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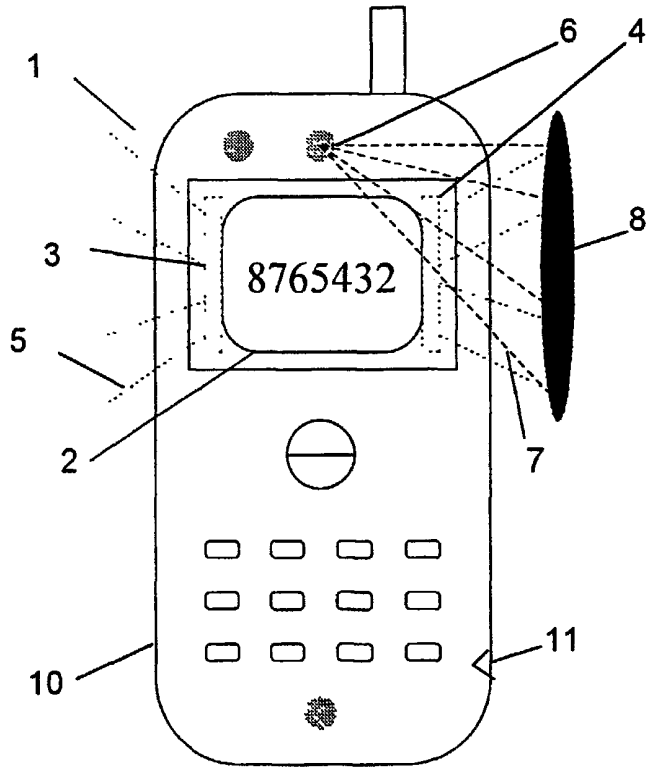
(54) Title: APPARATUS AND METHOD OF SENSING PROXIMITY BY MEANS OF LIGHT



(57) Abstract: The invention relates to an apparatus and a method for detecting the proximity of an object to an electronic device by means of light, using fewer components than the prior art. The problem is solved in a simple way by using the light (5) from the display (2) of an electronic device (1) to illuminate possible objects (8) in its vicinity and to detect the presence or absence of objects (8) by a light sensitive detector (6) located in the device near the display (2). The invention may be used to control functions such as loudspeaker volume, display illumination, etc. of electronic devices such as mobile telephones, laptop computers, portable music playing devices, etc.

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Apparatus and method of sensing proximity by means of light

This invention relates to an electronic device with a proximity sensor to determine whether an object is in proximity of the device, comprising: a display with means for illuminating the display and thereby for providing an optical signal; a proximity sensor for receiving an optical signal and for providing a control signal indicative of whether an object is in proximity of the device.

US Patent No. 5,684,294 discloses a proximity and ambient light monitor. The monitor comprises a light source in the form of a light emitting diode (LED) for generating an optical composite signal, a light detector, a circuit for separating a signal component corresponding to detected light emitted from the LED, and a switch for providing a control signal when the separated signal component is outside a preset range. The monitor further comprises an ambient light detector which receives the detected signal and provides an ambient light level signal. Thereby, it is possible to provide control of display back lighting in a personal communication terminal i.e. a handset. The display can be a liquid crystal display (LCD) including back lighting using one or more LED's to improve night time visibility of the display.

US Patent No. 5,224,151 discloses a handset with an infrared proximity detector activated when the distance between the receiver and the user's ear is less than a preset value, at which the operation of the terminal is switched from loudspeaker mode to receiver mode. The terminal disclosed in this patent comprises two infrared emitting devices arranged in a spatial relationship. The light is generated by each LED in alternative periods and

is then focused by an associated lens. The light emitted by the first LED is directed outwardly and is modulated at an RF frequency to produce a pulsed infrared output, which is distinguishable from incidental background light by a distance measuring circuit. The light reflected from the user is focused by another lens and is detected by a photodiode, which also receives direct light from the second LED. The second LED is used for a check of operability of the ranging function of the handset to prevent operation of the portable communication device in the loudspeaker mode upon failure of one of the infrared LED's or the detector.

However, the above cited prior art requires unnecessarily many components for proximity detection, which reduce battery operating time and which require additional space in small-sized products (e.g. a mobile phone). Further, the manufacturing expenses and the risk of break-down of the product due to component failures are increased.

An object of the invention is therefore to reduce the number of components in small-sized products having proximity detection.

This is achieved when the device mentioned in the opening paragraph is characterized in that the proximity sensor is adapted to modify the control signal in response to light, firstly, emitted by the display and, secondly, reflected by an object in front of the display.

Consequently, it is possible to determine the amount of light emitted by the display and reflected by an object in front of the display. This, in turn, allows for determination of whether an object in front of the display is in proximity of the display - or the device.

Further, the number of light emitting components is reduced. Such components are relatively fragile and therefore the reliability of the device is increased.

Expedient embodiments of the device according to the invention will appear from the dependent claims 2-13.

Moreover, the invention relates to a method of detecting proximity as stated in claim 14. Expedient embodiments of the method according to the invention will appear from the dependent claims 15-20.

The invention will be explained more fully below in connection with a preferred embodiment and with reference to the drawing in which:

fig. 1 shows a mobile telephone according to the invention, and

figs. 2a and 2b show the principle of proximity detection according to the invention using light sources placed in front of the display,

figs. 3a and 3b show the principle of proximity detection according to the invention using light sources placed behind the display,

fig. 4 shows a proximity detector according to the invention,

fig. 5 shows a light source modulated with an alternating signal component,

fig. 6 shows a proximity detector adapted to isolate an alternating signal component according to the invention,

fig. 7 shows a mobile telephone adapted to transmit and receive coloured light according the invention,

fig. 8 shows the control of the display light according to the invention,

fig. 9 shows a flow diagram of a method of sensing proximity of an object by means of light according to the invention,

Fig. 10a shows a display and proximity sensor of a mobile telephone,

Fig. 10b shows a display and proximity sensor of a mobile telephone where an object is in proximity of the mobile telephone, and

Fig. 11 shows a circuit for detecting proximity in response to back scattered display light and ambient light.

