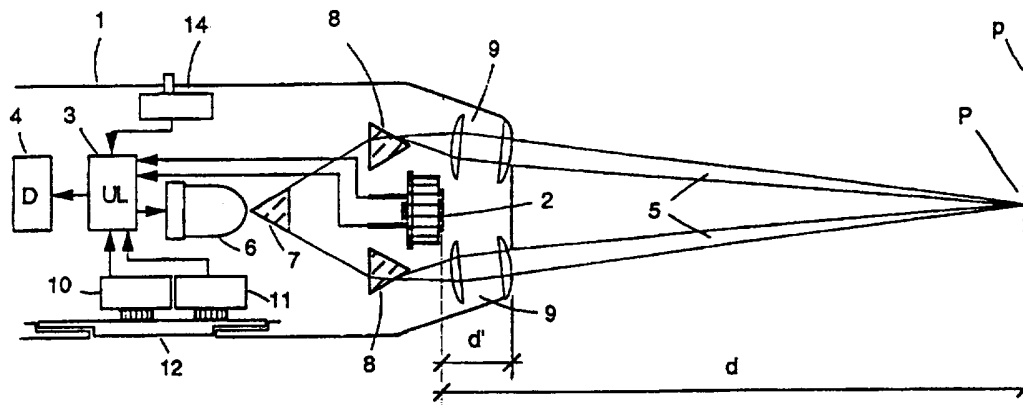




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/EP97/03531</p> <p>(22) International Filing Date: 4 July 1997 (04.07.97)</p> <p>(30) Priority Data: MI96A001399 5 July 1996 (05.07.96) IT</p> <p>(71) Applicant (for all designated States except US): LA TECNICA S.R.L. [IT/IT]; Piazzale Cocchi, 12, I-21040 Veduggio Olona (IT).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): BELLIFEMINE, Francesco [IT/IT]; Via Perla, 57, I-21100 Varese (IT). RUDI, Vincenzo [IT/IT]; Via Calatafimi, 18, I-21100 Varese (IT).</p> <p>(74) Agent: GERVASI, Gemma; Notarbartolo &amp; Gervasi, Corso di Porta Vittoria, 9, I-20122 Milan (IT).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</p>

(54) Title: INFRARED THERMOMETER COMPRISING OPTICAL AIMING SYSTEM



## (57) Abstract

A clinical thermometer is described, based on the measurement of the infrared radiation emitted by the patient, in which the body temperature of the patient is obtained in a non-invasive way and (normally) without any contact between the thermometer and the patient. During measurement of the temperature, the thermometer (1) is put at a preset distance (d) from the body of the patient, a distance which is normally determined by an optical aiming system consisting of two converging rays of light (5). A thermometer according to the invention may be used to obtain the temperature of the patient also by contact.

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## **Infrared thermometer comprising optical aiming system**

### Scope of invention

The invention consists of an infrared clinical thermometer which, during measurement of the body temperature of the patient, is put at a preset distance from the patient, a distance determined by an optical aiming system consisting of two converging light rays.

### Prior art

Traditional mercury thermometers are well known and still widely used for both medicine and veterinary purposes, even though they require excessively long times (4-5 minutes) to yield a response, and they are not always easy to read or very precise.

Fast-reading mercury thermometers have been developed, which, however, have not been very successful on the market because they are costly and brittle.

Digital thermometers, albeit representing an undoubted technical advance on clinical mercury thermometers, are not without certain drawbacks and limitations deriving basically from their response time, not less than 30-60 seconds, which is (or may be) too long when it is necessary to obtain the body temperature of particularly restless new-born babies, or else of animals.

Infrared clinical thermometers have recently come on the market, which comprise basically a sensor that detects in a very short time (2-3 seconds) the intensity of the infrared radiation emitted by a preset point of the body of the patient and a logic that processes the signal emitted by the sensor to determine the body temperature of the patient and to show it on a display, normally of a digital type, forming part of the thermometer itself.

