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I N T E R O F F I C E   C O R R E S P O N D E N C E

Richmond, Virginia

To: **K. Torrence** Date: **September 27, 2004**

From: **R. H. Moffitt**

Subject: **Operational Analysis of SBT Ruyan Atomizing Nicotine Inhaler**

Summary

Several samples of the "SBT Ruyan Atomizing Nicotine Inhaler" (fig. 1) were disassembled and examined to determine their operating principle and associated control functionality. The discussion section below details the findings.

fig. 1

Discussion

The SBT Ruyan electronic cigar/cigarette was disassembled for determination of its operating principle and electrical characteristics. Most of the internal components of the device were partially or completely potted or encapsulated in a hard, plastic-like material. The disassembly of the first device was destructive and resulted in a non-functional device. Based on the method of assembly, it is clear that the device was not designed for servicing. Learnings from the destructive disassembly enabled a second device to be disassembled with functionality preserved. The device appears to be manually assembled based on the component interconnection methods and circuit board soldering.

In addition to the replaceable mouthpiece with attached flavor containing cartridge (fig. 8), the device consists of (starting at the mouthpiece end): an aerosol generation chamber, a flow sensor/activation switch, two small circuit boards with surface mount electronic components, one replaceable lithium ion battery, and an LED indicator and pushbutton at the tip end. (fig. 2).

The evaluation of the electrical circuitry revealed that the circuit contains no programmable or logic based components (figs. 3 and 4). All of the circuitry is of an analog nature – power FETs, resistors, diodes, capacitors, etc. There is no evidence of ultrasonic operation such as the presence of piezoelectric materials or ultrasonic supporting electronic circuitry which is in contrast with some device literature that refers to an ultra-miniature pump and aerosol generated by a 2.2 MHz ultrasound wave.

Operational and Control Description:

The flow sensing mechanism is a flexible diaphragm with an attached magnet that, upon application of sufficient air flow, deflects and allows closure of a reed switch (fig. 6). The reed switch closure energizes a power FET driver that applies energy to the heater element. The heater is a wire wound element located in the upper portion of the aerosol chamber (fig. 5) just below a screen or mesh-like material that is in physical contact with the flavor cartridge. The heater location is in a cupped area of the chamber, surrounded by a larger mass of the mesh-like material. The apparent function of the mesh material is to provide a wicking path for the flavor solution from the flavor cartridge and, upon puffing, entrain the volatile flavor compounds in the air stream as it passes over the heater. This is evidenced by the liquid saturated mesh material observed after disassembly of the device.

Analysis of the electrical circuit indicated that the energy control is quite basic with little or no energy limiting control other than the resistive values of the components themselves. The device will activate as long as there is sufficient air flow to trigger the diaphragm mechanism. The pushbutton switch located at the tip end of the device is electrically in parallel with the flow sensing mechanism and applies power in exactly the same manner as the flow sensor. The multicolored LED component at the tip end (fig. 7) is electrically in parallel with the heater element and provides visual indication of device activation and limited indication of battery charge level. The LED is actually a self contained, three LED component with on-board oscillator circuitry. At maximum battery voltage, all three LEDs (blue, green, and red) are illuminated and flash at a 4 - 10 hz frequency. Due to differences in voltage requirements for each of the separate color LEDs, as the voltage level decreases, the blue LED drops out first, leaving just the green and red LEDs illuminated. As the voltage level further decreases, the green LED drops out, leaving just the red LED illuminated and signaling the user that a battery recharge is due soon.

A portion of the control circuitry does not appear to have any well defined function. It is suspected that it is intended to be a protective circuit based on its design configuration; however, it had no effect on the device's operation under any test conditions. One component of this circuit, located at the base of the mesh material chamber, exhibits crystal- or thermistor-like properties – showing small changes in resistive value upon changes in temperature, air flow, or physical pressure. The associated circuitry does not react when these changes occur. Based on the circuit design, it appears that if it did function, it would provide a shunt or bypass for current flow in parallel with the heater element – perhaps providing some level of protection for an excessive temperature condition. Again, this circuit could not be made to operate under any of our test conditions.

A battery run-down test was performed to determine the number of puffs or activations that could be supported on single charge. The test setup consisted of a controlled vacuum pump to provide sufficient draw to activate the flow sensor for a one second period (as indicated by the device's LEDs) with a 60 second puff interval. Under these conditions, 1460 puffs were observed before the battery level was too low to activate the device.

Puff activation was also tested to determine air flow requirements necessary to trigger the device. While the measured flow requirements varied from device to device (not unexpected based on the flow sensing mechanism), the nominal flow rate required was just under 3000cc/min, representing ~14 inches H_2O. For comparison, the EHCSS Series K product requires ~0.04 inches H_2O to activate under same test conditions. The device's RTD measured 88mm H_2O.

