



(19) **United States**

(12) **Patent Application Publication**
Hanisko

(10) **Pub. No.: US 2006/0027553 A1**

(43) **Pub. Date: Feb. 9, 2006**

(54) **HEATER FOR ENDODONTIC CONDENSER**

(57) **ABSTRACT**

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(21) Appl. No.: **10/915,159**

(22) Filed: **Aug. 9, 2004**

Publication Classification

(51) **Int. Cl.**
H05B 3/00 (2006.01)

(52) **U.S. Cl.** **219/221; 219/548; 219/553**

An endodontic condenser system includes a tip to pack gutta-percha or other materials into a tooth's canal, a heater to heat the tip, and a control circuit to determine the temperature of the tip while the heater heats the tip. The heater includes an electrically resistive heating element disposed in the tip and having a temperature coefficient of resistance at least $1.3 \times 10^{-4} / ^\circ\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm-m. The tip includes a body for radiating the heat generated by the heating element. The control circuit determines the temperature of the tip by determining the electrical resistance of the heating element as the heating element generates heat. With a temperature coefficient of resistance at least $1.3 \times 10^{-4} / ^\circ\text{C}$., the electrical resistance of the heating element is sensitive to the temperature of the heating element. With this sensitivity and the control circuit's ability to determine the resistance of the heating element while the heating element generates heat, the temperature of the condenser's tip may be accurately determined.

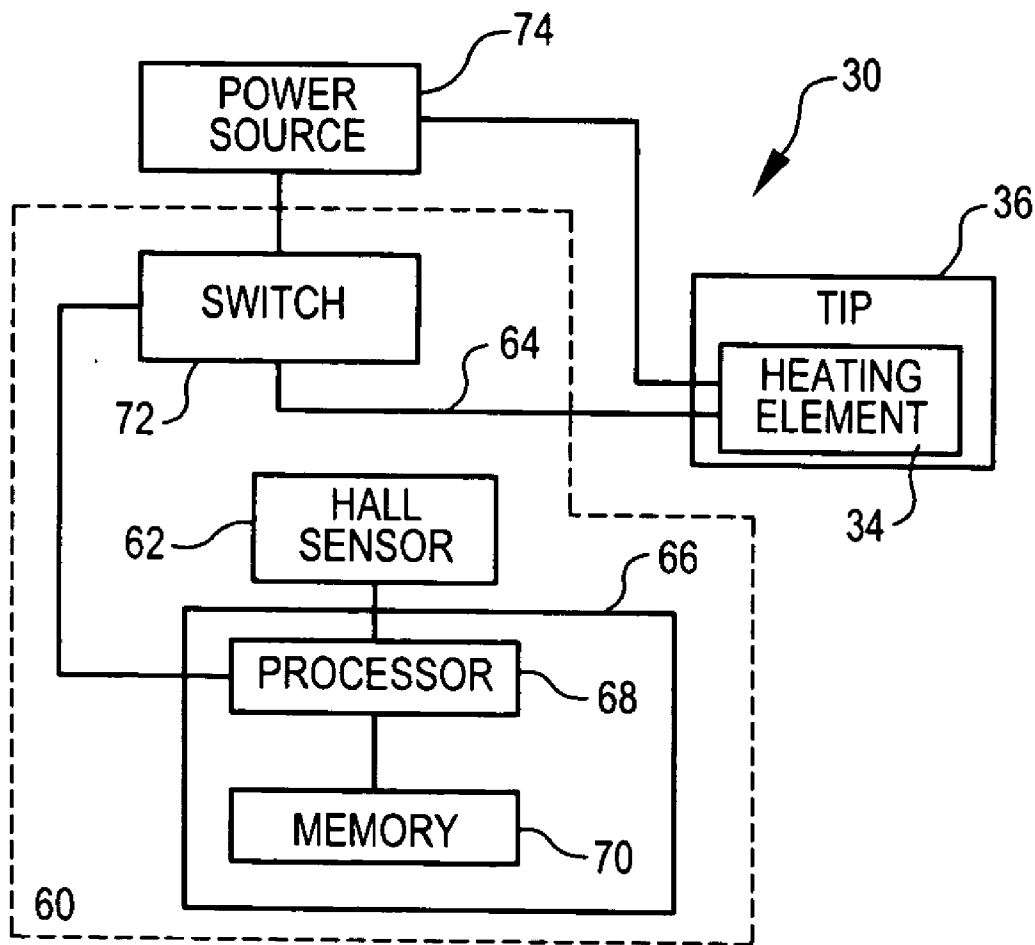


FIG. 1
(PRIOR ART)

