such limitations are included in the following claims. Further, it will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

1-375. (canceled)

376. A vape device, comprising:

a control assembly comprising a microcontroller and a power source, wherein the microcontroller is configured to control the power source so as to generate a power signal;

a cartridge comprising an atomizer, a payload reservoir, and an authentication device, wherein the atomizer is configured to heat a portion of the payload contained in the payload reservoir, and wherein the authentication device is configured to (a) implement an authentication protocol to determine whether the cartridge is authentic and (b) control transmission of the power signal from the power source to the atomizer based on an outcome of the authentication protocol; and

an electromechanical connector comprising a first connector releasably coupled to a second connector, wherein the first connector is provided as part of the control assembly and the second connector is provided as part of the cartridge.

377. The vape device of claim **376**, wherein the authentication device is configured to securely store authentication data.

378. The vape device of claim **377**, wherein the authentication data comprises a cryptographic key, and wherein the authentication protocol comprises a cryptographic handshake between the authentication device and the microcontroller to enable authentication of the cartridge and the control assembly.

379. The vape device of claim **377**, wherein the authentication data comprises a cryptographic key, and wherein the authentication protocol comprises a cryptographic handshake between the authentication device and an external computing device to enable authentication of the cartridge.

380. The vape device of claim **377**, wherein the authentication data comprises data from which an expiry date for the cartridge is determined, and wherein the authentication protocol comprises a comparison of the expiry date to a current date to determine whether the cartridge is expired.

381. The vape device of claim **377**, wherein the authentication data comprises a maximum allowed operational time for the cartridge, and wherein the authentication protocol comprises a comparison of the maximum allowed operational time to a current operational time of the cartridge to determine whether the maximum allowed operational time has elapsed.

382. The vape device of claim **377**, wherein the authentication data comprises a unique identifier for the cartridge, and wherein the authentication protocol comprises transmitting the unique identifier to an external computing device to determine whether the cartridge is a counterfeit.

383. The vape device of claim **376**, wherein the cartridge further comprises a power gate moveable between an open position and a closed position, wherein movement of the power gate to the open position disables transmission of the power signal from the power source to the atomizer, and wherein movement of the power gate to the closed position enables transmission of the power signal from the power source to the atomizer.

384. The vape device of claim **383**, wherein the authentication device causes movement of the power gate from the open position to the closed position when the cartridge is determined to be authentic.

385. (canceled)

386. The vape device of claim **376**, wherein the electromechanical connector is configured to (a) transmit the power signal from the power source to the atomizer and (b) transfer one or more data signals between the authentication device and the microcontroller as part of the authentication protocol.

387. The vape device of claim **386**, wherein the electromechanical connector comprises a two-conductor electrical interface that includes two conductors.

388. The vape device of claim **387**, wherein the power signal and the data signals are sequentially transmitted over the two-conductor electrical interface in accordance with a time division multiplexing scheme.

389. The vape device of claim **387**, wherein the power signal and the data signals are simultaneously transmitted over the two-conductor electrical interface in accordance with a frequency division multiplexing scheme.

390. The vape device of claim **387**, wherein the power signal and the data signals are simultaneously transmitted over the two-conductor electrical interface in accordance with a voltage level multiplexing scheme.

391. The vape device of claim **386**, wherein the electromechanical connector comprises a multiple-conductor electrical interface that includes at least three conductors.

392. The vape device of claim **391**, wherein the power signal and the data signals are simultaneously transmitted over the multiple-conductor electrical interface.

393. A cartridge for a vape device, comprising:
- a payload reservoir;
- an atomizer configured to heat a portion of the payload contained in the payload reservoir; and
- an authentication device configured to (a) implement an authentication protocol to determine whether the cartridge is authentic and (b) control transmission of a power signal to the atomizer based on an outcome of the authentication protocol.

394. The cartridge of claim **393**, wherein the authentication device is configured to securely store authentication data comprising one of the following:
- a cryptographic key, wherein the authentication protocol comprises a cryptographic handshake between the authentication device and a control assembly of the vape device to enable authentication of the cartridge and the control assembly;
- a cryptographic key, wherein the authentication protocol comprises a cryptographic handshake between the authentication device and an external computing device to enable authentication of the cartridge;
- data from which an expiry date for the cartridge is determined, wherein the authentication protocol comprises a comparison of the expiry date to a current date to determine whether the cartridge is expired;
- a maximum allowed operational time for the cartridge, wherein the authentication protocol comprises a comparison of the maximum allowed operational time to a current operational time of the cartridge to determine whether the maximum allowed operational time has elapsed; and
- a unique identifier for the cartridge, wherein the authentication protocol comprises transmitting the unique identifier to an external computing device to determine whether the cartridge is a counterfeit.

395-410. (canceled)

411. A method of authenticating a cartridge of a vape device, comprising:
- storing authentication data in an authentication device within the cartridge;
- implementing an authentication protocol that uses the authentication data to determine whether the cartridge is authentic; and
- controlling transmission of a power signal to an atomizer of the cartridge based on an outcome of the authentication protocol.

412-418. (canceled)

419. The method of claim **411**, further comprising the step of transmitting the power signal and one or more data signals used to implement the authentication protocol over an electrical interface between the cartridge and a control assembly of the vape device.

420-504. (canceled)

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