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G1A AAM AD10 AD4 AG1 AG10 AG11 AG2 AG7
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NENT NESS
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(54) Physiological monitor

(57) A sensing device (10) which incorporates detectors for various physiological functions is secured to a patient by a strap (15). Information picked up by the detectors it is transmitted to a remote receiver which indicates how the information compares with certain datum values. The system can monitor pulse rate, temperature and/or audible noise (eg: breathing).

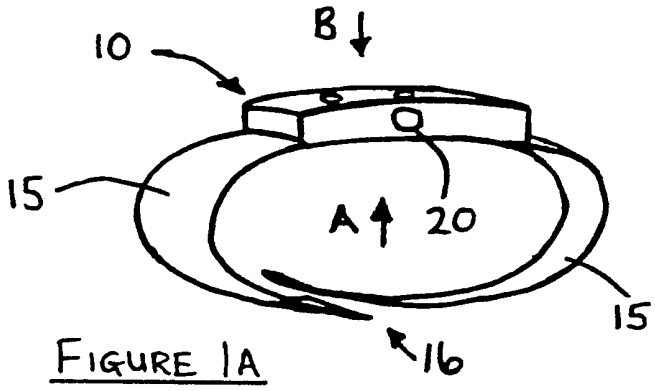

FIGURE 1A

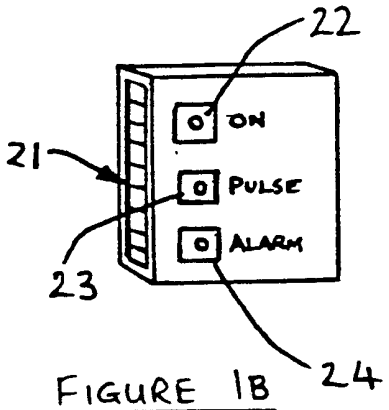

FIGURE 1B

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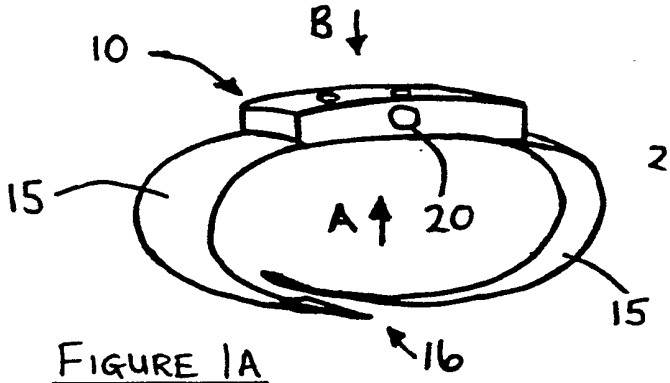

