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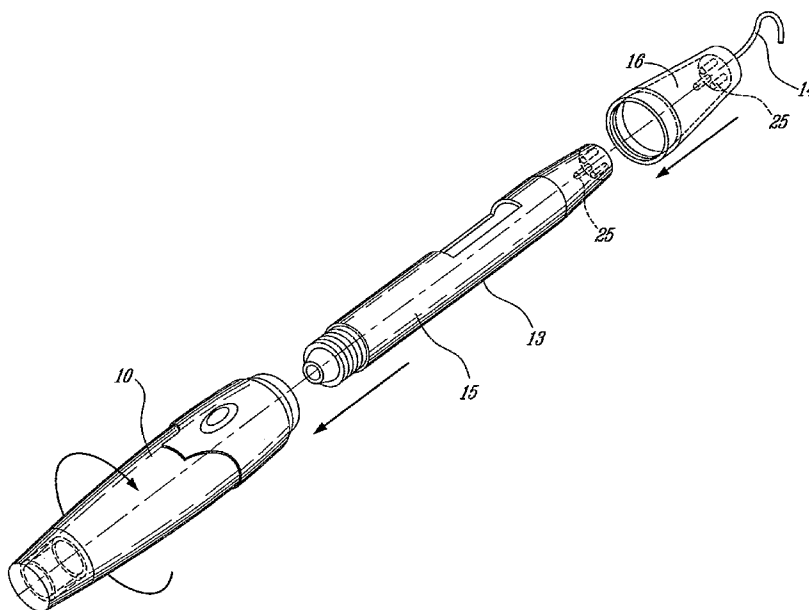
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(54) Title: APPARATUS AND METHOD FOR DETECTING DENTAL PATHOLOGIES



(57) Abstract: A diagnostic tool for detection of dental pathology is provided that functions as a self-contained, handheld unit. The tool includes a light probe and a housing within which are located an optical source, an optical detector, an analysis processor and a power source. The components within the housing are integrated on a support which is removable from the housing. The housing is in multiple pieces which may be connected together during operation, and disconnected to allow removal of the support. This allows for sterilization of the housing and light probe without the electrical components of the device.

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APPARATUS AND METHOD FOR DETECTING DENTAL PATHOLOGIES

FIELD OF THE INVENTION

The invention relates to devices for detecting dental pathology and more specifically to optical devices for detecting dental pathology.

5 CROSS-REFERENCE TO RELATED APPLICATIONS

This application takes priority from U.S. Provisional Patent Application Serial No. 60/805,661, filed June 23, 2006.

BACKGROUND OF THE INVENTION

10 There are various known methods that are used to detect the presence of dental caries, including visual and tactile investigations using the usual dental explorer. These methods and instruments have their limits and cannot detect dental caries reliably. X-ray investigation of teeth structure is also not reliable for detecting dental caries at the beginning of their formation in regions where a too
15 great superimposition of enamel is present on the X-ray film. These obstructing superimpositions of teeth structures are more typical for the occlusal aspect of the teeth, and when the angle between the teeth alignment and the X-ray irradiation axis induces superimposition. The X-ray evaluation technique also exposes the patient to potentially harmful radiations.

20 Transillumination is another technique used to detect dental caries. By irradiating visible light toward a tooth from an aspect (e.g. lingual) and by observing via another aspect (e.g. buccal) the transmitted light, the operator can sometimes confirm the diagnosis of dental caries by observing a luminosity contrast induced by a dental caries. This technique is not suitable for all dental
25 caries, especially for dental caries at their beginning phase. Recently, a viewing device has been developed to ease the viewing of transillumination of the teeth structure with the use of a camera.

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Other devices have been devised for the detection of dental caries using luminescence or fluorescence spectroscopy with variable efficiencies depending, amongst others, on the cleanliness of the tooth surface. When irradiated with one or more initial radiations at a specific wavelength, some tooth structures generate
5 a second radiation with a wavelength that is different from the initial radiations. The intensity and wavelength of such a second radiation is different for sound tooth structures from those for decayed tooth structures. See U.S. Pat. No. RE31,815, No. 4,479,499, No. 6,186,780, No. 6,102,704, No. 6,053,731, No. 6,135,774 and No. 5,306,144, and German Patent Publications No. DE-30 31
10 249-C2, No. DE-42 00 741-A1, No. DE-U1-93 17 984, No. DE-303 1249-C2 and No. DE-19541686-A1. However the fluorescence signal can be weak making detection difficult.

For instance, German Patent Publication No. DE-93 17 984-U discloses a device for the detection of dental caries using a light emission unit emitting
15 pulsed light beams and a detection unit being sensitive during a time interval delayed with respect to the emitted light pulse.

German Patent Publication No. DE-42 00 741-A1 and European Patent Publication No. EP-0 555 645-B1 describe a device for the detection of dental caries via a radiation source, working in a wavelength range from 360-500
20 nanometers and detecting filtered reflected radiation of wavelengths between 620 and 720 nanometers with respect to the presence or absence of dental caries.

German Patent Publication No. DE-297 04 185-U is directed to a device for the detection of caries, plaque or bacterial infections of teeth comprising an
25 emission/detection unit which has a plurality of individual emission fibers.

German Patent Publication No. DE-197 09 500-C1 teaches a method for the detection of dental caries, plaque or bacterial infections of teeth by comparing

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fluorescent light levels of different portions of a tooth in order to find those parts of the tooth which are most seriously affected by the caries.

German Patent Publication No. DE-297 05 934-U discloses a device for diagnosing tooth composition using a first light source as a detection light source
5 and a second light source as a therapeutic light source.

Electrical probes have also been developed for the detection of dental caries (U.S. Pat. No. 6,230,050) as well as ultrasonic-based detection systems.

International patent application WO03/094771 discloses a system for detection of dental caries that relies on the detection of reflected/transmitted infrared light.

10 Despite the availability of the above systems there is a need for improved detectors of dental caries and other dental pathologies.

SUMMARY OF THE INVENTION

In accordance with the present invention, a hand-held optical diagnostic
15 tool for detection of dental pathologies is provided that functions as a self-contained unit. The diagnostic tool can detect pathologies such as caries, tartar, plaque and the like using an optical signal. The signal penetrates, at least partially, a tooth structure, and the reflected or transmitted optical energy is indicative of structural details within the tooth.

