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United States Patent Application Publication	20250261692
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	Newton; Kyle D.

PERSONAL VAPORIZER CARTRIDGE WITH VISCOSITY CONTROL

Abstract

The present disclosure describes systems, methods, and an apparatus for controlling fluid viscosity within a personal vaporizer such as an electronic cigarette, a vape pen, vape kits, e-cig, or e-hookah, electronic nicotine delivery system. The apparatus can include a cartridge for a personal vaporizer that has a reservoir for containing fluid to be vaporized, a first heater configured to vaporize the fluid, the first heater located in an atomization chamber, a wick configured to deliver the fluid from the first heater, a second heater configured to warm the fluid in the reservoir without vaporizing the fluid, and a set of contacts configured to receive power and deliver the power to the first heater and the second heater.

Inventors:	**Newton; Kyle D. (Euless, TX)**
Applicant:	**Newton; Kyle D.** (Euless, TX)
Family ID:	**1000007697734**
Appl. No.:	**18/583536**
Filed:	**February 21, 2024**

Publication Classification

Int. Cl.: **A24F40/46** (20200101); **A24F40/10** (20200101); **A24F40/42** (20200101); **A24F40/51** (20200101); **A24F40/57** (20200101); **G05D23/20** (20060101); **H05B1/02** (20060101)

U.S. Cl.:

CPC **A24F40/46** (20200101); **A24F40/10** (20200101); **A24F40/42** (20200101); **A24F40/51** (20200101); **A24F40/57** (20200101); **G05D23/20** (20130101); **H05B1/0244** (20130101); H05B2203/021 (20130101)

Background/Summary

BACKGROUND

[0001] Personal vaporizers provide an alternative to smoking techniques which involve combustion of organic matter and inhalation of the vapor. Instead, vaporizers atomize a substance (e.g., a nicotine substance or cannabis substance) using a heating element to simulate the combustion found in traditional cigarettes. Personal vaporizers often use removable/replaceable cartridges containing a substance for atomization. Different substances may require different heating profiles for improved vaporization.

SUMMARY

[0002] The present disclosure involves systems, methods, and an apparatus for controlling fluid viscosity within a personal vaporizer such as an electronic cigarette, a vape pen, vape kits, e-cig, or e-hookah, electronic nicotine delivery system. The apparatus can include a cartridge for a personal vaporizer that has a reservoir for containing fluid to be vaporized, a first heater configured to vaporize the fluid, the first heater located in an atomization chamber, a wick configured to deliver the fluid from the first heater, a second heater configured to warm the fluid in the reservoir without vaporizing the fluid, and a set of contacts configured to receive power and deliver the power to the first heater and the second heater. Implementations can optionally include one or more of the following features.

[0003] In some instances, the second heater is configured to warm the fluid in the reservoir to no greater than 70° C.

[0004] In some instances, the apparatus includes a temperature sensor configured to generate a signal based on the temperature of the fluid in the reservoir but outside the atomization chamber. In some instances, the second heater is positioned on an outer surface of the atomization chamber, and the atomization chamber is within the reservoir.

[0005] In some instances, a puff sensor is included, the puff sensor configured to detect when airflow passes through the cartridge and output a puff signal.

[0006] In some instances, the second heater includes two conductors, a first conductor disposed along an outer diameter of the reservoir, and a second conductor disposed along an outer surface of the atomization chamber and along an inner diameter of the reservoir.

[0007] In some instances, the apparatus includes a power supply that has a battery, and a controller configured to receive the generated signal and deliver electrical power from the battery to the second heater to cause the second heater to warm the fluid. In some instances, the controller is configured to warm the fluid to a temperature less than 70° C. In some instances, the controller is configured to warm the fluid to a temperature of at least 26° C. In some instances, the controller delivers power to the second heater in an amount inversely proportional to the generated signal.

[0008] In some instances, the power supply portion and the cartridge portion are removably coupled together by a coupler, and the coupler includes a set of electrical contacts. In some instances, a first contact of the set of contacts is connected to the first heater, and a second contact of the set of contacts is connected to the second heater.

[0009] In some instances, a third contact of the set of contacts is connected to the temperature sensor.

[0010] The details of these and other aspects and embodiments of the present disclosure are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the disclosure will be apparent from the description and drawings, and from the claims.

