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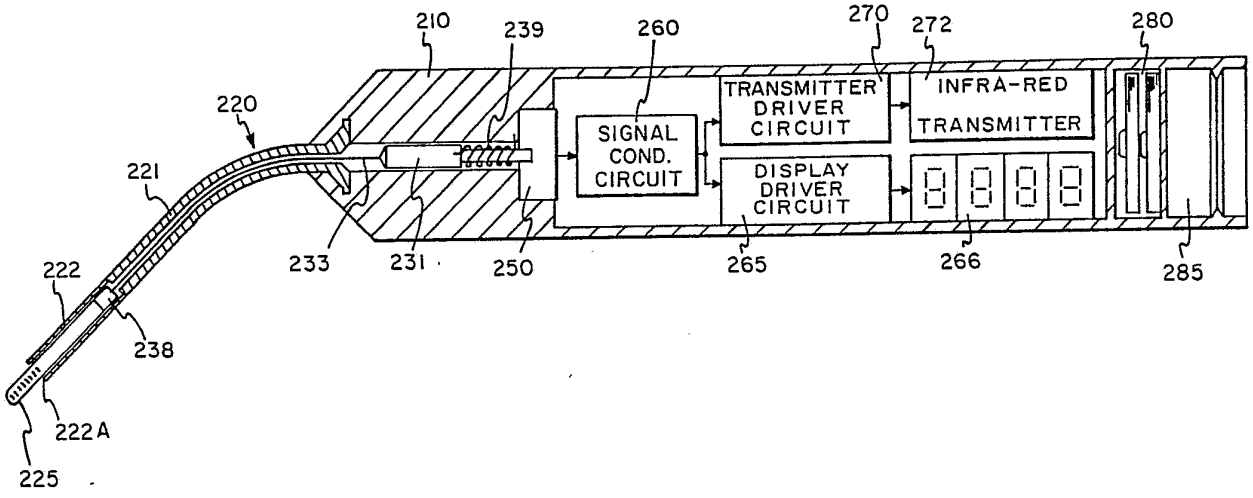
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Published
With international search report.

(54) Title: SYSTEM AND PROBE FOR INTRA-ORAL MEASUREMENTS



(57) Abstract

An intra-oral measurement probe includes a hand-held unit having a body (210) with a tubular sleeve (222) extending from its front end. A removable probe tip (225) is within the sleeve and has a forward portion that protrudes past the front end (222A) of the sleeve, and is movable in the sleeve. A wire (233) has its front end coupled to the rear portion (238) of the probe tip, the wire extending rearwardly into the body. A spring (239) biases the probe tip and wire, with substantially constant pressure, against rearward movement with respect to the sleeve. A transducer (250) in the body is coupled to the wire and generates electronic measurement information representative of the position of the probe tip within the sleeve. A transmitter (272) responsive to the electronic measurement information for transmitting through-the-air signals representative of the electronic measurement information to a remote receiver and recorder.

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SYSTEM AND PROBE FOR INTRA-ORAL MEASUREMENTS

BACKGROUND OF THE INVENTION

This invention relates to a system for obtaining and recording intra-oral measurements and also to a hand-held probe device for obtaining electronic measurement information indicative of measurements taken intra-orally or on a model of a mouth.

As an aid for both diagnosis and on-going treatment planning, it is vital for dental clinicians to accurately measure sulcular depth. This measure of sulcular depth should be reproducible; i.e., it should be the same when taken by different dental clinicians or by the same dental clinician at different times. In fixed rigid periodontal probes, differences in applied pressure during probing can be a major cause of error in measuring sulcular depths. Studies have shown pressures applied by different clinicians can vary by 3 to 130 grams and by 2 to 1 for the same clinician during repeated probings at the same examination site. These variations in applied pressure to sulcular tissues can result in variable depth measurements due to penetration of sulcular tissues. This is undesirable both from the standpoints of measurement inaccuracy and increase in the risk of tissue damage.

Prior art periodontal probing devices have been proposed which employ constant pressure, but proposed designs suffer one or more of the following disadvantages: inaccurate measurements, the need for complex mechanisms,

difficulty of use, difficulty of reading the measurements, inconvenient shape, size, or weight, and inadequacy with regard to sterilization.

Examples of prior art approaches can be found in U.S. Patents 4,340,069; 4,203,223; 3,943,914; 4,250,895; 4,364,730; 4,501,555; 3,935,640 and in the following publications: Vitek et al., "Development Of A Force Controlled Periodontal Probing Instrument", Journal of Periodontal Research, 14, pp. 93-94 (1979); Van Der Velden et al., "Introduction Of A New Periodontal Probe: The Pressure Probe", Journal of Clinical Periodontology. 5, pp. 188-197 (1978); Gibbs et al., "Description And Clinical Evaluation Of A New Computerized Periodontal Probe - The Florida Probe", J. Clinical Periodontal, 15, pp. 7-4 (1988).

It is among the objects of the present invention to provide improvement over prior art periodontal devices and techniques. It is among the further objects of the invention to provide a system for obtaining and recording intra-oral measurements with greater convenience and efficiency.

