A pressure-responsive syringe (10) having electrodes (18) attached to an external electrical power supply (24). The electrodes (18) supply a low potential voltage of about 3 to 9 volts to an endogenously heateable composition (36) containing carbon fibers therewithin. The low voltage heats the composition by virtue of the carbon fibers to a temperature between 120 to 140°F to plastify the mass for filling a root canal of a patient.
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TITLE OF INVENTION: Root Canal Implant-Proximity Indicative-Delivery Means

RELATED U.S. APPLICATION DATA
This application is a continuation in part of application serial number 06/499,392 filed 05/31/83, concerning which, a Notice of Issuance has been received.

A Disclosure Document concerning this C.I.P. has been filed.

U.S. PATENT DOCUMENTS:
Herskovitz et al. Nov. 2, 1982 433/224
4,357,136  "Method for Filling a Root Canal"
3,265,618  Herskovitz et al. May 5, 1981 433/32
"Electrically heated endodontic syringe for "injecting thermoplastic material into "a root canal cavity"

OTHER PUBLICATIONS
"Chemical and Energy-Dispersive X-Ray Analyses of Gutta Percha Points" by Bengt Moller, D.D.S., Ph. D., and Dag Orstavlk, D.D.S., Ph. D., Vol, 10, #9, pages
Publication is appended.
Drawings: 5 figures on one sheet
Claims: 6.
BACKGROUND OF INVENTION

1. Field of the Invention

This invention is in the field of endodontic pressure syringes for delivering softened root canal implant material for obturating a properly prepared dental root canal cavity wherein the softened material is endogenously heatable by reason of conductive carbon fibers comprised within the implant composition.

2. Description of the Prior Art "Using Heat Method" Shilder Technique

A method commonly employed in dentistry for filling root canal cavities with gutta percha is to apply small amounts of gutta percha heated to thermoplastic form into the root canal cavity. A heated probe is then used to compact the warm soft material into the cavity using a "condensor." This is the method used in the parent case of which this is a continuation in part. The composition comprises carbon fibers and is proximity indicative. It was found that the composition being endogenously heatable by virtue of the carbon fibers therewithin could be heated by means of a potential applied to the composition itself, the potential being of very low voltage, and thus safe for the patient. To take advantage of the unique modality for heating the root canal material for implant, it was found that a pressure syringe could be used of unique functionality different from all the pressure syringes used in the prior art are exemplified in U.S. Patent 4357136-Herskovitz et al: "Electrically heated Endodontic Syringe For Injecting Thermoplastic Material into a Root Canal Cavity." These pressure syringes are similar to the old "glue guns" or "hot melt guns."
They are used in dispensing hot melt adhesive compositions in a heated state for building and home workshop projects. They are further described in the references cited against the two U.S. patents just mentioned. In these hot melt pressure syringes the composition is heated from the outside and attains a plastified heated condition by the previous application of external heat supplied by the heating elements outside of the composition which lies in the barrel of the syringe. The heat is conducted from the outside of the mass. In the herein invented dental syringe the mass attains a heated plastified state endogenously and the heat is generated in every part of the mass endogenously. This is possible because of the unique proximity indicative feature. Proximity indicative feature is occasioned by the presence of carbon fibers in the novel endogenously heatable mass. A typical mass used in the syringes of the prior art is exemplified in the x-ray analyses of all the root canal points used in the major countries of the world. These analyses are given in the learned publication "Journal of Endodontics" Sept. 1984, Vol. 10, #9, pages 423 to 416. It is entitled, "Chemical and Energy Dispersive X-ray analyses of Gutta Percha Points" by Bengt Moller, D.D.S., Ph.D., and Dag Orstavik, D.D.S., Ph.D. Not a single analysis disclosed the presence of carbon fibers.

Indeed the presence of carbon fibers in an endodontic root canal implant composition only became known after its invention in the parent case of this C.I.P. The discovery of a pressure syringe as herein disclosed became thusly possible. This syringe provides the
modality of endogenous heating.

There is contained in the invented syringe two electrical contacting members separated from each other by the interposed novel endogenously heatable dental composition of gutta percha and carbon fibers. When electricity flows through the mass, the carbon fibers heat up and conduct the heat to the gutta percha which is intimately admixed therethrough.

The "hot melt glue guns" of the prior art deliver a hot, tissue searing extrudate into the dental cavity. The syringe herein provided delivers a low temperature highly plastified extrudate at a temperature low enough (about 135 F.) to safely fill any root canal cavity even those in dilacerated teeth. The endogenously heated obturation material is of course proximity indicative as shown in the parent case of this C.I.P.

The syringes of the prior art relying on externally applied heat outside of the barrel to heat the composition within the barrel are engineered to overheat the composition from the outside. By the time the entire mass within the barrel has been raised to thermoplastic flow capability, the mass within the barrel is at the threshold of heat degradation. Antioxidants and plasticizers are added to the compositions for use in the pressure syringes of the prior art and it is a matter for concern if these additives will depart from the known composition and long term use-approved gutta percha compositions as for example given in the analyses just quoted. The improved syringe with endogenous heating capability in contact with an endogenously heatable mass uses conventional time tested formulas long used in dentistry and having only the additive of
carbon fibers as the novel feature.

