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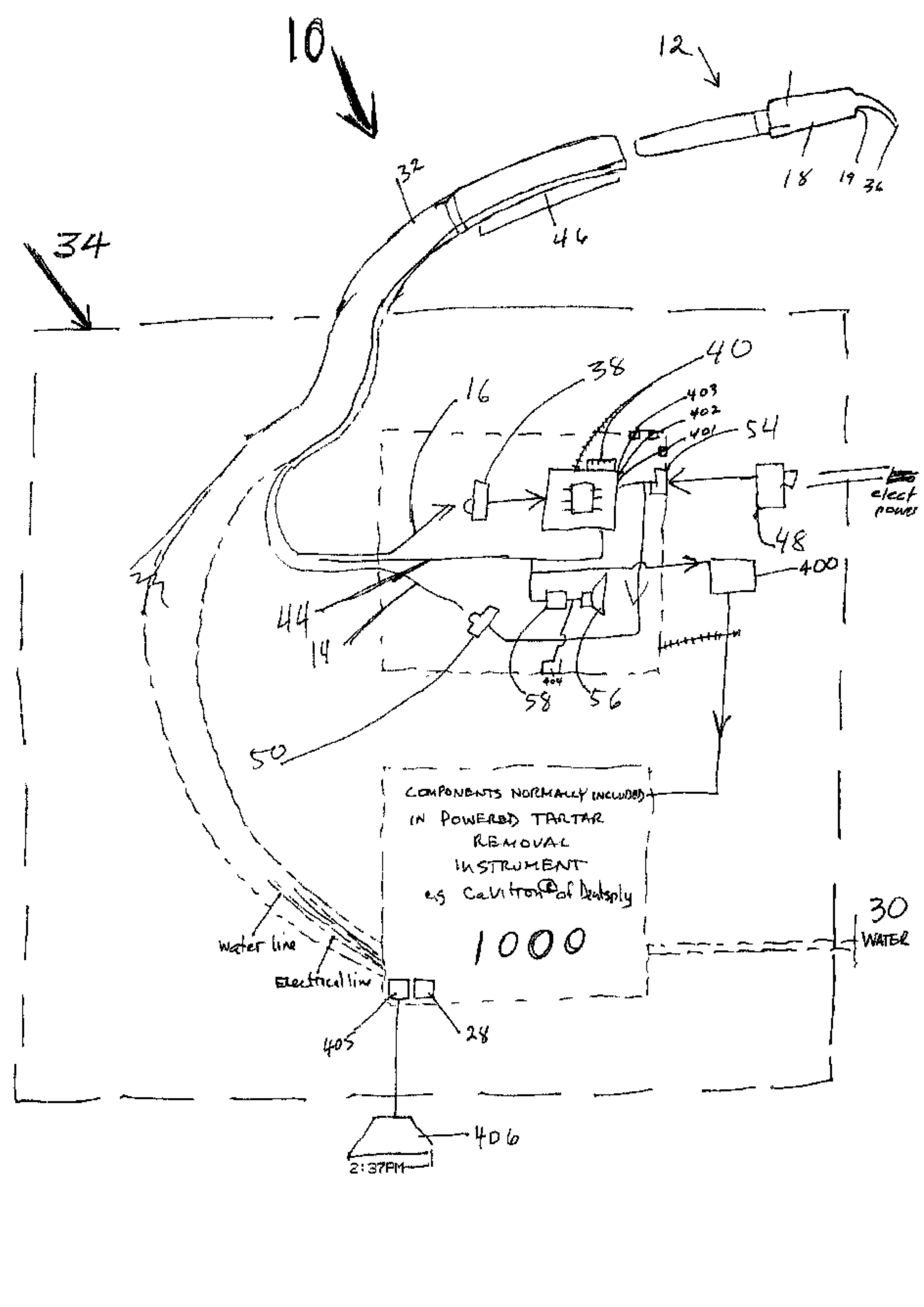
(54) Titre : SYSTEME ET METHODE DE DETECTION ET D'ELIMINATION DU TARTRE, P. EX. DU TARTRE SOUS-GINGIVAL

(54) Title: SYSTEM AND METHOD FOR DETECTION AND REMOVAL OF DENTAL TARTAR, E.G. SUBGINGIVAL TARTAR



SYSTEM AND METHOD FOR DETECTION AND REMOVAL OF DENTAL TARTAR, E.G. SUBGINGIVAL TARTAR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present relates to the detection of dental tartar and, more particularly, to the detection of subgingival tartar.

2. Description of the Prior Art

The removal of tartar, for instance with a scraper or a sonic or ultrasonic instrument, is important to prevent or to treat periodontal diseases, i.e. of tissues which surround the teeth, such as bone B, gums G, ligaments, etc. The tartar is calcified dental plaque that has accumulated on the tooth surface. Supergingival tartar and subgingival tartar S (see Figure 2) must be removed as tartar is a porous substance which contains bacteria and which favours the accumulation of these pathogenic bacteria on its structure.

In a healthy periodontium (see Figure 1) there is no periodontal pocket. However, when there is a periodontal disease (Figure 2), such a periodontal pocket P is formed by an inner surface of the gums 0 and by the root R of the tooth T and which is closed apically by the periodontal ligaments L. Subgingival tartar S can thus be found in this periodontal pocket P.

Therefore, to prevent periodontal problems 30 which can lead to severe health problems, it is important to remove tartar from the tooth surface as it is forming; on the other hand, the removal of tartar is done with difficulty and in a groping manner, subgingival tartar being normally invisible to the human eye in normal conditions as it is covered by the gums. To remove subgingival tartar (i.e. located behind the gum), the operator must try to locate tartar by tactile feeling using a probe, but one cannot actually view subgingival tartar to ensure a complete removal thereof without resorting to invasive surgical procedures.

The use of an endoscopic method and device for the removal of subgingival tartar is also known from U.S. Patents No. 5,230,621 and No. 5,326,365. In this system, an endoscopic probe is inserted in the gingival pocket or sulcus to endoscopically visualise the process of and/or effects of subgingival root planing, scaling or other plaque removal procedures carried out by other operative instruments. Alternatively, the endoscopic viewing apparatus may be incorporated in an operative instrument which itself is used to remove deposited material from subgingival tooth surfaces, whereby the operator may view and/or guide the instrument while using the plaque removal instrument itself. Therefore, the operator looks at a monitor that provides images of the endoscopic viewing and the operator detects the presence of subgingival tartar by looking at the monitor. This system is efficient, but somewhat cumbersome to use as the operator must stop looking into the mouth of the patient in order to look at the monitor. Moreover, this system is relatively expensive, as it requires a monitor and associated hardware.

Therefore, there is a need for a dental instrument which, using a tartar removal instrument or the like, can automatically detect the presence of subgingival tartar, which does not require the use of a monitor, and which allows the operator to concentrate on his/her task in the patients mouth by not having to look at a monitor and thus leave the patients mouth from his/her sight. Such an instrument would facilitate the operator's task of removing subgingival tartar by providing a system which assists the operator in the diagnostic while he/she is using a tartar removal instrument.

SUMMARY OF THE INVENTION

It is therefore an aim of the present invention to provide a novel system for the detection of dental tartar, including subgingival tartar.

It is also an aim of the present invention to provide a novel system for the detection of dental subgingival tartar that automatically detects the tartar based on its spectral reflectance characteristics (of which colour is a special case).

It is a further aim of the present invention to provide a system in which a visual, sound-based, or other, signal is given to the operator or to tartar removal apparatus (in this last case the signal would control the instrument) following detection of subgingival tartar, wherein this detection results from measurements made in the subgingival region and taken in one or more predetermined ranges of wavelengths that are appropriate for discriminating the spectral reflectance characteristics that constitute a signature of tartar presence.

Therefore, in accordance with the present invention, there is provided a dental tartar detection system, comprising a powered tartar removal instrument (e.g. ultrasonic scaler), illumination means for illuminating with an incident light a region on the tooth, detection means for collecting the light reflected thereat, and an analysing system for providing a signal to an operator of said tartar removal instrument or to the tartar removal instrument itself when measurements on the reflected light in one or more predetermined ranges of wavelengths fall within any first predetermined range of values that are characteristic of tartar, or when said measurements do not fall within any second predetermined range of values that are characteristic of artefacts other than tartar.

Also in accordance with the present invention, there is provided a method for removing dental tartar from teeth, comprising the steps of: (a) providing an incident light on a region of a tooth, (b) collecting and measuring reflected light from said region of the tooth; (c) analysing said reflected light to determine if said reflected light is representative of the presence of tartar; and (d) providing a signal to an operator of a tartar removal apparatus or to a tartar removal apparatus when presence of tartar has been detected in step (c).

Powered tartar removal instrument or tartar removal instrument may include sonicscaler, ultrasonic scaler, rotative scaler, piezo-electronic scaler, any hand currets (hand power) or any type of instrument suited for tartar removal by a dental operator.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration a preferred embodiment thereof, and in which:

Fig. 1a is a schematic vertical cross-sectional view of a tooth and its surrounding tissues;

Fig. 1 is an enlarged view of bubble 1-1 of Fig. 1a;

Fig. 2 is a schematic view similar to Fig. 1 but showing a periodontal pocket between the tooth's root and the gums, with subgingival tartar being shown lodged therein;

Fig. 3a and 3b are a schematic representation of tartar removal instrument with a system for the detection of dental tartar in accordance with the present invention;

Figs. 4 and 4a are schematic enlarged partial detailed views of the connector system of Fig. 3;

Fig. 4b is a schematic detailed view of some components of the casing of Fig. 3;

Fig. 5 is a view similar to Fig. 2 but showing the detection of subgingival tartar in the periodontal pocket using the system of the present invention; and

Figs. 6a, 6b and 6c are schematic views of three methods for combining a number of light beams and coupling them into one or more optical fibres.