20 In an exemplary embodiment of the invention, the diagnostic tool has an optical probe and a housing within which an optical source, an optical detector, an analysis processor and a power source are located. The electrical components, namely the optical source, optical detector, analysis processor and power source, are integrated on a support which is removably inserted in the
25 housing. To allow removal of the support, the housing has multiple portions, such as a proximal end and a distal end for a two-piece housing. The proximal and distal ends connect to each other with the support located inside to form a self-contained, handheld diagnostic tool.

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The optical source and optical detector may be adapted to generate and detect light, respectively, at two or more distinct wavelengths. Each of the optical source and optical detector may also be made up of one or more discrete components, such as an LED for the optical source and a photodiode for the
5 detector. The optical source couples an incident light beam of optical energy through one or more incident light ports, and the optical detector receives optical energy through one or more detection ports. In one variation, each of the incident light ports and detector ports may be dedicated to transmission or detection of a different wavelength range.

10 The light probe of the invention conducts light from the optical source to a tooth under examination, and conducts light from the tooth to the detector. The light probe may be connected to an adapter on a distal end of the housing, and may comprise optical fibers that transport the light. Different distal ends may also be used with the same proximal end, each being adapted to a different
15 dental pathology. Thus, the distal ends may be changed for performing a different type of examination. In such a case, a unique identifier may be included with each distal end.

The incident light ports and detection ports may have predetermined numerical apertures which may be adapted to control an amount and shape of
20 the incident light beam and the optical energy received by the detector. These ports may also be arranged so as to minimize overlapping between the incident light beam and the detected light. In one variation, an optically opaque divider may be provided between the incident light port and the detection port to prevent interaction between the incident light and the detected light. Optical couplers are
25 provided to couple the light source and the optical probe. The couplers may include a male portion and a female portion that are engaged when the proximal and distal ends of the housing are connected together.

The proximal end and the distal end of the housing may be manually connected together and separated. The connection may be, for example, a

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pressure fit, or may use a manually displaceable detent means. The ability to separate the housing portions and remove the support with the electrical components simplifies the task of sterilizing the tool. With the more sensitive support components removed, the light probe and the housing portions may be
5 placed in an autoclave, or may be chemically sterilized without risk to the tool.

The analysis processor also allows various functionality to the tool, including the ability to detect certain known pathologies and generate a signal indicative of their detection. The processor may also be used to initiate a "sleep" mode when the detected signal indicates that no examination is being performed.
10 In this mode, power to the optical source and detector is reduced. As the power source is typically a battery, this reduces unnecessary power consumption.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the present invention will become
15 apparent from the following detailed description, taken in combination with the appended drawings, in which:

Figure 1 is a perspective view of a dental pathology diagnostic tool according to the invention;

Figure 2 is a front view of a light probe of the diagnostic tool of Figure 1,
20 showing an optically opaque divider at the tip of the probe;

Figure 3 is a graphical representation of reflected light intensities for a diagnostic tool like that shown in Figure 1;

Figure 4 is an exploded perspective view of the diagnostic tool of Figure 1;
and

25 Figure 5 is a side view of the diagnostic tool of Figure 1 showing a proximal end, a support and a distal end.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention there is provided a diagnostic tool for detecting dental pathologies such as caries, residual caries, secondary
5 caries, plaque, tartar and the like. The operating principle of the device is the measurement of the reflection of an incident beam of light that is directed at a tooth region.

The diagnostic tool is a hand-held device that generally comprises within a housing one or more light sources, one or more light detectors, a power supply
10 and a processor for analyzing the detected light and generating an output indicative of the presence or absence of dental pathologies. The device is therefore self-contained.

An exemplary embodiment of the diagnostic tool is shown in Figure 1 and includes a housing comprising a proximal end 10 and a distal end 12. The distal
15 end comprises a light probe 14 and an adaptor 16, which can be removably connected to the distal end. The light probe 14 has incident light ports 18 and detector ports 20 through which the incident light from a light source exits and reflected/transmitted light is collected, respectively. Although the figure shows two incident light ports and two detector light ports, it will be appreciated that the
20 light probe may comprise any number of incident light ports and detector ports.

As will be further explained below, light can be propagated within the device through known optical components such as mirrors or optical fibers. In the embodiment of Figure 1, optical fibers are used, and optical coupling between the different parts of the device uses known optical couplers. The invention may
25 make use of an optical fiber or bundle of optical fibers similar, for example, to some of the optical fibers used for laser-based endodontic treatment. The optical coupling can also be provided by lens(es) and/or mirror(s) or any other material suitable for radiation transmission. It will be appreciated that filters can be used to select appropriate wavelengths or to filter out undesired wavelengths.

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In the exemplary embodiment, optical coupling between two parts of the device is provided with optical shielding to prevent cross-talk between channels as for example by using plugs. In one variation, the core diameter of the fibers can be chosen such that the light receiving end of a first fiber is larger than the
5 light exiting end of a second fiber to which the first fiber is coupled, thereby providing a greater cross-sectional area and ensuring that substantially all the light is captured and passed through the optical circuit.

The numerical apertures of the incident light port(s) and detection port(s) can be selected to control the amount of light that is injected on the surface of the
10 tooth and that is detected after reflection. The depth of the region being probed can be increased by selecting appropriate numerical apertures to increase the amount of light being injected. However the numerical apertures of the incident light port and the detection port should be chosen so as to avoid overlap of the incident and detected light. In the embodiment of Figure 1, the numerical
15 apertures are between 0.18 and 0.7.

To avoid the problem of light interference between the incident and detected light an optically opaque divider 22 (Figure 2) can be placed at the end of the light probe between the incident light ports and the detection ports. This divider 22 may be a permanent piece affixed to the end of the light probe and
20 may be, for example, molded plastic. The positioning of the divider 22 is such that the detection angle of the detection ports is limited in the direction of the divider, and such that any light emitted from the incident light ports at too sharp an angle is blocked by the divider.

Referring back to figure 1, the electronic components used for controlling
25 and analyzing light signals as well as the power source can be incorporated in a support 13 that can be removably inserted in the housing, preferably in the proximal end 10. The support 13 is a structure that can hold the desired components and, in the exemplary embodiment, it comprises a circuit board. The support 13 is made to be removable for ease of changing or sterilizing the

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housing, replacing parts and the like. Figures 4 and 5 show one favorable embodiment of the support 13. The electronic components are mounted to a circuit board that is located inside of a sleeve 15 that is shaped to fit within the proximal end 10 and the distal end 12 of the housing. The overall length of the sleeve is such that it may be completely contained by the two housing portions when they are connected together.