Fig. 1 shows a mobile telephone 1 according to the invention. The display 2 is provided with light sources 3, 4 that illuminate the display 2 and spread light 5 on possible objects 8 in the vicinity of the display. A proximity sensor 6 is placed near the display 2 to receive scattered light 7 from possible objects 8, e.g. a table, an ear of a human head, a cheek, a palm of the hand, etc., in the proximity of the telephone 1. A focussing lens may be placed in front of the proximity sensor to concentrate the received light. The display may be a liquid crystal display or any other display type.

In a preferred embodiment the mobile telephone 1 comprises a photo detector 11 for sensing ambient light. Preferably, the photo detector 11 is placed such that the sensing of ambient light is disturbed as little as possible when an object is in front of the display. The photo detector 11 can be placed on top of the phone, on the back of the phone, on one of the sides of the phone, etc.

Sensing of ambient light in connection with detection of proximity will be discussed further below.

Fig. 2 shows an embodiment of the invention where two light sources 103, 104 for illuminating the display 2 are placed in front of the display under the front cover 10 of the device 1. The front cover 10 may have built-in local variations in its transparency to light to optimize the combined function of illuminating the display 2 and possible objects 8 in its vicinity. Fig. 2a shows a situation with no objects in the vicinity of the display. Fig. 2b shows a situation where an object 8 is present close to the display 2. The proximity sensor 6 receives scattered light 7 from possible objects 8 in the proximity of the telephone 1 and provides a control signal Vctpr in response to the amount of light detected. If the amount of light detected by the proximity sensor 6 is outside a predetermined range, an output control signal Vctpr is provided whose value represents the situation "object present" (e.g. corresponding to a logical "1"). If, on the other hand, the amount of light detected by the proximity sensor 6 is inside a predetermined range, an output control signal Vctpr is provided whose value represents the situation "no object present" (e.g. corresponding to a logical "0"). The control signal may alternatively be a current or an optical signal directly.

Fig. 3 shows an embodiment of the invention where light sources 203, 204 for illuminating the display 2 are placed behind the display, so-called back lighting. The light sources 203, 204 are placed along the edges of a light guide in the form of a transparent plate 9 which guides the light from the light sources and illuminates the display from behind. The transparent plate 9 is covered with a light-reflecting sheet on its back side to ensure that as much of the light as possible is directed

through the display with the combined purpose of illuminating the display and providing light to be reflected by possible objects near the display. Fig. 3a shows a situation with no objects in the vicinity of the display. Fig. 3b shows a situation where an object 8 is present close to the display 2. In a special embodiment of the invention the light sources are fluorescent lamps, thus conserving power. The number of light sources is not confined to two, but may be any other number in agreement with the need for light and allowable power consumption. Alternatively, the light source may be a light emitting diode (LED), a light bulb or other means fulfilling the dual purpose of illuminating the display and supplying light for reflection of external objects and detection by the proximity sensor. More alternatively, the display may be self-illuminating, meaning that the illumination is an integral part of the display in the sense that no special means for illuminating it are required.

Fig. 4 shows an embodiment of the proximity detector 6. The light sensitive part is a photodiode 20, appropriately biased by means of the resistor 22, the bias voltage Vbias1 and ground (GND). Alternatively, the light sensitive part may be a photovoltaic cell, a photo transistor or the like. The anode of the photodiode 20, with voltage Vin, is connected to the input of a voltage range detector 21 whose output Vctpr is the control voltage indicating the presence or absence of objects, possibly at a logical voltage level representing logical "1" or "0". Vmin and Vmax are the appropriate minimum and maximum values of the input voltage Vin that delimit proximity. The input voltage Vin is (within relevant limits) an increasing function of the amount of received light. The voltages Vmin and Vmax represent amounts of light received by the proximity detector corresponding to the minimum and maximum amounts of light that delimit prox-

imity. The correspondence between the input voltage Vin of the range detector and the output voltage Vctpr indicating the presence or absence of objects is as follows. If Vin is inside the range between Vmin and Vmax, the interpretation is "no object present in proximity" or simply "no proximity", e.g. represented by a logical "0". If, on the other hand, Vin is outside the range between Vmin and Vmax, the interpretation is "object present in proximity" or simply "proximity", e.g. represented by a logic "1". This is indicated in table 1 below.

Vin	Vctpr	Interpretation
Vin < Vmin	'1'	Proximity
Vin > Vmax	'1'	Proximity
Vmin ≤ Vin ≤ Vmax	'0'	No Proximity

Table 1.

Fig. 5 shows an embodiment of the invention where the light source, implemented as an LED 40, illuminating the display 2 is modulated by an oscillating signal, e.g. generated by adding the signal Iosc from a current source 43, controlled by an AC-generator 42 to the normal bias signal Ibias for the light source. The LED is appropriately biased by means of the resistor 41, the bias voltage Vbias2 and ground (GND). The normal bias for the display light may be controlled by the switch 44 via the control voltage Vctdl. The switch may e.g. be implemented by a transistor to connect the resistor 41 to the bias voltage Vbias2 if Vctdl is logic "1", and to disconnect it if Vctdl is logic "0". This is indicated in table 2 below.

Vctdl	Interpretation
"1"	Display light on
"0"	Display light off

Table 2.

The AC modulation of the bias current for the LED leads to a corresponding modulation of the amplitude of the light emitted by the LED. In a special embodiment of the invention the modulation may originate from the light source itself, e.g. like in the case of an AC-fed light bulb. This additional AC component may be used in the detector part to separate the light emitted from the display from light from other sources (e.g. ordinary daylight or electric light depending on the environment in question) in that electrical filter means are employed for this purpose in the proximity detector.

An embodiment of a proximity detector 6 adapted for this purpose is shown in fig. 6, where a photodiode 120, appropriately biased by means of the resistor 122, the bias voltage Vbias3 and ground (GND), acts as the light-sensitive device. The anode of the photo diode 120, with voltage Vin, is connected to the input of a range detector 121 via a filter 23 for isolating the AC component of Vmod originating from the AC-modulation of the display light. To provide a 'stable DC-version' of Vmod, a rectifier 24, an integrator 25 and a Schmitt trigger 26 are included after the filter 23. The input voltage Vmod to the range detector is a function of the amount of received light scattered from possible nearby objects. The correspondence between the input voltage Vmod of the range detector 121 and the output voltage Vctpr indicat-

ing the presence or absence of objects is as above and as indicated in table 3 below.