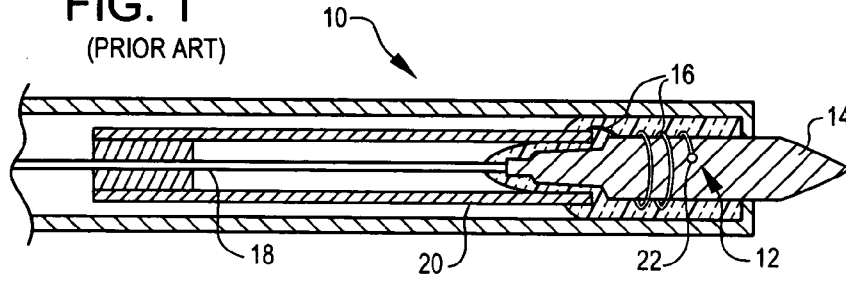


FIG. 2

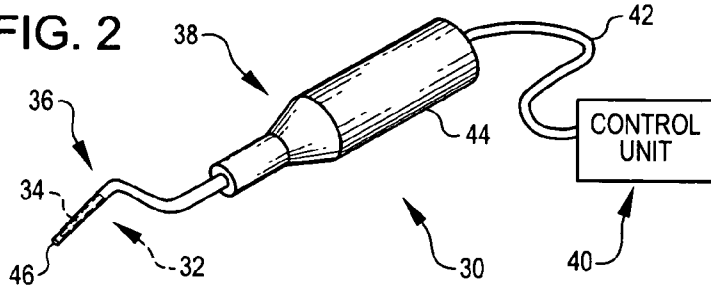


FIG. 3

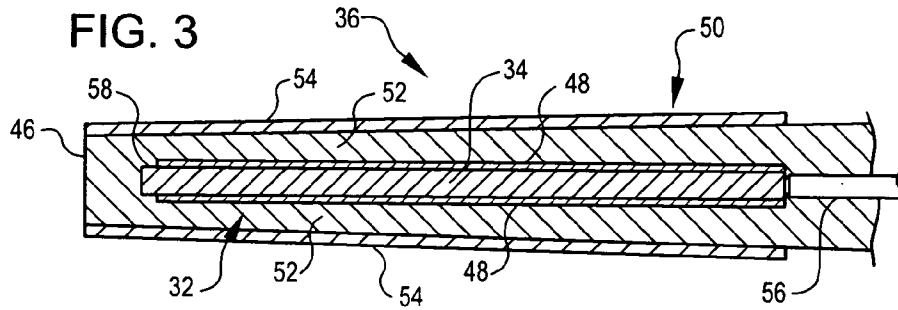


FIG. 4

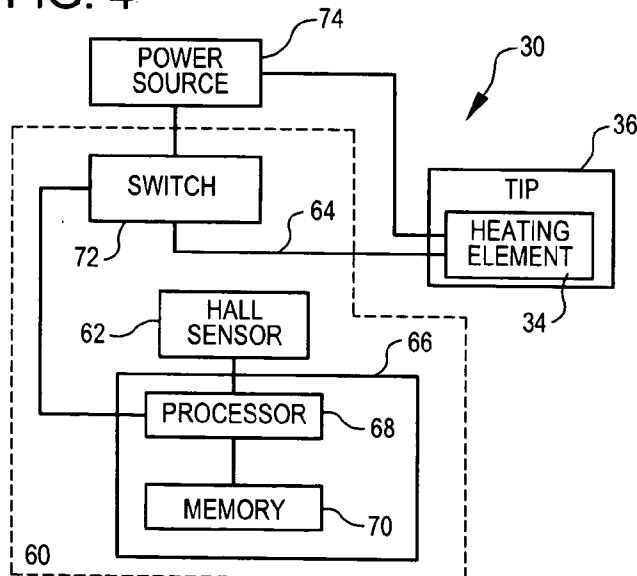
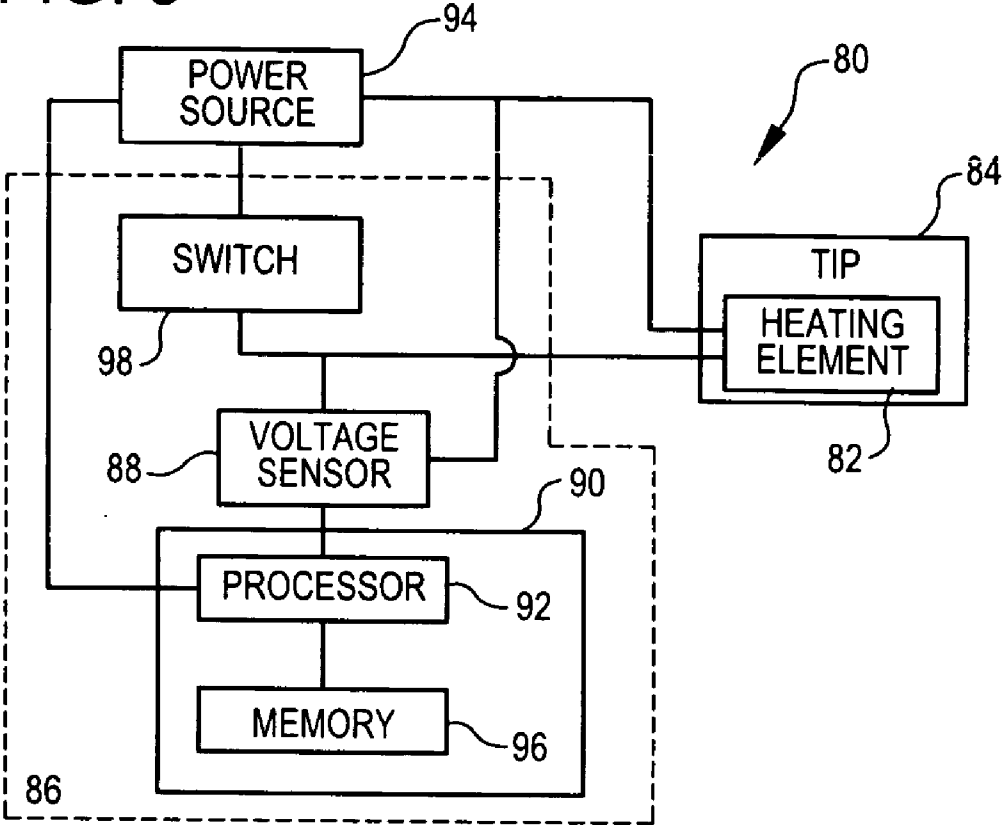