One particularly advantageous feature of the present invention is that all of the external surfaces may be sterilized without affecting the electrical components of the support 13. Thus, for example, the support 13 may be removed and the two housing portions 10, 12 placed in an autoclave. With all of the temperature sensitive elements of the tool being located with the support 13, the housing portions, along with the light probe 14, can thus be easily sterilized without damage to the tool. Moreover, as the support is completely contained within the housing portions, all surfaces that come in contact with the patient are sterilized. The sterilization of the housing (including the light probe) can also be effected by chemical sterilization, with the removable aspect of the support 13 providing the same advantages. In an alternative embodiment, the housing portions 10, 12 can be disposable. Since the more expensive components may be all located with support 13, this option may be desirable.

In the exemplary embodiment, the housing is detachable at the junction between the proximal and distal ends. As indicated above, the distal end comprises a light probe adapted to direct the light onto the surface of a tooth and to collect reflected/transmitted light. In the embodiment shown, the distal end comprises a probe having a generally curved shape which facilitates access to the teeth surfaces within the mouth so as to direct the incident light on a desired surface and to collect reflected light. The light probe 14 is attached and optically coupled to adaptor 16. The adaptor comprises optical components such as optical fibers and/or mirrors for directing the light, originating from the light source, to the probe and ultimately to the incident light ports. Likewise, the

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adaptor 16 has similar optical component for collecting the reflected/transmitted light and directing it to the optical detector.

As shown in Figures 4 and 5, optical connectors 25 are provided between adaptor 16 and support 13. The optical connectors may be any type of known connector and, in the embodiment shown, are plug and socket type connectors. The male portions of the connectors 25 are located in the adaptor 16, while the female portions reside with the support 13. When the support 13 is inserted into the adaptor 16, the male portions engage the female portions and align the light-carrying elements of the support and the adaptor. By assuring proper optical alignment, the connectors ensure a low degree of optical signal loss for the optical signals passing through the incident light and detection ports.

The source of light for the diagnostic tool may also take different forms and, for the present embodiment, is an electromagnetic radiation generator that can generate light within desired wavelength ranges of the UV-Visible-IR spectrum. The light source may therefore be made up of multiple sources that operate in different wavelength ranges and are coupled together to provide the different desired wavelength contributions. Filter(s) or other optical means can also be used to obtain the desired wavelength ranges. For example, visible light of around 630 nm wavelength can be combined with infrared radiation of around 860 nm wavelength. Examples of discrete components that may make up the light source include LEDs, laser-diodes, lasers, halogen lights, neon lights, or any other suitable type of radiation-emitting source. LEDs are used in the present embodiment due to their relatively low power operation and compact size. It will be appreciated that, regardless of the specific source components, the light intensity should be adjusted so as to avoid causing harm to the patient.

The detector may be any suitable detector such as a semiconductor detector (e.g., photodiode or LCD), or a photoresistor.

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In the exemplary embodiment, the detector and the light source are located with the support 13. This ensures that, if temperature-sensitive or chemically sensitive source and detector components are used, they will have been removed before any potentially destructive sterilization is applied to the housing components.

5 However, those skilled in the art will also recognize that the source and detector components could be located in the adaptor 16. In such a case, the components would have to be adequately sealed against the possibility of thermal or chemical degradation during a corresponding sterilization procedure, or a more surface specific sterilization process should be used.

10 The proximal and distal ends of the diagnostic tool are detachably connected together so as to provide proper alignment of the parts and, in particular, alignment of the optical components. In this respect, the support 13 may comprise one or more light sources and one or more detectors that are optically coupled to the adaptor. As such, the housing of the proximal end and
15 the support are adapted such as to properly align the support when it is inserted in the housing. Similarly the adaptor may be provided with proper connection guiding means to ensure proper connection to the support and the proximal end. As mentioned above, it is possible for the light source and/or the light detector to be located in the adaptor. In such a case, electrical coupling is provided between
20 the support and the adaptor to carry electrical signals to and from the electrical circuitry located at the support.

In the present embodiment, a positive connection is provided between the proximal and distal ends. That is, the two ends fit together snugly to form an integral tool. The connection may be of different types, such as a pressure fit or
25 a connection that uses a manually displaceable detent. The use of such a mechanism may also be such as to provide a signal to the user that the parts are properly connected. For example the distal end (through the adaptor) can be designed to "snap on" to the proximal end in a way that engages the detent and

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mechanism and correspondingly provides an audio and sensation signal to the user.

When a tooth structure is irradiated with an incident beam of light, the radiation is typically reflected in part from the structure surface and transmitted in part such that it penetrates the structure. Within the structure of the tooth, some or all of the penetrating radiation can be deviated and/or reflected. Depending of the composition and/or shape of the tooth, a specific wavelength may be reflected or transmitted differently than it would be when encountering a different structure. It will be appreciated that the intensity of the reflection also depends on the configuration of the injection and detection positions.

Thus the device relies on the measurement of the reflectance and/or transmittance properties of structures related to pathologies when these structures are irradiated with light of an appropriate wavelength such as visible or invisible ultra-violet (UV) or invisible infrared (IR) wavelength(s). The wavelength can be chosen as a function of the pathology. That is to say, the wavelength can provide specificity for the identification of the pathology. In this respect an analysis processor may be provided that automatically generates a signal that indicates the type of pathology that has been detected.

Light is brought to a region of a tooth by the light probe. In one embodiment of the invention the incident light is provided at two or more wavelengths. The reflected light is detected for each wavelength to provide measurements that are combined to derive values indicative of the presence of dental pathologies. For example, an infrared electromagnetic radiation of around 860 nm can be used alone or with an electromagnetic radiation of around 630 nm. Any other suitable wavelength or group of two or more wavelengths in the UV, visible or IR spectrum can be used.

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It will also be appreciated that a visible wavelength can be used to provide visual guidance to the user at the same time as providing optical data for the detection of pathologies.

