United States Patent [19]

Bloice

[11] **3,796,208**

[45] **Mar. 12, 1974**

[54] **MOVEMENT MONITORING APPARATUS**

[75] Inventor: **John Anthony Bloice**, Isleworth, England

[73] Assignee: **Memco (Electronics) Limited**, Isleworth, England

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[30] **Foreign Application Priority Data**

Sept. 7, 1971 Great Britain 41720/71

[52] **U.S. Cl.** ..... **128/2 R**, 128/2 A, 128/2.08, 340/279

[51] **Int. Cl.** **A61b 5/08**

[58] **Field of Search** ..... 128/2 R, 2 A, 2 S, 2 N, 128/2.08; 340/279, 258 A

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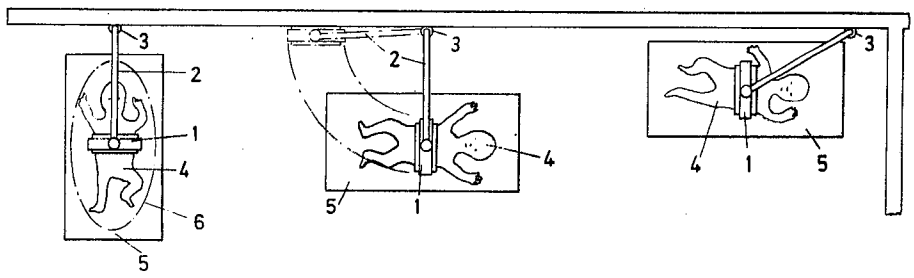
Primary Examiner—Kyle L. Howell

Attorney, Agent, or Firm—Robert W. Dilts; Harry G. Weissenberger; Carlisle M. Moore

[57] **ABSTRACT**

A system for monitoring movements of a patient and indicating when the degree of movement is such as to require attention includes a scanner providing a limited movement sensitive field surrounding at least part of the patient. Circuitry monitors variations in the field caused by the patients movements and controls alarm circuitry for calling attention to the patient, for example on cessation of normal breathing or at the onset of undue restlessness in a patient to be kept quiet. The scanner is suitably a microwave radar unit.

11 Claims, 7 Drawing Figures



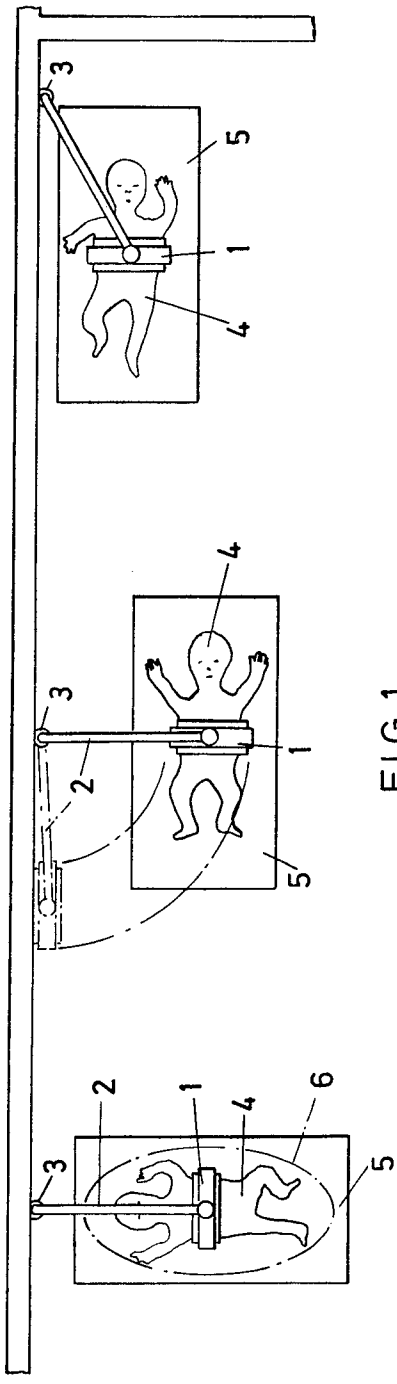


FIG. 1.

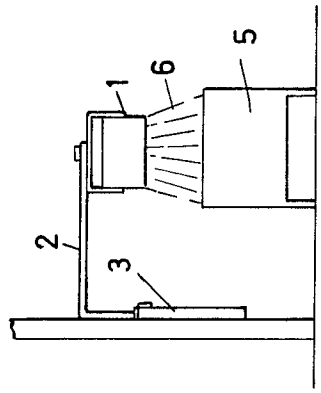


FIG. 2.

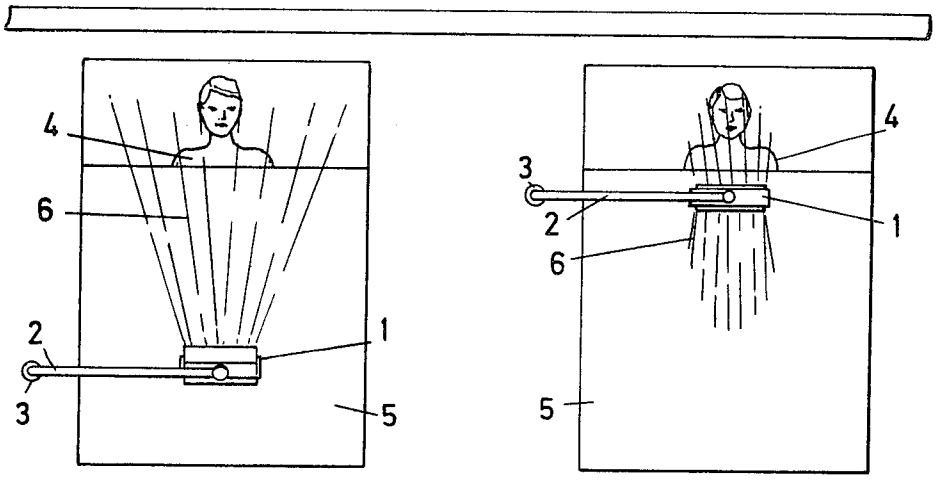


FIG. 3.