SUMMARY OF THE INVENTION

In accordance with a form of the present invention, there is provided a system for obtaining and recording intra-oral measurements, for example measurements of the depth of periodontal pockets, the size of teeth, and/or the spacing between teeth. In an embodiment of this form of the invention, an intra-oral probe device comprises a hand-held unit which includes a probe tip, means for generating electronic measurement information indicative of measurements taken with said tip, and a transmitter responsive to the electronic measurement information for transmitting through-the-air signals representative of the electronic measurement information. A receiving subsystem is located remotely from the hand-held unit, and includes means for receiving the transmitted signals and means for recovering and recording said electronic measurement information. This form of the invention has the advantage of providing convenient recording of electronic representations of intra-oral measurements without the need for wiring connections to the probe.

In a preferred embodiment of this form of the invention, the hand-held unit further comprises a numerical indicator display and means for coupling the electronic information to the numerical indicator display. Also, in this embodiment, a foot operated switch is provided and is adapted for use by the person holding the hand-held unit.

The foot operated switch is coupled to the receiving subsystem and is operative to control the information recorded by the receiving subsystem. Also, in a form of this embodiment, the receiving subsystem includes means for storing data pertaining to predetermined oral parameters, and means for indicating variations between the predetermined oral parameters and the electronic measurement information.

A form of the present invention is directed to a hand-held probe device for obtaining electronic measurement information indicative of measurements taken intra-orally or on a model of a mouth. In an embodiment of this form of the invention, a hand-held body is provided and has a tubular sleeve extending from its front end. A removable probe tip is within the sleeve and has a forward portion that protrudes past the front end of said sleeve, and is movable in said sleeve. A wire has its front end coupled to the rear portion of the probe tip, the wire extending rearwardly into the body. Biasing means, such as a spring, are provided for biasing the probe tip and wire, with substantially constant pressure, against rearward movement with respect to said sleeve. A transducer means in the body is coupled to the wire and generates electronic measurement information representative of the position of the probe tip within the sleeve.

Among the advantages of this form of the invention is

that probe sleeve and tip can be of a concise configuration and have a curved shape that facilitates efficient use of the probe while still achieving constant pressure operation.

Further features and advantages of the invention will become more readily apparent form the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram illustrating operation of an embodiment of the invention.

Fig. 2 is cross-sectional view, partially in schematic form, of an embodiment of the hand-held probe in accordance with an embodiment of the invention.

Fig. 3 is a block diagram of the receiving subsystem of the Fig. 1 embodiment.

Fig. 4 is a routine for programming the processor of the Fig. 3 embodiment for operation in accordance with a form of the invention.

Fig. 5 is another routine for programming the processor for operation in accordance with a form of the invention.

Fig.s 6 and 7 illustrate embodiments of the removable probe utilized in the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, there is shown a diagram which illustrates operation of an embodiment of the invention. A patient 110 is being examined by a dentist 115, or other person performing an intra-oral examination, such as a periodontist, orthodontist, or dental clinician. The dentist uses a hand-held probe 200 to take measurements in the patient's mouth. As noted above, these measurements can be of any desired type, including measurement of sulcular depth, measurement of tooth dimensions, measurement of spacing between teeth, etc. or combinations thereof. In this example it is assumed that measurements of sulcular depth are being made. The probe 200 is operated, in a manner to be described, to generate, within the probe, electronic measurement signals that are indicative of the measurements being made. The probe contains a transmitter which transmits this measurement information to a receiver subsystem which, in the present embodiment, is a table model console 300. The probe 200 also has a numerical display 266 (Fig. 3) which displays the electronic measurement information.

In the embodiment of Fig. 1, a foot-operated switch 150 is coupled by a wire 155 to the console 300, and can be used by the operator to indicate which of the transmitted measurements are to be stored. In the event that it is desirable to store all transmitted measurements, the foot-operated switch 150 can be used to flag measurements taken

at specific positions in the mouth.

In addition to features of the probe itself, to be described further, which render it compact, lightweight, and convenient to use, the absence of wire connections to the probe further facilitates its operation and convenience. The foot-operated switch further frees the measuring hand from specifying when measurements should be recorded of flagged.

Referring to Fig. 2, there is shown an embodiment of the hand-held probe 200 in accordance with the invention. A housing 210, which may be formed of plastic or metal, serves as a handle and includes a probe tip subassembly, 220 which is detachable from the housing. The subassembly 220 includes a sleeve base 221 and a detachable front sleeve portion 222 which contains a probe tip element 225 that is movable in the sleeve and protrudes from the front end or lip 222A of the sleeve portion 222. In the present embodiment, the sleeve base 221 snaps onto housing 210 and the front sleeve portion snaps onto sleeve base 221, although any suitable connection means can be utilized.

The probe tip, typically of stainless steel, has a rear portion which magnetically and mechanically snap locks into a recess in a front connector portion 238 of a piston drive assembly that includes a piston 231 and a metal drive wire 233 connected between the piston 231 and connector portion 238. A mechanical friction lock or other suitable mechanism

can alternatively be employed for attaching the probe tip. The metal wire 233 is selected for properties of being able to accurately transfer displacement without kinking or breaking. By readily traversing a curved portion of the tip, the drive wire permits a more compact probe of a configuration that is particularly advantageous for taking measurements in the mouth. It also facilitates the constant pressure operation of the probe. In particular, the piston 231 is movable within a cylindrical bore in the housing 210 and has a rear portion of reduced diameter that is surrounded by a coil spring 239 which is secured at its front end to the piston and at its rear end to the housing 210. The rear portion of the piston 231 communicates with a transducer 250 that functions to measure the piston displacement (and, accordingly, the displacement of wire 233 and probe tip 225). The transducer should be relatively small, sturdy, and reliable, and should provide an accurate electrical signal that is representative of the piston position or displacement. One such known type of transducer operates on an optical principle, in which a small light source, such as a light-emitting diode, is used in conjunction with a reflector that moves with the piston and a light sensor such as a photodiode. The light sensor output represents piston position. Other suitable transducers may operate, for example, on a principle of changing magnetic induction or electrical capacitance.