The novelty of the invention resides in the fact that a syringe is provided for injecting parent-case composition into the root canal while the composition is being endogenously heated by the application of an electric current to produce a resistance heating of the endogenously heatable composition.

An electrical current of low voltage lies along the path of the issuing hot thermoplastic (gutta percha) material. A preheating section may be placed within the barrel of the syringe in which the heating is by conventional conducted heat as in the conventional syringes of the prior art. The purpose is to slightly soften the rod-like thermoplastic composition in order to just start the response to pressure from the plunger of the syringe, after which the endogenous heating operation continues with the further heating and softening of the mass to the delivery plasticity. Conventional external heating of the barrel is only necessary for pre-softening. This, however, may be eliminated from the design by pre-softening in a water bath or oven. This pre-softening easily can be achieved in the pre-softening baths the dentist now uses to pre-soften carpules or hydrocolloid impression material.

In one modification of the invention, we find that it is possible to heat the composition within the very lumen of the needle in the region of the ultimate final delivery end of the syringe. Here parallel conductors are placed within the very bore of the needle. A low voltage is supplied to the pair of conductors. The preheated and softened mass emerging from the
barrel and into the needle section is in an endogenously heated condition.

Where the lumen of the needle is extremely small as in a 30 gauge needle, it is not possible to place two parallel conductors within the bore itself. Therefore, in a case such as this, we provide the modification wherein the metal needle is itself one terminal of the electrical power supply, the other terminal of the power supply is placed at the outlet of the barrel protruding into the bore of the needle at the proximal end thereof, and spatially disposed in noncontacing mode with reference to the wall of the needle. This modification permits the use of a conventional metal needle as is well known with the disposable needles used in medicine. The disposable needle with the unused gutta percha carbon fiber composition may be discarded after use. It would be impossible to clean the lumen of the needle for re-use and it would be economical to dispose of it. This is an economy and a convenience impossible of attainment with the "hot melt glue gun" type of syringe in the current art.

The entire syringe with this endogenous heating capability can be discarded after use and this is not possible with the "hot melt glue gun" type of syringe which costs several hundred dollars as witness the "Obtura" gun marketed by Bristol-Myers and the Pak 60 gun marketed by the Whaledent Division of Ipco Corp., and the dental syringe marketed by the Hygienic Rubber Co. of Akron, Ohio.

**DESCRIPTION OF THE DRAWINGS**

There are Five Figures on one Page.
Fig. 1:
Perspective view of the syringe having barrel 14 which is provided with a conventional pre-heating section at the proximal (top) end. There is a power source 24 on the outside of the syringe to provide current from source 26 for the preheating section and source 26 for the endogenous heating modality of the endogenously heatable gutta percha root canal composition. At the end of the barrel and leading into the delivery end of the syringe (12). There are two conductors 18 spaced from each other and parallel to each other. However, parallel placement is not the essential configuration just as long as the conductors are spaced from each other and do not touch, resulting in a short circuit. The conductors are powered by a low voltage electrical current supplied from the terminals 20 which are themselves connected to the main power source (26). The endogenously heated endodontic filling material (32) while exiting from the distal end (32) passes alongside the two conductors (18) which provide the electrical voltage to heat up the composition by virtue of the carbon fibers in the mass. The mass is heated right down to the distal end of the syringe and the fluidity is controlled by the variation of the impressed voltage. The syringe delivers the mass heated for dental filling purposes but not overheated as in conventional syringes. Conventional syringes which heat from the outside of the mass must resort to overheating in order to heat up the cross sectional areas (inner areas) of the slab (rod) of conventional gutta percha composition. The controlled heating within the mass itself right down to the very exit of
the syringe is the feature of this invention which is not found in the prior art. The plunger of the syringe is shown as 16. It is for applying manual pressure by depressing it down into the barrel of the syringe. However, other pressure means such as by air actuated plungers may be used to give the dentist the desired measure of control for the surgical procedure.

Fig. 2:

This is a cross-sectional view of the invented syringe (10). It shows a conventional preheating section (14) having resistance heating element (34) as in a conventional syringe used in endodontics. However, the sole purpose of this preheating section of the barrel (14) is to preplasify the mass.

It can be eliminated from the syringe especially if the syringe is to be disposable. Because the slight pre-plastification needed can be supplied by an external water bath from which the slightly softened mass can be inserted into the barrel of the syringe.

Conventional heating is not the heating means. The heating means is endogenous heating of the mass itself with the barrel or within the nozzle or within the lumen of the needle itself.

Nozzle section is numbered (12): within the nozzle (12) there are two electrodes (18) opposite polarity. The finished product, heated endogenously is shown as (320 seen emerging from the nozzle (12). The extruded product (32) can be placed at the proximal end of the prepared root canal cavity and condensed within the cavity. Where a finer stream of composition is desired the composition is further moved along a disposable needle affixed at the end of the nozzle (12) as shown in the figure 5 which will follow.
the composition is further moved along a disposable needle affixed at the end of the nozzle (12) as shown in the figure 5 which will follow.

Fig. 3:
This is a cross sectional view along the line 3-3 of figure 2. It shows the nozzle section (12) having the two electrodes 918) protruding within the path of the composition. Electrodes (18) are partially embedded in the wall of the nozzle and partially exposed to the path of the oncoming root canal mass.