FIGURE 1A

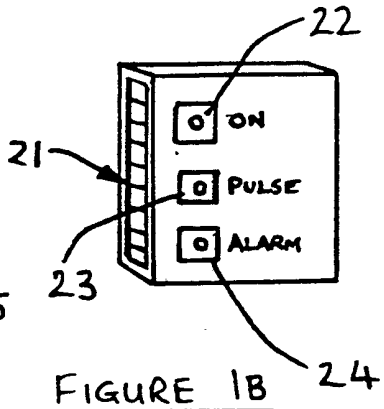

FIGURE 1B

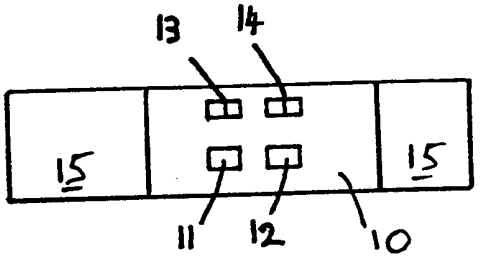

FIGURE 2

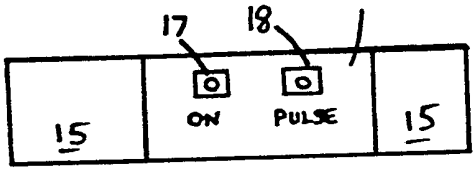

FIGURE 3

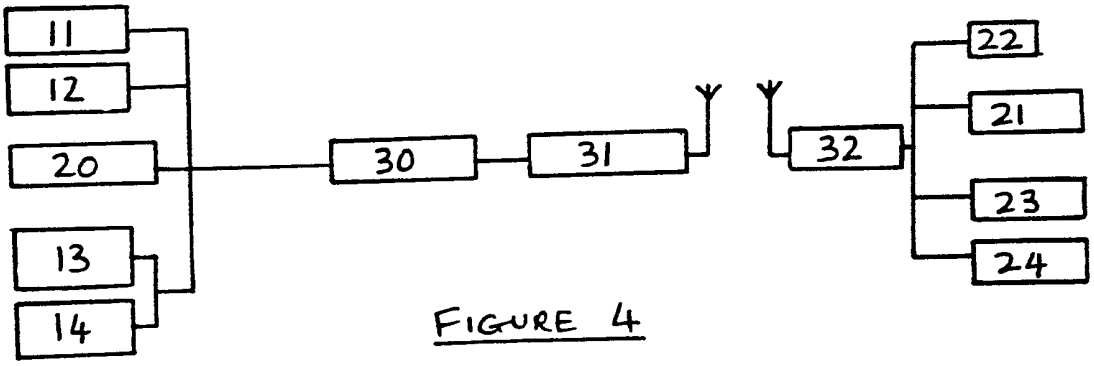

FIGURE 4

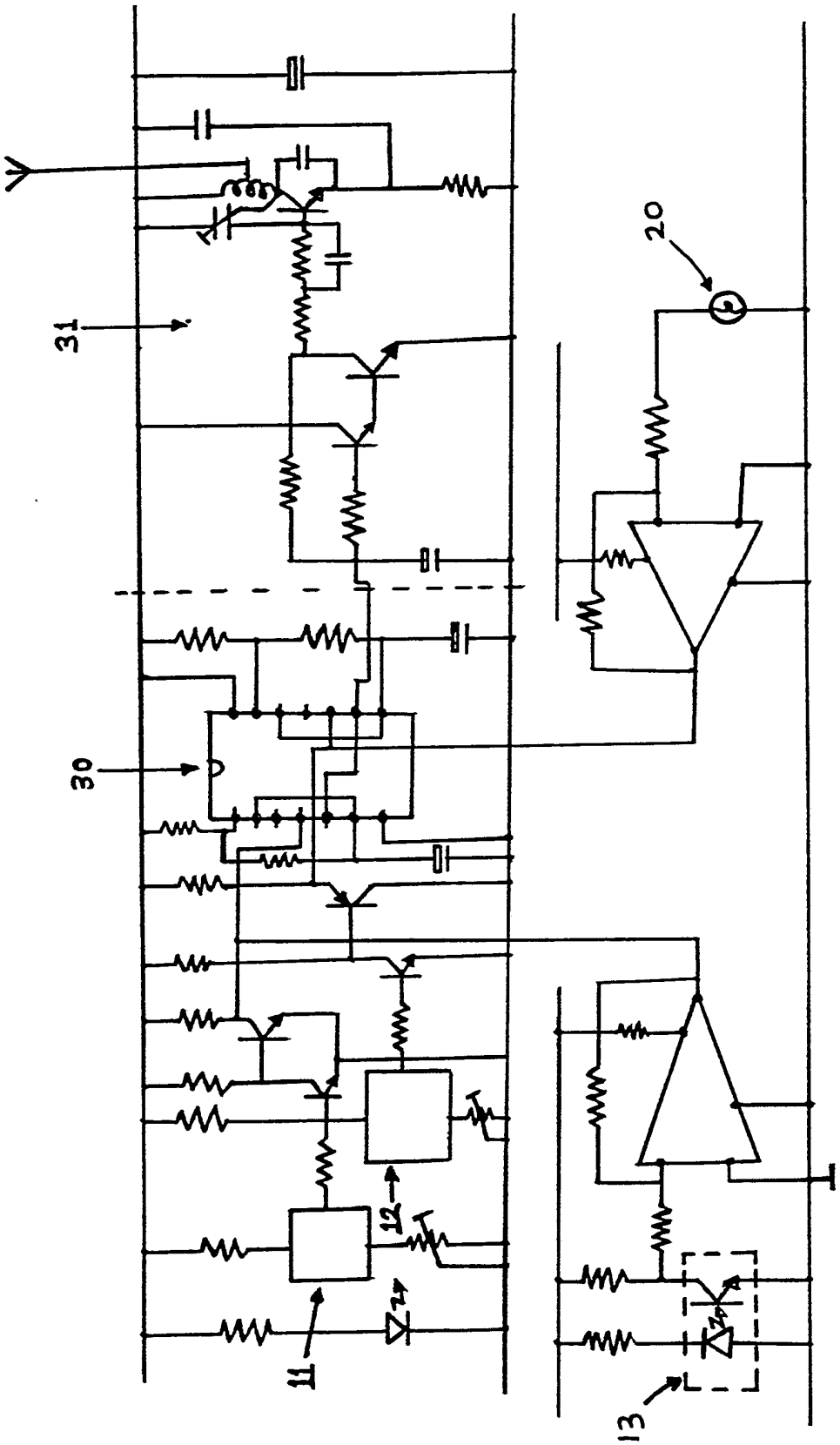

FIGURE 5

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PHYSIOLOGICAL MONITOR

This invention relates to a monitor of physiological functions and is particularly concerned with a monitor adapted for use in detecting functions such as temperature and pulse in the elderly or in young babies.