FIG. 5



HEATER FOR ENDODONTIC CONDENSER

BACKGROUND

[0001] Many dentists and other medical professionals use endodontic condensers to pack gutta percha and other materials into voids in a tooth. Voids are typically generated when a dentist or other medical professional removes decayed material from a tooth, such as the tooth's pulp. To fill the void left in a tooth a dentist or other medical professional first inserts pre-formed chunks of gutta percha or injects gutta percha through an endodontic obturator. Because the void in the tooth is often irregularly shaped and may contain branches or canals projecting from a main body of the void, inserting or injecting the gutta percha into the tooth rarely fills the void completely. Thus, a dentist or other medical professional often uses an endodontic condenser to work or pack the gutta percha into the remaining unfilled portions of the void.

[0002] Because gutta percha softens when warmed, most condensers include a heater at their tip to warm the gutta percha and facilitate its flow throughout the void. Gutta percha softens when warmed to a temperature between 53° C. and 57° C. If the heater overheats the gutta percha, however, the gutta percha can degrade. In addition, if the heater overheats the patient's tooth and/or gum, the tooth and/or gum may become painful and/or damaged. Therefore, many condensers include a component for determining the temperature of the condenser's tip, and circuitry for increasing and decreasing the temperature.

[0003] For example, FIG. 1 shows a conventional condenser 10 that includes a thermocouple 12 to approximate the temperature of the tip 14, which may be used to pack gutta percha and other materials into voids in teeth, and circuitry (not shown) to modify the temperature of the tip. The condenser 10 also includes an electrically resistive heating element 16 for generating heat, and a lead 18 connected to the tip 14 for powering the heating element 16. When the heating element 16 generates heat, electricity flows from the lead 18 through a portion of the tip 14 to the junction 22 of the heating element 16 and the tip 14, and then through the housing 20. By making the heating element 16 and tip 14 from different materials, the junction 22 also forms the thermocouple 12. To determine the temperature of the tip 14, power in the lead 18 is stopped and the voltage generated by the dissimilar materials of the junction 22 is measured. Because the voltage generated by the junction 22 corresponds to the temperature of the junction 22, an approximate temperature of the tip 14 may be determined.

[0004] Unfortunately, using the thermocouple 12 to determine the temperature of the tip 14 has some drawbacks. Because the thermocouple 12 generates a voltage at the junction 22, the heating element 16 must be turned off when sensing this voltage to avoid corrupting the voltage and thus altering the determined temperature of the tip 14. Consequently, the temperature of the tip 14 fluctuates between its coolest temperature, which occurs just before power to the heating element 16 is restored, and its warmest temperature, which occurs just before one stops power to the heating element 16 to measure the voltage generated by the junction 22. Thus, the temperature determined from the generated voltage does not reflect the temperature of the tip 14 when the heating element 16 generates heat, and is typically less

than the warmest temperature of the tip 14. Furthermore, the voltage generated by the thermocouple 12 may be easily corrupted by other junctions of dissimilar materials in the thermocouple's circuit, and/or electrical noise from other circuits of the condenser 10, and, thus, cause the determined temperatures to be inaccurate.

[0005] Another drawback to using the thermocouple 12 is that the materials selected to make the tip 14 and heating element 16 are typically selected to maximize the voltage generated by the thermocouple 12; not to maximize the heating and mechanical properties of the condenser 10. For example, the heating element 16 is typically made from the same material as the lead 18 to reduce the number of junctions having dissimilar materials. The lead 18 is typically made of copper because copper is an inexpensive and efficient electrical conductor. Therefore, the heating element 16 is also typically made of copper and does not efficiently generate heat by resisting the flow of electricity. Thus, the heating element 16 requires much power to heat the tip 14.