When a plot of the intensity of reflected light at one wavelength vs. the intensity of reflected light at another wavelength is obtained, regions of the plot correspond to a reflection characteristic of a state of the region of the tooth from which the reflection originates. Thus the relationship between the reflections at different wavelengths provides values indicative of healthy or damaged tooth tissue. A schematic representation of a plot of the intensity of reflected light at two wavelengths is shown in Figure 3.

The processor can respond to detected signals in any of a number of desired ways. Since different pathologies have varying effects on the selected wavelengths, the response parameters will depend on the specific application, the incident wavelengths, as well as other factors surrounding the diagnostic tool and procedure. However, the comparison of reflections using two different wavelengths is a known technique, and may be used with a configuration like that of the present embodiment. The data collected by the processor may be stored for subsequent examination. In addition, when the signals detected have the characteristics of a pathology of interest, the processor may identify these characteristics and generate a signal to alert the user. The signal may be an audible signal, a visual signal, a tactile signal or combination thereof.

In one embodiment of the invention, the processor can also generate a signal upon detecting reflected light that is not from a tooth surface or, if there is absence of reflected/transmitted light, to activate an auto shutdown mechanism. That is, if a detected signal indicates that the diagnostic tool is not being used for tooth analysis, the system would enter a "sleep" mode, in which energy for the power source is economized. Such sleep systems are known, particularly with regard to data processors, and the specifics of their implementation is not discussed in detail herein. In one embodiment, the sleep mode may include

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reducing the intensity of the incident light while there is no signal or while the detected signal is from a surface other than that of a tooth, and returning the light to its normal intensity when a tooth surface is detected. It is also possible that the device be completely turned off when no tooth surface is detected for a
5 predetermined amount of time.

As mentioned, the diagnostic tool of the present embodiment is completely self-contained. As such, power is provided by one or more batteries. The battery or batteries can be removably inserted in the support 13. Alternatively, one or more rechargeable batteries may be permanently inserted in the support..

10 The probe and the adaptor of the device can be designed to detect a specific pathology. This can be achieved, for example, by providing the appropriate optical components (LEDs, filters etc.) to operate the device at one or more predetermined wavelengths. In addition, several interchangeable adaptors/probes (distal end) can be provided to provide different lengths or
15 shapes as may be desired. In this context, the distal end may be provided with a proper identifier. However, it will also be appreciated that a single adaptor/probe may be used to detect multiple pathologies.

When multiple (two or more) wavelengths are used simultaneously the detection can be performed by modulating the incident beam of light and
20 synchronizing the modulation with the detector to distinguish the reflected/transmitted light from the incident beam, from other sources of light and from noise. This method is sometimes called a "lock-in system". One advantage of the lock-in system is its sensitivity even with very weak levels of radiation. Alternatively, the different wavelengths can be discriminated by using an "on/off"
25 mechanism by which one wavelength is used at a time with the other wavelength(s) being switched off. The modulation and "on/off" techniques may also be used together. Notwithstanding these distinctions, those skilled in the art will understand that the same detector may be used for detecting the different wavelengths.

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The number of incident light ports 18 and detector ports 20 may be chosen according to a desired application. In the present embodiment, two incident light ports are shown along with two detection ports. Each port is dedicated to the emission or detection of a particular wavelength or range of wavelengths which may be achieved, for example, by using appropriate filters. This arrangement also enables the use of several wavelengths simultaneously without recourse to modulation or "on/off" mode. The system may also use just a single port for the detector, and the control of signal transmission may be used to keep the signals segregated. It may also be desirable, in such an instance, to use just a single incident light port, and to couple together the light from different sources, if more than one are used. The light from the different sources would thus share the same optical paths through the device.

To enhance the detection, it may be desirable to characterize the typical response radiation with regard to different regions (e.g., healthy tooth) in the mouth of some patients prior to beginning the examination of dental pathology. In such a way, a baseline signal can be established by obtaining measurements from the baseline region, such as from healthy tissue. It will be appreciated that the baseline signal can also be established under "laboratory" conditions and stored in a memory within the electronic components of the device.

The device of the present invention can also include some recalibration and/or self-testing functions. For example, if optical fibers are used, it is possible to verify if the fibers are too worn out to be efficiently used and should thus be replaced by testing the intensity of a reference light that is passed through the fibers. Other self-testing functions may include the verification of battery levels.

The analysis processor of the device may comprise or be connected to a programmed microprocessor or microcontroller, such as a digital signal processor (DSP) and peripheral integrated circuit elements.

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In particular processors such as DSPs provides flexibility to the device by enabling a variety of functionalities. For example, as the diagnostic tool may have the ability to detect which distal end is connected to the device. The unit may also have a "sleep" mode in which the power consumption is reduced. In
5 this mode, the DSP provides a pulse at regular intervals and, from the reflected light characteristics, determine whether the light is being directed at a tooth. the diagnostic tool may also have the ability to store data of an analysis so that it can be reviewed later at a workstation. Other possible variations include the ability to wirelessly communicate with a base station using a wireless transceiver
10 controlled by the DSP, the ability to change the analysis algorithm by upload to the device from a base station, and the like.

For performing data transfer, the present embodiment of the diagnostic tool includes the ability to connect to a network by any available means. Such means may include a direct cable connection, wireless connection, a connection
15 over a wide area network or a local area network, a connection over an intranet, a connection over the Internet, or a connection over any other distributed processing network or system. The invention can also comprise an archiving feature in which collected data is saved for later use, for example, in a computer that may be connected to the tool.

20 In the present embodiment, the size shape and form figure of the diagnostic tool are made to be ergonomic for the dental professional and the patient. In addition, the device is sized such that it fits in station used by dentists, for example, in a standard dental tool holder. In this way, the tool may be simply added to an existing group of dental tools without requiring any extensive
25 modification.

The diagnostic tool of the present invention may be used for treating an individual in need thereof by enabling a user to detect a pathology. An optical tool such as this is particularly useful for the detection of dental caries, tartar, plaque and the like. Once diagnosed, the dental professional may apply an

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appropriate treatment such as removing the decayed tooth matter or tartar and filling the tooth when the pathology is caries. During such a procedure, the also invention may be used to verify if the decayed matter or the tartar has been completely removed.

- 5 The invention may also be adapted to work with a three-dimensional (3D) dental map. In such a case, the tool can register the detection of a signal indicating the presence of a pathology with the three-dimensional location of the pathology. This can be achieved for example by registering the device with the dental map and displaying said map together with an indication of the location of
10 the pathology.