As temperature measuring point, the ear drum membrane is normally used, which is located immediately near the hypothalamus (i.e., the gland which regulates body temperature) and which is normally reached by inserting a probe connected to the sensor into the auditory canal. This probe forms a single piece with the sensor and may be protected by a cap which is preferably interchangeable.

These infrared thermometers present, however, certain drawbacks.

In the first place, measuring the temperature at the ear drum cannot certainly be considered "non-invasive", since the probe anyway causes a certain discomfort to the patient. In addition, for obvious hygienic reasons it is necessary (or at least very advisable) to apply an interchangeable protective cap to the probe, or else  
5 clean the probe after each measuring. These are all things that are uncomfortable and inconvenient, especially in hospitals.

Finally, the precision of the thermometer reading may be impaired by a set of factors that are not always exactly foreseeable or assessable, such as, for example, an imperfect positioning of the end of the probe and/or the presence of  
10 wax in the auditory canal, etc.

On the other hand, the infrared sensors currently available on the market are of such a size that they cannot be introduced into the auditory canal of the patient, and hence it is essential to use a probe (containing a wave-guide having suitable characteristics) which "conveys" to the sensor the infrared radiation emitted by the  
15 ear drum membrane, at the same time preventing the sensor from being affected by the infrared radiation emitted by the surrounding areas, for example, the auricular region.

Subject of the present invention is an infrared clinical thermometer that is exempt the limits and disadvantages presented by infrared thermometers of a known type.

#### 20 Summary of invention

The subject of the present invention is an infrared thermometer comprising a sensor which detects infrared radiation and a logical unit which processes the signal emitted by the sensor and drives display means for displaying the body temperature of the patient.

25 During measurement of patient body temperature, the sensor is put at a preset distance from the body of the patient, determined preferably by means of an optical aiming system belonging to the thermometer and comprising two converging light rays.

#### List of figures

30 The invention will now be described in greater detail with reference to an embodiment thereof, which is presented purely for illustrative reasons and in no

way exhausts the possibilities. The invention is shown in the attached figures, where:

- Figure 1 shows a block diagram of a thermometer according to the invention, including a first embodiment of the optical aiming system;
- 5 - Figure 2 shows a schematic presentation of a second embodiment of the optical aiming system of Fig. 1;
- Figure 3 presents a schematic flow chart illustrating the operation of the logical unit of Fig. 1.

In the attached figures, the corresponding elements are identified by means of the same numerical references.

#### Detailed description

Figure 1 shows a block diagram of a thermometer according to the invention. In the figure are visible the outer casing of the thermometer (1), the sensor (2) for detecting the infrared radiation emitted by the body (p) of the patient, the logical unit (3) which receives and processes the signal emitted by the sensor (2) to determine the body temperature of the patient, which is displayed on a display (4) - preferably, but not necessarily of a digital type - and an optical aiming system which reveals visually a preset distance (d) generating a pair of light rays which converge in a preset point (P), the distance of which from the sensor (2) corresponds to the aforesaid preset distance (d).

An infrared thermometer is not described herein since it is already known (for example, from the published international patent application No. W0 94/20023). It will suffice to recall that, given the same body temperature of the patient, the amount of infrared radiation detected by the sensor (2) - and, consequently the amplitude of the signal emitted by the sensor (2) - is a function, among other things, of the distance between the sensor (2) and the body (p) of the patient, and that the body temperature detected by the thermometer (1) is in turn a function of the signal emitted by the sensor (2).

The thermometer (1) is (or may be) calibrated in a way that is in itself known to measure with the desired precision the body temperature of a patient when the sensor (2) is put at the preset distance (d) from the body (p) of the patient.

Consequently, the thermometer (1) is able to detect the body temperature of the patient with a precision that depends also on the precision with which the condition of placing the sensor (2) at the distance (d) from the body (p) of the patient is respected.

5 The optical aiming system belonging to the thermometer object of the present invention, which generates a pair of light rays (5) converging in the point (P) at a distance (d) from the sensor (2), is a simple, but effective, solution to the problem of determining rapidly and with acceptable precision whether the sensor (2) of the thermometer (1) is correctly positioned at the distance (d) from the body (p) of the  
10 patient.