It is an object of the present invention to provide a physiological monitor which is portable and can therefore be carried by the patient without harm or hindrance and signals from the monitor can be displayed on a receiver distanced from the patient.

The invention is of particular use in relation to monitoring babies who are at an age where the so-called "cot death" problem can arise. The monitor is intended to provide signals indicative of the well being of the child and to provide signals on the receiver carried by or visible to the parent such that the baby's condition can be continually monitored to provide peace of mind and alarm indications should the baby need attention.

It has previously been proposed to provide monitors. Traditional monitoring apparatus as installed in intensive care and other units of hospitals is normally bulky and non-portable. Portable monitoring apparatus is also known and numerous applications are known where heart rate or pulse monitoring is achieved, particularly for detecting heart conditions. Similar portable devices are known for sportsmen where pulse rate can be monitored

whilst running or jogging, see for example US patent 4224948.

Portable monitors which include, say, temperature sensing as well as pulse monitoring are also known. See, for example, US patent 4090504. A disadvantage of the device described in that patent is that the strap is required to pass over the shoulder of the patient which may not be at all suitable for an old person or young baby and, furthermore, the monitoring device has to be attached to the strap by an umbilical cord which clearly does not render the device sufficiently portable for everyday use. It is an object of the present invention to provide a device which can be monitored remotely from the patient. Furthermore, the device as described uses electro thermic transducers for temperature monitoring which do not provide a detection of absolute temperatures, rather only movement in temperatures which is not sufficient for present purposes. Furthermore, the pulse monitoring is by electro acoustic transducers which are unlikely to be sufficiently sensitive for the purpose of monitoring baby physiological functions.

A similar device shown in PCT application US 88/04262, publication No. WO89/05116, does propose a distant receiver with indicators for indicating the condition of the physiological functions to be monitored, but it will be seen that the device itself is large and cumbersome and adapted to fit around the trunk of a patient and is likely to be quite unsuitable for use in the elderly and babies. It is an object of the present invention to provide a monitor which is small and easily strapped to a limb of the body, e.g.

around the wrist, so that the device is virtually unnoticeable and will not disturb the rest of the patient when sleeping. Furthermore, the device described in international application US 88/04262 relies on movement of the belt to provide sensing of the respiration of the patient and it is unlikely that the movement in an elderly person or a baby will be sufficient for such monitoring to be effective. According to the present invention the sensing is provided by infrared sensors which are highly sensitive to pulses within veins of the body.

According to one aspect of the present invention there is provided a portable monitor of physiological functions comprising a flexible strap adapted to be fastened around the limb of a patient to be monitored, a sensing device within the strap for sensing the physiological function by sensors in surface contact with the patient's skin, a transmitter for transmitting signals indicative of the physiological functions being monitored and a receiver remote from the strap adapted to receive the signals and provide an indication of the state of the physiological function being monitored.

The typical functions to be monitored are temperature and pulse rate. The signals can provide absolute measurement of those functions and/or can indicate a change from a normal setting for each function. The indication could be visual or audible and could provide displays indicative of the value of the function being monitored, e.g. pulse rate or temperature.

According to another aspect of the present invention there is provided a portable monitor of physiological functions comprising a sensing device adapted to sense when the temperature adjacent the sensing device has either risen above or fallen below predetermined maximum and minimum temperature levels, a strap for holding the sensing device in contact with the skin of a patient to be monitored, a transmitter within the sensing device for transmitting a signal when the sensing device has sensed the temperature rise above or fall below the predetermined levels, a receiver for receiving the signal and an indicator for indicating that a signal has been received.

Preferably the monitor incorporates a pulse rate detector incorporating an infrared transmitter/receiver device, the strap being adapted to hold the infrared transmitter/receiver device in contact with the skin of the patient whereby the detector senses the pulse rate of a patient, the said transmitter being adapted to transmit a signal indicative of the detected pulse rate and an indicator associated with the said receiver for indicating the pulse rate so detected.