- While the invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modifications and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention
15 and including such departures from the present disclosures as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features herein before set forth, and as follows in the scope of the appended claims.

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CLAIMS

1. A dental pathology diagnostic tool for examining the structure of a tooth, the tool comprising:

a housing;

an optical source located within the housing for generating optical energy in a predetermined wavelength range;

an optical detector for detecting optical energy in a predetermined wavelength range and generating a signal indicative thereof;

an optical probe for conducting optical energy from the light source to the tooth and for conducting optical energy from the tooth to the light detector;

an analysis processor that receives the detector signal and analyzes it relative to predetermined signal characteristics indicative of dental pathology; and

a power source that provides power to each of the optical source, optical detector and analysis processor, wherein, during operation, the optical source, the optical detector, the optical probe, the analysis processor, the power source are all located within the housing and are all part of a self-contained, handheld unit.

2. The diagnostic tool as claimed in claim 1 wherein said analysis processor and power source are integrated on a support which is removably inserted in said housing.

3. The diagnostic tool as claimed in claim 1 wherein said optical source and optical detector are adapted to provide and detect light at two or more wavelengths.

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4. The diagnostic tool as claimed in claim 1 wherein said optical source couples an incident light beam of optical energy through one or more incident light ports and wherein said optical detector receives optical energy through one or more detection ports.
5. The diagnostic tool as claimed in claim 4 further comprising a plurality of incident light ports detection ports and wherein each port is dedicated to transmission or detection at a different wavelength range.
6. The diagnostic tool as claimed in any one of claims 1-5 wherein said housing comprises a distal end and a proximal end, and wherein said distal end comprises a light probe having a first end and a second end, said first end being optically connected to an adaptor that is capable of being connected to said proximal end.
7. The diagnostic tool as claimed in claim 1 wherein said optical source comprises a light emitting diode (LED).
8. The diagnostic tool as claimed in claim 7 wherein said LED is located in said adaptor.
9. The diagnostic tool as claimed in claim 1 wherein said detector comprises a photodiode.
10. The diagnostic tool as claimed in any one of claims 7-9 wherein the distal end is a first distal end and wherein the diagnostic tool comprises a plurality of interchangeable distal ends each adapted for detection of a different predetermined dental pathology.
11. The diagnostic tool as claimed in claim 10 further comprising an identifier for each distal end.

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12. The diagnostic tool as claimed in claim 4 wherein said incident light ports and detection ports have predetermined numerical apertures and wherein said apertures are adapted to control an amount and shape of the incident light beam and the optical energy received by the detector.

13. The diagnostic tool as claimed in claim 12 wherein the incident light ports and the detection ports are arranged so as to minimize overlapping between said incident light beam and said detected light.

14. The diagnostic tool as claimed in claim 12 or 13 wherein said numerical apertures are between 0.18 and 0.7.

15. The diagnostic tool as claimed in claim 6 wherein the incident light port and the detection port are located in the distal end.

16. The diagnostic tool as claimed in claim 15 wherein said incident light port and said detection port are separated by an optically opaque divider.

17. The diagnostic tool as claimed in claim 2 wherein said optical source comprises a light source located in said proximal end and wherein said proximal end and said distal end are optically coupled.

18. The diagnostic tool as claimed in claim 17 wherein said distal end and said proximal ends are optically coupled by optical couplers, portions of which are located at said distal end and at said support, respectively.

19. The diagnostic tool as claimed in claim 18 wherein said optical couplers each include a male portion and a female portion, and wherein the male and female portions of each coupler are engaged when the proximal and distal ends of the housing are connected together with the support located in the housing in proper alignment with the distal end.

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20. The diagnostic tool as claimed in claim 6 wherein said distal and said proximal ends of said housing are detachably connected.

21. The diagnostic tool as claimed in claim 20 wherein said distal end and said proximal end are adapted to generate a signal when connected together to indicate to a user that they are properly connected.

22. The diagnostic tool as claimed in claim 2 wherein optical source and the optical detector are integrated on the support.

23. The diagnostic tool as claimed in claim 22 wherein said housing is sterilizable and wherein the support may be removed from the housing prior to sterilizing.

24. The diagnostic tool as claimed in claim 1 wherein said housing is disposable.

25. The diagnostic tool as claimed in claim 6 wherein said light probe is characterized by a substantially curved shape to facilitate access to teeth surfaces within a mouth.

26. The diagnostic tool as claimed in claim 1 wherein said diagnostic tool is adapted to automatically detect a type of dental pathology and to provide an indication of its detection.

27. The diagnostic tool as claimed in claim 1 wherein said analysis processor controls power transfer from the power source to one or both of the optical source and optical detector, and wherein the analysis processor initiates a "sleep" mode in which power transfer from the power source to one or both of the optical source and optical detector is reduced when light is detected from a surface other than a tooth surface or when there is absence of detected signal.

28. The diagnostic tool according to Claim 27 wherein the "sleep" mode includes a reduction in activity by the analysis processor to further conserve energy.

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29. The diagnostic tool as claimed in claims 27 and 28 wherein said power transfer from the power source to one or both of the optical source and optical detector is automatically returned to normal when tooth surface is detected.

30. The diagnostic tool as claimed in claim 27 wherein said analysis processor can provide a signal to turn the diagnostic tool off after a predetermined amount of time without tooth surface signal detection.

31. The diagnostic tool as claimed in claim 26 wherein said signal indicative of presence of a dental pathology is selected from the group consisting of a sound signal, a light signal and a vibration signal.

32. The diagnostic tool as claimed in claim 1 wherein said power source is a battery that is replaceably inserted in said support.

33. The diagnostic tool as claimed in claim 1 wherein said power source is a rechargeable battery that is permanently inserted in said support.

34. A method for maintaining a dental pathology diagnostic tool for examining the structure of a tooth, wherein the diagnostic tool comprises an optical probe and a housing within which may be located an optical source, an optical detector, an analysis processor and a power source, and wherein said optical source, optical detector, analysis processor and power source are manually removable from the housing, the method comprising:

removing the optical source, optical detector, analysis processor and power source from the housing;

sterilizing the housing and the optical probe; and

replacing the optical source, optical detector, analysis processor and power source in the housing.

