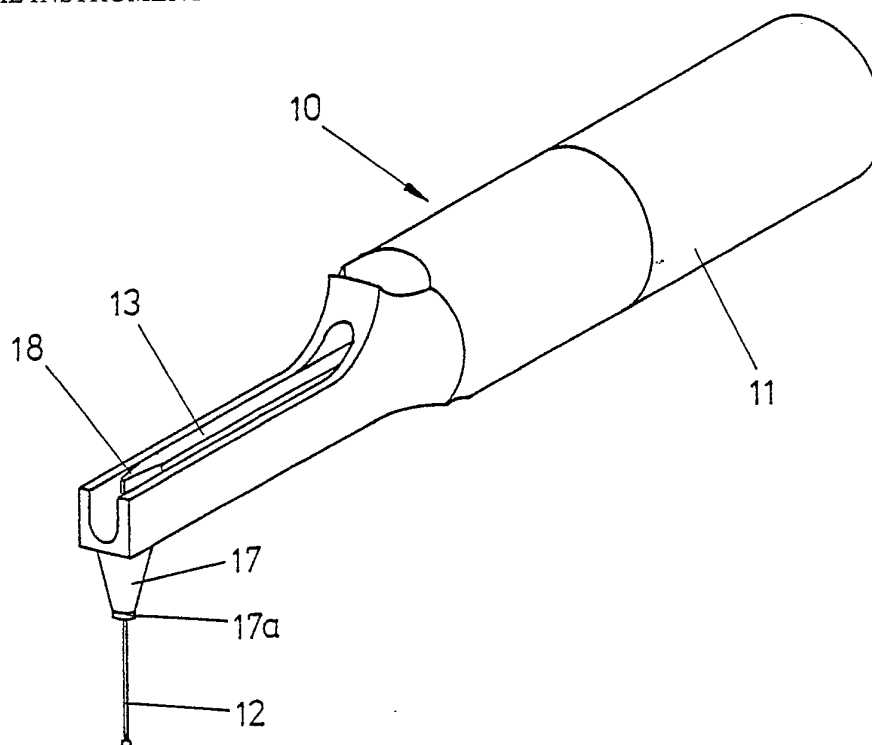




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(54) Title: DENTAL INSTRUMENT**(57) Abstract**

A dental instrument (10) for measuring the depth of a periodontal pocket comprises an elongate housing (11) and an activator arm (13) pivotally mounted at one end in the housing and operably coupled to a probe (12) at its other end. The probe (12) extends through the housing (11) generally perpendicularly to the longitudinal axis of the housing. An optoelectronic sensor device senses relative movement between the probe and the housing, and this is converted into a visual display (22) on an indicator unit (16).

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DENTAL INSTRUMENT

This invention relates to a dental instrument for determining the depth of a periodontal pocket and the compressibility of gingival tissues.

Dental care is increasingly concerned with monitoring the health of the gingivae (gums) over a period of time. The most commonly used measure of gingival health is the measurement of periodontal pockets. At present, these pockets are measured by inserting a solid graduated probe into the base of the pocket, and the depth of insertion is then read by visual inspection of the number of graduations on the probe which are visible above the gingival crest. This method is inaccurate, since the depth recorded is determined by the force applied by the operator, and is time consuming since a second person must write down up to 96 readings, as they are read out by the operator. A further problem arises in the long term monitoring of periodontal pockets, in that a change in the observed depth of the pocket may be due to a change in the level of attachment at the base of the pocket, or to a change in the state of the gingival crest. A number of instruments have been proposed for this measurement, using an instrument comprising a handle having a tubular sheath, and a probe adapted for movement longitudinally within the sheath, such that the depth of the pocket may be measured by determining the extension of the probe tip electrically, to provide a remote display.

The present invention has been developed primarily with a view to provide a dental instrument having a different arrangement of probe, and means for monitoring the movement of the probe, with a view to providing a more accurate and easily operated instrument.

According to the invention there is provided a dental instrument comprising:-

a generally elongate housing which is capable of being hand-held;

a probe arranged to extend through one end of the housing, generally perpendicularly of the housing;

5 an actuator arm extending generally longitudinally of the housing and operatively coupled at one end with the probe and, at or near its other end, being pivotally mounted in the housing;

an opto-electronic sensor device comprising an optical
10 beam generating element, a sensing element responsive to said optical beam, and an interruptor element which, in use, interrupts the optical beam as a result of relative pivoting movement between the arm and the housing; and

an indicator device electronically connected to the
15 sensing element to provide an indication of the relative angular orientations of the interruptor element and the optical beam.