Preferably the monitor comprises two infrared transmitter/receiver devices spaced within the sensing device to facilitate location of a sensitive area of the patient's skin where significant measurements of pulse rate can be achieved.

In a preferred embodiment the sensing device incorporates a microphone and the receiver incorporates a speaker whereby noises

made by the patient can be detected and transmitted to the receiver to provide an audible signal.

The sensing device itself, as strapped to the patient, may incorporate an indicator to indicate that the sensor is activated and functioning. The sensing device may also include an indicator indicating the pulse rate detected by the sensing device. Thus, two light emitting diodes on the sensing device can provide an indication as the device is being strapped to the patient's wrist or arm both that the device is functioning and also when indicating an adequate pulse rate that a vein has been located and an adequate signal has been achieved to provide an appropriate signal to the distant receiver.

Preferably the receiver includes an alarm for indicating when the temperature has risen above or fallen below the maximum and minimum preset temperature levels.

The receiver may also include a light emitting diode which flashes according to the pulse rate detected by the sensing device. Thus, the frequency of the pulsations will vary with pulse rate. That in itself can provide an adequate signal for the adult monitoring the receiver. In addition, the device could be adapted to activate the alarm should the pulse rate rise above or fall below predetermined levels.

In all applications the alarm can be an audible warning or could take the form of a light emitting diode which illuminates when the

alarm condition is reached either in temperature sensing or in pulse rate detection or both audible and visual alarms could be incorporated.

Preferably the monitor has a strap adapted to hold the sensing device in contact with the skin of a patient on a limb of that patient. The preferred location is on the wrist. Where the wrist does not provide adequate sensing for pulse rate or temperature the device can be strapped to the upper reaches of the arm or on a leg, wherever appropriate pulse rate detection can be achieved with the minimum discomfort to the patient.

In addition to or in place of any of the light emitting diode or audible sensors mentioned above, the receiver may be provided with alpha numeric displays which can provide absolute indicators of temperature or pulse rate or any other information which is desirable to build in to the apparatus.

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a view of a portable monitoring device according to the present invention with Figure 1A showing the sensing device with built in transmitter and Figure 1B showing the receiver used to monitor the condition of a patient wearing the device of Figure 1A.

Figure 2 is a diagrammatic view in the direction of arrow A of Figure 1A.

Figure 3 is a diagrammatic view in the direction of arrow B of Figure 1A.

Figure 4 is a diagrammatic representation of the circuitry of the device of Figures 1A and 1B, and,

Figure 5 is the circuit diagram for one embodiment of a monitor according to the present invention.

Referring to the drawings, there is shown in Figure 1A a sensing device 10 comprising a housing in which is located sensors 11 and 12 for detecting maximum and minimum temperatures and sensors 13 and 14 for detecting pulse rate. It will be seen that the detectors 11, 12, 13 and 14 are disposed on the underside of the sensing device 10 whereby the sensing devices can be placed in skin contact with the patient when the device 10 is strapped to the arm and preferably the wrist of a patient using a flexible strap 15 adapted to be fixed using hooks and eyes at location 16, for example of the well known VELCRO design.

Preferably, the device 10 and strap 15 are formed or partially formed to the shape of the limb with which they are designed to contact. Thus, for use on a baby's wrist the devices will be shaped to the general form of the wrist particularly around the underside of device 10 with the strap 15 being reasonably flexible to tighten around the wrist. Thus, the underside of device 10 will fit snugly on the wrist to improve contact with the sensors and prevent slippage of the device 10 around the wrist.

The devices 11 and 12 are semi conductors sensitive to temperature which have been preset during manufacture to detect and provide a signal indicative of a temperature fall below minimum preset level in respect of sensor 11 and a temperature rise of a preset temperature level for sensor 12.

The pulse rate detectors 13 and 14 are each of a type which combine in a single head an infrared transmitter and an infrared detector. A pulse of light is transmitted into the skin of the patient and is reflected from a pulsating vein such that the receiver detects the variation in the signal due to the pulsations. The receiver will provide a signal indicative of those pulsations. A second infrared transmitter/receiver is shown at 14. This transmitter/receiver is identical to device 13 but by providing two such transmitters/receivers this will facilitate the location of an appropriate vein within the wrist or arm of the patient thus facilitating the use of the monitor.