The output of transducer 250 is coupled to a signal conditioning circuit 260, the output of which is coupled to both a display driver circuit 265 and a transmitter driver circuit 270. The signal conditioning circuit 260 conditions the transducer output and may comprise, for example, an analog-to-digital circuit.

In the illustrated embodiment the output of display driver circuit 265 is coupled to a low voltage display 266, such as a conventional liquid crystal display, for digital display of the probe readings. An infra-red transmitter 272 is employed, and communicates with infra-red receiver 305 in the console 300 (Fig. 3). A storage battery subassembly 280 is provided and houses batteries that can be rechargeable. A recharging port 285 is also provided so that the batteries can be recharged when the hand-held probe 200 is placed in a recharging stand (not shown) in the console.

In operation of the hand-held probe, for example in measurement of sulcular depth, the probe tip 225 is inserted between the gum and tooth until it encounters the boundary of gum-tooth connection. Movement forward of the probe body will cause the sleeve 222 to move forward (with respect to the probe tip) until the front edge 222A of the sleeve abuts the gumline. (If desired a reference rim can be provided at the front edge of the sleeve.) As this is done, a substantially constant pressure is exerted by the probe tip due to the spring action on the tip (via the piston and wire).

Referring to Fig. 3, there is shown a block diagram of the recording subsystem which, in the present embodiment, is housed in the console 300 (Fig. 1). A microprocessor 310 is provided, together with conventional memory 311 and input/output circuitry (not shown) and clock circuitry 313. Suitable display 321 and printer 322 capability can also be provided. It will be understood that these functions can readily be implemented using a personal computer, for example an IBM personal computer. The infra-red receiver 305 conventionally includes a circuit for recovering the transmitted information from the received infra-red energy, and for decoding this information into a form suitable for input to the processor 310. The foot-operated switch 150 is another input to the processor 310.

Referring to Fig. 4, there is shown a flow diagram of a routine for operating the receiver subsystem to store a sequence of data from the probe 200 under the dentist's control. It is assumed in this routine that the dentist is taking a predetermined sequence of measurements, which is, for example, the way a dentist or periodontist or dental clinician typically works in measuring sulcular depths. The block 410 represents initialization of the routine, which can be implemented from the console or, for example, if two or more active positions are provided on the foot-operated switch, can be signalled therefrom. The initialization clears the appropriate registers and sets the measurement

sequence index at 1. Inquiry is then made as to whether a foot-operated switch indication has been received (diamond 415) and, if not, the loop 417 continues until such an event has occurred. When a foot-operated switch signal occurs, the block 420 is entered, this block representing the storage of the latest decoded measurement value in conjunction with the present measurement sequence index. The decoded measurement values are available at a processor input, as indicated in Fig. 3. Inquiry is then made (diamond 428) as to whether the measurement sequence index has reached its maximum. If not, the index is incremented (block 430), diamond 415 is reentered, and the loop 437 continues until the full sequence of data has been acquired, whereupon the answer to the inquiry of diamond 428 will be in the affirmative. A data printout can then be generated, as represented by block 445.

It will be understood that variations on this routine, including the ability of an operator to modify or restart a sequence or to specify a particular quadrant in the mouth, can be employed.

The present invention also facilitates real-time processing of the data to alert the operator that a measurement or group of measurements is, for example, outside a safe range. This is shown in the routine of Fig. 5 wherein the blocks 410, 415, 420, 428, 430 and 445 are similar to those in the routine of Fig. 4. In the Fig. 5

routine, however, when a current measurement value is stored (in conjunction with its measurement index), two additional operations are performed. In particular, after storage of the latest measurement value (block 420), inquiry is made (diamond 521) as to whether the measurement is within a predetermined range. If not, a suitable indication, such as audible indication and/or visible indication at the console can be provided (block 522). Further, the block 523 represents the inclusion of each measurement into a predetermined measurement function (for example, a cumulative or average value or any desired statistical value). This computed measurement value can then be compared against a predetermined value for the same number of data points (diamond 524) and, again, a suitable indication can be provided to the operator when the comparison of diamond 524 indicates that the computed measurement value is outside range. Such automatic monitoring can be useful in determining when measurements indicate either a physical problem or that there are problems with the measurements themselves or with the sequence.

Fig.s 6 and 7 illustrate further probe configurations which can be utilized in conjunction with the present invention. The probe of Fig. 6 has a disc 615 at its end which is useful in contacting a surface for distance measurement, for example between teeth. The probe of Fig. 7

has a caliper arm 720 extending substantially perpendicularly from its front end. A reference caliper arm 730 extends substantially perpendicularly from the front edge of sleeve 222, so that a caliper type of measurement can readily be made with the probe device.