In a preferred embodiment the optical beam generating element and sensing element are arranged within the housing
20 on respective sides of the actuator arm, and the interruptor element is mounted on the actuator arm.

However, the instrument may alternatively be arranged so that the optical beam generating element and sensing element are both mounted on the actuator arm and the
25 interruptor element is mounted within the housing.

Conveniently, the depth of a periodontal pocket may be measured by inserting the probe into the pocket and bringing the tip of the probe into contact with the base of the pocket, and then moving the instrument in a direction
30 generally parallel to the axis of the probe until contact is achieved, by a fixed element or portion on the housing, with the gingival crest. This causes a corresponding pivotal movement of the actuator arm, which is monitored by the opto-electronic sensor device and then indicated by the
35 indicator device. Preferably, the contact with the

gingival crest is obtained by means of the end of a guide tube which is fixed to the housing and through which the probe is taken.

The probe may be operatively coupled with the end of the actuator arm in any convenient manner, including direct mechanical connection. However, it is preferred that there is no direct connection between the probe and the actuator arm, but merely an interengagement when depth measurement takes place.

For health reasons, it is preferred that the probe comprises a disposable item which can be discarded after use on one patient, and therefore it is replaceably arranged within the housing and within the guide tube. To permit of ready replacement, it is preferred that the mounting of the actuator arm is such that it can be pivoted in a direction away from the probe to such an extent as to allow the probe to be withdrawn from the guide tube without engaging the actuator arm. This may be achieved by permitting the actuator arm to carry out an initial pivotal movement in one plane, followed by a small extent of movement laterally of this plane, to permit withdrawal of the probe from the guide tube.

Preferably, the indicator device is a remote instrument, or it may comprise a part of a computerised record system. In this latter case, this will enable automatic indication, and recording of the periodontal pockets of any particular patient, and therefore "automates" the entire procedure, with a single person being able to carry out the entire procedure.

In order to maintain firm engagement between the end of the actuator arm and the probe, it is preferred that a spring arrangement is provided, which acts on the actuator arm, so as to exert a substantially constant biasing force, throughout at least a major part of the pivotal movement of the actuator arm against the spring biasing. It has been

found that a tensator type spring is particularly suitable for this purpose.

If it is desired to be able to measure the pocket depth from the cemento enamel junction (CEJ), a ring may be
5 provided on the end of the guide tube, to provide the facility to measure the pocket depth from this junction.

Means may be provided to record the minimum depth recorded by the instrument, which is then displayed until another minimum is recoded. This may be achieved by a
10 microprocessor, or by analog sample and hold circuitry.

Since a large number of readings are normally required, the indicator device may include a display having a bar-graph display, to supplement or replace a digital read-out. In a preferred arrangement means are provided to
15 allow a translucent charting medium to be placed over the display. A mark may then be made on the chart, over an LED bar-graph, to provide a visual analog of the pocket depth.

In order to assess the degree of oedema of the gingival tissue (preferably the interdental papillae), the probe tip
20 may be placed against the gingival crest and compressed until the guide tube contacts the gingivae, the degree of oedema being correlated to the distance the probe tip advances or retracts into the guide tube.

In another embodiment of the invention, substantially
25 the same arrangement may be used, to assess the mobility of the teeth, or to measure the degree of fremitus i.e. the lateral deflection of an individual tooth during function. In this embodiment, the opto-electronic sensor device is used to measure the vibration of the tooth, the pivot of
30 the actuator arm being placed as far away from the sensor device as is practical, to provide a mechanical amplification of movement at the probe tip. Vibration of the tooth during function closure may then be measured, by resting the probe tip against the tooth so that the
35 amplitude of the movement can be detected by the sensor

device. Separate measurement of vertical and lateral forces may be made by rotating the probe tip through 90° .

Tooth mobility may be assessed by applying a vibration of known magnitude by means of a ratchet to the probe tip, and monitoring the change in amplitude of the observed vibration at the sensor device.

One embodiment of a dental instrument according to the invention will now be described in detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective illustration of a dental instrument in accordance with the present invention;

Figure 2 is a perspective view, partly cut-away of the instrument shown in Figure 1;

Figure 2A is a side view of the opto-electronic sensor device.

Figure 3 shows the instrument of Figures 1 and 2 being used to measure the depth of a periodontal pocket;

Figure 4 illustrates the replacement of the probe;

Figure 5 is a plan view of the display unit;

Figure 6 is an end elevation of the display unit;

Figure 7 is a side view of the instrument with the probe fully retracted;

Figure 8 is a plan view of the instrument; and

Figure 9 is a perspective view of a charting tray for use with the instrument and display unit.