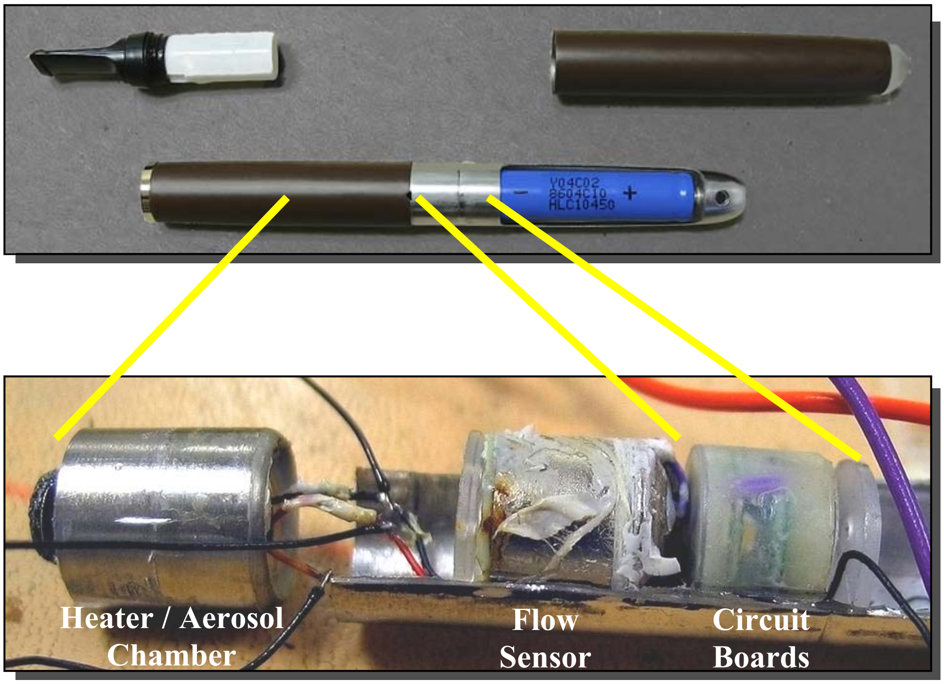


fig 2. Component Layout

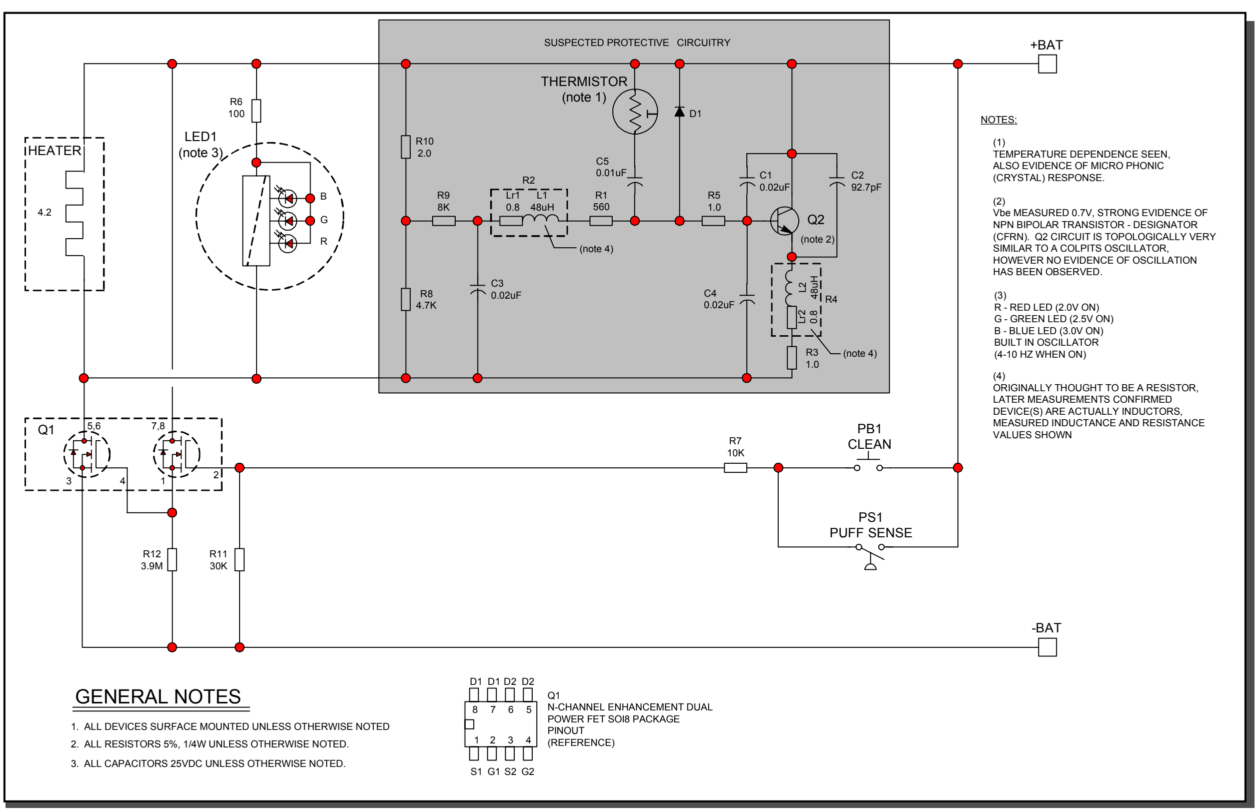
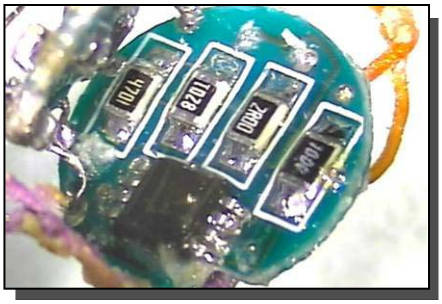
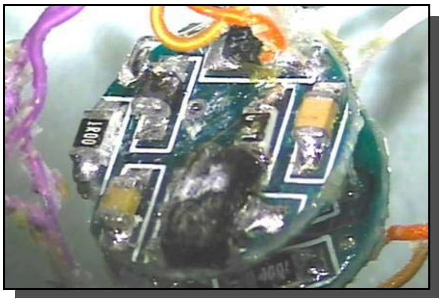