An optical aiming system according to the invention comprises means for generating the pair of light rays (5) that converge in the preset point (P) and optical means (9) that cause the aforesaid light rays (5) to converge in the preset point (P).

15 In the embodiment shown in Fig. 1, the means for generating the pair of light rays (5) include a light source (6), means (7) which split the light ray emitted by the source (6), and means (8) that deflect the light rays coming out of the splitting means (7) to make them converge in the preset point (P).

In Figure 1 the means for splitting the light rays (7) and the means for deflecting  
20 the light rays (8) consist of optical prisms, but, without departing from the scope of the invention, the splitting means (7) may consist of an optical prism, and the deflecting means (8) may consist of mirrors.

In the example of embodiment here illustrated each one of the optical means (9)  
25 that cause the aforesaid light rays (5) to converge in the preset point (P) consists of a pair of plane-convex lenses, but without departing from the scope of the invention it is possible to use biconvex lenses or other equivalent optical means.

In order to measure the body temperature of the patient, the operator pushes a first push-button (10) belonging to the thermometer (1), which activates the optical  
30 aiming system - in Fig. 1, the first push-button (10) activates, via the logical unit (3), the light source (6) -, displaces the thermometer (1) until the point (P) where the light rays (5) converge is positioned on the patient's skin, and pushes a

second push-button (11) belonging to the thermometer (1), which activates the thermometer 1 - in Fig. 1, the second push-button (11) drives the logical unit (3).

The optical means (9) illustrated in Figures 1 and 2 cause each of the two light rays (5) to be convergent so that they become pointlike only in the preset point (P). In this case, if the sensor (2) of the thermometer (1) is at the preset distance (d) from the patient's body (p), the two rays (5) coincide in point (P); otherwise, the operator sees on the body of the patient two distinct luminous areas, one for each of the light rays (5), which are reduced in width and get closer to one another as the distance between the sensor (2) and the body (p) of the patient gets closer to the preset value (d).

In fact, the light rays (5) reach the patient's skin before they meet if the thermometer (1) is too close to the body (p) of the patient; they reach the patient's skin after crossing one another and then diverging again if the thermometer (1) is too far from the body (p) of the patient.

In the embodiment described here the push-buttons (10) and (11) have a different mechanical response (i.e., they require a different pressure to be activated) and are operated by the operator through a single button (12); however, without departing from the scope of the invention, the push-buttons (10) and (11) may be operated directly by the operator, or a "double-action" push-button combining the functions of the push-buttons (10) and (11) may be used.

Figure 2 is a schematic representation of a second embodiment of the optical aiming system, where the means for generating said pair of converging light rays (5) include a pair of light sources (13), equal to one another, located at the sides of the sensor (2) and inclined with respect to the axis of longitudinal symmetry of the thermometer (1), so as to cause the light rays emitted by the light sources (13) to converge in the preset point (P).

According to one of its possible embodiments, the thermometer (1) may be used also to detect the body temperature of the patient by contact, i.e., by resting on the body (p) of the patient the end of the thermometer (1) corresponding to the window made of material that is transparent to infrared radiation (not explicitly indicated in the figures) behind which the sensor (2) is located. The distance

(which is known) between the window positioned at the end of the thermometer (1) and the sensor (2) is indicated in Figures 1 and 2 by (d').

The said thermometer (1) is hence calibrated, in a known way, to measure, with the desired precision, the body temperature of a patient when the distance between the sensor (2) and the body (p) of the patient has the aforesaid value (d) or (d'). The mode of operation of the thermometer (1) (at a distance or by contact) can be selected by the operator using a switch (or other functionally equivalent means) schematically indicated by (14) in Figures 1 and 2.