Vmod	Vctpr	Interpretation
Vmod < Vmin	"1"	Proximity
Vmod > Vmax	"1"	Proximity
Vmin ≤ Vmod ≤ Vmax	"0"	No Proximity

Table 3.

Alternatively, due to the fact that the voltage provided by the filter 23 can be a pulsed signal with a relatively low duty-cycle it can be convenient to supply this signal to a phase locked loop for determining whether proximity is present. Typically, this solution is more convenient to interface with a micro-processor.

Fig. 7 shows a special embodiment of the invention, where the light 105 emitted from the display 102 of a mobile telephone 1 has a characteristic colour component, achieved by means of a coloured glass 51 in front of the display 102. In another embodiment of the invention, the colour component may originate from a colour inherent in the light source 3, 4 (a specifically coloured LED, e.g.) or the display 2 itself. The colour component is used in the detector part to separate the light 105 emitted from the display from light from other sources (e.g. ordinary daylight and electric light according to the environment in question) in that an optical filter 50 is placed in front of the proximity detector 6, the filter 50 being especially transparent to the colour in question. The colour may preferably be selected in a wavelength range where the ambient light (or the artificial light, if relevant) has a relatively low component to enhance the

sensitivity of the proximity detector to the light from the display scattered 107 from nearby objects 8.

Fig. 8 shows a special embodiment of the invention where the signal Vin from the photodiode in fig. 4 (or a version of Vin in fig. 6 where the modulation part has been removed) is used to control the illumination of the display 2. If Vin is smaller than a reference voltage, Vref, corresponding to a certain amount of light received by the photodiode, the display light is turned on (corresponding to the control signal Vctdl in figs. 8 and 5 being logic "1"). If Vin is greater than Vref, the display light is turned off (corresponding to the control signal Vctdl in figs. 8 and 5 being logical "0"). Alternatively to the photodiode of the proximity detector, a separate photodiode included on a face of the cover (10) of the device (1) facing away from the object (8) may be used to control the on- and off-modes of the display light. In another embodiment of the invention, the display light may be regulated in steps according to the amount of light detected by the photodiode by means of the voltage Vin by regulating the bias voltage of the light source Vbias2 or by controlling the current Ils through the light source by sourcing current to or sinking current from the normal bias current Ibias (cf. fig. 5). In yet another embodiment of the invention, the display light is controlled via user interaction, e.g. via a push button or a choice from a menu, or by an external event such as an incoming telephone call in that the control signal Vctdl for the display light is forced to logic "1" by such an event. The level of illumination of the display light may be adapted to be relatively higher than normal, when activated by the user or by a predefined external event, by controlling the bias voltage or the current of the light source.

In the embodiments described above, it has been assumed that the light illuminating the display is on or turned on prior to 'object detection'. In a special embodiment of the invention, the proximity of an object to the display is decided on the basis of the following rules:

- Display light on and proximity photo detector detecting an amount of light lower than a certain threshold ⇒ no proximity (Vctpr "0")

- Display light on and proximity photo detector detecting an amount of light higher than a certain threshold ⇒ proximity (Vctpr "1")

- Display light off and proximity photo detector detecting an amount of light lower than a certain threshold ⇒ proximity (Vctpr "1")

- Display light off and proximity photo detector detecting an amount of light higher than a certain threshold ⇒ no proximity (Vctpr "0")

Again, the turning on and off of the diplay light may be controlled by an external event, the user, a separate light sensitive device, etc., as mentioned above.

All the embodiments of the invention described above presume that the display (2) and the proximity sensor (6), in particular the light sensitive part thereof, are physically located near each other. In this context 'near each other' is taken to mean located in relation to each other so that it is ensured that a substantial part of the light from the display scattered from an object in front of the display is received by the light sensitive part of the proximity sensor.

Fig. 9 shows a flow diagram of a method 60 according to the invention. The method comprises the step 61 of illu-

minating a display e.g. by back lighting or other methods to provide an optical signal serving the dual purpose of illuminating the display and possible nearby objects. The method further comprises the step 62 of detecting incident light on a photo detector and the step 63 of providing a control signal Vctpr indivative of whether an object is in proximity of the device. The method further comprises the step 64 of deciding whether or not an object is present in the vicinity of the display based on the light firstly emitted from the display, secondly scattered by the object, and finally received by the photo detector. The method finally comprises the steps 65 and 66 that modify the control signal Vctpr to represent the situation 'object present' and 'no object present', respectively. As described above, assuming that the display light is on or turned on before the 'object detection event', this decision may be based on whether the amount of light detected by the photo detector is inside or outside a range. If the amount of light detected by the proximity sensor 6 is outside a predetermined range, an output control signal Vctpr is provided whose value represents the situation "object present" (e.g. corresponding to a logic "1"). If, on the other hand, the amount of light detected by the proximity sensor 6 is inside a predetermined range, an output control signal Vctpr is provided whose value represents the situation "no object present" (e.g. corresponding to a logical "0"). Alternatively, as also described above, the decision may be based on the following set of rules:

- Display light on and proximity photo detector 'low' ⇒ no proximity (Vctpr "0")

- Display light on and proximity photo detector 'high' ⇒ proximity (Vctpr "1")

- Display light off and proximity photo detector 'low' ⇒ proximity (Vctpr "1")

- Display light off and proximity photo detector 'high' ⇒ no proximity (Vctpr "0")

Fig. 10a shows a display and proximity sensor of a mobile telephone. In this embodiment the display 2 is illuminated; thereby the display emits light 5. The proximity sensor 6 is arranged to detect the emitted light 5 when the light 5 is emitted and when a direct path of light between the display 2 and the proximity sensor 6 is not interrupted. Preferably, a loudspeaker 12 is arranged between proximity sensor 6 and the display 2.