The invention has been described with reference to particular preferred embodiment, but variations with in the spirit and scope of the invention will occur to those skilled in the art. For example, provision can be made for a fixed probe tip to be mounted in the hand-held probe. Also, a friction stop can be provided for facilitating changing of tips, and adjustable spring tension can be provided. Further, an anti-rotation mechanism can be provided in conjunction with the probe tip.

CLAIMS:

1. A system for obtaining and recording intra-oral measurements, comprising:

an intra-oral probe device comprising a hand-held unit which includes: a probe tip, means for generating electronic measurement information indicative of measurements taken with said tip, and a transmitter responsive to said electronic measurement information for transmitting through-the-air signals representative of said electronic measurement information;

a receiving subsystem located remotely from said hand-held unit, said subsystem including means for receiving said transmitted signals, means for recovering said electronic measurement information, and means for recording said electronic measurement information.

2. The system as defined by claim 1, further comprising a foot-operated switch adapted for use by the person holding said unit, said switch being coupled to said receiving subsystem and being operative to control the information recorded by said receiving subsystem.

3. The system as defined by claim 1, further comprising a numerical indicator display on said hand-held unit, and means for coupling said electronic measurement information to said numerical indicator display.

4. The system as defined by claim 2, further comprising a numerical indicator display on said hand-held unit, and means for coupling said electronic measurement information to said numerical indicator display.

5. The system as defined by claim 1, wherein said receiving subsystem includes means for storing data pertaining to predetermined oral parameters, and means for indicating variations between the predetermined oral parameters and said electronic measurement information.

6. The system as defined by claim 1, wherein said receiving subsystem includes means for storing data pertaining to predetermined oral parameters, means for determining computed oral parameters based on the recorded electronic measurement information, and means for indicating variations between the predetermined and computed oral parameters.

7. The system as defined by claim 1, wherein said hand-held probe comprises: a body having a tubular sleeve extending from its front end, said probe tip being removably positioned within said sleeve and having a forward portion that protrudes past the front end of said sleeve, said probe tip being movable in said sleeve; a wire having its front

end coupled to the rear portion of said probe tip, said wire extending rearwardly into said body; means for biasing said probe tip and wire, with substantially constant pressure, against rearward movement with respect to said sleeve; and transducer means in said body for sensing the position of said probe tip and generating electronic measurement information representative of the position of said probe tip within said sleeve.

8. The system as defined by claim 2, wherein said hand-held probe comprises: a body having a tubular sleeve extending from its front end, said probe tip being removably positioned within said sleeve and having a forward portion that protrudes past the front end of said sleeve, said probe tip being movable in said sleeve; a wire having its front end coupled to the rear portion of said probe tip, said wire extending rearwardly into said body; means for biasing said probe tip and wire, with substantially constant pressure, against rearward movement with respect to said sleeve; and transducer means in said body for sensing the position of said probe tip and generating electronic measurement information representative of the position of said probe tip within said sleeve.

9. The system as defined by claim 4, wherein said hand-held probe comprises: a body having a tubular sleeve

extending from its front end, said probe tip being removably positioned within said sleeve and having a forward portion that protrudes past the front end of said sleeve, said probe tip being movable in said sleeve; a wire having its front end coupled to the rear portion of said probe tip, said wire extending rearwardly into said body; means for biasing said probe tip and wire, with substantially constant pressure, against rearward movement with respect to said sleeve; and transducer means in said body for sensing the position of said probe tip and generating electronic measurement information representative of the position of said probe tip within said sleeve.

10. The device as defined by claim 7, further comprising a piston that is connected to said wire and is movable within said body, and wherein said transducer is coupled with said piston and senses the position of said probe tip within said sleeve by sensing the position of said piston.

11. The device as defined by claim 10, wherein at least a portion of said sleeve is curved, and wherein said wire conforms to said curve.

12. The device as defined by claim 7, wherein said biasing means comprises a spring.

13. The device as defined by claim 7, further comprising a reference caliper arm extending substantially perpendicularly from the end of said sleeve and a movable caliper arm extending substantially perpendicularly from the end of said probe tip.

14. A probe device for obtaining electronic measurement information indicative of measurements taken intra-orally or on model of a mouth, comprising: a hand-held body having a tubular sleeve extending from its front end; a removable probe tip within said sleeve and having a forward portion that protrudes past the front end of said sleeve, said probe tip being movable in said sleeve; a wire having its front end coupled to the rear portion of said probe tip, said wire extending rearwardly into said body; means for biasing said probe tip and wire, with substantially constant pressure, against rearward movement with respect to said sleeve; and transducer means in said body for sensing the position of said probe tip and generating electronic measurement information representative of the position of said probe tip within said sleeve.

15. The device as defined by claim 14, further comprising a piston that is connected to said wire and is

movable within said body, and wherein said transducer is coupled with said piston and senses the position of said probe tip within said sleeve by sensing the position of said piston.

16. The device as defined by claim 14, wherein at least a portion of said sleeve is curved, and wherein said wire conforms to said curve.