In the upper surface of the monitoring device shown in Figure 3 there is a light emitting diode 17 which will glow to indicate that the circuit within the monitoring device is functioning and an adequate power supply is functioning and a second light emitting diode 18 which will flash at the frequency of the pulse rate detected by the monitors 13 or 14, thus providing a direct indication of the pulse of the patient. The light emitting diode 18 will also provide a clear indication as the monitor is being strapped to the patient that an appropriate vein has been located and is directly adjacent the monitor 13 or 14 and an adequate

signal has been provided to activate the system.

As shown in Figure 1A the monitor also includes a microphone 20 built into the side of the monitor so that it will not be obstructed or covered should the patient turn over and the upper surface of the housing 10 is covered by a pillow or other bedding. The microphone 20 is adapted to detect any audible sounds made by the patient and could be sensitive enough to detect normal breathing and certainly crying and other such sounds.

Shown in Figure 1B is a receiver adapted for use by an adult monitoring the well being of the patient at a distant location from the patient. The receiver receives signals transmitted by the monitor 10 and will provide an audible signal through a speaker provided behind a baffle 21. The receiver is also provided with light emitting diodes 22, 23, 24. Diode 22 is lit to indicate that the device is activated and receiving signals from the transmitter on monitor 10. Diode 23 is adapted to flash at the pulse rate detected by the monitor 10. Diode 24 is adapted to be lit when an alarm condition is detected which can be when the temperature falls below or rises above the preset temperatures to be detected by sensors 11 and 12 or when the pulse rate rises above or falls below preset levels. In addition, the alarm condition can be indicated by audible sound from the speaker placed behind baffle 21. Furthermore, an indication of a possible alarm condition or projected alarm condition can be indicated by the pulse rate indicator 23 where the rate at which this is flashing could indicate a condition which is abnormal.

It will be appreciated that the number and type of indicators on the receiver shown in Figure 1B can be varied to suit the application. Thus, the alarm condition could be indicated by the same light emitting diode as that used for pulse indication. Thus, the one light emitting diode could flash at the frequency of the pulse rate detected but could be made to emit continuously coupled with, say, an audible alarm should the pulse rate rise or should the temperature move outside the predetermined levels previously preset. Furthermore, the alarm condition for temperature and/or pulse rate could be indicated by appropriate liquid crystal displays to present a message indicating the alarm condition and which factor is affected. An audible alarm could accompany the display.

It will also be appreciated that not all the combination of monitors described above need be included in the device. Any one or more of the devices could be excluded such, for example, as the audible monitor or the pulse detector.

The circuitry for the transmitter or receiver is shown in Figure 4 with more detailed circuit diagrams for the transmitter being shown in Figure 5. Signals from the detectors 11, 12, 13, 14 and the microphone 20 are sent to an oscillator 30 and then to a transmitter 31 at which signals are transmitted to be picked up by a receiver 32 to provide signals for activating the light emitting diodes 22, 23, 24 and the speaker 21. The signals transmitted by the transmitter 31 will vary in frequency according to the signal which has been detected and the indicator which is to be activated

at the receiver 32. Transmission frequency between the transmitter and receiver will be within the V.H.F. range, possibly within the range of 90 to 105 mHz.

Although as described above the portable monitor is enclosed within a housing similar to a watch case and strapped to the patient's limb using strap 15, it will be appreciated that the monitor need not be housed in such a device but could, for example, be built into the strap 15 itself depending on the manner in which the various components are assembled. It will be appreciated that all the circuitry will be contained within a microchip the physical constraints of the device being the size of the heads of the detectors 11, 12, 13 and 14 and the microphone 20. These devices need to be large enough to pick up signals which may be extremely weak and the size needed to ensure that an appropriate signal is detected is likely to determine the physical constraints on the size of the monitor 10.

The receiver shown in Figure 1B can also be a portable piece of equipment which could be carried by the person monitoring the patient's well being. Thus the device could be in the form of a pager carried by the person or it could be a stand alone piece of equipment for use in the home or in hospital.

Although described for use on the wrist or upper part of the arm of a patient, the monitor could equally well be adapted for use on the leg of a patient with corresponding adjustment to the size of the strap 15. The monitor will be used on that part of any limb where an appropriate signal can be detected for those

physiological functions being monitored. The most difficult to be detected of those described above is likely to be pulse rate and one of the monitor heads 13, 14 needs to be placed in reasonably close proximity to a pulsating vein to provide an appropriate signal.

It will be appreciated that the present invention provides a highly portable monitoring unit which can be strapped to a patient with the least discomfort and the maximum mobility with transmission of signals of essential physiological functions being transmitted to a distant receiver where the state of the patient can be continually monitored.