Referring now to the drawings, there is shown a dental instrument intended, amongst other things, for determining the depth of a periodontal pocket, and the compressibility of gingival tissue. The instrument is designated generally by reference 10 and comprises a generally elongate housing 11 which is capable of being hand-held. A probe 12 is located at one end of the housing, and extends through the housing, generally perpendicular to the longitudinal axis of the housing. An actuator arm 13 extends generally

longitudinally of the housing 11 and is operatively coupled at one end 18 with the probe 12 and, at or near its other end, it is pivotally mounted in the housing 11 on pivot 15.

An opto-electronic sensor device 14 is arranged in the housing 11 for generating an optical beam 14C, and this is shown schematically by a double-spaced blade arrangement 14 located near the inner end 19 of the actuator arm 13. An interruptor element 20 is coupled with the end 19 of the actuator arm 13 and is movable, relative to the optical beam generated between the blades 14, upon pivoting of the actuator arm 13 as the probe 12 is used to carry out measurement of the depth of a periodontal pocket. An indicator device 16 is electrically connected to the sensor device 14 and is operable to provide an indication of periodontal depth as a function of the extent of movement of the interruptor element 20 relative to the sensor beam during depth measurement. The indicator device 16 is shown only schematically, and may comprise a remote instrument giving digital or analog display, as well as a recording facility, or it may comprise a part of a computerised record system.

One embodiment of the interruptor element 20 is shown in Figure 2A and comprises a substantially rectangular vane 20 in which is cut a number of triangular slots 20A, the slots extending in the plane of pivoting of arm 13. As the end 19 of the arm pivots downwardly as shown by arrow X, more of the light from the beam generating element 14A will reach the sensing element 14B, causing the indicator means 16 to change accordingly. This arrangement overcomes the disadvantage of a solid interruptor element, the sensitivity of which depends on the positioning of the interruptor element relative to the beam. With the slotted interruptor, the reading on the indicator unit is not dependent on the relative longitudinal positions of the interruptor and the beam, only on their relative angular

orientations.

In order to prevent moisture accumulating in the slots 20A, the vane 20 is preferably covered in a waterproof translucent tape 20B.

5 The end 18 of the actuator arm 13 is operatively coupled with one end of the probe 12, but it is not directly connected mechanically. A spring arrangement is provided which exerts a substantially constant biasing force to the actuator arm 13, towards engagement with the
10 upper end of the probe 12, and provides a substantially constant resistance during upward pivoting of the actuator arm 13. A tensator spring arrangement is preferred.

The depth of a periodontal pocket is measured by inserting the probe 12 into the pocket and bringing the tip
15 of the probe into contact with the base 2 of the pocket, as shown in Figure 3. Thereafter, the instrument 10 is moved in a direction generally parallel to the axis of the probe 12 until contact is achieved with the gingival crest 3 by a fixed element or portion on the housing 11. This causes a
20 corresponding pivotal movement of the actuator arm 13, which is monitored by the sensor device 14 and then indicated by the indicator device 16. In the illustrated embodiment, contact with the gingival crest is obtained by means of the end of a guide tube arrangement 17 which is
25 fixed to the underside of the housing 11 and through which the probe 12 is taken.

For health reasons, the probe 12 comprises preferably a disposable item which can be discarded after use on one patient, and is replacably mounted on the housing 11 and
30 within the guide tube arrangement 17. To permit ready replacement of the probe 12, the mounting of the actuator arm 13 is such that it can be pivoted upwardly away from engagement with the end of the probe 12 against the spring biasing, and then displaced laterally to a small extent,
35 thereby to allow the probe 12 to be withdrawn through the

guide tube arrangement 17 and from its mounting in the housing 11. A replacement probe 12 can then readily be mounted in position. This procedure is illustrated in Figure 4 which also illustrates the end portion 11b of the instrument being removed during replacement of the probe in order to avoid damage to the opto-electronic sensor 14.

The tip of the probe 12 has a spherical end to minimise damage to the tissue in the base of the periodontal pocket, and has a flattened end at its other end to provide a stop to prevent the tip falling through the guide tube arrangement 17. The diameter of the spherical end of the probe tip is designed to be the same as the internal diameter of the guide tube, to allow the guide tube to be automatically cleaned as the probe is withdrawn.