Figs 7a, 7b and 7c are schematic views of three different method to combine fiber to the powered tartar removal instrument insert tip and different methods to enable a radial view at the distal end of the insert.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a system 10 for the automated detection of the presence of subgingival tartar S with a tartar removal instrument adapted to act as an endoscopic-like device using an optical method based on the spectral reflectance properties of tartar to discriminate the tartar present on the teeth from the healthy areas thereof, from the gums, from blood, and in fact from any artefact other than tartar that such tartar removal instrument may encounter when it is inserted between a tooth and the gums

More particularly, the system 10 comprises three main mechanisms, that is (1) a tartar removal instrument, (2) a casing containing optical components, light sources, and acquisition and signal processing electronics, as well as a water inlet capable of being connected to a water supply, all the components normally found in a powered tartar removal instrument (e.g. in a Cavitron®), and (3) a cable strand that includes optical fibres,, all the components normally found in a powered tartar removal instrument cable and which connects the tartar removal instrument insert to the casing.

Indeed, the system 10 comprises a powered tartar removal instrument insert, containing optical fibers and, more particularly, one or more illumination fibers 14 used for illuminating the subgingival region and one or more detection fibers 16 for receiving the light reflected by the tooth T for the subsequent determination of the spectral reflectance characteristics in this region. It is contemplated that a single optical fiber could be used for both illumination and detection functions. The powered tartar removal instrument insert has a curved pointy end section 60 with the illumination fibers 14 and detection fibers 16 being contained in the pointy end section 60 and extending up to an open free or distal end 36 thereof and having their respective distal ends thereat.

The powered tartar removal instrument insert includes a handle 10 fiber The powered tartar removal instrument insert also includes a connector on the proximal end of the handle 18. water injection on the subgingival region is carried out by the same system than in a powered tartar removal instrument the periodontal pocket P is irrigated in order to provide for further detection efficiency.

The irrigation system can be used without activating the powered tartar removal instrument contrary to conventional powered tartar removal instruments where the pedal simultaneously activate the irrigation system and the powered tartar removal instrument.

A cable strand 32 links the powered tartar removal instrument insert to an electronic system that is provided in a casing 34 which could have the shape and size of a powered tartar removal instrument casing which would be adapted to be connected to an outside power supply (unless the casing 34 may be powered with batteries placed in it) and to the water source 30 (that may be a portable reservoir integrated in the casing 34), thereby rendering the system 34 portable. The light propagated by distal sections of the illumination and detection fibers 14 and 16 in the powered tartar removal instrument insert is thus further conveyed to or from the casing 34 by proximal sections of these fibers 14 and 16 that are part of the cable strand 32. The cable strand 32 carries and protects the illumination and detection fibers 14 and 16 and the components normally found in a powered tartar removal instrument cable (which includes a water supply tube and electric power for the insert). The cable strand 32 is detachably connected to the connector provided at a proximal end 32 of the handle 18 of the powered tartar removal instrument insert so that the powered tartar removal instrument insert can be detached from the cable strand 32 for allowing the powered tartar removal instrument insert to be sent alone to an autoclave for its sterilisation. The powered tartar removal insert could also be of the single-use type and would thus be discarded instead of sterilised.

Each of the one or more illumination fibers 14 provided to illuminate the site (i.e. the periodontal pocket P) has one of its extremities facing a light source (which may be provided or not with an optical wavelength selective filter) and its other extremity at the distal free end 36 of the powered tartar removal instrument insert. Each such fiber 14 is interrupted (or sectioned) at the connector between the cable strand 32 and the powered tartar removal insert 12.

Each of the one or more detection fibers 16 (which may be the same one as that or those optical fibers 14 used for "**illuminating**" the periodontal pocket P) is used for receiving the reflected "**light**" (electromagnetic waves: UV, visible, IR…) coming from the periodontal site. Each such detection fiber 16 has one of its extremities at the distal end 36 of the powered tartar removal instrument insert and its other extremity facing a photodetector (or an electronic light transducer) 38 (which may or not comprise an optical wavelength selective filter) . Each such fiber 16 is interrupted (or sectioned) at the connector between the cable strand 32 and the powered tartar removal instrument insert.

This detector 38 is connected to an electronic system housed in the casing 34

At the detector or from the signal delivered by the detector, there may be an electronic or physical (optical) filtration system to remove from the received wavelengths those that results from non-tartar structures or that are not necessary for the detection and therefore enhance the significant signal.

The signal obtained after this filtering or directly from the detector without any filtering is then analysed by an electronic processor to determine whether tartar is present at the distal end 36 of the powered tartar removal insert 12 or not.

If tartar is detected, an indicator (luminous, sound, or any other means sensible by the operator) is actuated so that the operator is informed of the presence of tartar in the region being examined by the distal end of the powered tartar removal instrument. Simultaneously to inform the operator or without informing the operator the system could, when tartar is detected, power the tartar removal instrument by actuating the control box 400 easing the removal of the tartar at the distal end of the powered tartar removal instrument insert at that moment. For instance, the indicator can take the form of a luminous indicator 42 located on the powered tartar removal instrument insert to which light generated in the casing 34 is conveyed by one or more optical fibers 44 between the casing 34 and the handle 18 of the powered tartar removal insert 12 such as to terminate at the S indicator 42 provided on the handle 18, and such that the operator can see the light conveyed by the optical fibers 44 upon detection of tartar. Also, the luminous signal could come from a warning LED (light emitting diode) positioned on the handle 18 and electrically connected to a switch located in the casing 34 and triggered automatically upon detection of tartar

A connector 46 at the end of the cable strand 32 provides a detachable connection mechanism between the handle 18 of the powered tartar removal instrument insert and the cable strand 32 (see Figs. 4 and 4a) . The cable strand 32 is again a flexible sheath for the illumination and detection optical fiber(s) 14 and 16, the components normally found in a powered tartar removal instrument cable (which includes a water supply tube and electric power) and the optical fiber(s) 44 for the luminous indicator 42 on the powered tartar removal instrument insert, if any.

The casing 34 includes an electrical input power supply 48 (the power supply can be internal or external), one or more light sources 50 (halogen bulb, laser or diode) which may be or not filtered by an optical wavelength selective filter, the photodetector 38, an electronic processor (at least one transistor) and memory chip (or a set of resistances) with an input for an electronic card 40 (which could serve for example to store information or to transfer information to an electronic system [e.g. computer, printer…]) , or the like, an interrupter or switch 54, an button to activate the calibrating procedure of the instrument 401, one or more control(s) button for the adjustment of the detection sensitivity 402, one or more control(s) buttons for the calibration to the patient dental and periodontal characteristics 403, an interrupter to turn on/off the speaker 404, a speaker 56 with an amplifier 58 to emit sounds to warn the operator of the presence of tartar, an electronic/electric actuator to power the powered tartar removal instrument when tartar is detected (the intensity of the power may be controlled or not to be proportional to the intensity of signal corresponding to the tartar ; a high tartar signal would lead to a high power to the powered tartar removal instrument.

Therefore, the system 10 can transmit light having an appropriate spectral composition via the illumination fiber(s) 14 in the periodontal pocket and can retrieve the light reflected by the by the tissues and artefacts composing the periodontal pocket or present in that pocket via the detection fiber(s) 16 which may, or not, be distinct from the illumination fiber(s) 14. This reflected light is then detected by a photodetector present in the casing 34 such as to be analysed. Depending on how the spectral composition of the incident light is altered by the reflection thereof by the tissues and artefacts present in or composing the periodontal pocket, an algorithm allows to determine from the photodetector signal if the distal end 36 of the powered tartar removal instrument insert is against, or not, tartar. Therefore, if the spectral composition of the reflected light falls within the ranges previously determined for dental tartar, the algorithm sends a sensory signal to the operator and/or activates the powered tartar removal instrument, such as by actuating the luminous indicator 42 on the handle 18 via the optical fiber 44 which conveys light generated in the casing 34 to the indicator 42, although the signal could also be given in the form of sound, vibration, etc.

In figures 7a we can see four different ways of integrating fibers 14 and 16 inside the working end of the insert. In 500 the fibers are directly inserted in a hole inside the working end; in 501 a metal tube where the fibers are inserted is inserted inside the hole. Figure 7b shows possible means to enhance radial elimination and collection of light. Figure 7c shows different methods to attach fiber optics to the tartar removal instrument insert working end.

With reference particularly to Fig. 4b, the illumination fiber(s) 14 is (are) used to carry light from two LEDs 62 and 64, having different emission spectra and located in the casing 34, up to the distal end 36 of the powered tartar removal insert 12. The light emitted by the two LEDs 62 and 64 is coupled into the illumination fiber(s) 14 and, for this coupling, a dichroic mirror is used, also called a dichroic beamsplitter, as it is selective in wavelengths in transmitting light to pass within a range of wavelengths while reflecting light in another range of wavelengths. Such a dichroic mirror or dichroic beamsplitter is also called hot mirror or cold mirror, depending on the wavelength ranges for which the mirror is reflective or transmissive. A set of lenses in a **"Y"** configuration, or any suitable means, may also be used instead of the dichroic mirror or dichroic beamsplitter to combine the light beams emitted by the LEDs 62 and 64 and couple them into the illumination fiber(s) 14. In Fig. 4b, which illustrates the coupling in the illumination fiber 14, numeral 66 refers to lenses while numeral 68 is for the dichroic beamsplitter which is at around 45 degrees , or any other suitable angle, and which transmits the light in the wavelength range emitted by LED 62 and reflects the light in the wavelength range emitted by LED 64

The LEDs 62 and 64 are chosen based on the spectral bands in which the reflectance properties of tartar are different from the reflectance properties of the other artefacts which could possibly be encountered by a powered tartar removal instrument insert inserted between a tooth and its gum (healthy or non-healthy parts of the tooth and gum) , and this even when blood is present. In fact, in these spectral bands, the spectral transmission of blood has minimal effect. The choice of the spectral bands was determined by a spectral study of the reflectance properties of tartar for the wavelength range of the electromagnetic spectrum between 400 nm and 1,000 nm. This spectral study was conducted in the presence and in the absence of blood. LED 62 emits in the red area of the spectrum and its emission spectrum has its peak at approximately 625 nm and extends from 600 nm to 650 nm. For LED 64, its emission spectrum extends between 800 nm and 920 nm. The LEDs 62 and 64, or any other appropriate light source, could also operate with other wavelengths that are appropriate for the discrimination of tartar, such as in the green region of the spectrum.