The device is of particular value in monitoring tiny babies who may be subject to the risk of "cot death" and the device can provide a continuous signal to reassure parents and provide an alarm condition should the condition of the baby vary from normal.

It is envisaged that the sensing device 10 could also include in its circuitry a microprocessor, EPROM and RAM which will enable various parameters to be programmed in order to provide predetermined levels.

Firstly the desired maximum and minimum heart beat rates or pulse rates could be inputted via a keypad so that if the wearer's heartbeat increased or decreased so as to be outside the programmed levels, a liquid crystal display will flash. The display could also show the actual heart rate (or body temperature), and this could possibly be at the touch of a button. At these or other preprogrammed levels the piezoelectric

alarm could sound.

This modification is useful for sick or old people or angina sufferers and the sensing device will compare body temperature and heart rate with information stored in the RAM and EPROM. The microprocessor, when sampling the rates can interpret whether they are dangerous. If they are dangerous then a signal can be transmitted to a modem connected to a telephone which automatically dials appropriate people such as doctors, relatives to warn them of the situation.

The microprocessor, EPROM and RAM can all be included on a single integrated circuit small enough to be housed within the sensing device 10, which could also incorporate a small keypad and display. This could also show the time when not displaying heart rates etc.

Also the EPROM, which has the ability to be custom programmed by the manufacturer, can be easily adapted for a variety of monitor uses for example cot death, sportsmen, angina sufferer. It can also be re-programmed to include new monitor features and any modifications to the software by simply plugging it into a programmer which is then downloaded.

Claims

1. A portable monitor of physiological functions comprising a flexible strap adapted to be fastened around the limb of a patient to be monitored, a sensing device within the strap for sensing the physiological function by sensors in surface contact with the patient's skin, a transmitter for transmitting signals indicative of the physiological functions being monitored and a receiver remote from the strap adapted to receive the signals and provide an indication of the state of the physiological function being monitored.

2. A portable monitor of physiological functions comprising a sensing device adapted to sense when the temperature adjacent the sensing device has either risen above or fallen below predetermined maximum and minimum temperature levels, a strap for holding the sensing device in contact with the skin of a patient to be monitored, a transmitter within the sensing device for transmitting a signal when the sensing device has sensed the temperature rise above or fall below the predetermined levels, a receiver for receiving the signal and an indicator for indicating that a signal has been received.

3. A monitor as claimed in claim 1 or claim 2 including a pulse rate detector incorporating an infrared transmitter/receiver device, the strap being adapted to hold the infrared transmitter/receiver device in contact with the skin of the patient whereby the detector senses the pulse rate of a patient, the said transmitter being adapted to transmit a signal indicative of the detected pulse rate and an indicator

associated with the said receiver for indicating the pulse rate so detected.

4. A monitor as claimed in claim 3 comprising two infrared transmitter/receiver devices spaced within the sensing device to facilitate location of a sensitive area of the patient's skin where significant measurements of pulse rate can be achieved.

5. A monitor as claimed in any preceding claim wherein the sensing device incorporates a microphone and the receiver incorporates a speaker whereby noises made by the patient can be detected and transmitted to the receiver to provide an audible signal.

6. A monitor as claimed in any preceding claim wherein the sensor device incorporates an indicator to indicate that the sensor is activated and functioning.

7. A monitor as claimed in claim 6 wherein the sensing device includes an indicator indicating the pulse rate detected by the sensing device.

8. A monitor as claimed in any preceding claim wherein the receiver includes an alarm for indicating when the temperature has risen above or fallen below the maximum and minimum preset temperature levels.

9. A monitor as claimed in any previous claim wherein the sensor device incorporates a microprocessor whereby one or more physiological function is constantly sampled and compared with stored information.

10. A monitor as claimed in claim 9 wherein the

stored information is programmed by the wearer by using a keypad which is built-in or can be plugged in to the sensing device.

11. A monitor as claimed in claim 9 or claim 10 wherein there is also provided an EPROM to enable the monitor to be custom programmed.

12. A monitor as claimed in any one of claims 1 to 11 wherein a display is provided on the sensing device to give details of the physiological functions.

13. A monitor as claimed in any preceding claim wherein the strap is adapted to hold the sensing device in surface contact with the skin of the patient on a limb of the patient.

14. A monitor as claimed in claim 13 wherein the strap is adapted to fit around the wrist of a patient.

15. A monitor substantially as herein described with reference to and as illustrated in the accompanying drawings.

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