A remote display unit 16 may be provided in which the signal to it goes through auto-zeroing to automatically calibrate the instrument, or calibration may be performed by manually adjustable potentiometers 24, 26. The display 22 may be digital, or in analog form. In the preferred embodiment, the display is in the form of an LED bar-graph.

To calibrate the instrument manually, the display unit 16 (which is battery operated) is activated by pressing the square power button 28 once. Once activated the unit will automatically switch off after three minutes to conserve battery life. The probe tip is pressed against a hard surface until it is fully retracted as shown in Figure 7. With the probe in this position potentiometer 24 is adjusted until LED 22a (corresponding to a zero reading) is lit. Then, with the probe tip fully extended, the potentiometer 26 is adjusted until LED 22b (corresponding to a reading of nine) is lit.

An annular ring 17a is provided on the end of the guide tube arrangement 17, to provide the facility to measure the pocket depth from the cemento enamel junction

(CEJ), if desired by providing tactile feedback to the operator.

A charting tray 30 may be provided which includes a well 31 for receiving the display unit 16. Surrounding the well 31 there is a recessed platform 32 for receiving a translucent charting medium. A mark may then be made on the chart over the LED bar-graph, to provide a visual analog of the pocket depth. To chart the maxillary pockets the chart is positioned against the lower ledge 34 of the tray, and to chart the mandibular pockets the chart is placed against the upper ledge 33, sliding left or right as required. The "nine" LED 22b is continuously lit as a reference and must always be aligned with the 9mm segment of the chart 35 for both maxillary and mandibular chartings. A cross is then marked in the appropriate segment directly above the lit LED corresponding to the particular pocket depth being measured.

In order to assess the degree of oedema of gingival tissue (preferably the interdental papillae), the tip of the probe 12 may be placed against the gingival crest and compressed until the guide tube arrangement 17 contacts the gingivae. The degree of oedema is correlated to the distance the probe tip advances or retracts into the guide tube arrangement 17.

In another embodiment (not illustrated), substantially the same system may be used, in order to assess the mobility of the teeth, or to measure the degree of fremitus i.e. the lateral deflection of an individual tooth during function. In this embodiment, the optical sensor arrangement is used to measure the vibration of the tooth, the pivot of the actuator arm 13 being placed as far as possible away from the sensor arrangement, to provide a mechanical amplification of movement at the probe tip.

Vibration of the tooth during functional closure may then be measured by resting the probe tip against the tooth, the

amplitude of the movement being detected by the sensor arrangement. Separate measurement of vertical and lateral forces may be made by rotating the probe tip through 90° .

Mobility may be assessed by applying a vibration of 5 known magnitude by means of a ratchet to the tip of the probe, and monitoring the change in amplitude of the observed vibration at the sensor.

While the preferred arrangement of the sensor arrangement 14 and interruptor element 20 is as shown in 10 the drawings, it should be understood that the roles of these items could be interchanged, if desired. Thus, an opto-sensor device could be mounted on the actuator arm 13 for movement therewith, and a fixed trigger element could be mounted in the housing in order to interrupt a sensor beam 15 which moves during the pivotal movement of the actuator arm 13.

CLAIMS

1. A dental instrument comprising:-
 - 5 a generally elongate housing which is capable of being hand held;
 - a probe arranged to extend through one end of the housing, generally perpendicularly of the housing;
 - an actuator arm extending generally
 - 10 longitudinally of the housing and operatively coupled at one end with the probe and, at or near its other end, being pivotally mounted in the housing;
 - an opto-electronic sensor device comprising an optical beam generating element, a sensing element
 - 15 responsive to said optical beam, and an interruptor element which, in use, interrupts the optical beam as a result of relative pivoting movement between the arm and the housing;
 - and
 - an indicator device electrically connected to the
 - 20 sensing element to provide an indication of the relation angular orientations of the interruptor element and the optical beam.
2. A dental instrument according to Claim 1, in which the optical beam generating element and sensing
- 25 element are arranged within the housing on respective sides of the actuator arm, and the interruptor element is mounted on the actuator arm.
3. A dental instrument according to Claim 1, in which the optical beam generating element and sensing
- 30 element are both mounted on the actuator arm and the interruptor element is mounted within the housing.
4. A dental instrument according to any of the preceding Claims in which the housing is formed at one end into a guide tube through which the probe extends.
- 35 5. A dental instrument according to any of the