With respect to the detection principle used in the present system 10, it operates on the basis of the following. The light reflected by the artefacts that composes or are present in the periodontal pocket p is received by the detection fiber 16 and is conveyed to a photodiode located in the casing 34 so as to be transduced into an electric signal. The electronic detection of the light reflected by the tooth and transmitted by the detection fiber(s) 16 operates under the "lock-in" detection principle (also referred to as phase-sensitive detection), although other signal processing approaches could be contemplated. Generally, this principle consists in modulating the intensity of a light source at a given and known modulation frequency (which should not be confused with the optical frequency of the light source). The modulated light is sent onto the medium being inspected and the light, resulting from the interaction with the medium, is detected with a photodetector that converts it into an electric signal. This electric signal is then demodulated such as to extract therefrom only its component having the frequency at which the light source was modulated. This principle allows for the detection of very small signals with great efficiency

In the system 10, there are two light sources (i.e. the LEDs 62 and 64, although there could be more or less, e.g. 3 LEDs) that are modulated at different frequencies, thereby permitting the detection of the light emitted by both LEDs with a single photodiode by demodulating the electric signal of the photodiode at the two modulation frequencies of the LEDs to obtain a measurement of the amount of the light reflected by the tooth in the two spectral bands associated with the LEDs 62 and 64. These levels appear as signals V1 and ***V2*** at the outputs of the two lock-in circuits associated with the emission channels of the LEDs 62 and 64, respectively, and are used by the processing algorithm.

The lock-in detection is herein used for two purposes:

(1) it allows to electronically separate (at the detection) the light of both chosen spectral bands impinging on a single detector, and (2) the light levels reflected by the tooth and then detected are very weak and the lock-in method is exploited for its sensitivity. The signals ***V1*** and ***V2*** at the exits of the lock-in circuits are processed in real time by an electronic processor integrated with the rest of the electronic components of the casing 34. The processing algorithm is

programmed in this processor. The processing algorithm produces the ratio of these two signals ***V1*** and ***V2, y=*** Vi/v2 (the order in which this ratio is taken is irrelevant) . If this ratio is in a range of values associated with tartar (this range having been previously established using calibration measurements), then the powered tartar removal insert is located on tartar. In this case, the algorithm sends a signal to activate a warning sound (that can be deactivated by the operator, if desired) and to activate the warning LED in the casing 34 with the light of the warning LED being transmitted through the optical fiber(s) 44 and being visible through the indicator 42 located on the powered tartar removal instrument insert handle 18.

To determine the range of values of the ratio y associated with tartar, a large number of measurements are taken on teeth at various healthy locations thereof and where there is tartar, and this with different levels of blood. By knowing, for each of these measurements, if it was taken on a healthy part or where there is tartar, data are obtained for each of these two situations. By bringing the histograms of these data on a graphic, the range of values associated with tartar is determined.

The operator (1) uses the powered tartar removal instrument insert to determine where there is tartar and then (2) proceeds to removing the tartar in a conventional manner by powering the powered tartar removal instrument insert 12 in regions where tartar has been so detected. The operator then (3) verifies with the powered tartar removal instrument insert that the removal of subgingival tartar is complete, and steps (2)and (3) are then repeated until no tartar is detected. The operator must also ensure adequate supply of water to the periodontal pocket p by adjusting the position of the water regulator 28, the solenoid valve 105 may be operated via a foot pedal 106 to enable water supply. or with a control provided on the handle 18 of the powered tartar removal instrument insert. When the operator receives a sensory stimulation or signal (e.g. from the illumination of the optical fiber 44, through the indicator 42, or any other means of indication in replacement or in addition to the indicator 42, such as a buzzer, vibrations, etc.) from the electronic system, the operator knows that there is some subgingival tartar at the location of the distal end 36 of the powered tartar removal instrument insert and thus visually notes the position of the distal end 36 of the powered tartar removal instrument insert such that the operator can then proceed with step (2) which again consists in using the "powered" powered tartar removal instrument insert, for removing the remaining tartar at that location.

The powered tartar removal instrument insert 12 may be used only as a tartar detection mean.

The powered tartar removal instrument insert 12 may be used only as a tartar removal instrument.

The powered tartar removal instrument insert 12 could be powered ON continuously and used more specifically in regions where tartar is detected.

Here, for coupling the light from the LEDs 62 and 64, a particular approach has been presented using a dichroic mirror and lenses, but any other configuration, such as a "Y" configuration, which allows to couple the light from the LEDs into the fibers would do as well, the fundamental point being the coupling of light into the fibers 16.

For instance, Fig. 6a illustrates a coupling 100 by fusion of two optical fibers 102 and 104 into a single fiber 106. Two LEDs 108 and 110 are used, each emitting light through a pair of lenses 112 and 114. Reference numeral 116 denotes a fused region. This method is commercially known as a WDM coupler

Fig. 6b illustrates another coupling 200 which uses a **"Y"** configuration to couple the two lights. More particularly, two LEDs 202 and 204 are positioned each behind a pair of lenses 206 and 208 such as to emit light therethrough. The lenses 206 and 208 focalise the light on the extremity of an optical fiber 210. Reference numeral 212 denotes the optical axis of the fiber 210.

Fig. 6c illustrates a further coupling 300 which also uses a "Y" configuration but here to couple four lights that are produced by four LEDs 302, 304, 306 and 308 positioned each behind a pair of lenses 310 and 312 such as to emit light therethrough. The lenses 310 and 312 focalise the light on the extremity of an optical fiber 314. Reference numeral 316 denotes the optical axis of the fiber 314. It is noted that in a further coupling, also in a **"Y"** configuration, there could be three LEDs instead of the two and four LEDs found respectively in just-described couplings 200 and 300 of Figs. 6b and 6c.

Also, as regards the detection principle described above (i.e. the lock-in detection) , other principles could be used as well. Any approach that can deliver signals that are sufficiently insensitive to noise to provide for discrimination between tartar and other artefacts that can be found in a periodontal pocket P can be considered. Furthermore, in a numeric system, there could be used for instance two LEDs having different wavelengths (but possibly of same frequency) e.g. a red and a green LED, which are activated repeatedly one after the other and with a delay there between.

As an alternative to the processing algorithm presented hereinabove, combinations of the signals ***V1*** and ***V2*** other than the above ratio y could be considered. Indeed, the classification of the data into "is tartar" and "is not tartar" could be done in a two-dimensional space, for instance by plotting V1 versus ***V2,*** or any other function of V1 and ***V2*** versus another function of V1 and ***V2*** that is independent from the previous function. Also, if more than two LEDs or other sources of light (such as lasers, halogen lamps, spectral lamps, filtered lamps, etc.) are used, information can be gathered and analysed in two or more dimensions

Furthermore as an alternative to the approach just described, a spectrometer could be used to measure a spectrum of the light reflected by the tooth and this spectrum would then be analysed with an algorithm to determine if it corresponds to a spectrum of tartar or to a spectrum of another artefact. Any other suitable method may be used to analyse the spectrum received and compare it with the spectrum of tartar with a view to detecting the presence of tartar.

The present system could, by varying the spectrum to be detected, be used to locate other structures having distinctive spectral characteristics and positioned in a buccal site where access is limited (e.g. dental decay, periodontal ligament, inflamed gum [high content in blood], dental plaque, dental fillings, melanoma, any marked substance with a tracing substance...)

The system 10 could also include a recalibration function. A warning signal can also be provided to indicate when too much blood is present in the area being examined by the powered tartar removal insert and that the system 10 cannot make an adequate reading and thus cannot determine with sufficient precision if tartar is present on the tooth in this area.

A further feature could be included to indicate if the powered tartar removal instrument insert or, more specifically, the illumination and/or detection fibers 14 and 16 thereof are too worn out to be efficiently used and should thus be replaced. Such a state could be detected by insufficient light being received in the electronic system provided in the casing 34.

In addition to providing to the operator the luminous (or other) signal that indicates the presence of tartar with an indicator (such as the illustrated optical fiber 44) , the system 10 may also include a monitor that displays further information to the operator such as electronic signals within the system which would help his/her diagnostic.

There may also be included a means of 35 collecting data from the electronic system (e.g. via a computer and software, including an electronic card 40,etc.), to be saved in any kind of storing medium for allowing the patient's history to be followed For the present embodiment of the system 10, the reflectance properties of tartar in the range between 400nm and 1,000nm have been studied, and light sources in that range are used (the two LEDs 62 and 64). However, use of light sources emitting below 400nm in the ultraviolet (UV) range or above 1,000nm in the far infrared could also be envisaged.