Description

DESCRIPTION OF DRAWINGS
[0011] FIG. **1** depicts a perspective view of an example implementation of a personal vaporizer.
[0012] FIG. **2** depicts a side view of an example personal vaporizer with a removable cartridge removed.
[0013] FIG. **3** illustrates a schematic diagram of some internal components of a personal vaporizer cartridge and power supply.
[0014] FIGS. **4**A-**4**D illustrate example configurations of contacts for operation of a personal vaporizer cartridge.
DETAILED DESCRIPTION
[0015] This disclosure describes a system and method of controlling fluid viscosity for a fluid within a personal vaporizer such as an electronic cigarette, a vape pen, vape kits, e-cig, or e-hookah, electronic nicotine delivery system. In some personal vaporizer implementations, a power supply portion operates a disposable cartridge portion. The cartridge includes a reservoir containing the substance to be vaporized, and a heating element. However, some substances may have different flow properties or viscosity and may not operate well within the cartridge over a wide range of ambient temperatures. This disclosure describes a system and techniques for enabling the power supply portion of a personal vaporizer to control the fluid viscosity within the cartridge, in order to ensure proper operation over a wide range of temperatures.
[0016] Certain substances that may be used in a personal vaporizer are solid or near-solid at relatively warm temperatures. These substances (e.g., THC oil) can be waxy, or highly viscous at ambient temperatures where vaporizer use is desirable. Because of this high viscosity, the substance may not flow well, and voids can form around the wick within the reservoir, causing “dry out” or a “burnt hit” where insufficient substance is wetting the wick of the device during use. One solution to encourage the fluid to flow freely to the wick and therefore into the atomization chamber is to pre-heat or otherwise warm the fluid in the cartridge reservoir. This lowers the substance's viscosity and improves overall performance. A warming coil (separate from the heating element that vaporizes the substance in the atomization chamber) can be provided in a reservoir where the fluid is stored. In some instances, the warming coil can be controlled to provide enough heat to soften or encourage flow of the substance in the reservoir, without causing any evaporation or boiling of the substance or otherwise overheating other components of the cartridge.
[0017] The use of a secondary warming coil to heat substance in the reservoir is advantageous in that it allows use of a broader range of substances with a personal vaporizer in a broader range of ambient temperatures. Additionally risk to the user is reduced in that they are less likely to cause overheating and damage to the wick material due to insufficient fluid flow during use.
[0018] Turning to the illustrated example implementation, FIG. **1** is a perspective view of a personal vaporizer. While illustrated in the form factor of an electronic cigarette, the concepts herein could be applied to other types of personal vaporizers such as e-hookahs, vape kits, vape pens, etc. The example personal vaporizer **2** includes a housing having a first elongated portion **10** and a second elongated portion **12**. The second elongated portion **12**, also referred to as the “cartridge” in certain illustrative implementations, includes a mouthpiece end **4**, which has an acrosol outlet (depicted in FIG. **3**) for drawing air through the cartridge **12**. The first elongated portion **10** and the second elongated portion **12** are removably joined together with a mechanical coupler **14**. One or more air inlet vents **16** are provided about the coupler **14** for allowing airflow into the cartridge **12** when the user draws air through the personal vaporizer **2**. The first elongated portion **10** includes a tip end **6**, which in the illustrative implementation, is fabricated from a translucent material enabling the transmission of light therethrough. Within the second elongated portion **12** is disposed a liquid reservoir (not fully shown). In some implementations, the liquid

reservoir includes a clear or translucent window **13** to the exterior of the housing **12** for visually determining the liquid level **15** within the liquid reservoir.

[0019] FIG. **2** depicts a side view drawing, respectively, of a cartridge portion **12** and a power supply portion **10** of a personal vaporizer **2** according to an illustrative embodiment of the present invention. The mechanical coupler **14** can have two parts, one that is part of the cartridge portion **12** and one that is part of the power supply portion **10**, e.g., one part being female and configured to receive the other, male, part. The mechanical coupler can be, for example, threads, a lug/channel connector, a recessed magnetic connector or other suitable means for coupling the two portions of the personal vaporizer **2**. FIG. **2** shows the mechanical coupling **14** portion on the power supply portion **10** in the form of a threaded extension **20** of the housing that engages female threads of the mechanical coupler **14** portion on the cartridge portion **12**. In some implementations (as shown below and discussed with reference to in FIG. **3**), the cartridge **12** can include a threaded or male portion, which engages with female threads of the power supply portion **10**. In addition, an electrical connection can also be facilitated in the connection between the mechanical coupler **14** parts (as shown in more detail below with respect to FIG. **3**). The power supply portion **10** can include one or more circuits for controlling operations of the cartridge portion **12**. The circuits can be analog or digital and can include, for example, a microcontroller and various sensors to enable operation of the personal vaporizer **2**. In this example illustration, the cartridge portion **12** can thus be installed, uninstalled, and replaced as needed. The cartridge portion contains the liquid reservoir and window **13** provides the visual indication as to the liquid remaining.