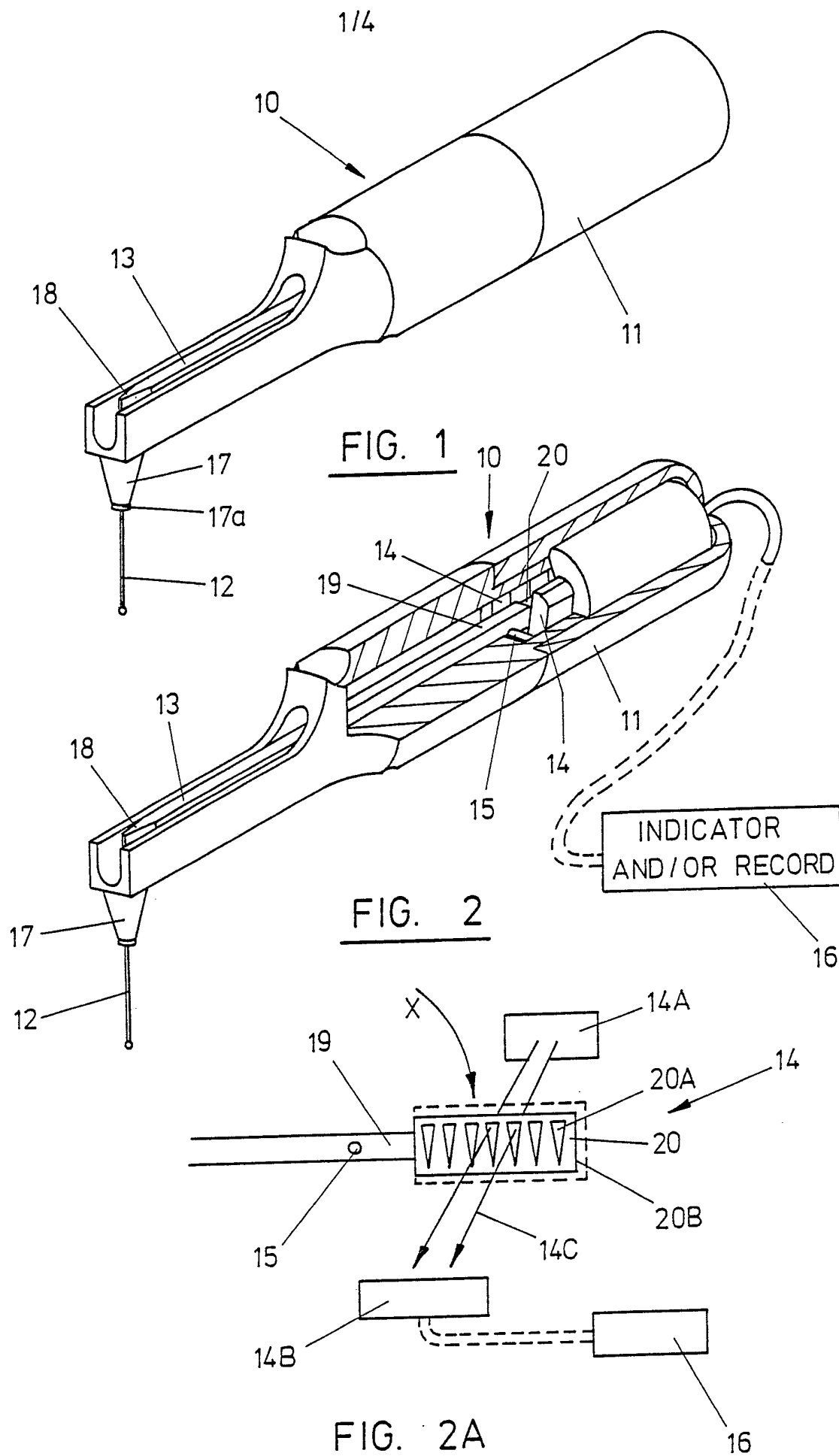
preceding Claims in which the probe is operatively coupled to the actuator arm by means of a spring which acts to bias the probe and actuator arm towards each other.

6. A dental instrument according to any of the preceding Claims in which the probe is replaceable.

7. A dental instrument according to any of the preceding Claims in which the indicator device includes a bar-graph display.

8. A charting tray for use with an instrument as claimed in Claim 6, comprising a well for receiving the indicator unit and a recessed platform substantially flush with the top of the indicator unit when placed in the well, and guide means for locating against the edge of a translucent chart placed on said platform whereby the display of the indicator unit may be observed through the chart.