Fig. 10b shows a display and proximity sensor of a mobile telephone where an object is in proximity of the mobile telephone. The object 8 can e.g. be the ear of a user. When the object 8 is present, the direct path of light between the display 2 and the proximity sensor 6 is interrupted. This can also be used for detecting proximity.

Accordingly, a decision of whether there is proximity may be based on the following set of rules:

- Display light on and proximity photo detector 'low' ⇒ proximity (Vctpr "1")

- Display light on and proximity photo detector 'high' ⇒ no proximity (Vctpr "0")

The above rules assumes that back light is turned on, at least for the purpose of determining whether there is proximity or not.

Fig. 11 shows a circuit for detecting proximity in response to back scattered display light and ambient light. The voltage V in connection with the resistors 82 and 83

provides bias current to the photodiodes 84 and 85, respectively. The photodiode 85 is used to sense light, firstly, emitted by the display 2 and, secondly, reflected by an object 8 in front of the display 2. The photodiode 84 is used to sense ambient light (e.g. daylight or artificial light from lamps). The photodiodes 85 and 84 provides voltages V1 and V2, respectively. The amplifier 81 is connected to amplify the difference V2-V1 and provide an output voltage. This output voltage can be supplied to the range detector 21 for determining whether an object is present in proximity of a device. Thereby, it is possible to compensate for variations in ambient light. Without such a compensation it can be difficult to determine proper threshold values or limits for proximity determination.

Moreover, the voltage V1 can be supplied to a control circuit for controlling or adjusting the illumination of the display.

Although the invention has been described in connection with a mobile telephone, it may be applied in similar devices such as other communications devices, laptop computers, portable music playing devices, etc., where the detection of the proximity of an object to the display of the device is of interest for the control of certain functions of the device, such as on/off-, standby/on-switching, control of display illumination, volume control of loudspeaker, etc.

CLAIMS

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1. An electronic device (1) with a proximity sensor (6) to determine whether an object (8) is in proximity of the device (1), comprising:

a display (2) with means (3, 4) for illuminating the display and thereby for providing an optical signal (5);

a proximity sensor (6) for receiving an optical signal (7) and for providing a control signal (Vctpr) indicative of whether an object (8) is in proximity of the device (1);

characterized in that

the proximity sensor (6) is adapted to modify the control signal (Vctpr) in response to light, firstly, emitted by the display (2) and, secondly, reflected by an object (8) in front of the display (2).

2. An electronic device according to claim 1, characterized in that the device (1) comprises oscillation means (42, 43) for supplying an alternating signal component, of a specified type, to the optical signal; and filter means (23) for isolating an alternating signal component, in the light, of the specified type.

3. An electronic device according to claims 1-2 characterized in that the means (40) for illuminating the display (102) are adapted to emit an optical signal (105) having characteristic colour components; and optical filter means (50) for detecting whether the light comprises

colour components of a specified type within a predetermined range.

4. An electronic device according to claims 1-3, characterized in that the means for illuminating the display (2) are back lighting means (9, 203, 204).

5. An electronic device according to claims 1-4, characterized in that the display (2) is a self-illuminating type.

6. An electronic device according to claims 1-5, characterized in that the proximity means (6) are adapted to modify the control signal (Vctpr) according to the following rule:

if the amount of light received by the proximity detector (6) is outside a preset range, the control signal (Vctpr) is modified to represent proximity;

if the amount of light received by the proximity detector (6) is inside a preset range, the control signal (Vctpr) is modified to represent no proximity.

7. An electronic device according to claims 1-6, characterized in that the device comprises a photo detector (20; 120) and display control means (44; 70) for controlling the illumination of the display (2; 102).

8. An electronic device according to claims 1-7, characterized in that display control means (44; 70) are arranged to detect an event which can involve a user interaction and to control the display (2; 102) to be illuminated by a relatively high illumination.

9. An electronic device according to claims 1-8, characterized in that the device comprises a photo detector (11; 84) to detect ambient light.

10. An electronic device according to claims 9, characterized in that the device comprises means for controlling illumination of the display (2) in response to detected ambient light.

11. An electronic device according to claims 9-10, characterized in that the device comprises means (81) for modifying the control signal (Vctpr) in response to ambient light.

12. An electronic device according to claims 1-11, characterized in that the device has a front cover (10), through which access to the display (2; 102) is enabled, and a photo detector (20; 120) for detecting light incident on a region of the front cover (10).

13. An electronic device according to claims 1-12, characterized in that the device is a mobile telephone (1).

14. A method (60) of detecting whether an object (8) is in proximity of a device (1), comprising the steps of:

(61) illuminating a display (2) to emit an optical signal (5);

(62) receiving an optical signal (7) incident on a photo detector (20; 120);

(63) providing a control signal (Vctpr) indicative of whether an object (8) is in proximity of the device (1);

characterized in that the method further comprises the step of:

(64, 65, 66) modifying the control signal (Vctpr) in response to light, firstly, emitted by the display (2) and, secondly, reflected by an object (8) in front of the display (2).

15. A method according to claim 14, characterized in that the method further comprises the steps of:

supplying an alternating signal component, of a specified type, to the optical signal; and

filtering, a signal representative of the light, to isolate an alternating signal component of the specified type.

16. A method according to claims 14-15, characterized in that the method further comprises the steps of:

illuminating the display (102) to emit an optical signal (105) having characteristic colour components; and

filtering a signal representative of the light (107), optically to detect whether the light comprises colour components of a specified type within a predetermined range.

17. A method according to claims 14-16, characterized in that the method further comprises the step of modifying the control signal (Vctpr) according to the following rule:

if an amount of the light is outside a preset range, the control signal (Vctpr) is modified to represent proximity;

if an amount of the light is inside a preset range, the control signal (Vctpr) is modified to represent no proximity.

18. A method according to claims 14-17, characterized in that the method further comprises the steps of:

detecting an event which can involve a user interaction; and

controlling the display (2) to be illuminated by a relatively high illumination.

19. A method according to claims 14-18, characterized in that the method further comprises the steps of:

controlling illumination of the display (2) in response to detected ambient light.

20. A method according to claims 14-19, characterized in that the method further comprises the steps of:

modifying the control signal (Vctpr) in response to detected ambient light.