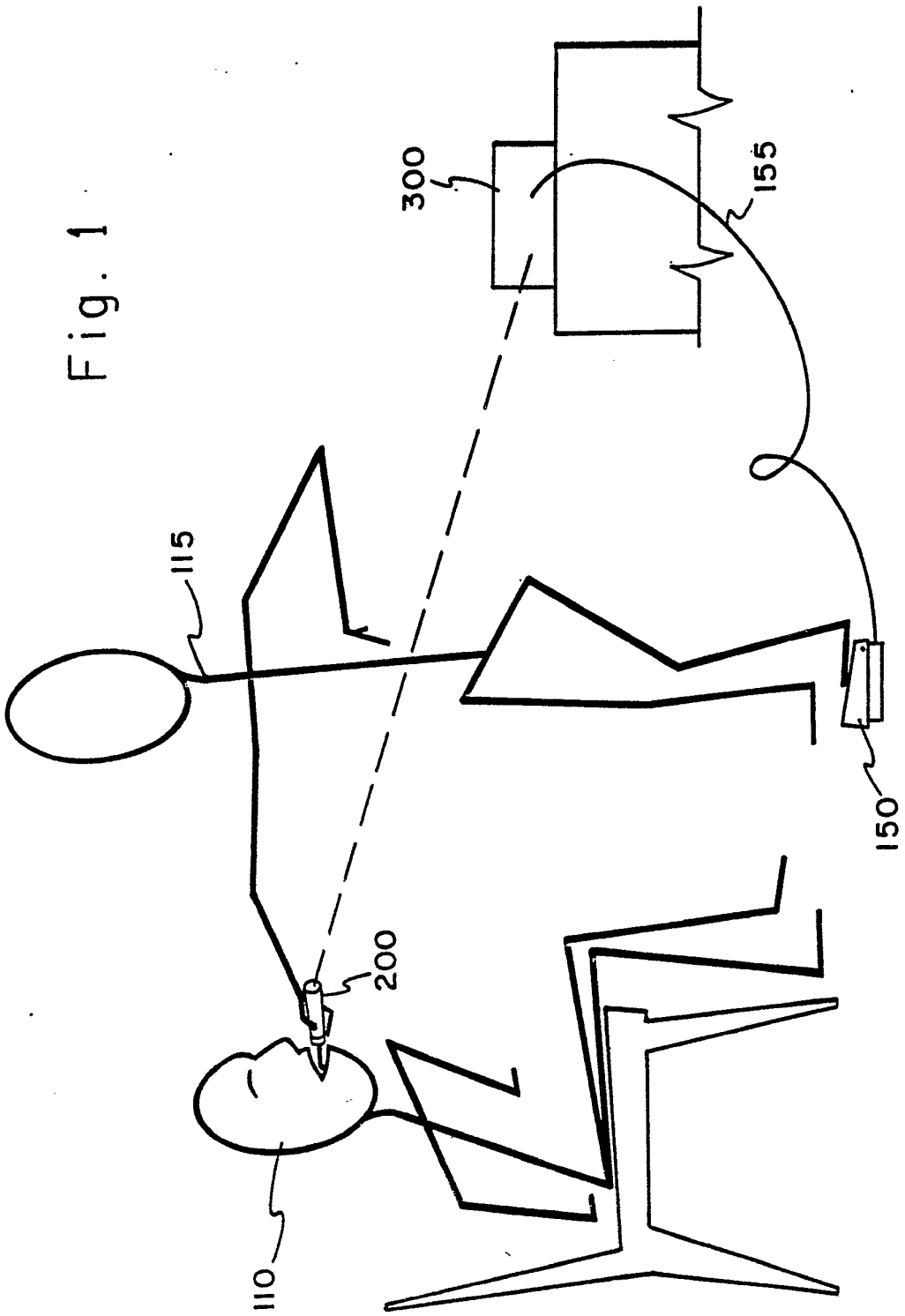
17. The device as defined by claim 15, wherein at least a portion of said sleeve is curved, and wherein said wire conforms to said curve.

18. The device as defined by claim 14, wherein said biasing means comprises a spring.

19. The device as defined by claim 17, wherein said biasing means comprises a spring.

20. The device as defined by claim 14, further comprising a reference caliper arm extending substantially perpendicularly from the end of said sleeve and a movable caliper arm extending substantially perpendicularly from the end of said probe tip.