9. A method of measuring the depth of a periodontal pocket, the method comprising inserting a probe into the pocket until the tip of the probe touches the base of the pocket, sliding a housing over the probe until the edge of the housing touches the gingivival crest, and measuring, opto-eletronically, the degree of relative movement between the probe and the housing to provide an indication of the depth of the pocket.



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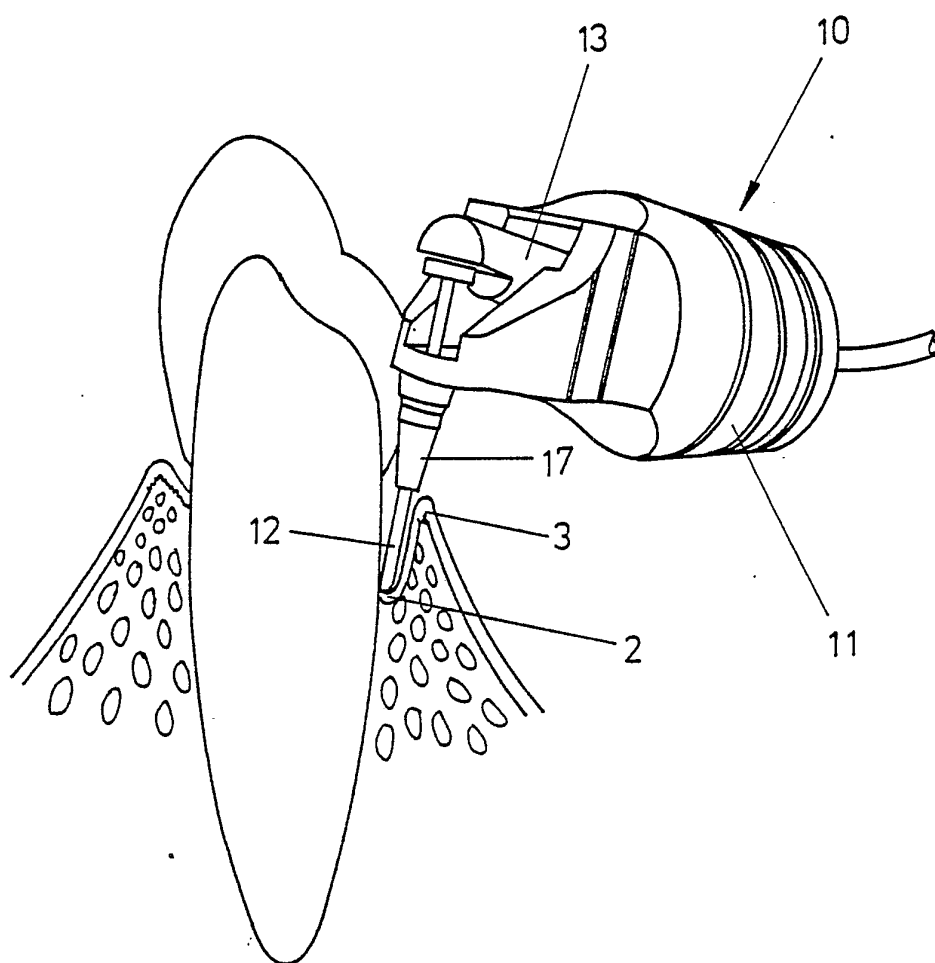