fig. 3. Schematic

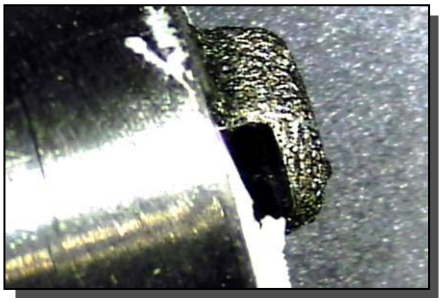

Circuit Board 1 Top View

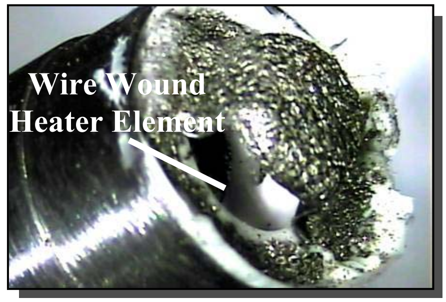

Circuit Board 1 Bottom View


Circuit Board 2 Top View


Circuit Board 2 Bottom View

fig. 4. Circuit Boards


Heater Unit Side View



Heater Unit Angle View


Heater Unit Top View

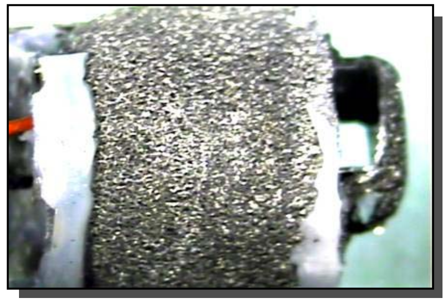
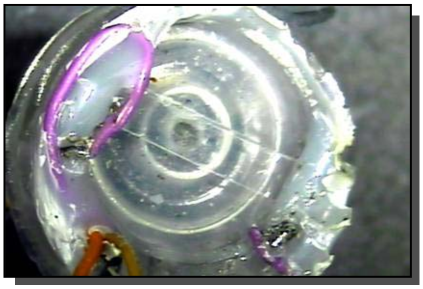

Heater Unit Cut Away View

fig. 5. Heater / Aerosol Chamber



Magnetic Reed Switch / Diaphragm Top View

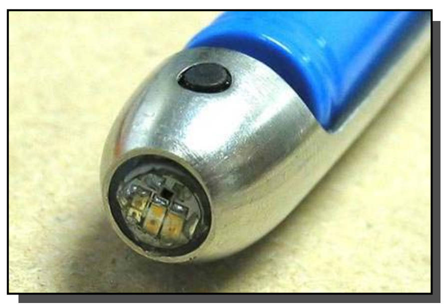
Magnetic Reed Switch / Diaphragm Bottom View

Air Inlet Holes

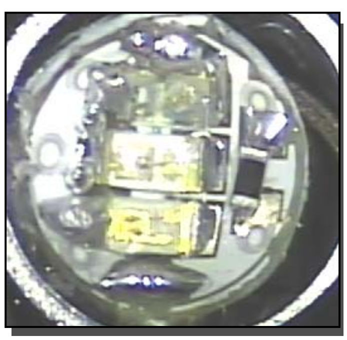
Air Inlet Holes – Cover Removed

fig. 6. Flow / Activation Sensor

LED and Lens



LED and Cleaning PB



LED Component

fig. 7. LED Indicator

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