Fig. 1



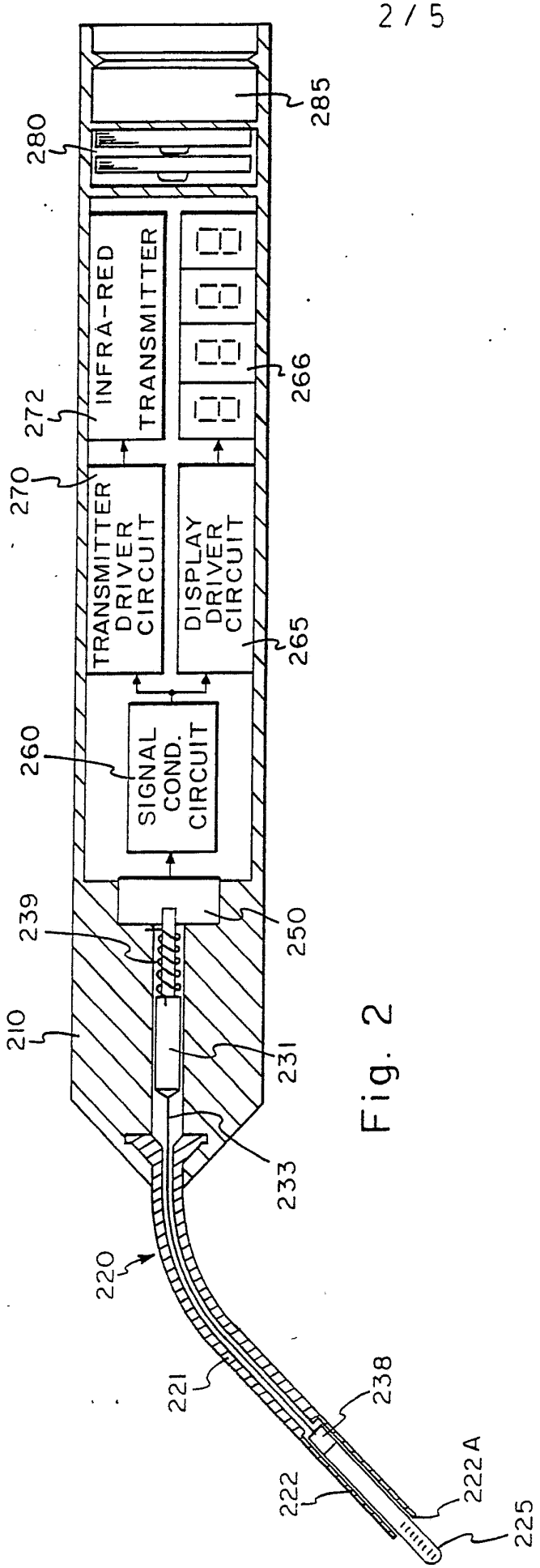


Fig. 2

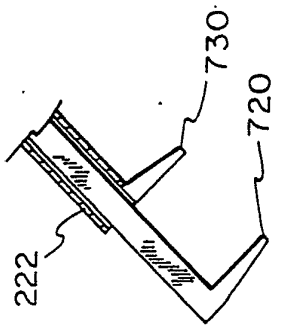


Fig. 7

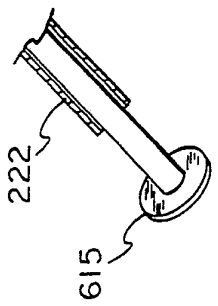


Fig. 6

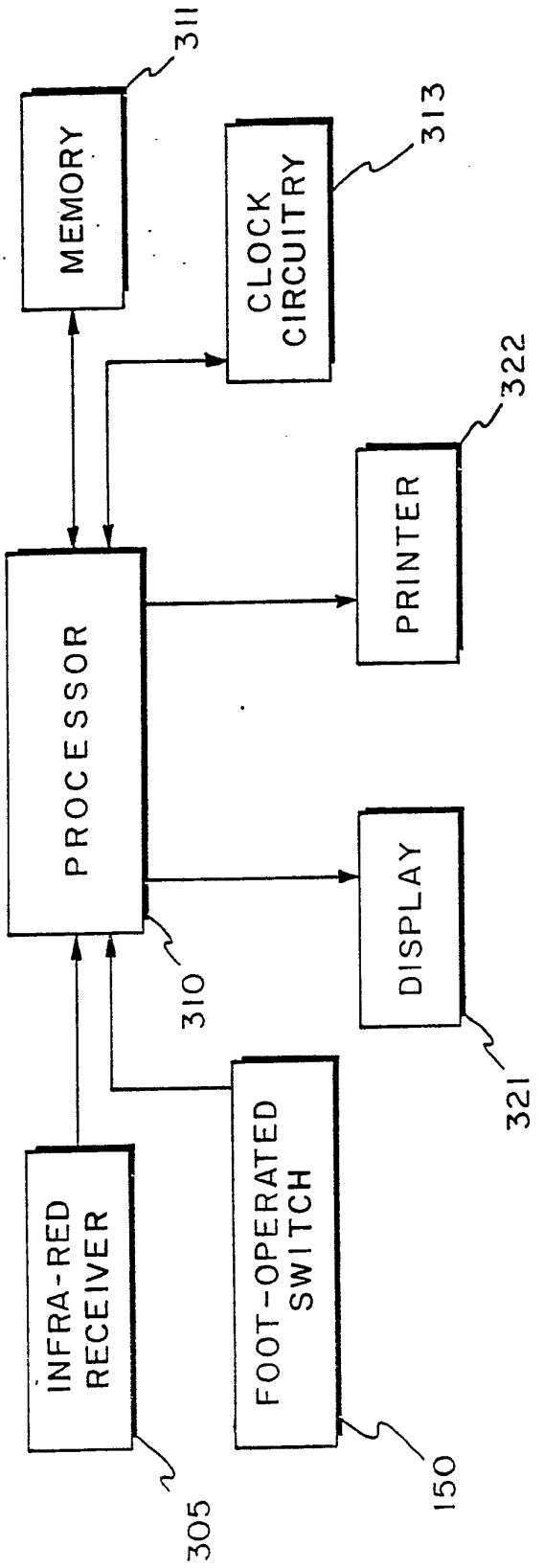

MEMORY
311
CLOCK CIRCUITRY
313
PRINTER
322
PROCESSOR
310
DISPLAY
321
INFRA-RED RECEIVER
305
FOOT-OPERATED SWITCH