Fig. 4:
This is a cross sectional view along the line 4-4 of figure 2. The inner lining of the barrel 35 is surrounded by the insulated heating element (34). The barrel of the syringe is shown as the external wall 14. This modality of preheating as shown in figure 4 is not part of the process or the invention. It merely serves to point out an expedient that could be used for preheating the mass very slightly so it yields to the pressure of the plunger. It is not the means for heating to injectable plasticity, which function is by the endogenous heating process herein invested. Minimal preheating for the convenience of starting the plunger can be achieved by preheating in a water-bath, and oven, or any way that heat can be applied.

Fig. 5:
This is the preferred modality for delivery of an endogenously heatable injectable mass. It shows a disposable needle 40 attached to the end of the barrel 12 attachment might be the conventional "luer" fitting or
fitting within the bore of the needle (40). (36) represents the endogenously heatable mass in the end of the barrel section. The body of the needle itself is the second electrode, the first being as explained, the trochar type electrode (42).

The mode of operation is thusly described:

The rod-like preform of the endodontic mass is pre-softerned. It is inserted into the barrel of the syringe. The plunger exerts pressure to extrude the material. As the material progresses towards the distal end of the apparatus, it is forced past bare electrical conductors which apply an electrical current through the mass. This brings into function the endogenous capability of the invested endodontic composition. By this function the entire mass is heated, not from the outside to the inside but through and intimately therewithin, as soon as power flows from one terminal to another within the mass.

SUMMARY OF THE INVENTION

The dental syringe of this invention is the delivery means for an endogenously heatable root canal implant material. The endogenously heatable root canal implant material is comprised of thermoplastic resin can be in a single rod to fit inside the barrel of the syringe. Or it can be in the form of many individual "points" which will be bundled or tamped down into the barrel. Or it could be pelletized into pellet form familiar to extrusion technology. Or it could be in comminuted powdered from to be handled as a free flowing powder for feeding into the barrel of the novel syringe. The endogenously heatable composition is of
the exxence. The physical form in which it is served to the syringe is a matter of convenience. In com-
minuting the material into powder form it is advisable to use cryogenic grinding since the thermoplastic mass will, if heated in grinding, tend to stick together or "block" in storage or use the composition produced by the machinery in example (9)(b) is preferred and the manufacturing process is economical.

EXAMPLES
Example #1

A thermoplastic resin is coated onto Carbon Fiber Tow. The thermoplastic resin is gutta percha. The tow is "Celion" Carbon Fiber K 3000 made by the Celenese Corp., New YOrk, NY. K 3000 signifies that there are 3000 filaments in the strand of tow. The gutta percha is pressure-extruded on the strand of tow using a short barrel 15:1 rubber extruder heated 200 F. - 225 F. - 250 F., the last heat being at the die. Upon cooling the carbon fiber tow is compacted and bonded into a thin rod-shape about 0.013" in diameter. This rod, coated as described, is used as a root canal implant for narrow root canals.

When inserted into the prepared and evacuated root canal, the distal end when it touches the apex of the tooth will show a conductivity of 40 (gutta percha) and carbon fibers. The composition for delivery by the subject syringe is any form or size capable of being accommodated within the barrel of a syringe as con-
templated.

The manufacture of feed stock for the syringe is described. Essentially, it is in rod form. Rod form is the most common shape of the barrel of the syringe,
and its interior chamber. The endogenously heatable compositions are described more particularly as being in size suitable for conventional use irrespective of the syringe. The reason is that many points could be pushed into the barrel of the syringe and thus many different sizes of rods need not be made and stocked. Furthermore, the individual points can be sold to dentists who do not have the practice sufficient to warrant the purchase of a syringe. With an extensive practice a dentist can afford a syringe as described herein.

Therefore, in all the following compositions and in all the compositions as formulated, the dimensional restriction does not apply.

All manner of incorporated carbon fiber with gutta percha or similar described thermoplastic resin will be pertinent. The formulations should not be restricted to the specific examples of the ingredients or the mixing procedure or the methods or incorporated the resin and the fibers into a proximity indicating root canal implant material. There are many varieties of carbon fiber, and many formulation equivalents for all the components used. These equivalents being well known to and within the armamentarium of the formulating chemist or technician.

The formulation of the following examples can be used in any way and any form desired for a feed-stock for the novel syringe, the material micro-amps and will indicate to the dentist that optimal intrusion has been reached. At this point, heat is applied to either end to soften the entire implant and cause it to thermoadhesively bond to and into the root canal. Meter
readings will be different for different sets of conditions.

EXAMPLE #2.

The tow of example #1 is strip-coated using a strip-coating or "wire coating" die in a four heat-zoned 20:1 barrel. The coating does not completely imbed itself around each fiber but is concentrated on the outside surface. The coated tow, when cooled will be a roe-shaped material, about 0.016" in diameter. The ends of the rod make better electrical contact at the apical end of the root canal. The rod is cut into 1.5 inch lengths for root canal implants. Apical indication is at 40 micro-amps approx. Implant is then heated and caused to flow into and bond into the root canal. Heating may be by conventional means or by use of the endogenous heating capability of the implant as here disclosed said heating continuing at any stage of implantation.

EXAMPLE #3.