[0006] Other methods of determining the temperature of the tip 14 include using a Wheatstone bridge (not shown) to determine the resistance of the heating element 16. Because a resistor's resistance depends on the temperature of the resistor, one can determine the resistor's temperature from the resistor's resistance. A Wheatstone bridge includes three resistors whose resistance is known and a fourth resistor—the heating element—whose resistance is not known arranged to form a conventional bridge circuit.

[0007] Unfortunately, a Wheatstone bridge has some drawbacks too. The additional resistors in the Wheatstone bridge generate heat when electricity flows through them. The heat raises the temperature of each additional resistor, which consequently changes the resistance of each additional resistor. Therefore, one must determine the actual resistance of the additional resistors to accurately determine the resistance of the heating element.

SUMMARY

[0008] In one aspect of the invention, an endodontic condenser includes a tip to pack gutta-percha or other materials into voids of a tooth, such as an empty root canal, a heater to heat the tip, and a control circuit to determine the temperature of the tip while the heater heats the tip. The heater includes an electrically resistive heating element disposed in the tip and having a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^\circ\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm-m. The tip includes a body for radiating the heat generated by the heating element. The control circuit determines the temperature of the tip by determining the electrical resistance of the heating element while the heating element generates heat. With a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^\circ\text{C}$., the electrical resistance of the heating element is sensitive to the temperature of the heating element. With this sensitivity and the ability of the control circuit to determine the resistance of the heating element while the heating element generates heat, the temperature of the condenser's tip may be accurately determined.

BRIEF DESCRIPTION OF THE FIGURES

[0009] FIG. 1 is a cross-sectional view of a conventional endodontic condenser that incorporates a thermocouple.

[0010] FIG. 2 is a perspective view of an endodontic condenser system that incorporates a heater according to an embodiment of the invention.

[0011] FIG. 3 is a cross-sectional view of a tip of the system in FIG. 2 showing a heating element of the heater in FIG. 2.

[0012] FIG. 4 is a schematic view of the endodontic condenser system in FIG. 2.

[0013] FIG. 5 is a schematic view of an endodontic condenser system according to another embodiment of the invention.

DETAILED DESCRIPTION

[0014] The following discussion is presented to enable one skilled in the art to make and use the invention. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the generic principles herein may be applied to other embodiments and applications without departing from the spirit and scope of the present invention as defined by the appended claims. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[0015] FIG. 2 is a perspective view an endodontic condenser system 30 that incorporates a heater 32 according to an embodiment of the invention. The heater 32 includes a heating element 34 (discussed in greater detail in conjunction with FIG. 3) disposed in a tip 36 of the system 30. The heating element 34 comprises material having a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^{\circ}\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm-m, and generates heat by resisting the flow of electricity through it. The condenser system 30 includes a condenser 38 that a dentist or other medical professional grips and maneuvers to pack gutta percha into a void in a tooth (not shown) or to pack other materials into voids in other tissues (not shown), a control unit 40 to power the heater 32, and a cable 42 to couple the condenser to the control unit. The condenser 38 includes a hand-piece 44 for gripping the condenser, and the tip 36, which may be releasably fastened to the hand-piece or not, to exert pressure on the gutta percha or other materials. The control unit 40 includes control circuitry (not shown but discussed in greater detail in conjunction with FIGS. 4 and 5) to determine the temperature of the heating element 34, and thereby the temperature of the tip 36, while the heating element generates heat. The control circuitry may also modify the power to the heating element 34 in response to the determined temperature of the heating element.

[0016] Because the electrical resistance of most materials changes as the temperature of the material changes, the temperature of the heating element 34 can be determined from knowing the value of the electrical resistance of the heating element. For some materials the relationship between the electrical resistance and the temperature is linear or substantially linear. For example, a 50 increase in the materials temperature will increase the materials electrical resistance 2 ohms over a range of temperatures. For other materials the relationship between the electrical resistance and the temperature is not linear. For example, an increase in the materials temperature from 100° to 105° (a 50 increase) will increase the material's electrical resistance

2 ohms, and an increase in temperature from 105° to 110° (another 50 increase) will increase the electrical resistance 4 ohms. In addition, for some materials the material's electrical resistance increases as the material's temperature increases, for example nickel, iron, copper and gold, and for other materials the material's electrical resistance decreases as the material's temperature increases, for example carbon. To indicate the sensitivity of a material's electrical resistance to the material's temperature, each material has a temperature coefficient of resistance.

[0017] If a temperature coefficient of resistance is a positive value, then by choosing a material with an increased thermal coefficient of resistance one can increase the change in the heating element's electrical resistance relative to a change in the heating element's temperature. Thus, one can more easily sense changes in the heating element's electrical resistance. Therefore, by using a heating element 34 comprising material having a temperature coefficient at least $1.3 \times 10^{-4}/^{\circ}\text{C}$. to generate heat, and determining the resistance of the heating element 34 while the heating element generates heat, one is able to more accurately determine the temperature of the heating element. Thus, the likelihood of overheating gutta percha or a patient's tissues may be avoided.