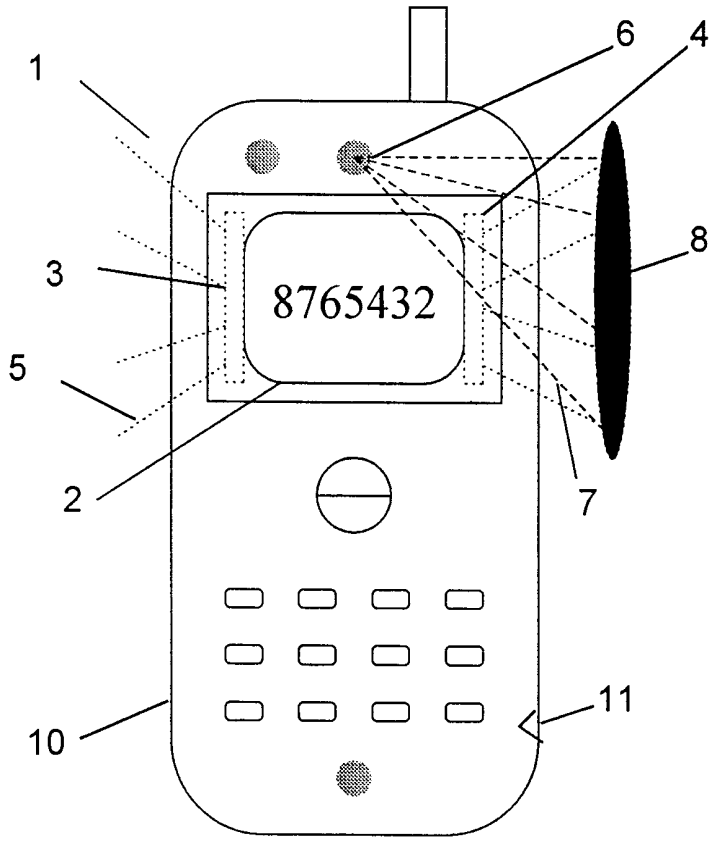

Fig. 1

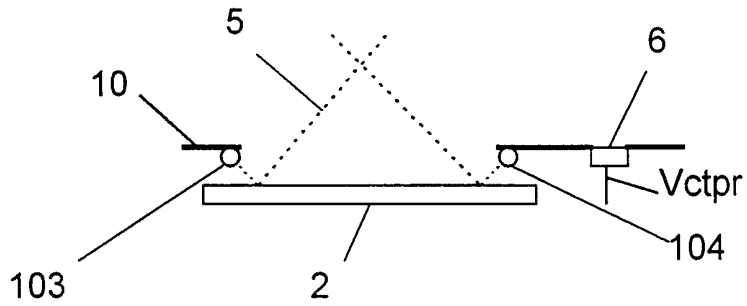

Fig. 2a

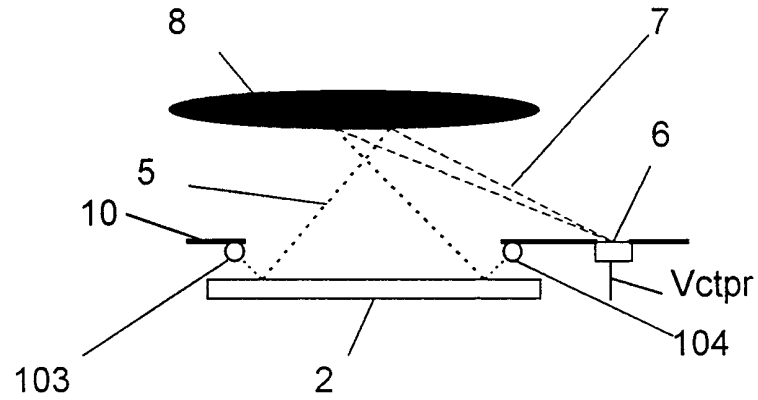

Fig. 2b

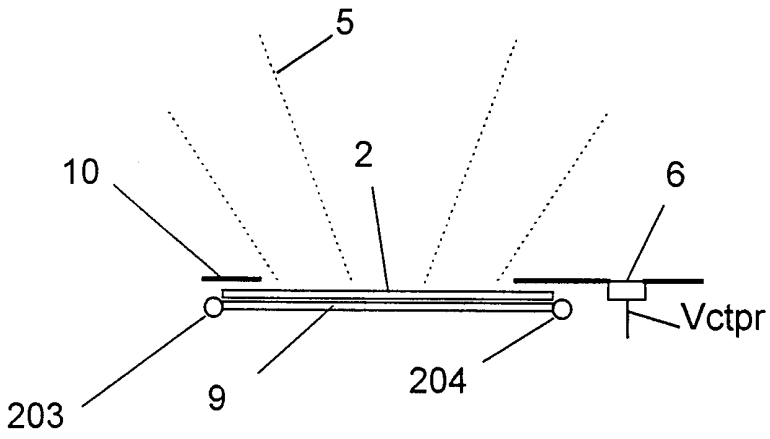

Fig. 3a

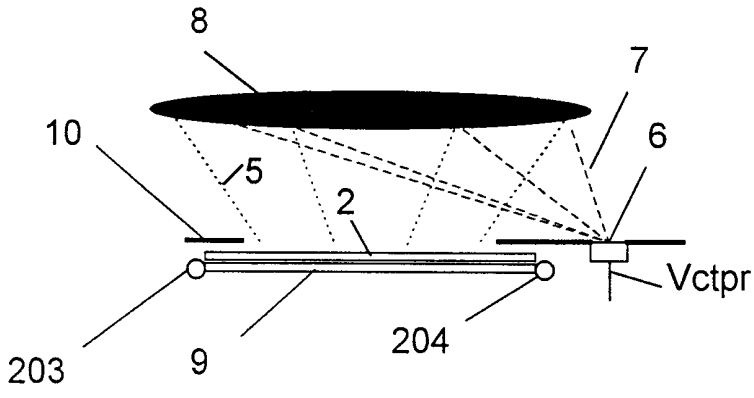

Fig. 3b