This was a repeat of example #1 except that the Gutta Percha was compounded with a filler in a particulate form.

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<th>Component</th>
<th>Grams</th>
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<td>GUTTA PERCHA:</td>
<td>100</td>
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<tr>
<td>Zinc Oxide, Lead-free</td>
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<tr>
<td>Inert Color e.g. Red oxide Color (Fe2O3)</td>
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<tr>
<td>Tio2</td>
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Extruder temperatures were increased 5 degrees F in the first and second zones and by 10 degrees F in the final zone.

EXAMPLE #4.

This is an improvement on example #3, in that the
particulate filler is highly radio-opaque in comparison with the other ingredients. His Bismuth oxychloride was used.

GUTTA PERCHA: 100 grams
BISMUTH OXYCHLORIDE 25 grams
Zinc Oxide, lead free 25 grams
Inert color (e.g., FE203) 3 grams

Extruder conditions are the same as example #3. Virgin stock is preferred here, because re-cycled or re-worked scrap showed a tendency to develop non-uniform coloration in the finished gutta percha point.

EXAMPLE #5

This is an improvement deriving form and pertaining to examples 1, 2, 3, 4, and succeeding examples where carbon fiber is used. It is the achieving of greater radio-opacity of the carbon fiber component by plating said fibers with a metal.

CARBON FIBER (Tow) of example 1 -
one length

Metallized carbon fiber tow - 
one length

The lengths are placed alongside each other in any configuration. Thus, one length may lie alongside the other and parallel thereto either contiguously or spaced therefrom. The disposition of the lengths may not only be in parallel fashion. They could be twisted together: intertwined; braided, or one length could be served with the other. The measurement of "one length" signifies that the filament content of the tow can be widely different whether it be the graphite fiber tow or the radio-opaque metallized carbon fiber tow. The more carbon fibers the more radiolucent, the more
metallized carbon fibers, the more radio-opaque, and their relative proportions may vary from 0.5 to 99.5% and vice versa. In example that was specifically used as a benchmark we used an exact 1:1 ratio, there being 3,000 filaments in the length of carbon fiber tow, and the same filamentary composition of the same denier was used:

For the graphite fiber: CELIONr 3000 K carbon sold by Celanese Corp., New York, NY

For the metallized carbon fiber: CORE FIBER was CELIONr 3,000 K METAL PLATING was nickel. Silver also was used, and is preferred in this dental use.

CHARACTERISTICS OF METAL PLATING:
Coating is 0.5 microns thick.
Coating is 50% of total fiber weight.

While the metallized fibers are more radio-opaque than the carbon fibers, due to the higher position of the metals in the atomic table, compared with carbon, we found that the electrical conductivity of the root canal implant was improved. A comparative tabulation is as follows:

ELECTRICAL CONDUCTIVITY
Fiber | Ohms/cm | Ohms/1000 strands/cm
Gold coated fiber was also used, and this is the most radio-opaque. However, the metal coating can be of any metal cation, with the obvious exclusion of toxic metals and/or radioactive metals, and/or physiologically unacceptable metals, taboo for oral use.

**EXAMPLE #6.**

This concerns the use of gutta percha from solvent suspension.

- Gutta percha: 100 grams
- Toluene: 200 grams
- Methylene Dichloride: 200 grams
- Aceton (or other ketone): 200 grams

Heat, mix and dissolve. Use closed mixer in standard fire-proof techniques. The gutta percha lacquer is coated onto tow; in this case, the same tow used in example 1, namely Celionr Carbon Fiber 3000 K. The tow is coated in the manner of a wire-enamelling machine, slightly modified, modification mainly designed to minimize abrasion of the fibers during handling. The first dip into the lacquer achieves compact rod-form bundling. The second and subsequent dips + sizings will built up the coating so that the final root canal implant conforms to the dimensions used in dentistry namely: (these are the popular sizes)

- Gutta percha "point" #15
- Gutta percha "point" #20
- Gutta percha "point" #25
- Gutta percha "point" #35
In this example and its modifications, the carbon fiber tow may be of any number of filaments, from 100 through 12,000 per strand of tow. Furthermore, the tow coated may be a composite of unmodified carbon fibers and metal-plated carbon fibers, as explained in example #6.

EXAMPLE #7.

The solids material used in solution-coating of example #6 comprises particulate material: for 100 grams gutta percha substitute:

<table>
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<tr>
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<th>Amount</th>
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<tr>
<td>Gutta percha</td>
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<tr>
<td>Zinc oxide</td>
<td>25 grams</td>
</tr>
<tr>
<td>Inert color</td>
<td>2 grams</td>
</tr>
<tr>
<td>TiO₂</td>
<td>1 gram</td>
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EXAMPLE #8.

The solids material used in solution coating of example #6 comprises particulate material of non-conductive material and particulate material of conductive material. Particulate conductive material may be used with or without other particulate materials. Particulate material with conductivity is selected from conductive carbon black particles which may be either of furnace black, channel black, lamp black, or of graphitic fibers, singly or in any combination.