FIG. 3

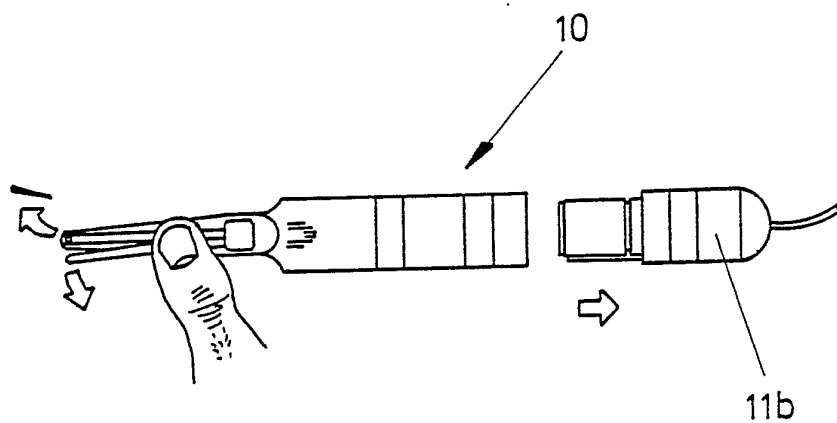


FIG. 4

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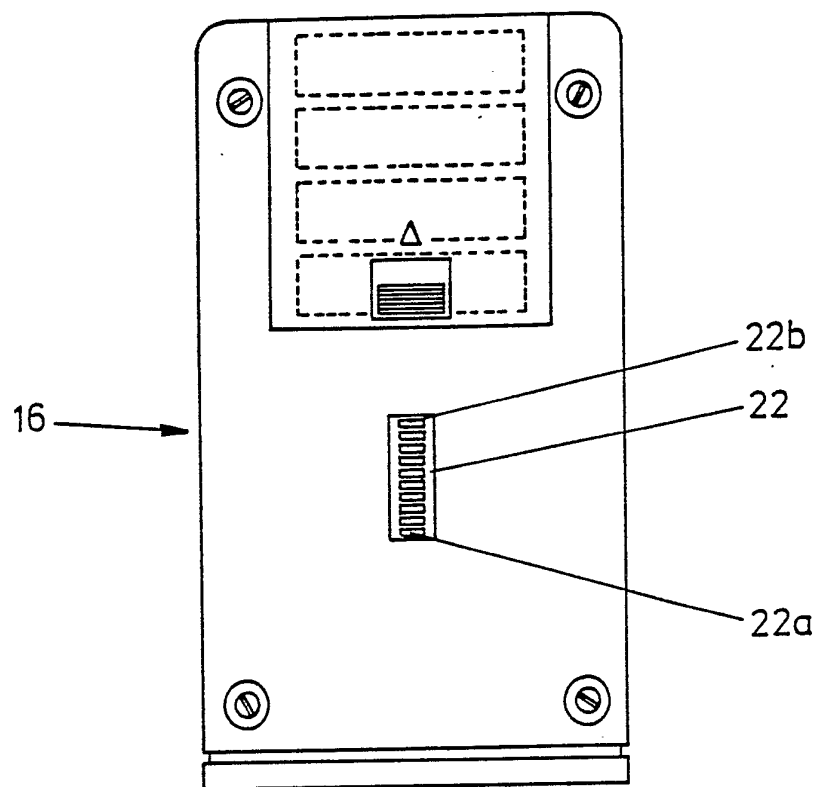


FIG. 5

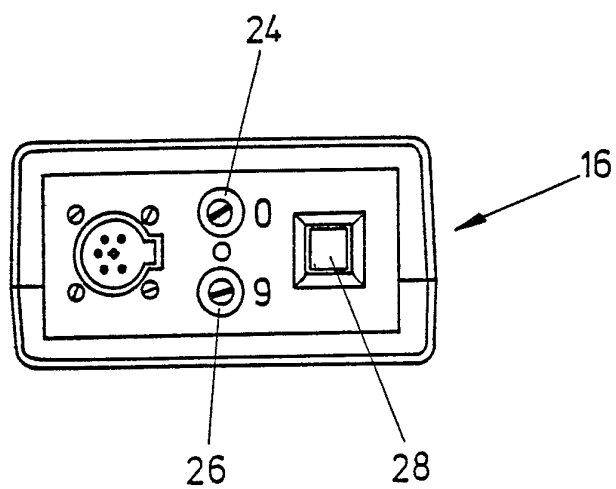


FIG. 6

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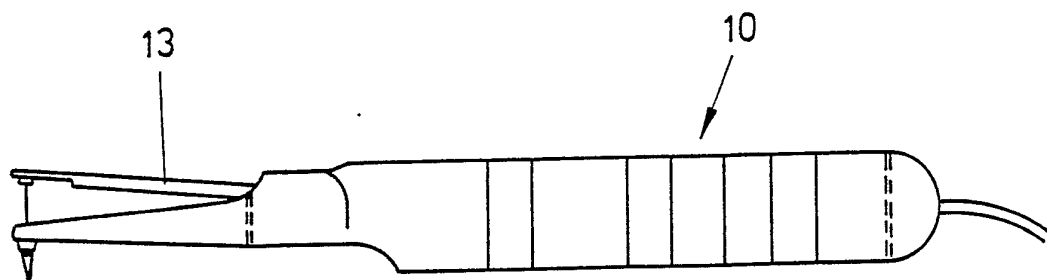