[0020] FIG. **3** illustrates a schematic diagram of some internal components of a personal vaporizer cartridge **12** and power supply **10**.

[0021] Cartridge **12** includes a reservoir **30** and an atomization chamber **32**. The atomization chamber **32** receives a primary substance in liquid form from the reservoir **30** via the wick **34**. The wick **34** can be a fibrous bundle that draws liquid via capillary action from the reservoir **30**. The wick **34** extends from the primary reservoir into the atomization chamber **32**. It can be formed of a heat-resistant wicking material, such as aramid, fluorocarbon, sulfide, melamine, polyimide, carbon, glass fibers, or any combination thereof. An atomizer **36** can be a resistive coil that generates heat when electrical current passes through it. The atomizer **36** can be supplied with electrical power from the power supply portion **10** of the personal vaporizer. The atomizer **36** is located proximal to the wick **34** (in the example illustrated in FIG. **3** it is wrapped around the wick **34**). Atomizer **36** heats the liquid carried from the primary reservoir **38** by the wick **34** and atomizes the primary substance which mixes with air in the atomization chamber to form an acrosol. One or more air inlet vents **16** near the bottom of the cartridge **12** allow airflow from the air inlet vent **16**, through the atomization chamber **32** and out the chimney **38**.

[0022] Chimney **38** provides a flow path from the air inlet vent **16**, through the atomization chamber **32**, and out the aerosol outlet **40** in the mouthpiece **4** portion of the cartridge **12**. Mechanical coupler **14**, illustrated as a threaded nipple, can include one or more electrical contacts **42**A, which are configured to mate with corresponding contacts **42**B on the power supply **10**. In some implementations, the mechanical coupler **14** can be another type of coupler (e.g., a snap fit, pin and groove, magnetic, etc.). These contacts **42**A can provide an electrical flow path from the battery **48**, via the controller **52**, through the atomizer **36**. In some implementations, contacts **42**A are a simple two pin system, with a positive and a common connection. In some implementations, contacts **42**A are more complex, and can include, for example, serial connections, dedicated transmit/receive connections, or other configurations. Cartridge **12** can include one or more puff sensors **35** which can be, for example, a microphone, or pressure sensor, that transmits a “puff” signal to the controller to enable the power supply **10** to activate the atomizer **36** when a user induces airflow through the cartridge **12**. In some implementations, sensor data is transmitted from the cartridge **12** to the power supply **10** wirelessly, e.g., using Bluetooth Low Energy, or ZigBee. In some implementations, sensor data (e.g. temperature data, puff data, or other information) is transmitted via contacts **42**A and **42**B.

[0023] In addition to a pressure or puff sensor **35**, a temperature sensor **44** or viscosity sensor **44** can be provided. The temperature sensor **44** can be a thermistor, resistive sensor, resistance temperature detector (RTD), or other device that provides a signal that is a function of the temperature at the sensor. In some implementations the temperature sensor **44** is a passive device, and controller **52** or sensor/reader **46** (as described below) interrogate or supply power or a signal to temperature sensor **44**, which modifies that signal based on the sensed temperature. While illustrated at the bottom of the cartridge **12**, the temperature sensor **44** can be located near the top, on the sides, or elsewhere within the reservoir **30**. Further, multiple temperature sensors **44** can be provided and can measure temperature at various locations within cartridge **12**. In some instances, an external temperature sensor can measure the ambient air or environment temperature in addition to or alternatively to the internal fluid temperature.

[0024] Warming heaters **43** are provided throughout the cartridge **12**. In the illustrated example warming heaters **43** are positioned around the inside of the outside wall of the reservoir **30** and around the atomization chamber **32**. In some implementations, the warming heaters **43** arc only positioned in one location (e.g., on the atomization chamber). Warming heaters **43** on the exterior wall of the reservoir **30** can provide general heat to the bulk of the fluid within reservoir **30**. Warming heaters **43** located on the atomization chamber **32** can ensure there is good flow into and around the wick intake area by maintaining fluid in the intake area at a temperature that has a low enough viscosity to readily flow into the wick. In general, warming heat can be applied to fluid in the reservoir to maintain the viscosity of the fluid below a certain target and ensure favorable flow properties. In some implementations, the warming heaters **43** are a single element that wraps or spirals around both the outside and inside of the reservoir. In some implementations, multiple separate warming heaters **43** are used, each with an independent conductor and independently activated. The warming heaters **43** can be a resistive coil that is configured to generate heat when electrical current is passed through it. In some implementations, the warming heater **43** can be constructed with physical properties (e.g., resistance, length, thickness, etc.) that ensure it does not exceed a safe temperature during normal operation when supplied with power from the power supply portion **10**, but still heats the fluid in the reservoir sufficiently to maintain a reduced viscosity. For example, when the fluid in the reservoir has a boiling point of 50° C., the warming heaters **43** can be configured not to exceed 25° C., or 40° C. Alternatively, if plastics are involved in the construction of the reservoir, the warming heaters **43** can be designed to ensure they do not melt any structural components, and do not exceed, for example, 70° C. Safe temperature can be a temperature below which there is limited or no risk of structural damage to the device, and the fluid inside is not significantly chemically altered or does not evaporate.