A measurement by contact may be advantageous if compared to a measurement at a distance when the environmental conditions (e.g., very ventilated and/or very hot or very cold conditions) could affect the precision and/or reliability of a measurement at a distance. In a clinical/hospital field, it may be considered useful and/or advantageous to be able to confirm, through a measurement by contact, the result of a measurement at a distance (or vice versa) when the body temperature of a patient measured through the former measurement is unexpectedly high or low, or else when it is higher than a preset value  $T_0$ .

Figure 3 is a schematic representation of a flow chart illustrating the operation of a logical unit (3) belonging to a thermometer (1). First of all the operation will be illustrated of a logical unit (3) belonging to a thermometer (1) able to carry out only measurements at a distance; subsequently, this description will be integrated with that of the further functional steps carried out by the logical unit (3) of a thermometer (1) suitable for making also measurements by contact.

When the thermometer (1) is activated, the logical unit (3) performs (phase 1) possible self-diagnostics procedures, and checks (phase 2) whether the first push-button (10), which activates the optical aiming system, has been pushed. If the first push-button (10) has not been pushed, the logical unit (3) checks (phase 3) whether a preset deactivation time  $t_1$  has elapsed (e.g., 30 seconds) before switching off (phase 4) the display (4), if this was on, and checks again (phase 2) whether the first push-button (10) has been pushed.

This condition (return to phase 2) will be hereinafter referred to as "return to wait state".



If the first push-button (10) has been pushed (phase 2), the logical unit (3) activates (phase 5; in Fig. 3 this passage is schematically indicated by a dashed line) the optical aiming system, enables (phase 16) operation of the second push-button (11) and, after verifying (phase 6) that the second push-button (11) has been pushed, activates (phase 7) the procedure (not described herein because it is in itself known) for temperature measuring at a distance, and switches on (phase 8) the display (4) to display for a preset period of time the temperature measured before returning to the wait state.

If the second push-button (11) has not been pushed, the logical unit (3) checks (phase 9) that the first push-button (10) has been released before switching off (phase 10) the optical aiming system and returning to the wait state; otherwise, it checks again (phase 6) whether the second push-button (11) has been pushed.

If the thermometer (1) is able to carry out also measurements by contact, it includes also the switch (14), and the logical unit (3) is able to perform at least the following further functional steps:

- if the first push-button (10) has been pushed (phase 2), the logical unit (3) acquires (phase 11) the position of the switch (14): if the switch (14) is positioned on "measurement at a distance" (phase 12), the logical unit (3) activates (phase 5) the optical aiming system and enables (phase 16) operation of the second push-button (11); otherwise, it checks (phase 13) whether the switch (14) is positioned on "measurement by contact";
- if the switch (14) is positioned on "measurement by contact" (phase 13), the logical unit (3) disables (phase 14) the optical aiming system; otherwise, it checks again whether the switch (14) is positioned on "measurement at a distance" (phase 12);
- once the optical aiming system has been disabled (phase 14), the logical unit (3) first verifies (phase 15) that a preset time interval  $t_2$  (e.g., 8 seconds), necessary for stabilizing the internal temperature of the sensor (which might have changed on account of the previous measurement by contact), has elapsed since the previous measurement by contact, and then enables (phase 16) operation of the second push-button (11). If the preset time  $t_2$  has not elapsed, the logical unit

(3) checks again whether the switch (14) is positioned on "measurement at a distance" (phase 12);

- if the second push-button (11) has been pushed (phase 6), the logical unit (3) checks (phase 17) whether the switch (14) is positioned on "measurement at a distance" before activating (phase 7) the aforesaid procedure for measuring temperature at a distance; otherwise, it activates (phase 18) a procedure (not described herein because it is in itself known and anyway similar to that for temperature measuring at a distance) for measuring the temperature by contact and switches on (phase 8) the display (4) to display for a preset period of time the temperature measured, before returning to the wait state.

In the embodiment illustrated in the flow chart of Fig. 3, after switching on (phase 8) the display (4) to display for a preset period of time the temperature measured, the logical unit (3) first verifies (phase 19) that the switch (14) is positioned on "measurement at a distance" and that the temperature measured is higher than the aforesaid preset value  $T_0$ , and then shows on the display (4) (phase 20) for a preset time a prompt to carry out a control measurement by contact before returning to the wait state; otherwise, it returns directly to the wait state.