Also, as the spectral responses of various artefacts other than tartar are known, such as those of enamel, of the tooth's root surface, of the gum, of blood, of tooth decay (caries), of tooth fillings, etc., it is possible to adapt, e.g. program, the system 10 so that a tartar-presence signal is given to the operator as a result of the detection of spectral characteristics that are not representative of those of the aforementioned artefacts. Therefore, if the system 10 detects only spectral characteristics of these artefacts (wherein the term "artefacts" herein excludes tartar) there is no tartar in the region under examination.

As tartar does not respond to UV light, whereas other artefacts do, if UV light is directed onto the tooth, absence of fluorescence may be an indication of the presence of tartar..

Also, a tracing substance (e.g. organic dye [erythrosine]) could be used, which would adhere to tartar but not to other artefacts. By then illuminating the tooth with a light source, the tracing substance would emit at a specific wavelength such that if this wavelength is detected, tartar is present. It is also possible to use a substance which reacts with the components of tartar such that a spontaneous emission of light at a specific wavelength is emitted. This spontaneous emission of light is collected with the optical probe. If the specific wavelength is detected, there is tartar. This method may possibly be used without a light source at the patient's mouth.

It is also possible for the tartar to be detected using non-luminous electromagnetic wavelengths or by other similar methods, e.g. far infrared, ultraviolet, piezoelectric, ultrasound, magnetic resonance, shadows, etc…

An other use of the present invention would be the detection of a periodontal or a dental artefacts that has a specific affinity with a known tracing substance (e.g. reddish reflectance of erytomysine marker with dental plaque) that has a particular reflectance signature could be used to detect a desired substance that has a distinct affinity to that substance.

Means other than optical fibers may be used to illuminate the teeth and to collect light reflected therefrom as long as the reflected light is of sufficient intensity to allow it to be analysed.

The present invention could also include periodontal pocket measuring device(s) that would enable the measure of the deepness of a periodontal pocket those measurements could be transmit electronically the data to a computer or the like.

The automated detection system could be replaced by a display screen or an equivalent mode to transfer an image of the region under study while the operator is performing the scaling.

CLAIMS:

1. A dental tartar detection system, comprising a powered tartar removal instrument adapted to be displaced along a tooth, illumination means for illuminating with an incident light a region on the tooth, detection means for collecting the light reflected thereat, and an analysing system for providing a signal to an operator of said probe when measurements on the reflected light in one or more predetermined ranges of wavelengths fall within any first predetermined range of values that are characteristic of tartar, or when said measurements do not fall within any second predetermined range of values that are characteristic of artefacts other than tartar.