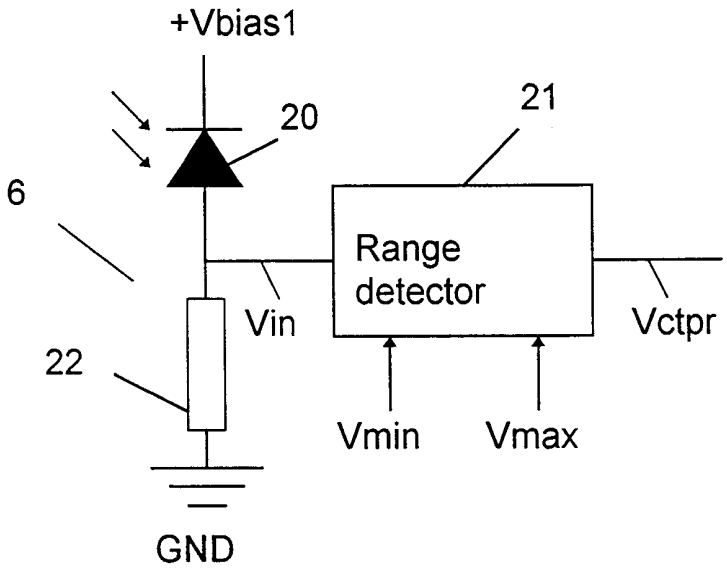

Fig. 4

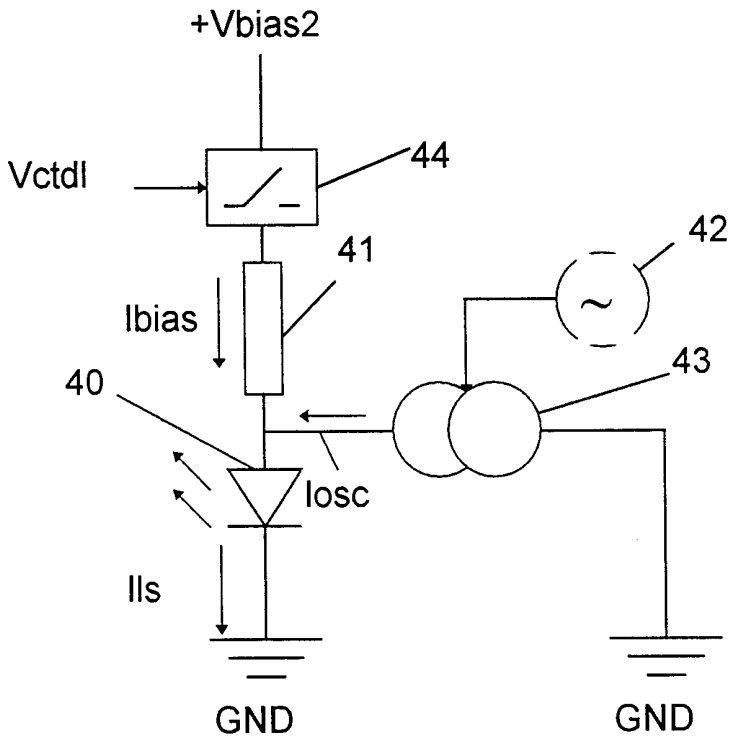

Fig. 5

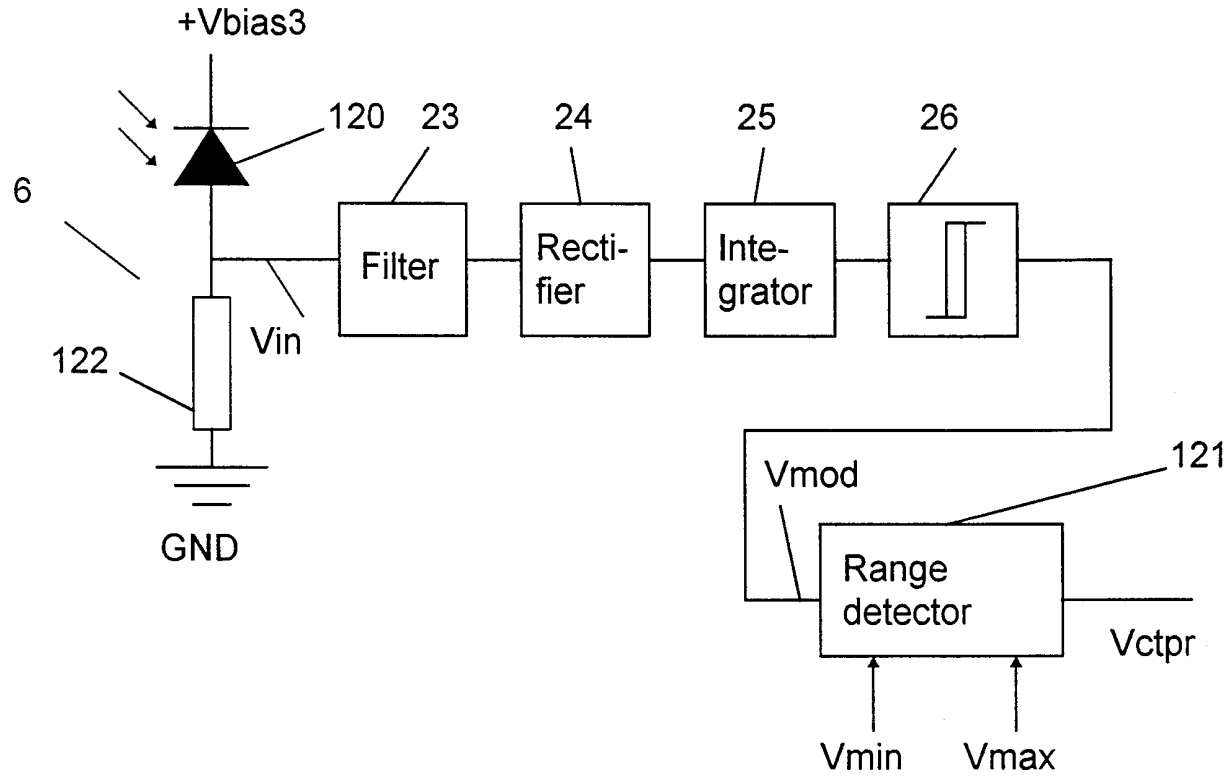
+Vbias3
120
23
24
25
26
6
Filter
Recti-
fier
Inte-
grator
Vin
122
GND
Vmod
121
Range
detector
Vctpr
Vmin
Vmax