[0025] Power supply **10** includes a complementary mechanical coupler **15** and complementary contacts **42**B which can receive and couple to mechanical coupler **14** and contacts **42**A, completing an electrical connection and enabling power transfer and communication between power supply **10** and cartridge **12**. In some implementations, the mechanical coupler **15** are threads that engage the threaded nipple of mechanical coupler **14** and physically support the cartridge **12**. A battery **48** supplies electrical power to power supply **10**, and can be rechargeable (e.g., via interface/charging port **54**).

[0026] A memory **50** can store instructions for controller **52**, and can be for example, a flash memory, or EEPROM, or other memory type. Memory **50** can represent a single memory or multiple memories. The memory **50** can include any memory or database module and can take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, random access memory (RAM), read-only memory (ROM), removable media, or any other suitable component. In general, memory **50** stores operating instructions for controller **52**, and can include a database of cartridge types and settings. For example, memory **50** can store a database of operation settings, including heat intensity, duration, and frequency associated with a number of different cartridges. In some implementations, the controller **52** can periodically update this database by communicating with an external system via interface **54**. Interface **54** can be a serial interface such as a universal serial bus (USB) type A, C, micro or mini, or other connection. In some implementations, interface **54** serves a dual purpose of providing external communications to power supply **10**, as well as electrical power for recharging battery **48**.

[0027] Controller **52** generally controls power supplied to the contacts **42**B and thus to atomizer **36**. In some implementations, controller **52** receives additional sensor inputs. For example, controller **52** can receive a signal corresponding to whether a cartridge is installed on power supply **10**, and if not, prevent power from being sent to contacts **52**B. In another example, controller **52** receives a "puff" signal from one or more sensors in cartridge **12** and uses the puff signal in addition to the cartridge type in order to determine how much power to supply to contacts **42**B.

[0028] The controller **52** can be used to control operation of warming heaters **43** in addition to the atomizer **36**. In some implementations, controller **52** provides power to warming heaters **43** simultaneously with the atomizer **36**. That is, every time the user puffs or every time the puff sensor **35** is triggered, current is applied to both the atomizer **36** as well as the warming heaters **43**. In some implementations, the controller **52** operates the warming heaters **43** independently of the atomizer **36**. For example, the controller can receive an ambient temperature from sensor/reader **46**, and/or temperature sensor **44** and can periodically apply power to warming heaters **43** to maintain the fluid in the reservoir **30** above a desired temperature and therefore below a target viscosity. Maintaining the fluid in the reservoir **30** below the target viscosity ensures it flows freely throughout the reservoir **30** and can readily enter or flow along the wick **34**. The sensor/reader **46** can be a separate sensor located on the power supply **10**, or can be a part of, or component used in reading parameters from sensors (e.g., temperature sensor **44**) installed in the cartridge **12**.

[0029] FIGS. **4**A-**4**D illustrate example configurations of contacts for operation of a personal vaporizer cartridge. FIG. **4**A illustrates a three-prong connecter with three contacts **42**A that can be compression type contacts, or "pogo" pins. In some implementations, these contacts are spring loaded and, when the cartridge **12** is threaded otherwise mated onto the power supply portion, the contacts **42**A are pressed against conductive plates in the power supply portion, compressing a spring to ensure positive connection between each pin and the plate. In the three-prong example of FIG. **4**A, one prong can be a ground or common prong, one can be connected to the vaporization heating element **36** as shown in FIG. **3**, and one can be connected to the warming clements **43** as shown in FIG. **3**. This enables independent activation of the warming elements **43** and the heating element **36**.