Fig. 1a

Figure 1

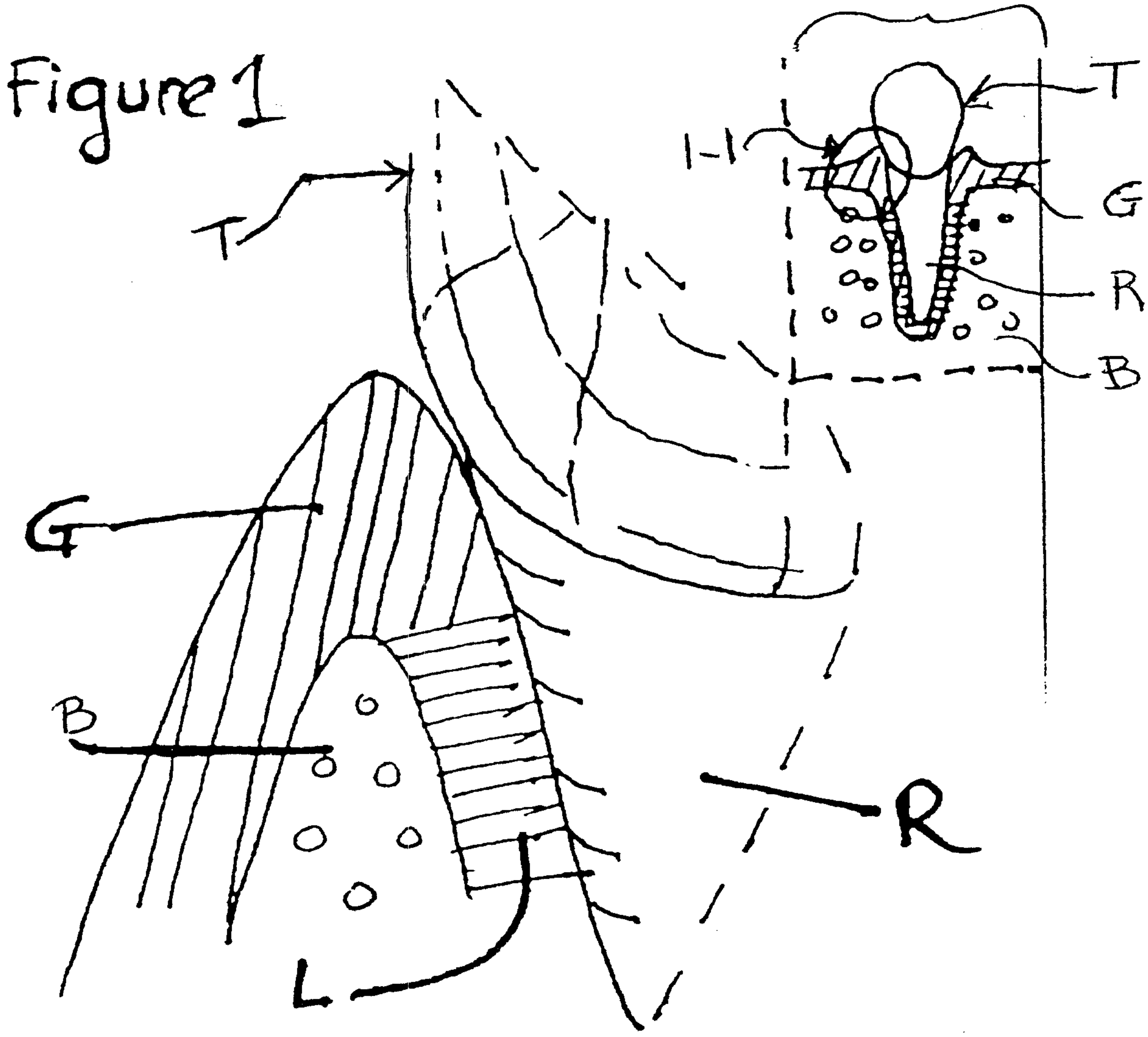


Figure 2

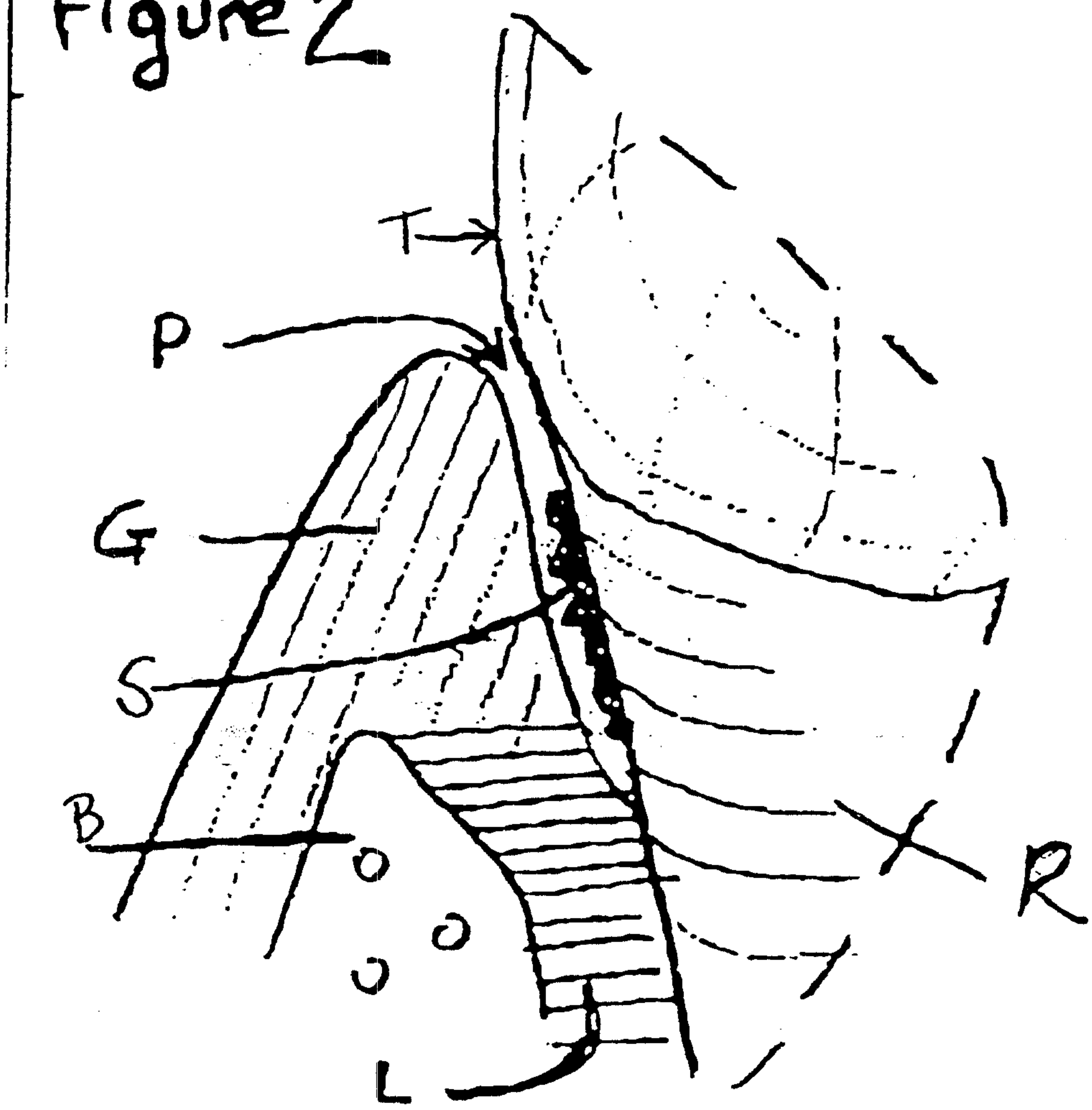
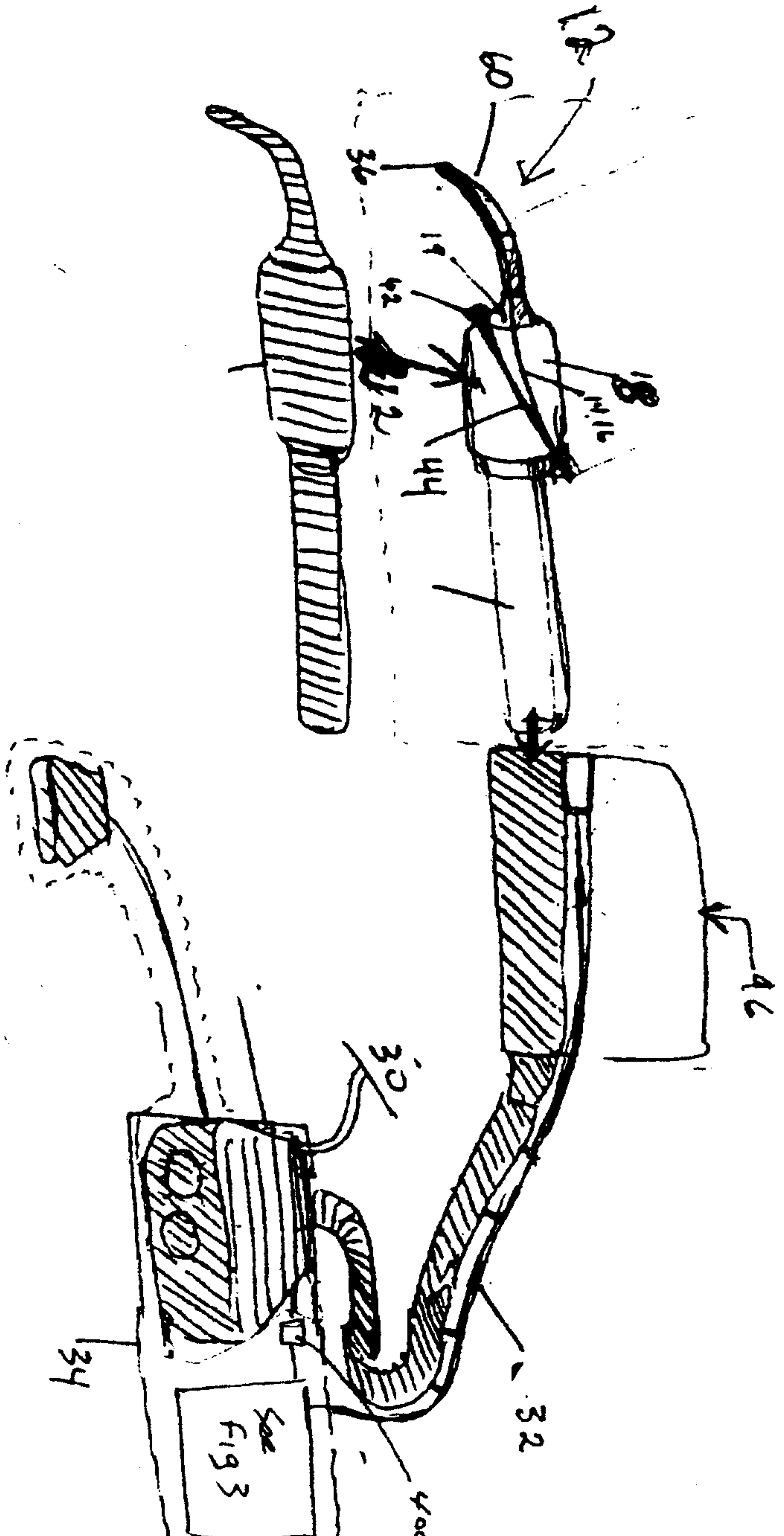
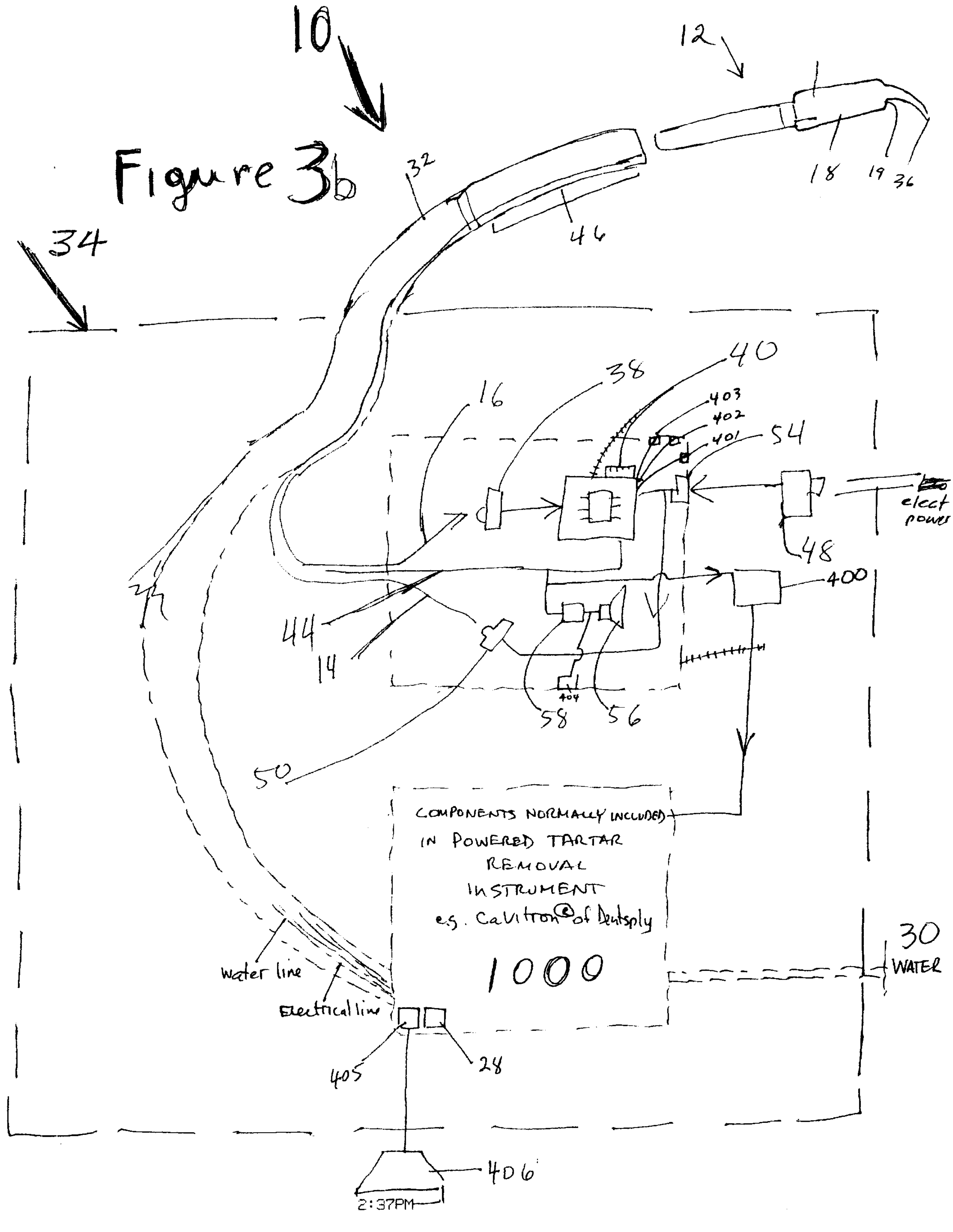