150

Fig. 3

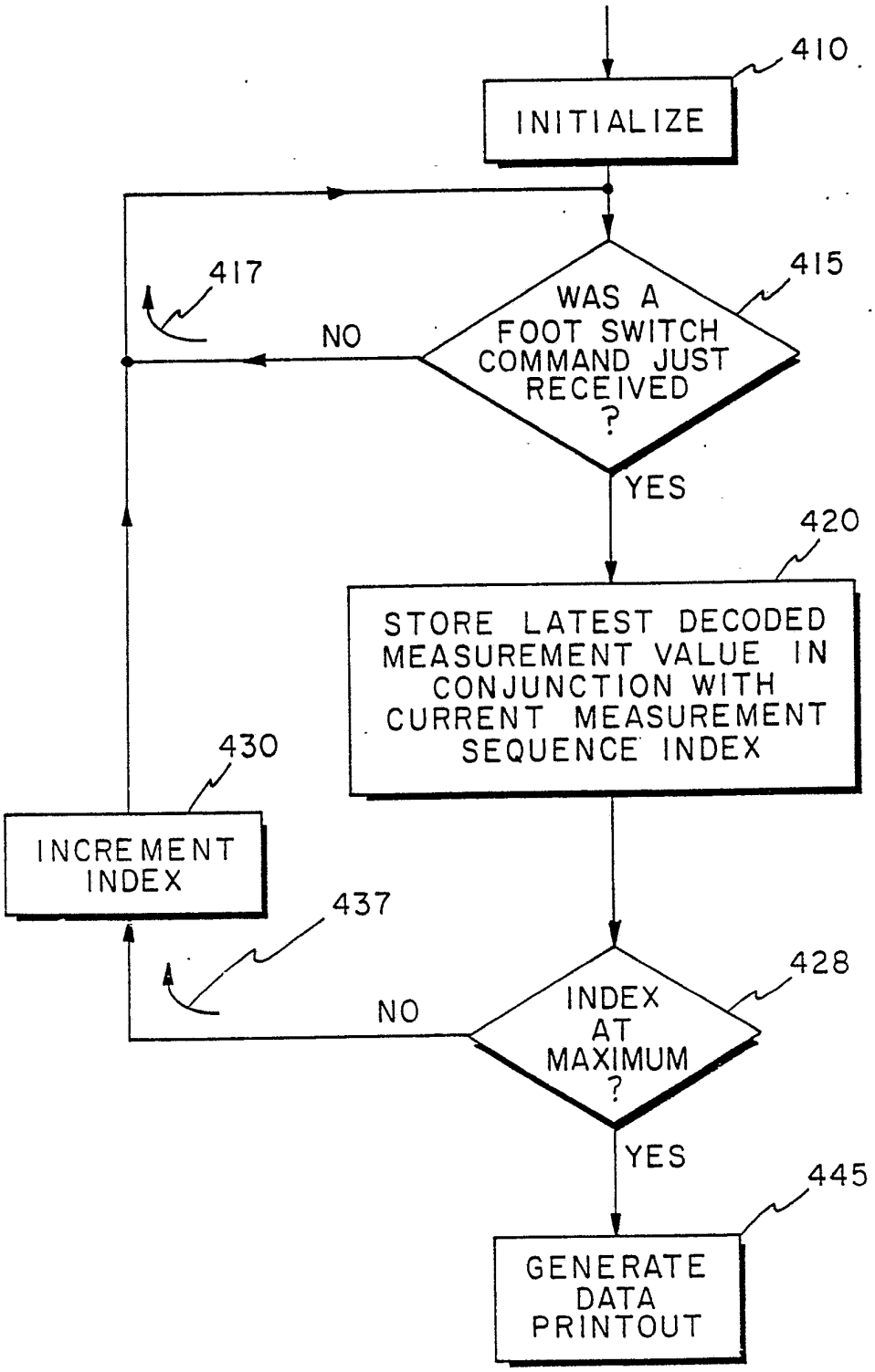

410
INITIALIZE
415
WAS A FOOT SWITCH COMMAND JUST RECEIVED ?
NO
417
YES
420
STORE LATEST DECODED MEASUREMENT VALUE IN CONJUNCTION WITH CURRENT MEASUREMENT SEQUENCE INDEX
428
INDEX AT MAXIMUM ?
NO
437
YES
430
INCREMENT INDEX
445
GENERATE DATA PRINTOUT