Without departing from the scope of the invention, it is possible for a technician to make an optical aiming system, subject of the present description, all the modifications and improvements suggested by normal experience and by the natural evolution of techniques to the infrared thermometer comprising.

CLAIMS

- 1 1. Infrared thermometer comprising at least one sensor (2) for detecting infrared  
2 radiation emitted by the patient, and a logical unit (3) for processing the signal  
3 emitted by said sensor (2), display means (4) driven by said logical unit (3) for  
4 displaying the body temperature of said patient measured by said thermometer  
5 (1), characterized in that, during measuring of said body temperature, said sensor  
6 (2) is put at a preset distance (d) from the body of said patient, determined by  
7 means of an optical aiming system belonging to said thermometer (1) and  
8 comprising a pair of light rays (5) converging in a preset point (P).
- 1 2. Thermometer according to Claim 1, characterized in that said optical aiming  
2 system comprises means for generating said pair of light rays (5) and optical  
3 means (9) that cause the aforesaid light rays (5) to converge in the preset point  
4 (P), the distance of said preset point (P) from said sensor (2) being equal to the  
5 said preset distance (d).
- 1 3. Thermometer according to Claim 2, characterized in that said means for  
2 generating said pair of light rays (5) include a light source (6), means (7) for  
3 splitting the light ray emitted by said light source (6), and means (8) for deflecting  
4 said light rays (5) coming out of said splitting means (7) to make them converge in  
5 said preset point (P).
- 1 4. Thermometer according to Claim 3, characterized in that said splitting means  
2 (7) and said deflecting means (8) consist of optical prisms.
- 1 5. Thermometer according to Claim 3, characterized in that said splitting means  
2 (7) consist of an optical prism and said deflecting means (8) consist of mirrors.
- 1 6. Thermometer according to Claim 2, characterized in that said means for  
2 generating the said pair of light rays (5) include a pair of light sources (13), equal  
3 to one another, located at the sides of said sensor (2) and inclined with respect to  
4 the axis of longitudinal symmetry of said thermometer (1), so as to cause the light  
5 rays emitted by said light sources (13) to converge in the said preset point (P).

- 1 7. Thermometer according to Claims 3 or 6, characterized in that each one of said  
2 optical means (9) for causing said light rays (5) to converge in the preset point  
3 (P) consists of plane-convex or biconvex lenses.
- 1 8. Thermometer according to Claim 1, characterized in that it comprises a pair of  
2 push-buttons (10, 11), the first (10) of said push-buttons activating said optical  
3 aiming system, the second (11) of said push-buttons activating said thermometer  
4 (1).
- 1 9. Thermometer according to Claim 8, characterized in that said push-buttons  
2 (10, 11) have a different mechanical response requiring a different pressure to be  
3 activated.
- 1 10. Thermometer according to Claim 8, characterized in that said push-buttons  
2 (10, 11) are operated through the same button (12).
- 1 11. Thermometer according to Claim 1, characterized in that said logical unit (3)  
2 carries out in order at least the following sequence of functional steps:  
3 - check whether the first push-button (10) has been pushed;  
4 - if said first push-button (10) has not been pushed, check whether a first preset  
5 deactivation time  $t_1$  has elapsed before turning-off said display means (4) and  
6 return to wait state; otherwise, activate said optical aiming system and enable  
7 operation of said second push-button (11);  
8 - if said second push-button (11) has been pushed, activate the procedure for  
9 temperature measuring at a distance, switch on said display means (4) to display  
10 the temperature measured for a preset period of time and return to the said wait  
11 state; otherwise, check whether the said first push-button (10) has been released;  
12 - if said first push-button (10) has been released, switch off said optical aiming  
13 system and return to said wait state; otherwise, check again whether the said  
14 second push-button (11) has been pushed.
- 1 12. Thermometer according to Claim 11, able to perform also measurements by  
2 contact, characterized in that it comprises also a switch (14) for enabling said  
3 thermometer (1) to carry out, alternatively, measurements at a distance and  
4 measurements by contact, and in that the said logical unit (3) carries out in order  
5 at least the following further functional steps:

- 6 - if said first push-button (10) has been pushed, acquire the position of said  
7 switch (14);
- 8 - if said switch (14) enables said thermometer (1) to carry out measurements at a  
9 distance, activate said optical aiming system and enable operation of said second  
10 push-button (11); otherwise, check whether said switch (14) is enabling said  
11 thermometer (1) to carry out measurements by contact;
- 12 - if said switch (14) is enabling said thermometer (1) to carry out measurements  
13 by contact, disable said optical aiming system; otherwise, check again whether  
14 said switch (14) is enabling said thermometer (1) to carry out measurements at a  
15 distance;
- 16 - once said optical aiming system has been disabled, first verify that a second  
17 preset time interval  $t_2$  has elapsed since the previous measurement by contact,  
18 and then enable operation of said second push-button (11);
- 19 - if the said second preset time  $t_2$  has not elapsed since the previous  
20 measurement by contact, check again whether said switch (14) is enabling said  
21 thermometer (1) to carry out measurements at a distance;
- 22 - if said second push-button (11) has been pushed, check whether said switch  
23 (14) is enabling said thermometer (1) to carry out measurements at a distance  
24 before activating the said procedure for measuring temperature at a distance;  
25 otherwise, activate the procedure for measuring the temperature by contact and  
26 switch on said display means (4) to display for a preset period of time the  
27 temperature measured, before returning to the wait state.
- 1 13. Thermometer according to Claim 12, characterized in that after switching on  
2 the said display means (4) to display for a preset period of time said temperature  
3 measured, the said logical unit (3) carries out at least the further functional steps  
4 of verifying that said switch (14) is enabling said thermometer (1) to carry out  
5 measurements at a distance and that the said temperature measured is higher  
6 than a preset value  $T_0$ , and then showing on said display means (4) for a preset  
7 time a prompt to carry out a control measurement by contact before returning to  
8 said wait state.