Figure 3a

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12
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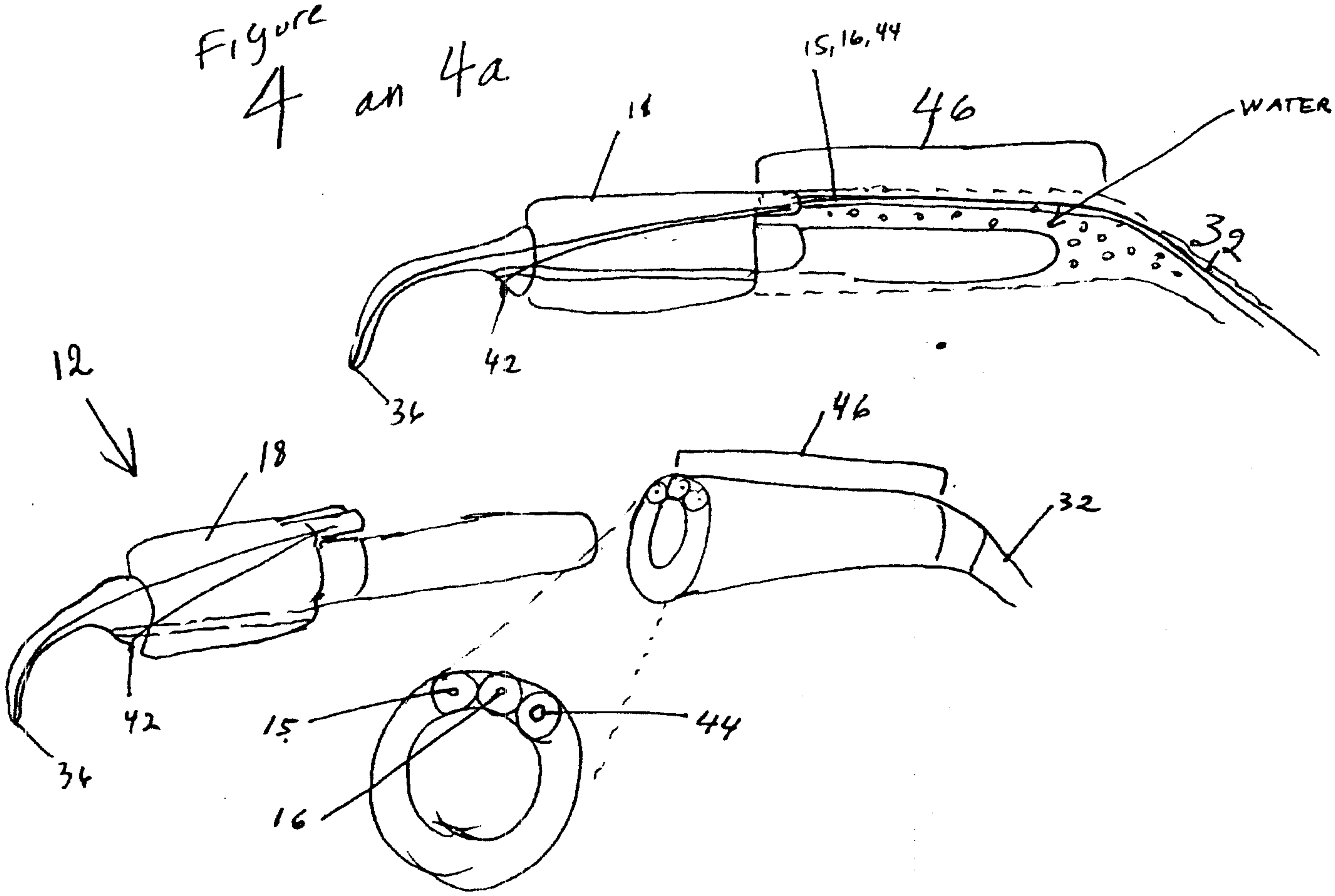
COMPONENTS NORMALLY INCLUDED IN POWERED TARTAR REMOVAL INSTRUMENT
e.g. Cavitron® of Dentsply
1000
30
WATER
water line
Electrical line
405
28
406
2:37PM

Figure 3b

Figure 4 an 4a



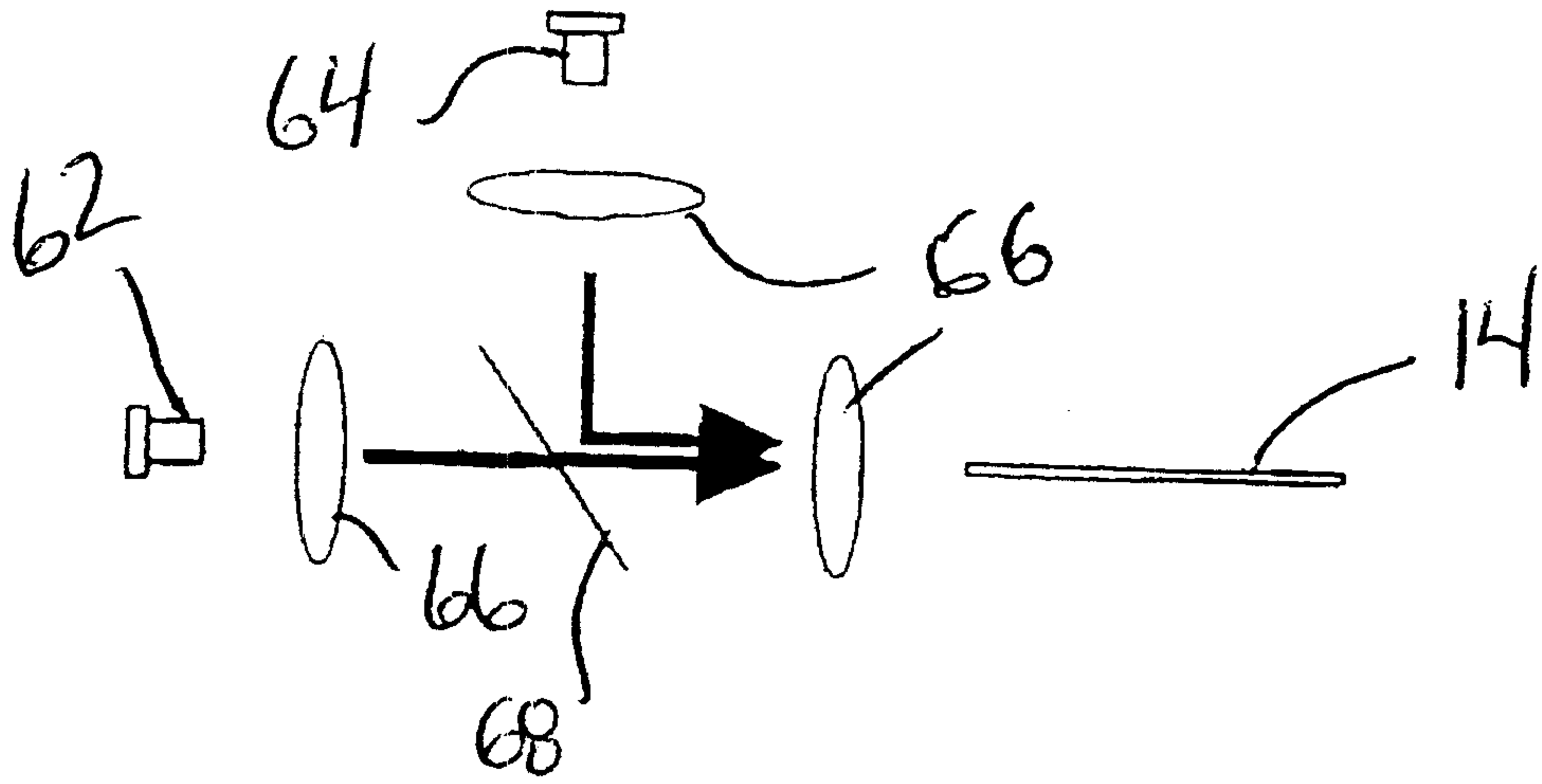
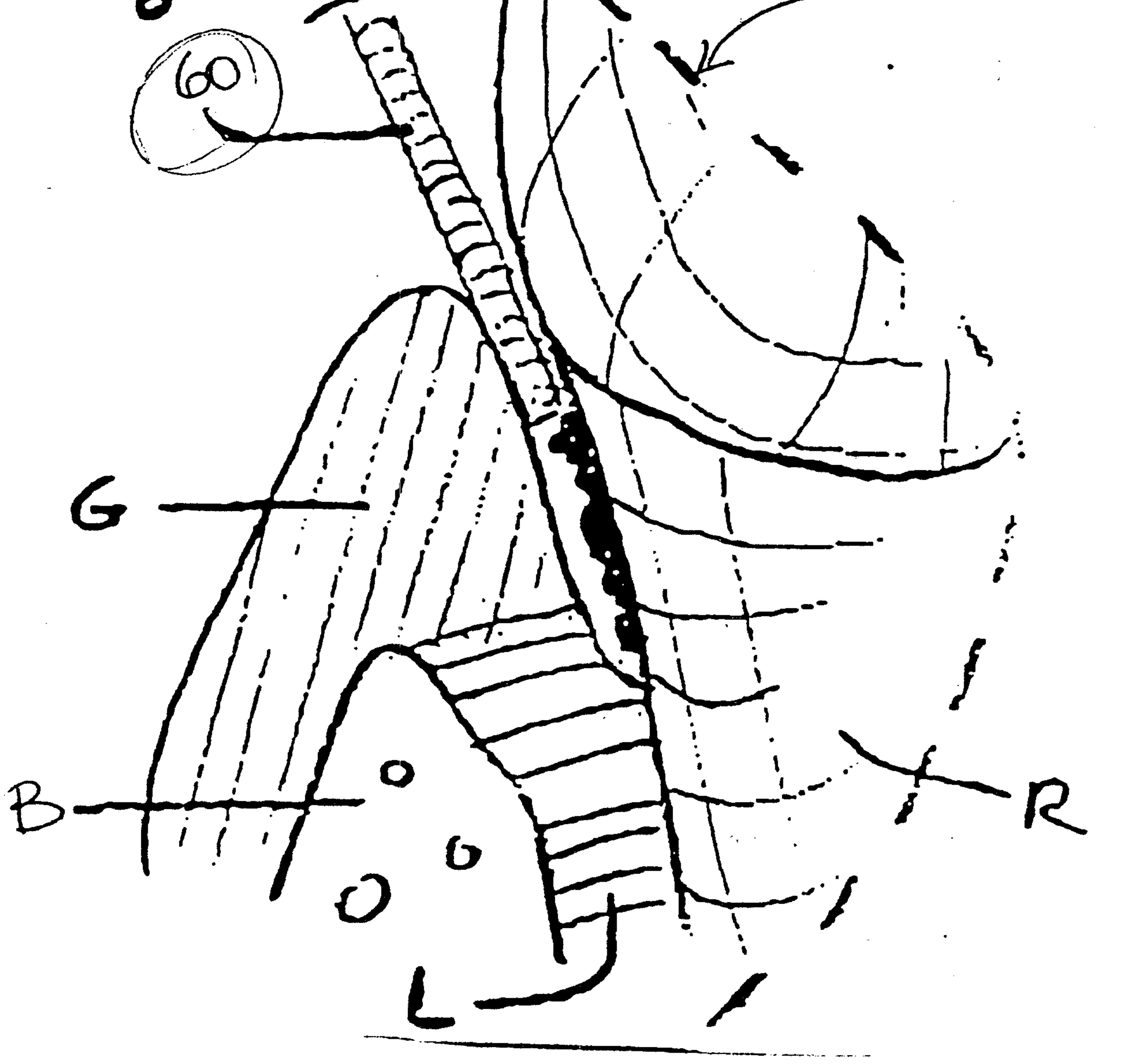