Fig. 4

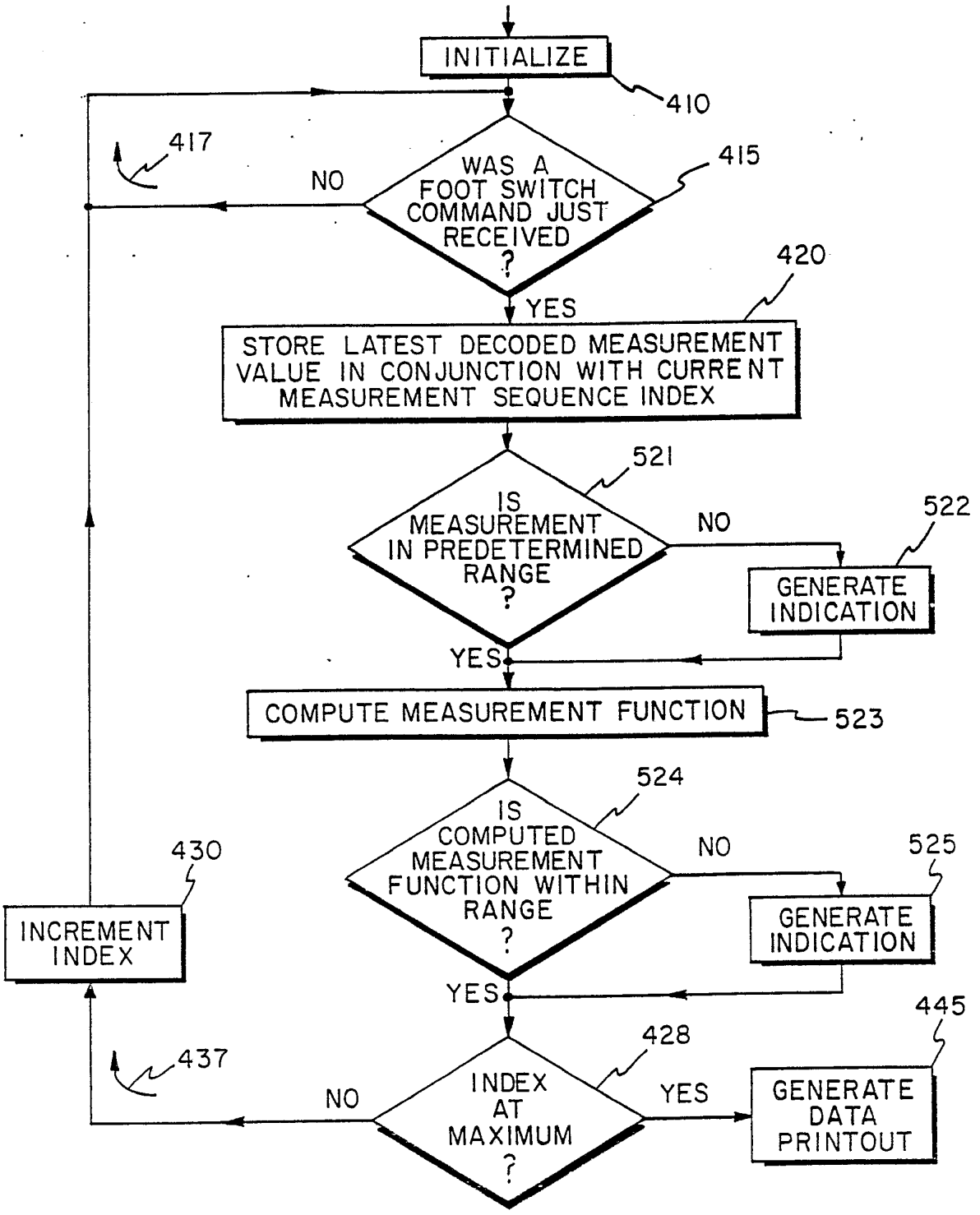

INITIALIZE
410
417
WAS A FOOT SWITCH COMMAND JUST RECEIVED ?
415
NO
YES
420
STORE LATEST DECODED MEASUREMENT VALUE IN CONJUNCTION WITH CURRENT MEASUREMENT SEQUENCE INDEX
521
IS MEASUREMENT IN PREDETERMINED RANGE ?
NO
522
GENERATE INDICATION
YES
COMPUTE MEASUREMENT FUNCTION
523
524
IS COMPUTED MEASUREMENT FUNCTION WITHIN RANGE ?
NO
525
GENERATE INDICATION
YES
430
INCREMENT INDEX
437
428
INDEX AT MAXIMUM ?
NO
YES
445
GENERATE DATA PRINTOUT

Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/04281

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

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

IPC (4): A61B 5/10
U.S. Cl. 128/776; 433/72; 33/514

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	128/774, 776, 777; 33/513, 514; 433/72, 141

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4,665,621 (ACKERMAN ET AL.) 19 May 1987 (19.05.87), see the entire document.	1-20
Y	Journal of Clinical Periodontology, Volume 5, issued 1978, Van Der Velden et al., "Introduction of a new periodontal probe: the pressure probe," see pages 188-197.	1-20
Y	NL, A, 7,703,431 (DE VRIES) 03 October 1978 (03.10.78), see abstract and English translation.	1-20
Y	US, A, 3,058,225 (WARD) 16 October 1962 (16.10.62), see Figure 5, element 85, and Figure 2, element 20.	3, 4, 13, 20
P, Y	US, A, 4,764,114 (JEFFCOAT ET AL.) 16 August 1988 (16.08.88), see Figure 1, element 24.	3-4
A	US, A, 3,559,292 (WEISSMAN) 02 February 1971 (02.02.71), see the entire document.	1-20

* Special categories of cited documents: [10]

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

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"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
12 February 1989	30 MAR 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	John C. Hanley

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 3,943,914 (GRENFELL ET AL.) 16 March 1976 (16.03.76), see Figure 1.	1-20
A	US, A, 4,203,223 (LAUTENSCHLAGER ET AL.) 20 May 1980 (20.05.80), see the entire document.	1-20
A	US, A, 4,340,069 (YEAPLE) 20 July 1982 (20.07.82), see the entire document.	1-20
A	US, A, 4,677,756 (SIMON ET AL.) 07 July 1987 (07.07.87), see the entire document.	1-20

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers . . , because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

3. ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A, E	US, A, 4,791,940 (HIRSCHFELD ET AL.) 20 December 1988 (20.12.88), see Figures 6 and 7.	1-20