FIG. 1

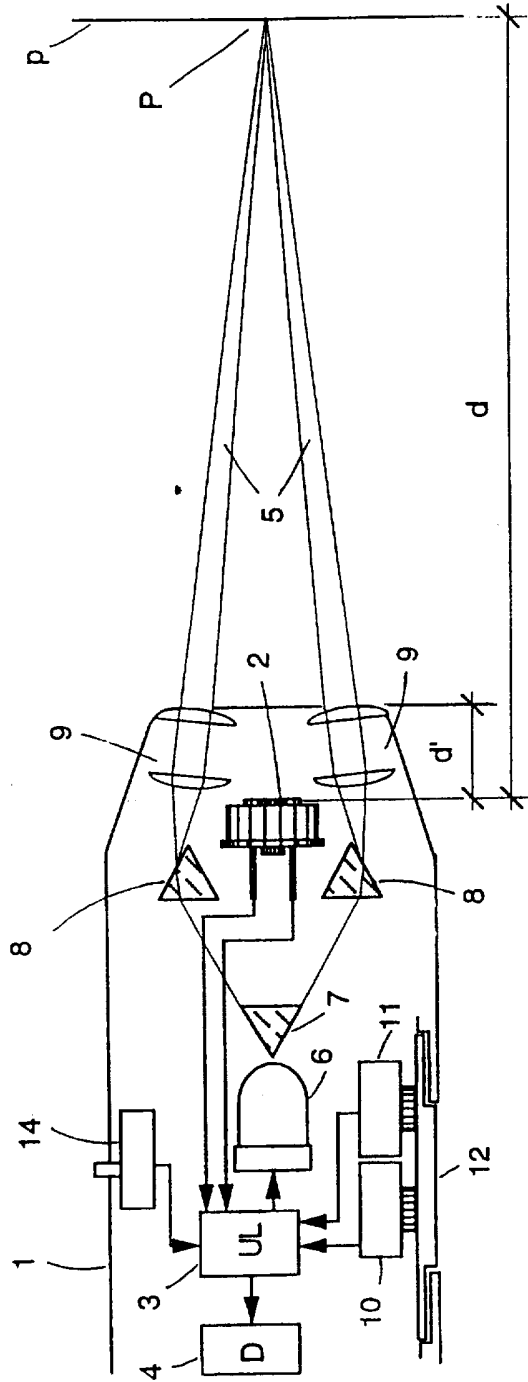
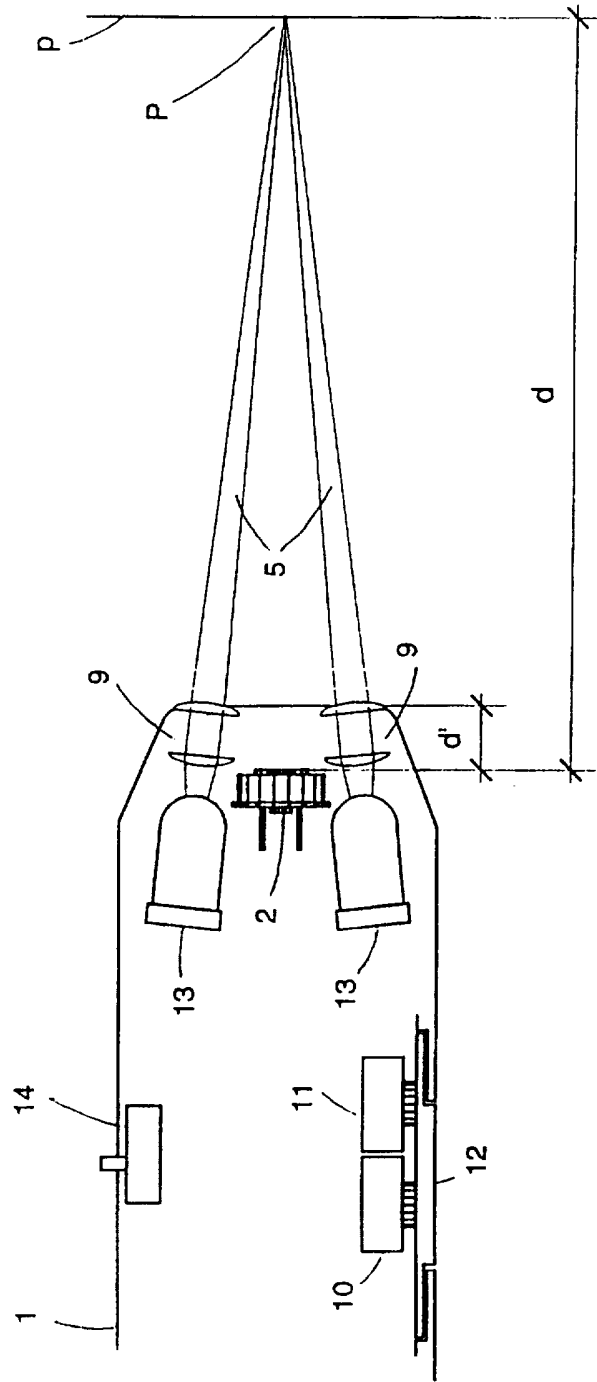


FIG. 2







# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 97/03531

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 G01J5/08 A61B5/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G01J A61B G01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 92 02792 A (ORTOMEDIC) 20 February 1992  see abstract see page 4, line 7 - line 32 see page 5, line 6 - line 18 see page 6, line 32 - line 34; figures 1,3,5  ---	1,2,6 3-5
Y  A	GB 2 291 498 A (RAYTEK SENSORIK GMBH) 24 January 1996  see abstract see page 3, line 31 - page 4, line 24 see page 5, line 19 - line 25 see page 9, line 10 - line 33 see page 10, line 9 - line 24; figures 1,2  ---  -/--	3-5  1,8,9

Further documents are listed in the continuation of box C.

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/EP 97/03531

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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