[0018] Still referring to FIG. 1, the tip 36 may be shaped as desired to facilitate access to a void in the tooth or other tissue, and packing gutta percha or other material into the void. For example, in one embodiment the tip 36 is curved to facilitate a dentist's or other medical professional's access to a void in a patient's tooth that opens to the patient's mouth through the top of the tooth. Furthermore, the distal end 46 of the tip 36 is flat or substantially flat to exert pressure on the gutta percha or other material in a direction that is substantially aligned with the tip. In other embodiments, the tip 36 may be straight or substantially straight to facilitate a dentist's or other medical professional's access to a void in a patient's tooth that opens through the side of the tooth. And the distal end 46 of tip 36 may be pointed (not shown) to exert less pressure on the gutta percha or other material than one can exert with the substantially flat distal end 46 and in a direction that is not substantially aligned with the tip.

[0019] Other embodiments of the system are contemplated. For example, the control circuitry of the control unit 40 may be disposed within the hand-piece 44. Or, a battery (not shown) for powering the heater 32 and the control circuitry may be disposed within the hand-piece 44. This may be desirable to allow a dentist or other medical professional to use the condenser system 30 where the dentist or other medical professional cannot access a conventional power outlet like those mounted to a wall of the dentist's or other medical professional's office.

[0020] FIG. 3 is a cross-sectional view of a portion of the tip 36 of the system 30 in FIG. 2 according to an embodiment of the invention and shows the heating element 34 of the heater 32 in FIG. 2.

[0021] The heating element 34 may comprise any desired material that has a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^{\circ}\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm-m. For example, in one embodiment the heating element 34 comprises nickel. Nickel's temperature coefficient of resistance is approximately $5.866 \times 10^{-3}/^{\circ}\text{C}$. at 20°C . and nickel's electrical resistivity is approximately $7.0 \times$

10^{-8} ohm·m. With an electrical resistivity greater than the electrical resistivity of copper and other conventional conductors that are chosen to improve thermocouple performance, the heating element **34** generates more heat from electricity flowing through it than heating elements made from conventional conductors. Consequently, the heating element **34** is more efficient than heating elements made from conventional conductors. In other embodiments, the heating element **34** may comprise iron, steel, platinum, molybdenum, tungsten, zinc, nickel-iron. The temperature coefficient of resistance and electrical resistivity for each of these materials is provided in the table below.

Table Of Materials And Their Respective Approximate Temperature Coefficient Of Resistance At 20° C. And Approximate Electrical Resistivity

Material	Temperature Coefficient of resistance	Electrical Resistivity
Iron	$5.6 \times 10^{-3}/^{\circ}\text{C}$.	9.6×10^{-8} ohm · m
Steel (99.5% iron .5% Carbon)	$3.0 \times 10^{-3}/^{\circ}\text{C}$.	1.6×10^{-7} ohm · m
Platinum	$3.7 \times 10^{-3}/^{\circ}\text{C}$.	1.0×10^{-7} ohm · m
Molybdenum	$4.5 \times 10^{-3}/^{\circ}\text{C}$.	5.3×10^{-8} ohm · m
Tungsten	$4.4 \times 10^{-3}/^{\circ}\text{C}$.	5.2×10^{-8} ohm · m
Zinc	$3.8 \times 10^{-3}/^{\circ}\text{C}$.	5.9×10^{-8} ohm · m
Nickel-iron	$3.3 \times 10^{-4}/^{\circ}\text{C}$.	1.2×10^{-6} ohm · m

[0022] From the table, iron's temperature coefficient of resistance is approximately $5.671 \times 10^{-3}/^{\circ}\text{C}$. at 20° C., and iron's electrical resistivity is approximately 9.6×10^{-8} ohm·m. Thus, iron would work well as a material for the heating element **34**. Platinum's temperature coefficient of resistance is approximately $3.729 \times 10^{-3}/^{\circ}\text{C}$. at 20° C. and remains constant or substantially constant, i.e. the relationship between the electrical resistance and the temperature is linear or substantially linear, from 0° C. to approximately 250° C., and platinum's electrical resistivity is approximately 1.0×10^{-7} ohm·m. Thus, platinum would work well as a material for the heating element **34**.

[0023] Other embodiments are contemplated. For example, the heating element **34** may comprise a material whose thermal coefficient of resistance decreases as the temperature of the material increases.

[0024] Still referring to FIG. 3 the heater **32** also includes an insulator **48** to ensure that the electricity flowing through the heating element **34** flows through a substantial portion of the heating element's length. The insulator **48** may be any conventional material capable of electrically insulating the heating element **34** throughout the range of temperatures that the heating element **34** heats the tip **36** to. For example, in one embodiment the insulator is Kapton® and is mounted to the heating element **34** using conventional techniques.