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35. The method as claimed in claim 34 further comprising a support with which the optical source, optical detector, analysis processor and power source are integrated, the support being removably locatable within the housing.

36. The method as claimed in claim 34 wherein the diagnostic tool is a self-contained handheld device.

37. The method as claimed in any of claims 34-36 wherein the housing has a plurality of sections that may be connected together, and wherein the sections are separated from one another to allow removal of the optical source, optical detector, analysis processor and power source.

38. The method as claimed in any of claims 34-36 wherein the sterilizing comprises sterilizing in an autoclave.

39. The method as claimed in any of claims 34-36 wherein the sterilizing comprises chemical sterilizing.

40. The method as claimed in claim 37 wherein said plurality of sections are held together by a pressure fit.

41. The method as claimed in claim 37 wherein said plurality of sections are held together by one or more manually displaceable detents.

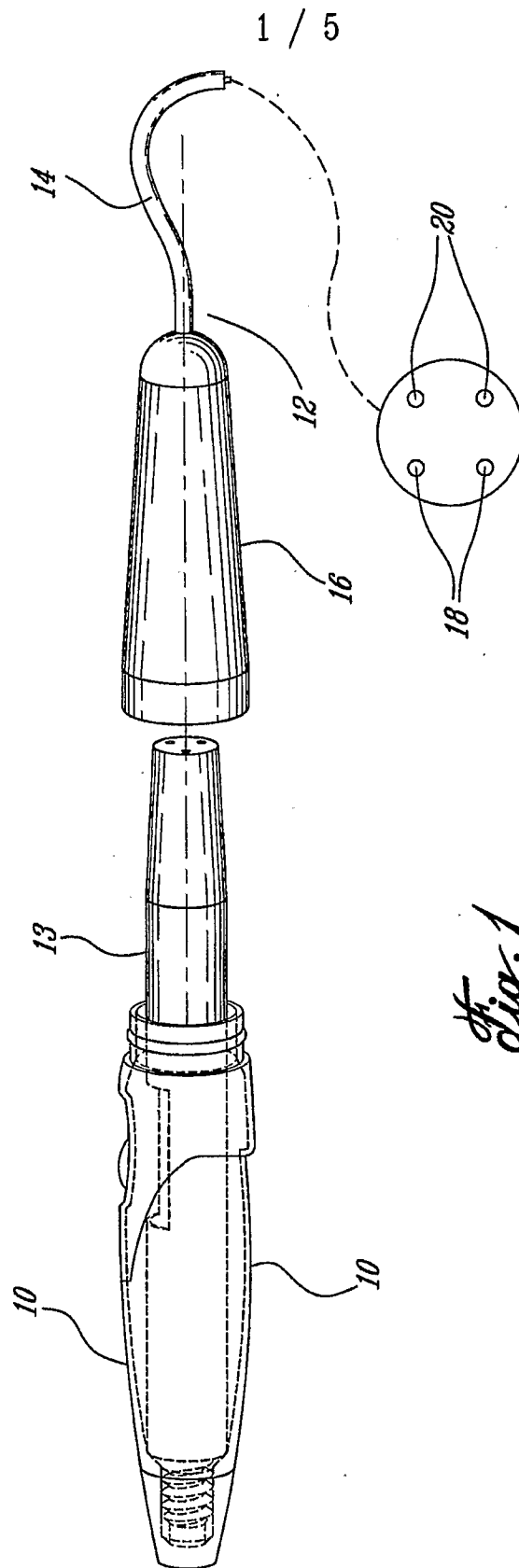


Fig. 1

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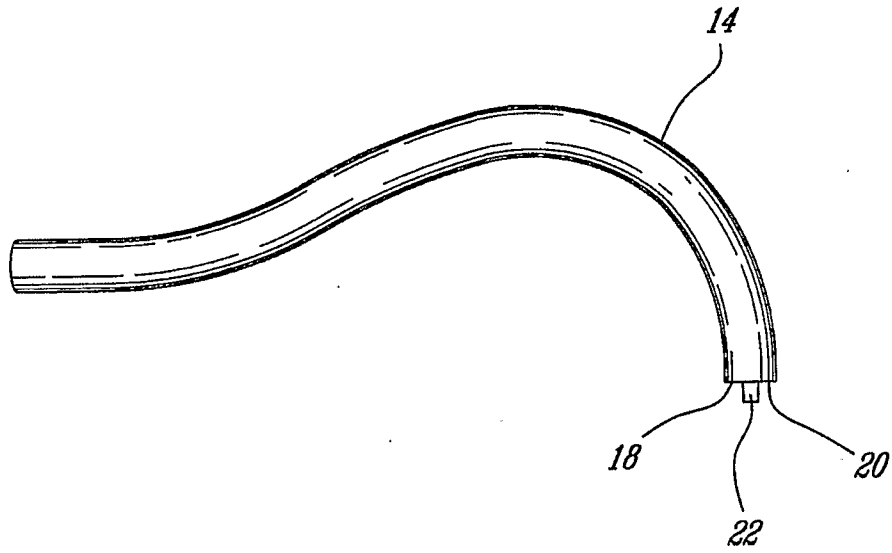