For the graphitic fibrous particles, the source is carbon fiber chopped to a small size. Representative materials being:

a. "THORNEL"r of the Union Carbine Corp., Chicago, IL 60606 (fiber chopped to 0.040".)

b. "MAGMAMITE"r of the Hercules Corp., Wilmington, DE, USA. Fiber marked "MAGMAMITE"r also a
trademark of the Hercules Corp. Grade used was 1800/AS chopped 0.250". These relatively long fiber particles had the unusual result of making a better root canal implant composition than the pulverized chopped "Thornel"r which had a length of 0.040. The probable reason is that the "Magmamite"r ⅛" fibers broke down during compounding to a satisfactory size, but in so doing, did it in a manner that maintained high conductivity, again postulating or surmising a reason that the slow separation of the fibers did not permit immediate encapsulation by the insulating gutta percha.

The coating formula thus is representative of other coating formulations and comprises: (for its solids component)

**FORMULA 8-1**

- Gutta percha: 50 grams
- Carbon fiber particles: 10 grams

**FORMULA 8-2**

- Gutta percha: 50 grams
- Acetylene Black (conductive): 20 grams

**FORMULA 8-3**

- Solids of formula 8-1: 50 grams
- Solids of formula 8-2: 50 grams

**TOTAL** 100 grams

NOTE: The proportion of 8-1 and 8-2 may vary with reference to each other from 1:100 down to 100:1. Fillers known in the art may be readily
added, e.g., ZnO; TiO₂ Fe₃O₄ (black conductive) Fe₂O₃ (red iron oxide), to the limit of the cohesiveness and shape retentivity of the final gutta percha implant, and responsive to the extrudability limits of the herin invented syringe.

EXAMPLE #9.

A straight-through extrusion process is used as an alternative to the coating of longitudinal carbon fibers, which are not used here. The much cheaper and more easy to handle chopped carbon fibers are used. The chopped carbon fibers are described in example #8 above. A compound is devised as follows suitable for extrusion into strands or calendering into sheets or for pelletizing into a molding compound suitable for injection molding or for compression molding.

- Gutta percha: 100 grams
- Chopped carbon fiber: 5 - 300 grams
- Zinc oxide, lead free: 50 - 75 grams
- Inert fillers for color: 5 grams

Compounding is effected on a 6" x 12" rubber and plastics mill made by Reliable Machinery Co. in New Jersey. The back roll is faster than the front roll. The rolls are heated to 180 degrees F. The gutta percha is thrown onto the mill, the fillers added gradually and the heat on the rolls being maintained to about 250 degrees F. Adiabatic (frictional) heat generates the additional heat. Use scraper blade to strip off the highly sticky mass. Rolls are closed 0.010", cooled and the compound is then easily cut off and stripped from the mill roll. Right after stripping, the sheets are placed in a multiple platen
slab cooler to cool down into a smooth flat sheet. The compounds with the high percentage of carbon fiber to polymer are used in heavy cross section root canal implants. Furthermore, the subsequent processing of the compound will diminish the electrical conductivity until the final desired mechanical shape is fabricated. Where much grinding and shredding and mechanical shear is exerted as in extrusion, it is necessary to use the higher percentage carbon fiber compound. The final products are thusly fabricated:

a. By rolling. This is the ancient method of producing the shape referred to in example #6, where the sizes are given. The flat sheet produced by this example is slit into fine ribbons, about 0.050" wide. A ribbon is immersed into hot water (160 degrees F), stretched and rolled between the fingers, or through the opening section of a rolling machine. The rolling machine, which may or may not be proprietary is fairly simple. There are two belts, one over the other and tensioned one over the other. One belt moves faster than the other and this differential speed produces a rubbing action which rolls the strip into a rod shape.

b. By extruding. A one-inch vertical extruder is mounted over a tank of cooling water under the surface of which is a conveyor belt. The gutta percha compound is extruded through a spaghetti die as strands. These strands when cooled are dried by a cool air jet and chopped into 1½" lengths. A Foster-Allen Chopper is preferred
from the many in the field. The vertical extruder is made by Killion in New Jersey. It is electrically heated and thermostatically controlled in the heating zones and in the die-head.

c. By Injection Molding: The compound is chopped and fed into the hopper of the injection molding machine. Cooling time is necessary for a period longer than the conventional polyolefin and usual injection molding compounds, because in the case of this compound it is essential that the material be cooled from the hot state where it is sticky and amorphous, to the cool state when it becomes crystalline and hard. The phase change must take place before the molded point is stripped from the mold.

d. By Compression Molding: Press at 250 degrees F until the mold halves close. Cool underconfinement and remove. Heating is for the shortest time possible. With steam at 100 p.s.i. heating took 15 seconds. Mold was aluminum. Cooling with water at 55 degrees F took 3 minutes. Press was 9" x 12".

EXAMPLE #10.

This improved root canal implant has a dual functionality. It retains its rod-form shape and stiffness while in contact with the environs of the apical end of the root-canal and continuously indicates the location and proximity of the apex, even after the gutta percha is being softened and forced into intimate contact with the interior of the canal, with the action
of heat and pressure from the dental compactor. After the filling and compacting process is on the way to completion, the distal end will begin to soften and fill the convoluted minute channels and passageways at the apical end. It retains its electrical proximity sensitivity almost to the end of the operation. To achieve this the central core consisting of carbon fiber filaments is given a priming coat of a resin solution applied and dried thereon. The priming coat of a resin solution applied and dried thereon. The priming coat comprises a resin which softens at a temperature higher than the enveloping gutta percha compound.