[0025] The tip **36** includes a body **50** to radiate the heat generated by the heating element **34** and to exert pressure on the gutta-percha and other materials to pack them into a void in a tooth or other tissues. The body **50** includes a core **52** to protect the heating element **34** and strengthen the tip **36**, and a jacket **54** to distribute the heat generated by the heating element **34** across the body **50**.

[0026] Because the system **30** (FIG. 2) does not incorporate a thermocouple to determine the temperature of the

body **50**, the core **52** and jacket **54** may comprise any material having a desired combination of thermal conductivity and thermal capacity that provides the tip **36** desired thermal effects. Thermal conductivity is a measure of a material's ability to transmit heat through it, and thermal capacity is a measure of a material's ability to store heat within it. A material having high thermal conductivity and low thermal capacity will quickly reach a level of heat saturation and quickly radiate additional heat added to the material. When heat is no longer added to this material, the material will quickly cool down. A material having a low thermal conductivity and high thermal capacity will not quickly reach a level of heat saturation and not quickly radiate additional heat added to it. When heat is no longer added to this material, the material will slowly cool down. Therefore, to provide a tip **36** whose temperature changes quickly relative to changes in the heat generated by the heating element **34**, and thus is more thermally responsive, the tip **36** should comprise materials having high thermal conductivity and low thermal capacity.

[0027] In one embodiment of the body **50**, the core **52** comprises stainless steel, whose thermal conductivity is approximately $16 \text{ W/m}^{\circ}\text{K}$ and whose thermal capacity is approximately $0.50 \text{ J/g}^{\circ}\text{C}$., and the jacket **54** comprises copper, whose thermal conductivity is approximately $386 \text{ W/m}^{\circ}\text{K}$ and whose thermal capacity is approximately $0.39 \text{ J/g}^{\circ}\text{C}$. The core **52** is clad with the jacket **54** using conventional copper cladding techniques. With the jacket **54** having a higher thermal conductivity than the core **52**, the jacket can distribute heat it receives from hotter portions of the core to cooler portions of the core, and thus evenly distribute the heat generated by the heating element **34** across the tip **36**.

[0028] Other embodiments are contemplated. For example, the core **52** may comprise tantalum whose thermal conductivity is approximately $54.40 \text{ W/m}^{\circ}\text{K}$ and whose thermal capacity is approximately $0.15 \text{ J/g}^{\circ}\text{C}$. Because tantalum is more expensive and more difficult to work with than stainless steel, tantalum may be desirable if the added expense can be justified. For another example, the jacket **54** may comprise gold, which has similar thermal conductivity and capacity characteristics as copper, or the copper may be clad with gold to protect the copper. In addition, the jacket **54** may comprise silver and/or tantalum.

[0029] Still referring the FIG. 3, in one embodiment, the heater **32** heats the tip **36** as follows. Electricity flows through a lead **56**, which is connected to the heating element **34** and coupled to the control unit **40** (FIG. 1), and enters the heating element. Upon entering the heating element **34**, the electricity is directed to flow through a substantial portion of the heating element's length by the insulator **48**. Once the electricity reaches the end **58** of the heating element **34**, the electricity flows through the un-insulated portion of the heating element and toward the jacket **54**. By resisting the flow of electricity, the heating element generates heat that the tip's body **50** radiates. Once in the jacket **54**, the electricity flows toward the hand-piece **44** (FIG. 2) and returns to the control unit **40**.

[0030] FIG. 4 is a schematic view of the endodontic condenser system **30** in FIG. 2. The control unit **40** (FIG. 1) powers the heater **32** (FIGS. 2 and 3) and includes control circuitry **60** to determine the temperature of the heating

element 34, and thereby the temperature of the tip 36, while the heating element generates heat. By determining the temperature of the heating element 34 while the heating element generates heat, the control circuitry 60 can determine the temperature of the heating element more accurately than a thermocouple can. Thus, the control circuitry 60 can permit quick, more accurate regulation of the heat generated by the heating element 34.

[0031] As previously discussed, the temperature of the heating element 34 can be determined from knowing the value of the electrical resistance of the heating element. From Ohm's law, the value of the heating element's electrical resistance can be determined from knowing the voltage across the heating element 34 and the amount of current flowing through the heating element. Therefore, the temperature of the heating element can be determined from knowing the amount of voltage the control unit supplies the heating element 34, the amount of electrical current flowing through the heating element, and the relationship of the heating element's resistance to the heating element's temperature.

[0032] In one embodiment, the control unit 40 includes the power source 74 that supplies a constant or substantially constant, known voltage to the heating element 34, and the control circuitry 60 includes a Hall-effect sensor 62 to sense the amount of electrical current flowing through the heating element. The Hall-effect sensor 62 is located near the lead 64 that supplies the voltage from the power source 74 to the heating element 34. When electricity flows through the lead 64 the current generates a magnetic field around the lead that is proportional to the amount of electricity flowing through the lead. The magnetic field causes the Hall-effect sensor 62 to generate a voltage that is proportional to the magnetic field. By measuring the voltage generated by the sensor 62, one can determine the electrical current flowing through the heating element 34. With the current through the heating element 34 and the voltage across the heating element known, one can determine the resistance, and thus the temperature, of the heating element.