Fig. 2

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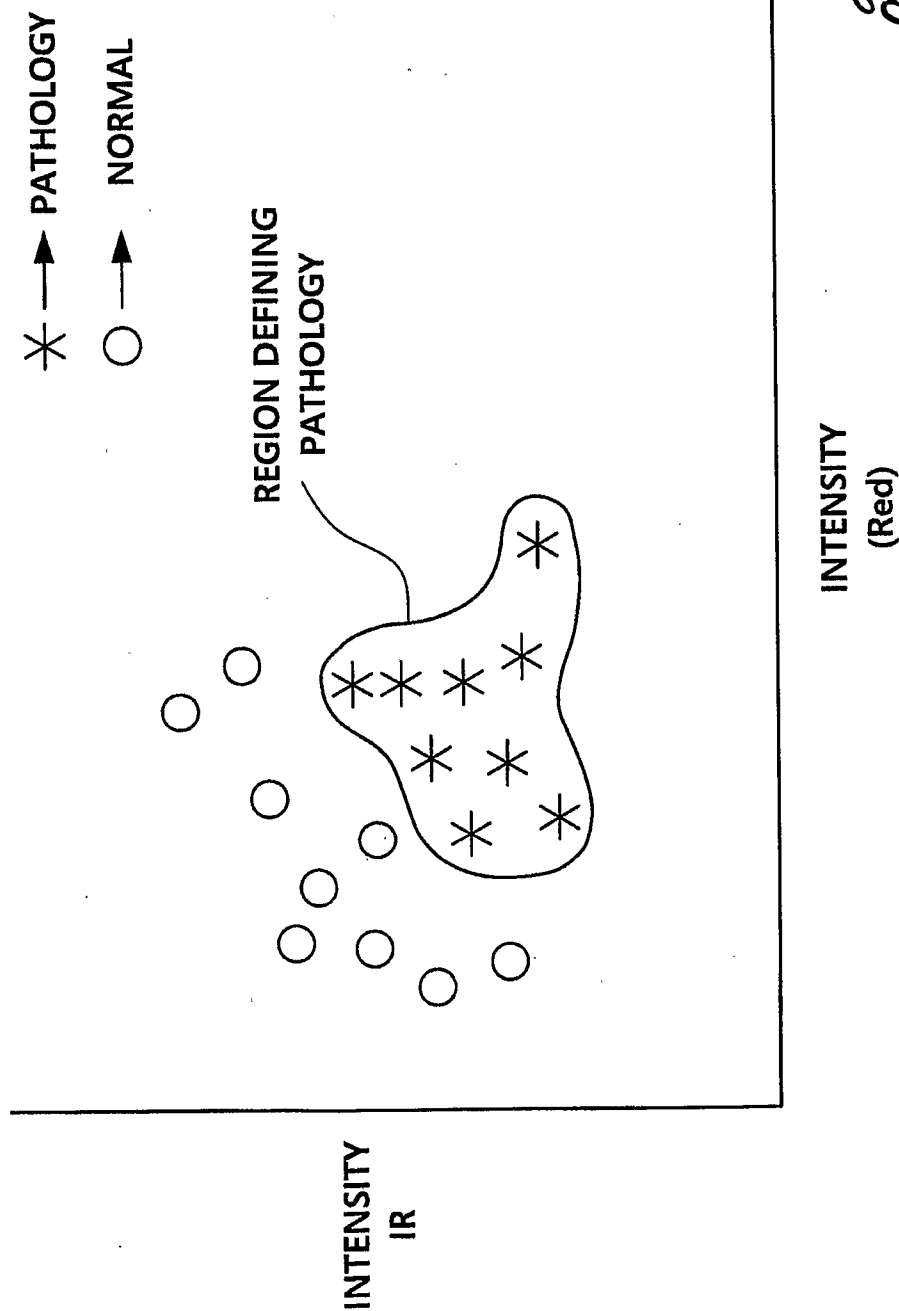


Fig. 3

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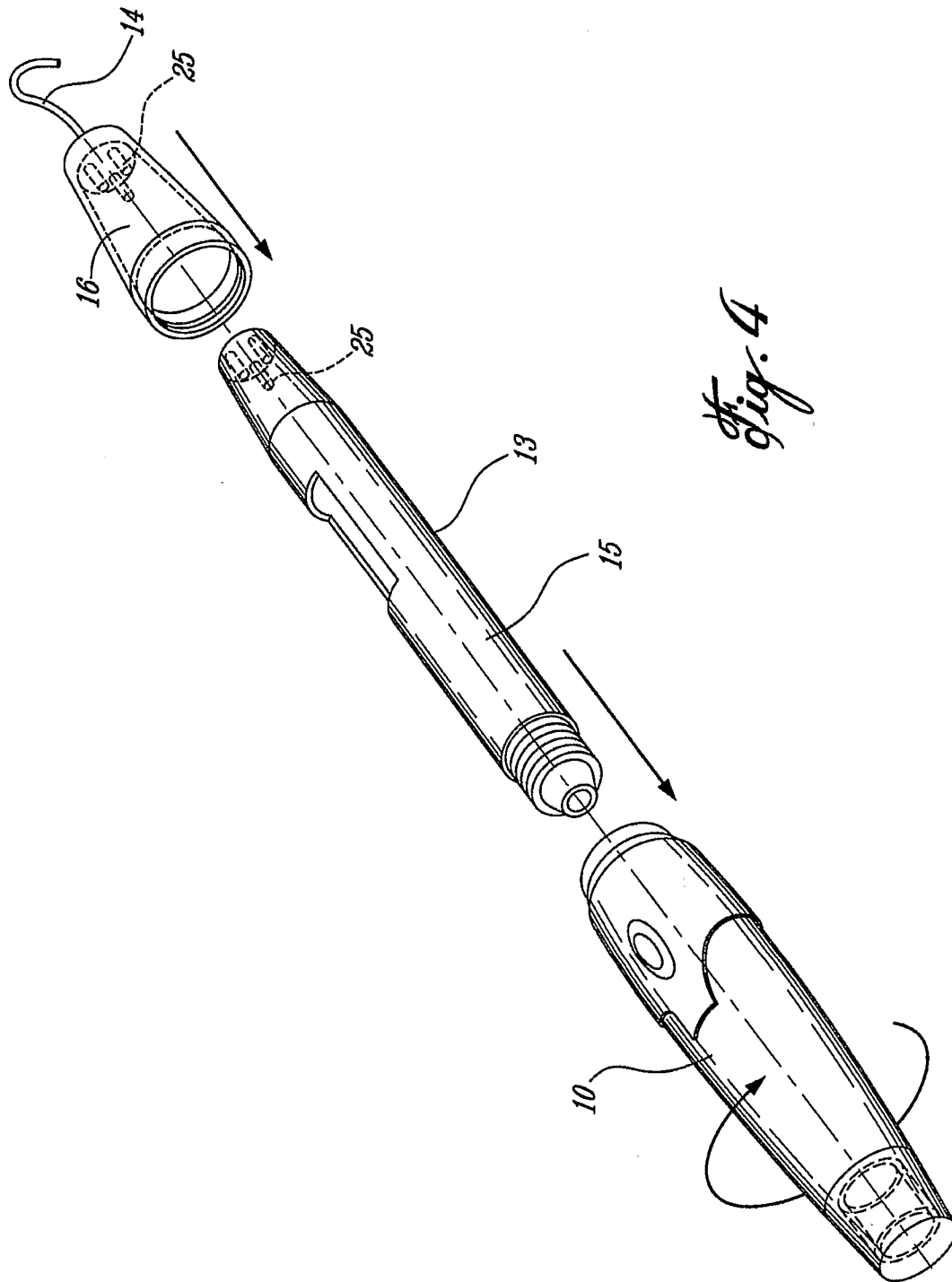