Fig. 4b

Figure 5



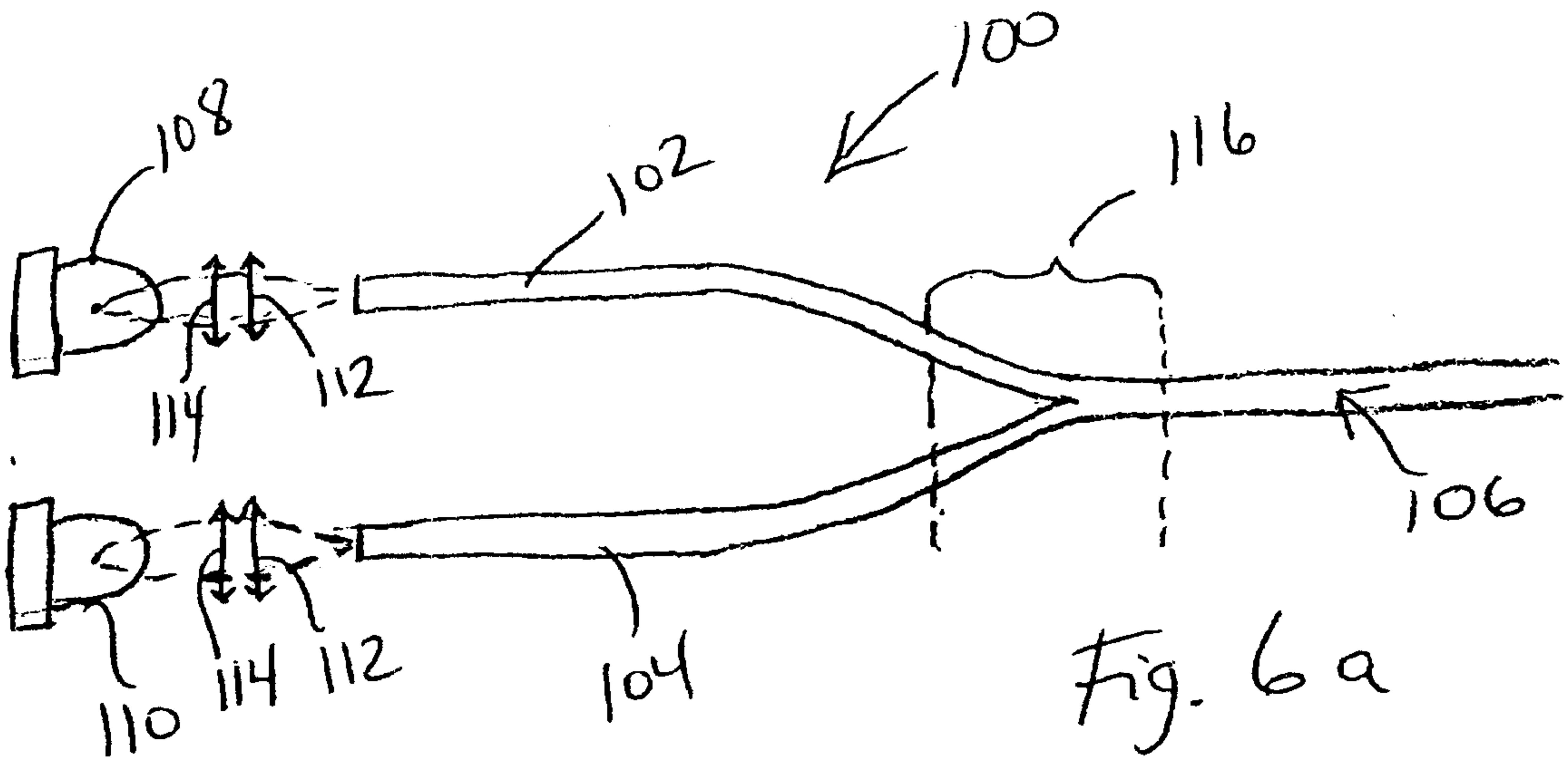


Fig. 6a

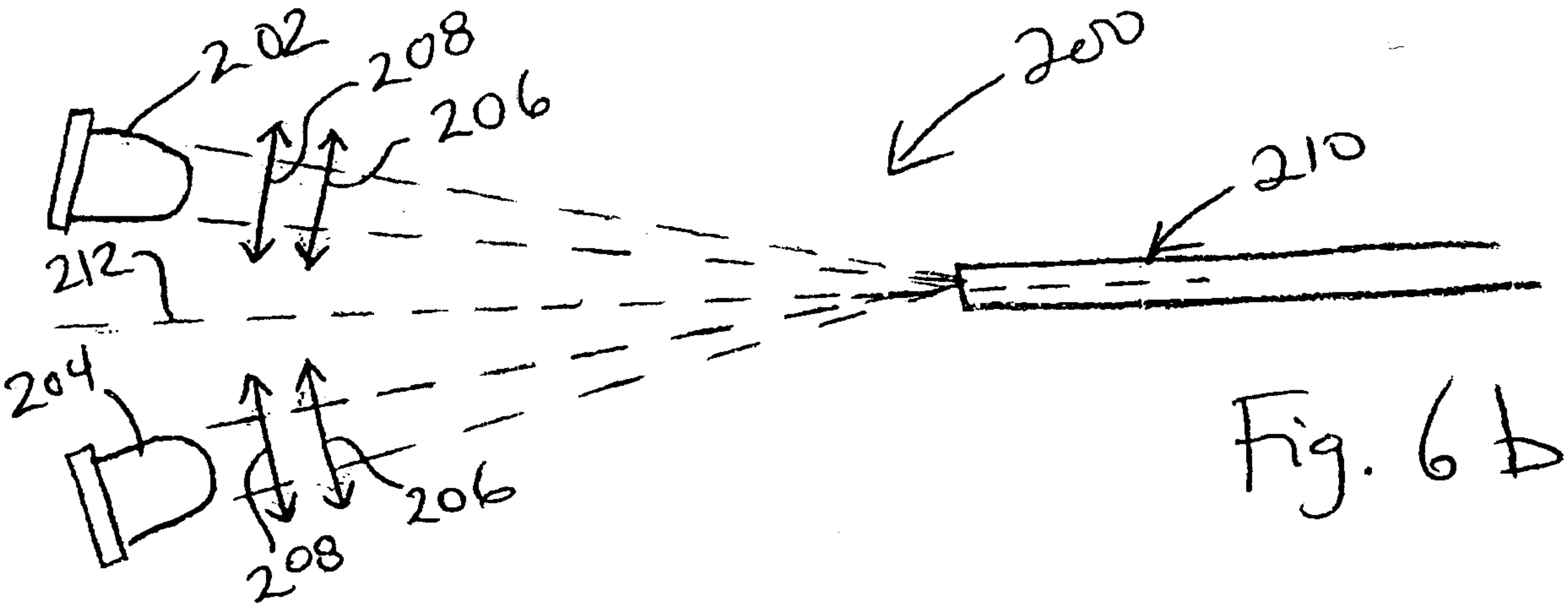


Fig. 6b

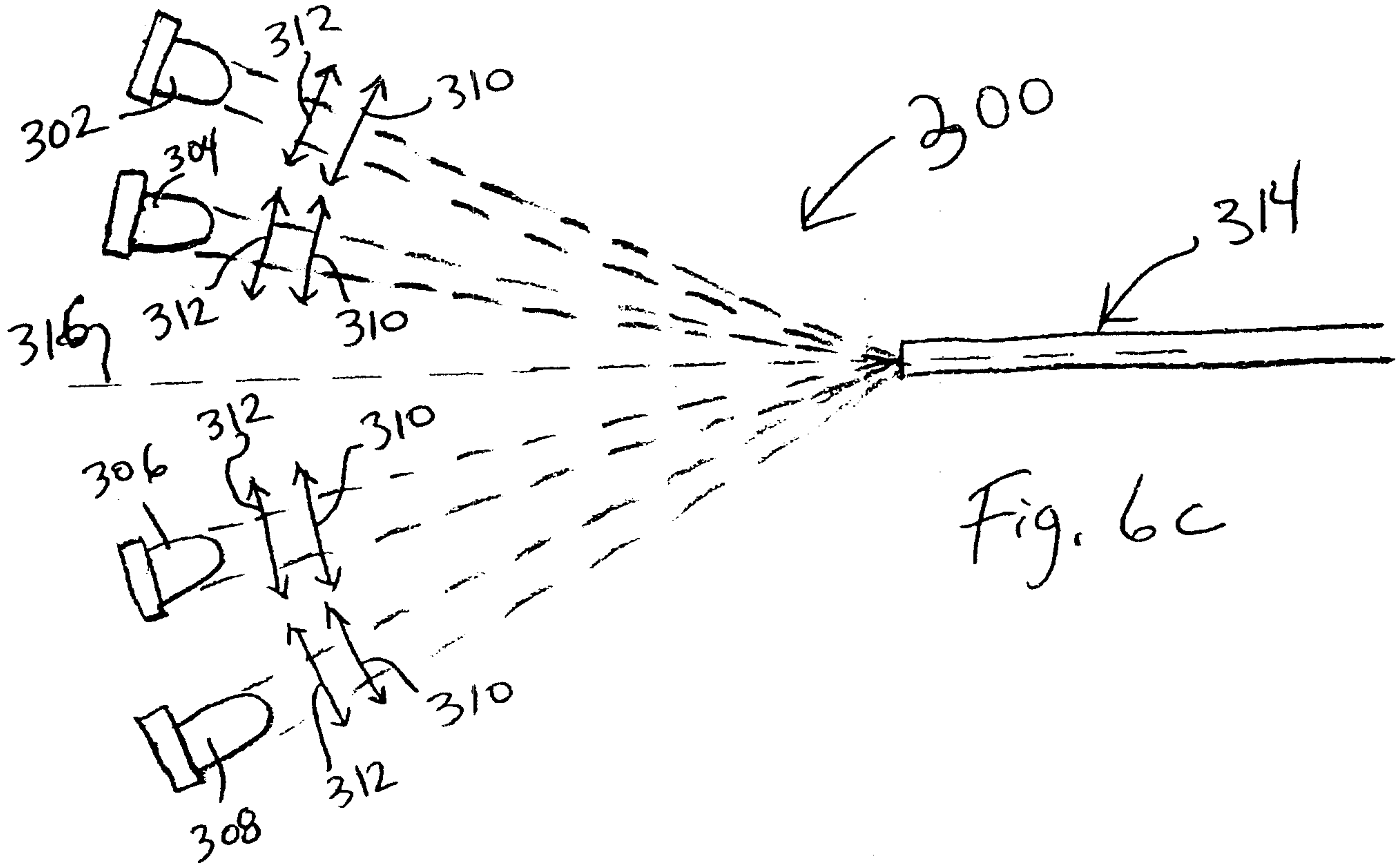
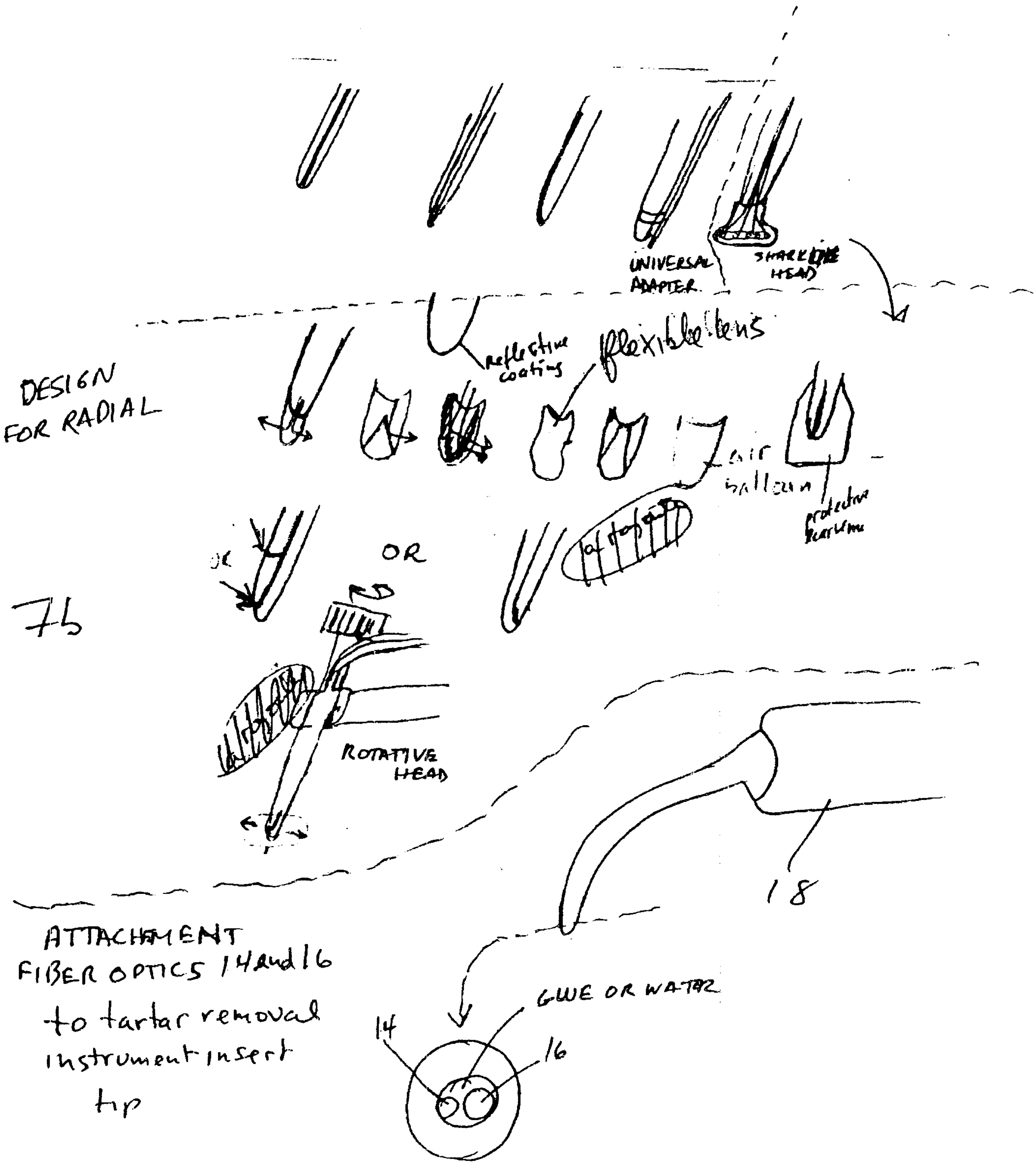


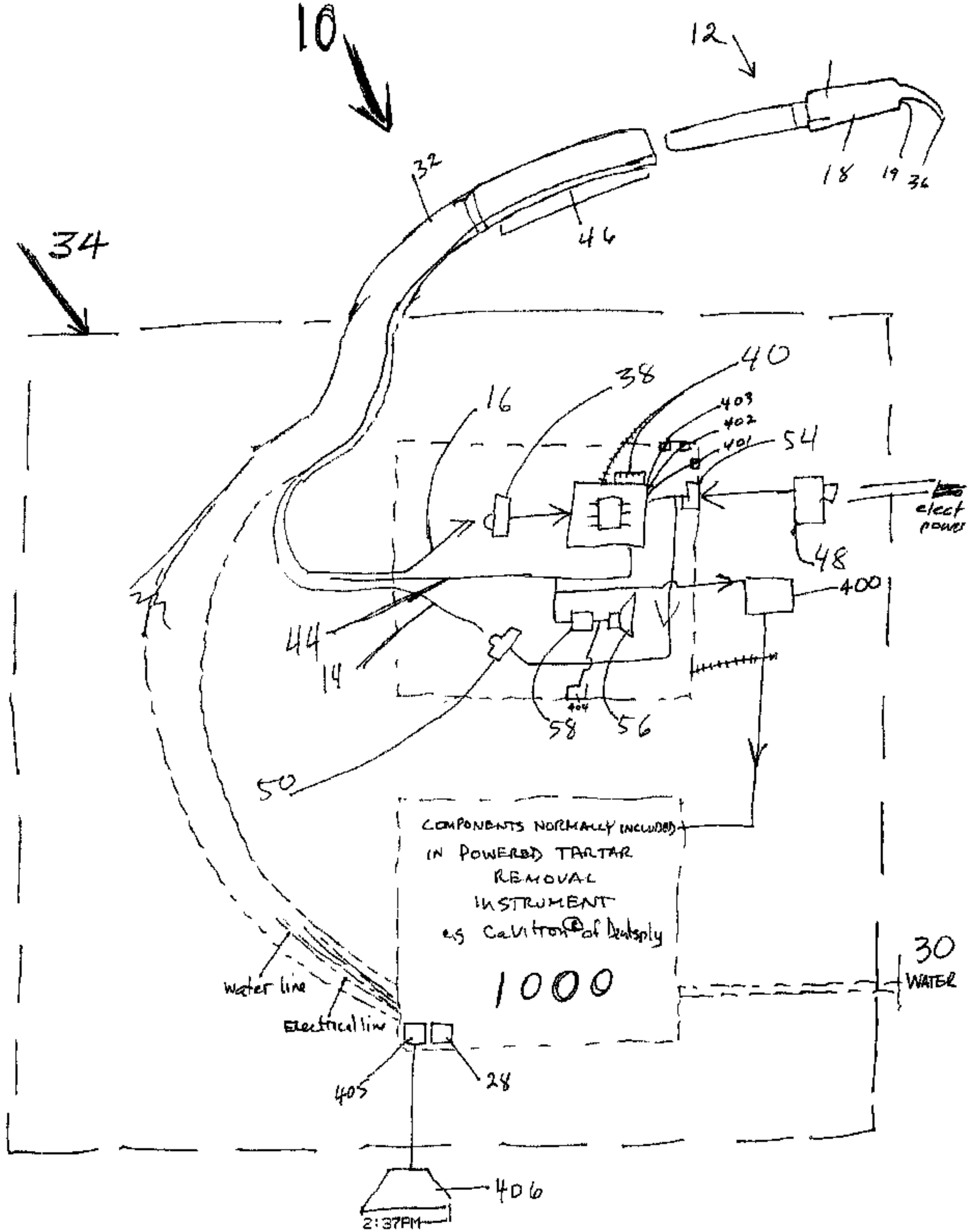
Fig. 6c

Figure 7a



7b

7c


10
12
18
19
36
32
46
34
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38
16
403
402
401
54
elect power
48
400
44
14
404
58
56
50
COMPONENTS NORMALLY INCLUDED IN POWERED TARTAR REMOVAL INSTRUMENT eg Cavitron® of Dentsply
1000
30
WATER
water line
Electrical line
405
28
406
2:37PM