A suitable priming resin is gum Copal which has a long history of acceptance as an endodontic material. This priming resin is designed to melt after the gutta percha around it melts, and amalgamate with the gutta percha when both are hot. If they are not compatible, as for example when the priming coat is made of collodion, there will be no amalgamation with the gutta percha. Separation and exfoliation will take place. The Copal core is completely compatible with the gutta percha. There are other resins which will achieve this dual-functionality root canal implant. Preferred resins are: (amongst others)

a. Polyterpenes, m.p. 100 degrees C. "PICCOlyte"
b. Hydrocarbon Resins- "PICCOpale" 85 (85 degrees C.) "Piccoalyte" and Piccopale are trade marks of the Neville Co., Pittsburgh PA.

Around the prime coated special purpose functionality-oriented Carbon fiber tow, are added coatings of a softer (135F to 160F) gutta percha. The
root canal implant will retain its shape when heated and pushed into the root canal. While the outside Gutta integument is soft, amorphous, thermoadhesive and flowing into the inner rugosities of the canal, the central fiber bundle is shape retentive. The dentist pushes it into the region of the apex, and the position is readable because of the conductivity of the still-intact bundle of fibers. Simultaneously, and "pari passu" the outside gutta percha has achieved softness and adhesion, thermoadhesively, to the inside of the canal at the proximal end of the invented 'point,' and the heat is about the reach towards and soften the distal end. Then the distal end will reach its destination and be adhered in the apical area. The heating process amalgamates the inside stiff prime coating on the Carbon fibers with the outside Gutta Percha, and the entire implant will have been sealed in its cavity. The significant proximity-indicating aspect of this modification is that the distal end will not get soft till the near-termination of the operation, and therefore will not fold over upon itself, blocking further progress of the "point" towards the increasingly narrowing channels at the approaches to the apex.

This example of the root canal implant may be referred to as the dual thermoplasticity implant, the thermoplasticity of the binder at the binder on the outside layers.

As a variation it is possible to use the same thermoplastic resin, but in two formulations. The first formulation is made by adding plasticizer to the first formulation; for example:
Binder for the central core carbon fibers: gutta percha binder for the outer part: gutta percha 100 parts with cerasin wax 10 parts, as plasticizer.

EXAMPLE #11.

This is a modification of example #10. The binder around the central core fiber bundle resists heat softening as compared with the outer gutta percha, but this is achieved in a different fashion, by using a binder that is not a thermoplastic resin. Said binder is an inorganic cement, namely cement such as zinc oxide-eugenol. The central core thusly bonded will permit intrusion into the root-canal because of its comparative rigidity under heating event past the temperature at which the outer gutta percha has achieved softening and heat flow under pressure. However the rigidity of the central fiber core is easily destroyed by additional pressure from the dental instrument applied during the penultimate stages of the operation. The formulation thus will be:

Binder for the central fiber core: ZnO-Eugenol
Binder for the outer section: Gutta Percha.

EXAMPLE #12.

In this example conductive carbon fibers are thermaoadhesively impressed into any gutta percha point as continuous filaments extending from proximal end to distal end and on the outside surface of the point. The outside surface need not be completely enveloped by these longitudinal carbon fibers. A few filaments and theoretically a single filament affording contact with an electrical terminal at each end of the point and along its entire length will be sufficient. In
practice, and due to difficult conditions of handling these fine filaments, about 10 to 1,000 filaments are used.

EXAMPLE #13.

A gutta percha point of conventional construction, as is commonly used in dentistry, is the starting material. Around this point is wrapped carbon fiber filaments in spiral fashion, serving as a conductive jacket all around the point. The wrapping is adhered into the outer surface of the point. This jacketed point will conduct electricity from distal end to proximal end and will thusly have the apical proximity indicating feature claimed in this invention.

EXAMPLE #14.

One hundred percent solids dental resin in liquid form (curable) 100 grams.

Chopped carbon fiber, see example #8: 5 to 50 grams

Chopped metal plated carbon fiber: (as x-ray opacifier 2-25 grams.) A thermoplastic point is not used. Instead the fluid composition above is injected into the root canal with mild hydraulic pressure, and is converted into its final solid condition by heat or by accelerator of the polymerization reaction. What is referred to here as 100% solid resin is a trade term signifying that it is not a lacquer with a large proportion of liquid volatile solvents which evaporate and leave a void in their place. In dentistry, acrylic monomers, beta stage polymers, and other curable fluids are used capable of change from a fluid state to a solid state. One such system, also based on acrylic beta stage resins appears in Chemical Week, Aug
and consisted of "HYDRON" resin, made by National Patent Development Corp., New York, NY. X-ray photos must still be considered necessary — see column 3 of the work cited — because there is no proximity indicating attribute in the filling material. In this example a dental casting resin is rendered proximity indicating by conversion into a composite comprising conducting carbon fibers, for the purpose of filling a root canal.

EXAMPLE #15.