Fig. 4

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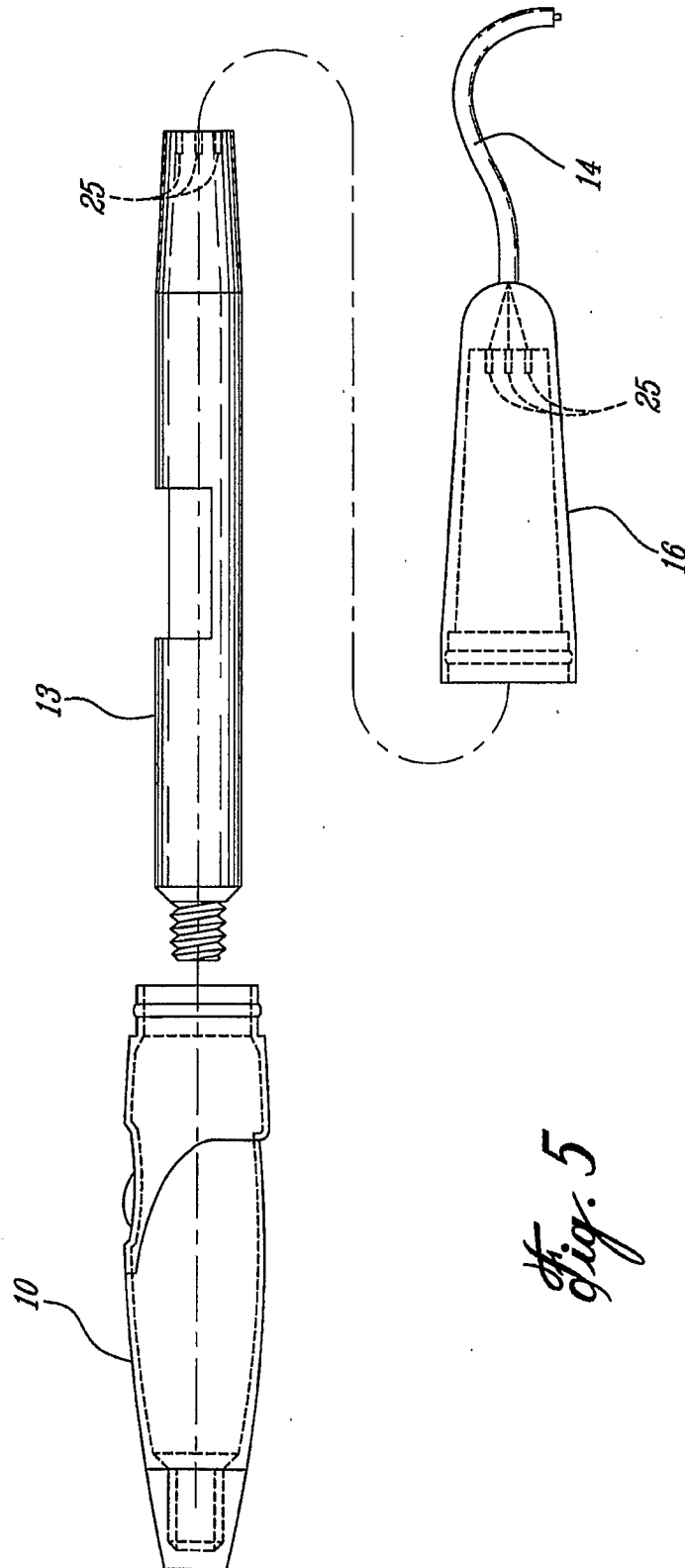


fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2007/001131

A. CLASSIFICATION OF SUBJECT MATTER IPC: A61B 6/14 (2006.01) , A61L 2/04 (2006.01) , A61L 2/16 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC																																			
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC: A61B (2006.01) (all subclasses) in combination with keywords Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Delphion, Canadian Patent Database, United States Patent Database, WEST, IEEE (keywords: dental, hand-held, optical, wavelength, removable, sterilize)																																			
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>US 2005/0255424 A1 (Hack et al.) 17 November 2005 (17-11-2005)</td> <td>1-6, 8-41</td> </tr> <tr> <td>Y</td> <td>* figures 1, 2a, 7, 17</td> <td>7</td> </tr> <tr> <td>Y</td> <td>* paragraph 39, 44, 52, 58-61, 65, 66, 67, 70, 78, 79</td> <td>7</td> </tr> <tr> <td>Y</td> <td>US 5,040,539 (Schmitt et al.) 20 August 1991 (20-08-1991)</td> <td>7</td> </tr> <tr> <td>Y</td> <td>* abstract</td> <td></td> </tr> <tr> <td>A</td> <td>US 6,179,611 B1 (Everett et al.) 30 January 2001 (30-01-2001)</td> <td>1-41</td> </tr> <tr> <td>A</td> <td>* figures 1, 2a</td> <td></td> </tr> <tr> <td>A</td> <td>* column 4, line 40</td> <td>1-41</td> </tr> <tr> <td>A</td> <td>US 5,570,182 (Nathel et al.) 29 October 1996 (29-10-1996)</td> <td></td> </tr> <tr> <td>A</td> <td>* see entire document</td> <td></td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 2005/0255424 A1 (Hack et al.) 17 November 2005 (17-11-2005)	1-6, 8-41	Y	* figures 1, 2a, 7, 17	7	Y	* paragraph 39, 44, 52, 58-61, 65, 66, 67, 70, 78, 79	7	Y	US 5,040,539 (Schmitt et al.) 20 August 1991 (20-08-1991)	7	Y	* abstract		A	US 6,179,611 B1 (Everett et al.) 30 January 2001 (30-01-2001)	1-41	A	* figures 1, 2a		A	* column 4, line 40	1-41	A	US 5,570,182 (Nathel et al.) 29 October 1996 (29-10-1996)		A	* see entire document	
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Date of the actual completion of the international search 2 October 2007 (02-10-2007)		Date of mailing of the international search report 12 October 2007 (12-10-2007)																																	
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2007/001131

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