[0030] FIG. **4**B shows an example set of contacts **42**A in the form of a USB port—for example a USB type C connector. The USB connector can include multiple contacts which can perform the same functions as described in FIG. **4**A plus additional ones. For example, USB-C typically includes **12** separate contact pins, which can be used for communication, timing, ground, power transfer, or other purposes. The contacts **42**A of FIG. **4**B can be a male or female USB connection, with the opposite installed on the power supply portion. In some implementations, when USB connections are used, a magnetic mechanical coupler **14** is used instead of a threaded coupler to avoid the necessity of rotating the cartridge **12** relative to the power supply. While USB-C is illustrated, other USB ports are feasible, including USB-A, USB-B, Mini USB, Micro USB, or other serial connections.

[0031] FIG. **4**C illustrates a two-prong layout. In FIG. **4**C, one contact **42**A can be for the vaporization heating element, while the other is for the warming elements. In this configuration, the chassis, or case of the device can act as a common or ground connection between the cartridge **12** and the power supply. In some implementations, the heating element and the warming elements can be connected in series and only require a single contact. In these implementations, one of the pins can be ground.

[0032] FIG. **4**D illustrates a concentric contact layout. One or more rings of conductive material can be isolated by insulators and enable mating with similar contacts on the power supply. An advantage of the concentric contacts is that they function regardless of the relative rotation angle between the cartridge **12** and the power supply. That is, the cartridge **12** can be rotate relative to the power supply without interrupting the connection, there is no particular alignment requirement for the contacts **42**A to function.

[0033] Although this disclosure has been described in terms of certain embodiments and generally associated methods, alterations and permutations of these embodiments and methods will be apparent to those skilled in the art. Accordingly, the above description of example embodiments does not define or constrain this disclosure. Other changes, substitutions, and alterations are also possible without departing from the spirit and scope of this disclosure.

Claims

1. An apparatus comprising: cartridge for a personal vaporizer comprising: a reservoir configured to contain a fluid to be vaporized; a first heater configured to vaporize the fluid, the first heater located in an atomization chamber; a wick configured to deliver the fluid to the first heater; a second heater configured to warm the fluid in the reservoir without vaporizing the fluid; and a set of contacts configured to receive power and deliver the power to the first heater and the second heater.

2. The apparatus of claim 1, the second heater is configured to warm the fluid in the reservoir to no greater than 70° C.

3. The apparatus of claim 1, comprising a temperature sensor configured to generate a signal based on the temperature of the fluid in the reservoir but outside the atomization chamber.

4. The apparatus of claim 3, wherein the second heater is positioned on an outer surface of the atomization chamber, and wherein the atomization chamber is within the reservoir.

5. The apparatus of claim 3 comprising: a power supply portion comprising: a battery; a controller configured to: receive the generated signal; and deliver electrical power from the battery to the second heater to cause the second heater to warm the fluid.

6. The apparatus of claim 5, wherein the controller is configured to warm the fluid to a temperature less than 70° C.

7. The apparatus of claim 5, wherein the controller is configured to warm the fluid to a temperature of at least 26° C.

8. The apparatus of claim 5, wherein the controller delivers electrical power to the second heater in an amount inversely proportional to the generated signal.

9. The apparatus of claim 5, wherein the cartridge portion and the power supply portion are removably coupled together by a coupler, and wherein the coupler comprises a set of electrical contacts.

10. The apparatus of claim 9, wherein a first contact of the set of contacts is connected to the first heater, and a second contact of the set of contacts is connected to the second heater.

11. The apparatus of claim 9, wherein a third contact of the set of contacts is connected to the temperature sensor.

12. The apparatus of claim 1, comprising a puff sensor configured to detect when airflow passes through the cartridge and output a puff signal.

13. The apparatus of claim 1, wherein the second heater comprises two conductors, a first conductor disposed along an outer diameter of the reservoir, and a second conductor disposed along an outer surface of the atomization chamber and along an inner diameter of the reservoir.

14. A method for atomizing fluid in a personal vaporizer comprising: storing the fluid in a reservoir; heating the fluid with a second heater without vaporizing the fluid to reduce a viscosity of the fluid; allowing the fluid to flow from the reservoir along a wick into an atomization chamber; and heating the fluid with a first heater to atomize the fluid from the wick.

15. The method of claim 14, wherein heating the fluid with the first heater comprises heating the fluid with the first heater in response to detecting airflow through the atomization chamber.
16. The method of claim 14, wherein heating the fluid with the second heater comprises heating the fluid to a temperature that does not exceed 70 C.
17. The method of claim 14, wherein heating the fluid with the second heater comprises heating the fluid with the second heater based on a measured temperature of the fluid.
18. The method of claim 14 comprising coupling a cartridge portion with a power supply portion of the personal vaporizer.