In this embodiment a precuror sheet is made, and from it the finished points are chopped and rolled to size.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutta percha</td>
<td>100 grams</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>5 - 75 grams</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.5 grams</td>
</tr>
<tr>
<td>Inert color</td>
<td>1 - 5 grams</td>
</tr>
</tbody>
</table>

Composition is compounded on a rubber mill or in a Banbury or in a Masticator, or in a "MILLSTRUDER". A Millstruderr is a combination machine which is able to mix a compound in its mixing section and discharge it through a milling section between two mill rolls which press down and size the material as a sheet the width of the mill rolls. Clearance between the rolls determines the thickness of the sheet. The sheet is cooled and pressed flat. The thickness for the most desired finished points should be 0.010", as the thickness of the precursor sheet.

At this state, carbon fiber filaments are laminated or otherwise adhered to the surface of the sheet as threads running mostly in the warp direction. As a modification, cover sheet of gutta percha is laminated
or adhered to the top of the laminated fiber sheet thus creating a sandwich of carbon fiber threads between plies of gutta percha. The carbon fibers may be laminated in any direction or even incorporated as random fibers, and not confined to a warp direction. Either the sandwich of carbon fibers or the single ply lamination is then cut into strips the width of the desired gutta percha point size, and rolled into rod form if desired as in example #9. The points made in this way have uninterrupted electrical conductivity of the conductive carbon fibers from distal to proximal ends and are proximity indicative in functionality.

EXPLANATION OF THE EXAMPLES

A new dentistry has been created, of advantage to the patient. Root canal filling technology has been rendered expeditious, less costly, and with a minimum of x-ray exposure to the patient. Conductivity of the root canal implant is the enabling means. Reviewing the technique of root canal preparation, the dentist during instrumentation of the canal must know when to stop sort of the apex. Step by step he enlarges the canal with a metal wire having cutting edges, (a "file") which also gauges and visualizes and is visualized by x-ray in the tooth as to its progression and location and depth. Repeated x-rays of the file in the tooth are exposed during progression towards the apex. The file being metal is also used to indicate electrical readings which are translated to apical proximity readings. However, it cannot go all the way in a dilacerated tooth, in most cases. Therefore the "file" cannot act as proximity indicator in such cases, locating the apex. It cannot act as a flexible
sinuously proceeding conductor like the root canal implant herein specified in these specifications. It cannot be left in place. It cannot be heat-softened and adhered and condensed into the root canal, to be left in situ as a permanent root canal implant.

Present point has all these modalities available to it. The electrical values attained at the conclusion of the insertion and close to the apex is approximately 40 microamps, for the file or for a silver wire point. The same meter gives the same values for the conductive point herein invested. One measuring device is called "FORMATRON" made by Parkell in New York. A better device is made by Amadent Corp. in Pennsylvania. Other methods of electric sensing and depth measurement are by means of eddy currents or by capacitance, and proximity to the apex can be measured by the very point which will later be heat-sealed into the canal. Instead of a metal "file," as stated, a silver point may be used for proximity indication in the same way as metal file or the specified invented root canal implant is used. Silver wiper point may indeed be left in the canal as a point and used in a manner similar to a gutta percha point. There is a defect inherent to the silver point however. It cannot be heat-sealed in place. Objections may be catalogued thus:

Objection #1: The silver root canal implant is not thermoplastic nor is it thermoadhesive. It cannot be softened in the canal.

Objection #2: The silver root canal implant will not make intimate contact with the inside of the root canal cavity, and therefore will permit the flow of bacteria past it and into the region of the apex.
Therefore the silver implant ("wire") must be cemented into place.

Objection #3: A cement, or dentally accepted zinc oxide-eugenol is used, but is not efficacious because it does not lute the silver intimately to cementitious paste, and again fissures, cracks, passageways will form between the silver point and its peripheries and the rugosities of the root canal in which it has been cemented.

Objection #4: The silver point cannot be drilled out for a metal post preparation where indicated conditions for post exist.

Objection #5: The silver point is subject to galvanic corrosion in the electrolytic ambience of the oral cavity.

THE COMPARATIVE ADVANTAGES OF THE INVENTED POINT AGAINST SILVER

In answer to objection #1:
Invested point is thermoplastic and thermoadhesive. It can be softened to an adherable condition to bond to the inside cavities of the canal.

In answer to objection #2:
Invested root canal implant makes intimate adhesive contact with the irregular surface configuration of the canal. No bacteria can flow past it.

In answer to objection #3:
Invested point is highly conforming and heat-adherable. An interface of an incompatible cement is not needed. If zinc-oxide-eugenol paste is used as a lining of the cavity, the softened adherable implant of this invention will amalgamate with the exposed profile of the surface of the cement pushing it
strongly into the walls of the canal.

Heat-softening of the invented point is by conventional heating or by endogenous heating which occurs upon the application of external power. Silver points cannot be heated and if heated will serve no useful dental purpose. Silver is not thermoadhesive like a thermoplastic resin is.

In answer to objection #4:
Invested implant can indeed be drilled out for later post preparation. Drilling out is almost better and quicker than drilling conventional gutta percha points, due to the presence of carbon fibers.

In answer to objection #5:
The carbon fibers comprising invented root canal implant are not subject to galvanic corrosion. They are extremely chemically inert. They provide in addition a conductive ambience within the canal contiguous to the canal walls. This conductivity is true tissue conductivity from wall to wall, whereas the silver point, which is conductive per se, does not provide a complete conductive ambience due perhaps to corrosion, insulation of its outside surface by the luting cement. It is accepted that a conductive environment is tissue-friendly. Known gutta percha points are non-conductive. Present invented gutta percha point is conductive.