FIG. 7

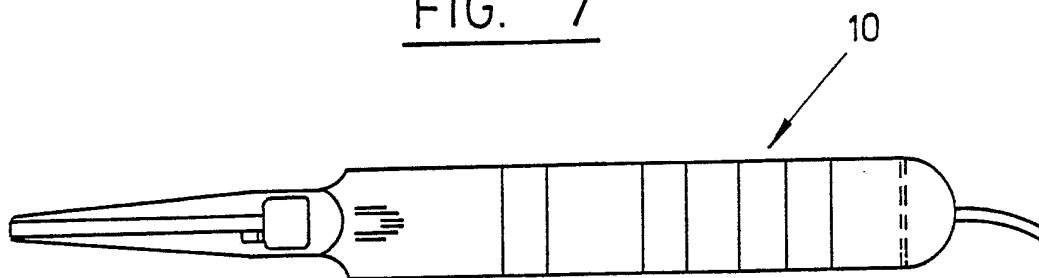


FIG. 8

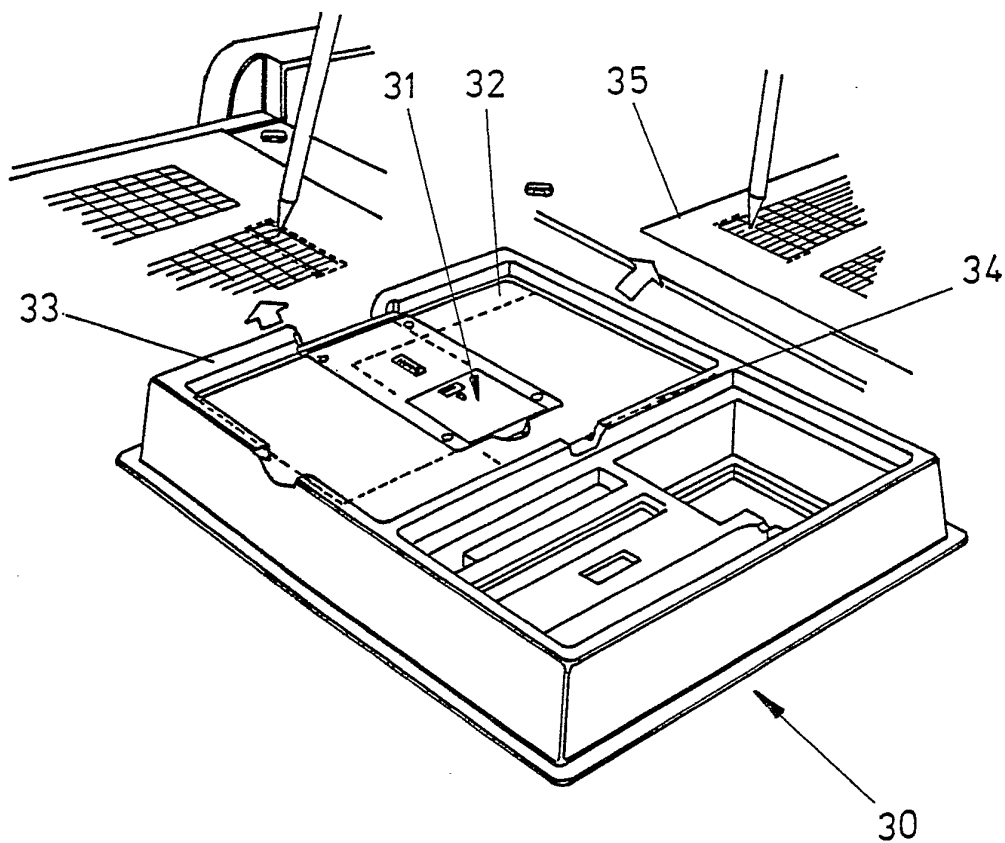


FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00877

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : A 61 C 19/04		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	A 61 C; G 01 B; G 01 D	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	EP, A, 0093896 (SIEMENS) 16 November 1983 see abstract; figure 3 --	1
A	EP, A, 0194083 (FOSTER-MILLER INC.) 10 September 1986 see page 4, line 32 - page 5 --	1
A	US, A, 3943914 (GRENFELL et al.) 16 March 1976 see figures 1,6 --	1
A	US, A, 4338722 (DELMAS) 13 July 1982 see abstract -----	1
* Special categories of cited documents: ¹⁰ "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. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
17th February 1988	06 APR 1988	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 8700877

SA 19717

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 28/03/88. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0093896	16-11-83	DE-A- 3215498	27-10-83
		JP-A- 58192535	10-11-83
		US-A- 4482324	13-11-84
EP-A- 0194083	10-09-86	JP-A- 62122655	03-06-87
US-A- 3943914	16-03-76	JP-A- 50037295	07-04-75
US-A- 4338722	13-07-82	None	