[0033] The control circuitry 60 also includes processing circuitry 66 to determine the temperature of the heating element 34. The processing circuitry 66 includes a processor 68 and a memory 70 coupled to the processor for performing desired calculations and tasks. For example, in one embodiment the processor 68 receives data that corresponds to the output voltage of the Hall-effect sensor 62. The processor 68 then retrieves a look-up table from the memory 70 to obtain the amount of current flowing through the heating element 34 that correlates with the sensor's voltage. The processor 68 then receives data that corresponds to the voltage delivered to the heating element 34 and then calculates the resistance from the two types of data. Next, the processor retrieves a look-up table from the memory 70 to obtain the temperature of the heating element that correlates with the element's electrical resistance. The look-up table correlating temperature to electrical resistance is often generated from empirical data and allows the heating element 34 to comprise material that does not have a linear or substantially linear relationship between the material's electrical resistance and temperature.

[0034] Other embodiments are contemplated. For example, the processor 68 may determine the heating

element's temperature by solving an equation that correlates the heating element's electrical resistance to the element's temperature. This may be desirable when the heating element's electrical resistivity has a linear or substantially linear correlation with the element's temperature or when an equation correlating the electrical resistance with the temperature is known.

[0035] With the temperature of the heating element 34 determined, the control circuitry 60 may then correspondingly modify the voltage delivered to the heating element 34, and thus the amount of current flowing through the heating element, to increase or decrease as desired the heat generated by the heating element. For example, in one embodiment the control circuitry 60 includes a switch 72 coupled to the processor 68. The switch 72 may be any conventional switch that may be set to permit electricity to flow through the heating element 34 or prevent electricity from flowing through the heating element. To set the switch 72, the processor 68 sends the switch 72 data corresponding to instructions to permit electricity to flow toward the heating element 34 or prevent electricity from flowing toward the element.

[0036] Other embodiments are contemplated. For example, the power source 74 may generate different voltages to be supplied to the heating element 34, or the switch 72 may modify the voltage—other than permitting or preventing electricity to flow toward the heating element. In addition, the processor 68 may send data corresponding to instructions to modify the voltage supplied to the heating element 34 according to the determined temperature of the heating element and may be coupled to the power source 74, switch 72 or both. This may be desirable to decrease the time the tip 36 takes to reach a desired temperature. For example, when the tip 36 is initially heated to raise its temperature from ambient temperature, the heating element requires a large amount of current to raise the temperature, and after the tip has reached the desired temperature, the heating element requires less current to maintain the temperature. To provide the heating element 34 the appropriate amount of current to quickly raise the temperature and then to maintain the temperature, the control unit 40 would supply the heating element different voltages for each function.

[0037] FIG. 5 is a schematic view of the endodontic condenser system 80 according to another embodiment of the invention. The system 80 is similar to the system 30 (FIGS. 2-4) except the control unit 40 (FIG. 2) provides a known amount of current to the heating element 82 of the tip 84, and the control circuitry 86 includes a voltage sensor 88 to sense the voltage across the heating element 82. With the amount of current delivered to the heating element 82 and the voltage across the heating element known, the control circuitry 86 may determine the electrical resistance of the heating element, and thus the temperature of the heating element.

[0038] In one embodiment, the control circuitry 86 includes processing circuitry 90 to determine the temperature of the heating element 82 and correspondingly modify the current delivered to the heating element, and thus the voltage across the heating element. The processing circuitry 90 includes a processor 92 coupled with the voltage sensor 88 to receive data that corresponds to the voltage across the heating element 82. The processor 92 is also coupled with

the power source **94** to receive data corresponding to the amount of current delivered to the heating element **82** and to send data to the power source to modify the amount of current delivered to the heating element. In addition, the processor **92** is coupled to the memory **96** that stores a look-up table or equation correlating the temperature of the heating element **82** with the data corresponding to the voltage across the heating element. The control circuitry **86** also includes a switch **98** to allow a dentist or other medical professional to permit or stop electricity from flowing to the heating element **82**.

[0039] Other embodiments are contemplated. For example, the switch **98** may be used to modify the current delivered to the heating element **82**, and the processor **92** may be coupled to the switch **98** and send data to the switch for modifying the current.