In Summary:
No dental implant in the endodontic root canal art provides the mechanical strength of the fibrous reinforcement, the fibers being inert chemically and biologically, the fibers being conductive, and the implant being proximity indicative when measured by
instruments known and readily available. It can be heated from end to end or sectionally in any sectional part. It can be heated by electrical resistance within the tooth during the operation or outside the tooth. It can be heated ultrasonically within the tooth during the operation.

Sources of carbon fiber:
Carbon fiber as used in this invention may be from any precursor base carbonaceous material, including polyacrylonitrile fibers: pitch, cellulose, coal. Composition of the fiber is not relevant as long as it has conductivity and chemical inertness.

Suppliers are:
Union Carbine Corp., Greenville, SC, trade name "Thornel"
Celanese Corp., RockHill, SC, trade name "Celion"
The Hercules Co., Magna, UT, trade name "Magnamite"
Toho Rayon Co., Japan (selling through Celanese Corp.)
Courtaulds Ltd., London, England
Dexter Corp., Windsor Locks, CT, Hysol Div., trade name "Grafal"

Gutta percha equivalents: for the purposes of this invention, use: gutta percha is the trans polymer of isoprene. It is a naturally occurring polymer, Palaquium Gutta. It analyzes as 90% hydro carbon for the best grade from Malaysia. An inferior grade is known as balata and is familiar in golf balls. It comes from a related tree in South America, Mimusops Balata.

Both gutta percha and balata may be used,
separately or mixed in any ratio, the higher the balata, the softer the mass.

*Synthetic gutta percha:* this is the trans polymer of isoprene and is a synthetic product. It is sold by Polysar Corp., Sarnia, Ontario, Canada under the trade name of "Trans Pip PP 301".

*Other thermoplastic binders for the conductive carbon fibers:*

1. Thermoplastic polymers of acrylic monomers, e.g., butyl methacrylate, isobutyl methacrylate, mixed methyl methacrylate polymers
2. Styrenic block polymers, such as SBS, SIS, S-hydrogenated-butadiene-S
3. Polyester thermoplastics, such as "Santoprene" sold by Monsanto Co., Akron, OH
4. Ethylene polymers and terpolymers

The precondition is thermoplasticity corresponding to the range of gutta percha to which dental techniques are adapted by ancient usage, and also freedom from physiological irritants. The contained carbon fiber in the finished thermoplastic implant being very chemically inert will not contribute to the catalytic break-down of the polymer, to reversion, to embrittlement and the like.
Claims

1. A pressure syringe comprising bare electrical contacting electrodes disposed within the barrel, anywhere from proximal end to distal end for electrically contacting material contained there within.

2. The syringe of Claim 1 wherein the nozzle end extends into a disposable needle as the end point, said needle comprising bare electrical contacts within the lumen.

3. The syringe of Claim 1 wherein contained material is a dental root canal implant comprising a unitary structure of thermoplastic resin and electrically conductive carbon fibers. Wherein said material is capable of conducting electricity for measuring the proximity of the implant to the apex of the root canal and for heating the thermoplastic resin.

4. A Dental syringe for applying a voltage to an endogenously heatable dental composition for root canal implant use.

5. A dental process for root canal therapy comprising:
   a. providing dental syringe capable of impressing an electrical voltage upon the contained endogenously heatable composition
   b. preparing the canal of a tooth
   c. extruding a root canal implant from syringe into root canal cavity, root canal implant
   d. comprising a thermoplastic resin and electrically conductive carbon fibers
e. impressing an electrical voltage upon the root canal implant material thereby heating it to a thermoplastic adhesiveness by heat generated in the fibers by the application of electrical energy

6. A disposable needle for dental use comprising an outer electrically conductive tube, adapted to co-act electrically with centrally disposed electrical conductor electrode wherein resistance heating is achieved within an endogenously heatable mass during its travel through the lumen to the distal end of the needle.
INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 3

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): A61C 5/04
U.S. Cl.: 433/90

II. FIELDS SEARCHED

Minimum Documentation Searched 6

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<td>U.S.</td>
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Documentation Searched other than Minimum Documentation to the extent that such Documents are Included in the Fields Searched 4

III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document, 14 with indication, where appropriate, of the relevant passages 17</th>
<th>Relevant to Claim No. 18</th>
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<tbody>
<tr>
<td>X</td>
<td>DE, C, 727,586 (SCHNEBEL) 06 NOVEMBER 1942 See page 2, lines 63-97</td>
<td>1, 3-4</td>
</tr>
<tr>
<td>X</td>
<td>US, A, 1,189,735 (QUINTIN) 04 JULY 1916 See page 1, lines 33-100 and page 2, lines 50-60</td>
<td>6</td>
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<tr>
<td>A</td>
<td>US, A, 4,265,618 (HEKS Kovitz) 05 MAY 1981 See entire document</td>
<td></td>
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* Special categories of cited documents: 15

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"A" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 1

27 AUGUST 1986

International Searching Authority 1

ISA/US

Date of Mailing of this International Search Report 3

11 SEP 1986

Signature of Authorized Officer 10

John W. Wilson

Form PCT/ISA/210 (second sheet) (May 1986)