Fig. 6

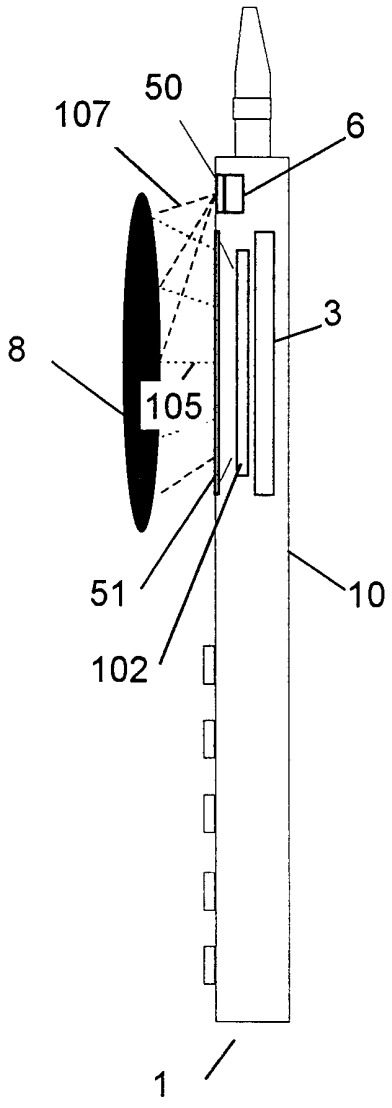

Fig. 7

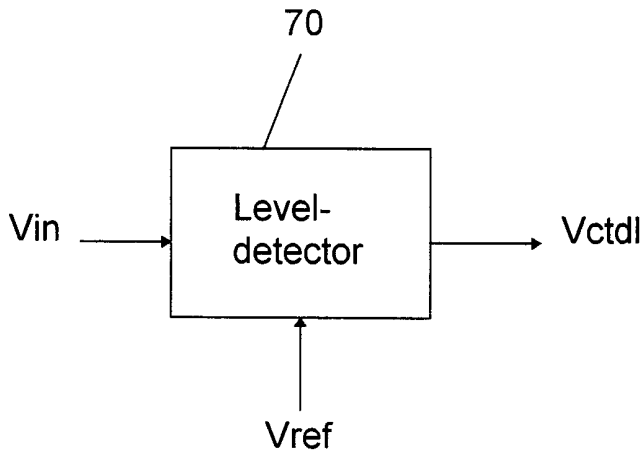

Fig. 8

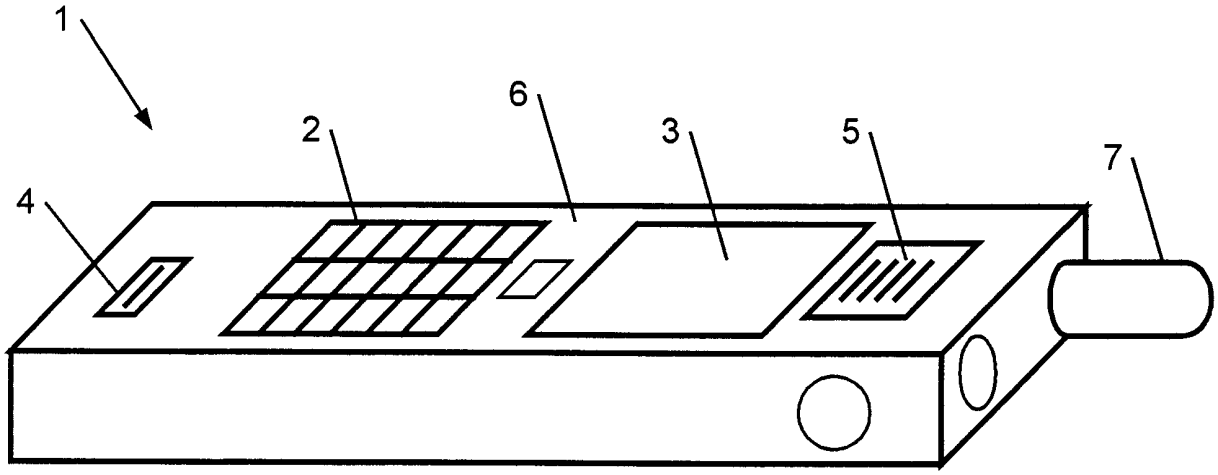

Fig. 10

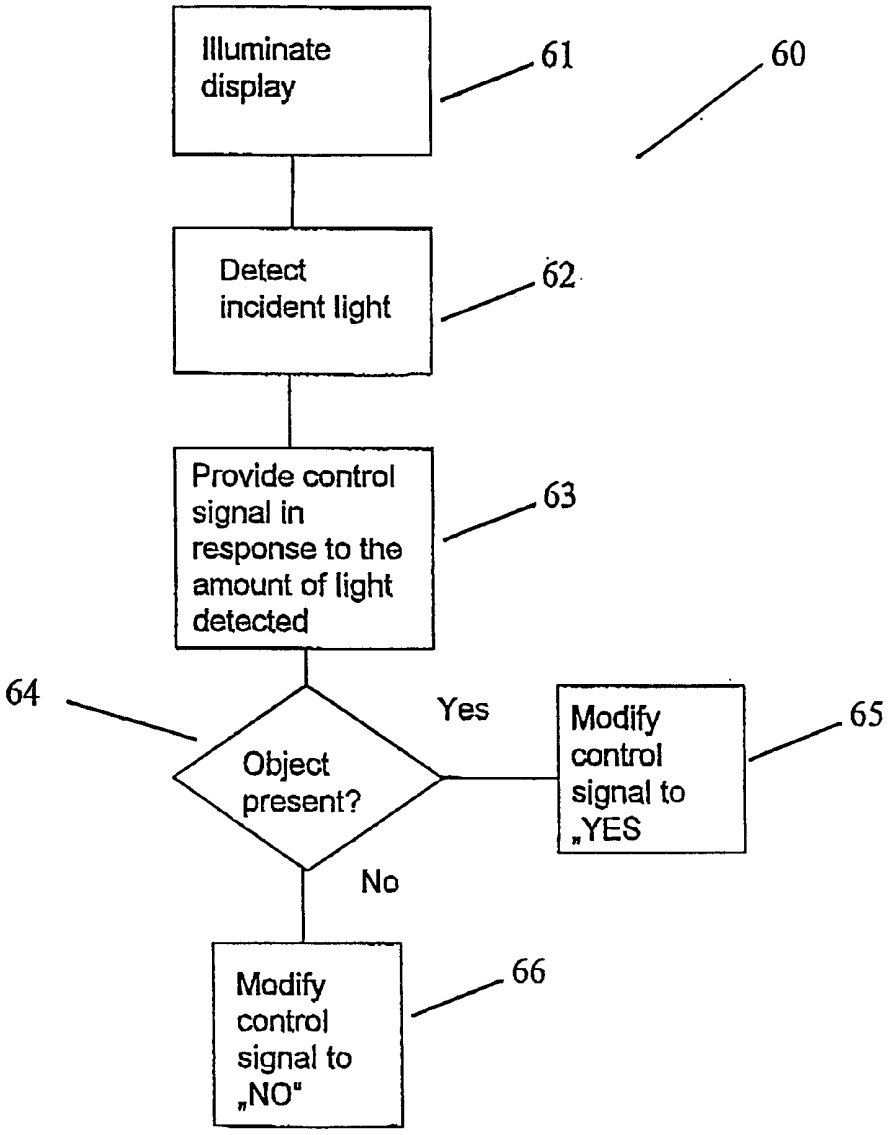
Illuminate display
61
60
Detect incident light
62
Provide control signal in response to the amount of light detected
63
64
Object present?
Yes
Modify control signal to „YES
65
No
Modify control signal to „NO"
66

Fig. 9

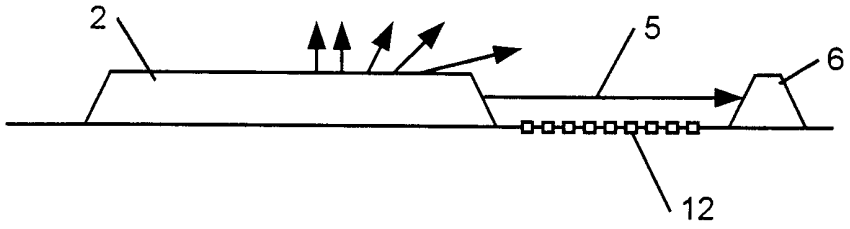

Fig. 10a

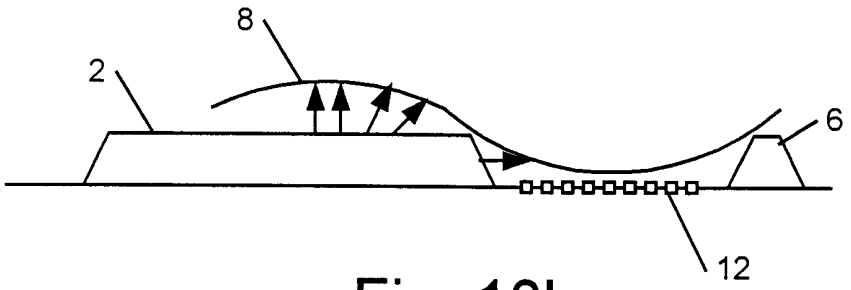

Fig. 10b

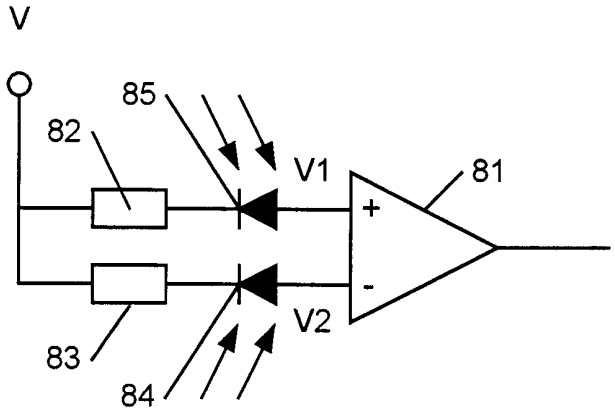

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01218

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04M 1/00
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)

IPC7: H03K, H04B, H04M, H04Q

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, 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.
A	US 5684294 A (ROSS GEORGE KOUHI), 4 November 1997 (04.11.97), column 3, line 21 - column 6, line 23, figures 1A-4, abstract ---	1-20
A	US 5224151 A (DONALD J. BOWEN ET AL), 29 June 1993 (29.06.93), column 2, line 10 - column 6, line 31, figures 1-10, abstract ---	1-20
A	US 5729604 A (ANDRE JOHN VAN SCHYNDEL), 17 March 1998 (17.03.98), column 3, line 40 - column 5, line 35, figures 1-3B, abstract ---	1-20

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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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 when the document is taken alone
"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

Date of the actual completion of the international search	Date of mailing of the international search report
26 July 2000	16 -08- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Roland Landström/MN Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01218

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5894298 A (HENRY HOEKSMA), 13 April 1999 (13.04.99), column 2, line 61 - column 6, line 49, figures 1-5, abstract -- --------	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SE 00/01218

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5684294 A	04/11/97	CA 2233044 A	30/04/98
		EP 0886920 A	30/12/98
		JP 11506544 T	08/06/99
		WO 9818205 A	30/04/98
US 5224151 A	29/06/93	AU 652892 B	08/09/94
		AU 3515393 A	07/10/93
		CA 2090167 A,C	02/10/93
		DE 69318613 D,T	01/10/98
		EP 0564160 A,B	06/10/93
		ES 2116409 T	16/07/98
		JP 6046123 A	18/02/94
		SG 44422 A	19/12/97
US 5729604 A	17/03/98	NONE	
US 5894298 A	13/04/99	CA 2231257 A	14/09/98