What is claimed is:

1. A heater comprising:
 - an electrically resistive heating element having a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^{\circ}\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm·m, and operable to generate heat.
 2. The heater of claim 1 wherein the temperature coefficient of resistance is $5.86 \times 10^{-4}/^{\circ}\text{C}$.
 3. The heater of claim 1 wherein the temperature coefficient of resistance increases relative to an increase in temperature of the heating element.
 4. The heater of claim 1 wherein the temperature coefficient of resistance decreases relative to an increase in temperature of the heating element.
 5. The heater of claim 1 wherein the temperature coefficient of resistance increases linearly or substantially linearly relative to an increase in temperature of the heating element.
 6. The heater of claim 1 wherein the temperature coefficient of resistance increases linearly or substantially linearly relative to an increase in temperature between 40°C . and 80°C . of the heating element.
 7. The heater of claim 1 wherein the electrical resistivity is 7.0×10^{-8} ohm·m.
 8. The heater of claim 1 wherein the electrically resistive heating element comprises Nickel.
 9. A heater comprising:
 - an electrically resistive heating element for generating heat; and
 - a control circuit operable to determine a temperature of the heating element while the heating element generates heat.
 10. The heater of claim 9 wherein the control circuit senses electrical current flowing through the heating element to determine the temperature of the heating element.
 11. The heater of claim 9 wherein the control circuit includes a Hall-effect sensor operable to sense the electrical current flowing through the heating element.
 12. The heater of claim 10 wherein the control circuit includes a processor operable to determine the heating element's electrical resistance from the electrical current sensed.
 13. The heater of claim 12 wherein the processor is operable to execute at least one of the following programs, a program for solving an equation relating the heating element's temperature to the heating element's electrical resistance and a program for retrieving a look-up table that

correlates a temperature of the heating element with the heating element's electrical resistance.

14. The heater of claim 9 wherein the control circuit senses a voltage across the heating element to determine the temperature of the heating element.

15. The heater of claim 9 wherein the control circuit includes a voltage sensor operable to sense the electrical current flowing through the heating element.

16. The heater of claim 14 wherein the control circuit includes a processor operable to determine the heating element's electrical resistance from the voltage sensed.

17. The heater of claim 16 wherein the processor is operable to execute at least one of the following programs, a program for solving an equation relating the heating element's temperature to the heating element's electrical resistance and a program for retrieving a look-up table that correlates a temperature of the heating element with the heating element's electrical resistance.

18. An endodontic condenser tip comprising:

- an electrically resistive heating element having a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^{\circ}\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm·m, and operable to generate heat; and
- a body for radiating the heat generated by the heating element.
19. The tip of claim 18 wherein the heating element is disposed within the body.
20. The tip of claim 18 wherein the heating element has a length, and includes an electrically insulating layer to direct electricity through the length or a substantial portion of the length.
21. The tip of claim 18 wherein the body includes:
 - a core to strengthen the tip, and
 - a jacket having a coefficient of thermal conductivity at least $380 \text{ W/m}^{\circ}\text{K}$ and operable to distribute the heat generated by the heating element across the body.
22. The tip of claim 21 wherein the core comprises stainless steel.
23. The tip of claim 21 wherein the jacket comprises copper.
24. A system comprising:
 - a hand-piece;
 - an endodontic condenser tip fastenable to the hand-piece and including a body for radiating heat; and
 - a heater having an electrically resistive heating element having a temperature coefficient of resistance at least $1.3 \times 10^{-4}/^{\circ}\text{C}$. and an electrical resistivity at least 1.7×10^{-8} ohm·m, the heating element being disposed in the tip and operable to generate heat.
25. The system of claim 24 further comprising a power source couplable to the hand-piece and operable to power the heating element.
26. A system comprising:
 - a hand-piece;
 - an endodontic condenser tip fastenable to the hand-piece and including a body for radiating heat;
 - a heater having an electrically resistive heating element disposed in the tip and operable to generate heat; and

a control circuit operable to determine the temperature of the heating element while the heating element generates heat.

27. The system of claim 26 wherein the control circuit is operable to regulate the heat generated by the heating element.

28. The system of claim 26 wherein the control circuit is operable to sense the electrical current flowing through the heating element to determine the temperature of the heating element.

29. The system of claim 28 wherein the control circuit is operable to modify the current flowing through the heating element.

30. The system of claim 26 wherein the control circuit is operable to sense the voltage across the heating element to determine the temperature of the heating element.

31. The system of claim 30 wherein the control circuit is operable to modify the voltage across the heating element.

32. A method for heating a tip of an endodontic condenser, the method comprising:

powering an electrically resistive heating element of a heater to generate heat; and

determining the temperature of the heating element while the heating element generates heat.

33. The method of claim 32 wherein determining the temperature of the heating element includes determining the electrical resistance of the heating element.

34. The method of claim 33 wherein determining the electrical resistance of the heating element includes sensing electrical current flowing through the heating element.

35. The method of claim 34 wherein sensing electrical current flowing through the heating element includes sensing a magnetic field generated by the flow of current through the heating element.

36. The method of claim 33 wherein determining the electrical resistance of the heating element includes sensing a voltage across the heating element.

37. The method of claim 32 further comprising distributing heat generated by the heating element through a jacket of a body of the heater.

38. The method of claim 32 further comprising modifying the power to the heating element in response to the determined temperature of the heating element.

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