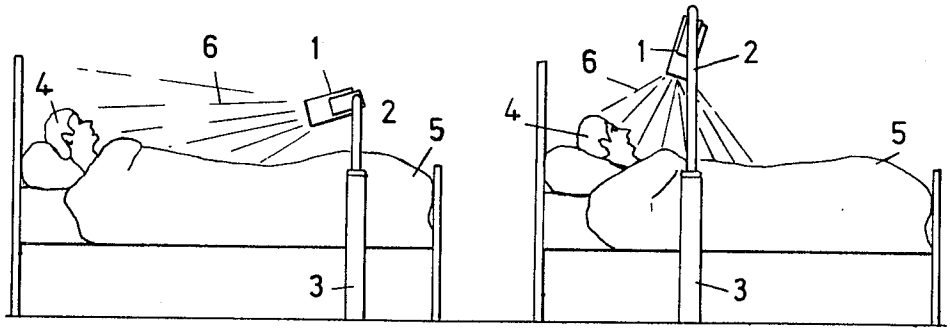


FIG. 4.

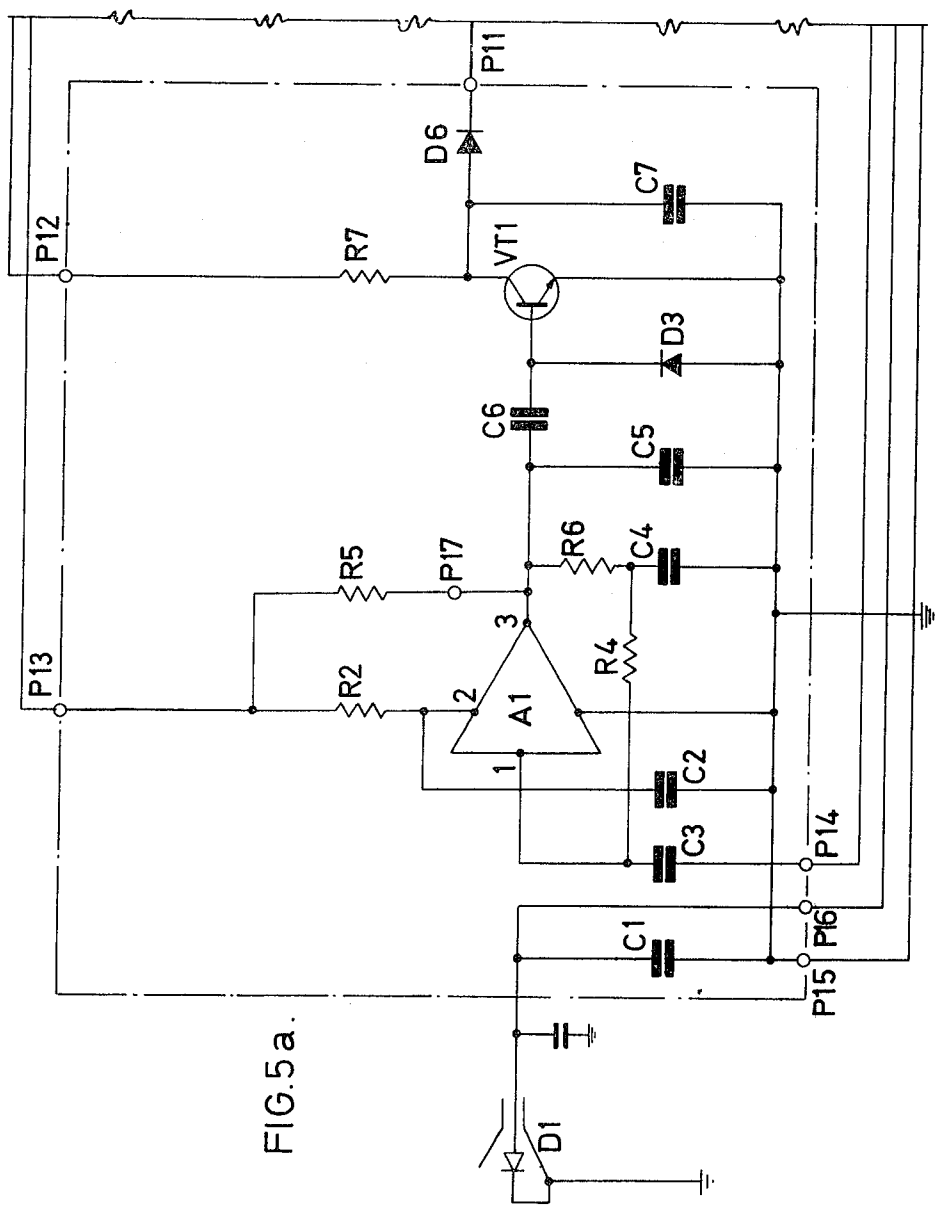

P11
D6
C7
P12
R7
VT1
D3
C6
C5
R6
C4
R5
P17
3
R4
P13
R2
2
A1
1
C2
C3
P14
P16
C1
P15
D1

FIG.5a.

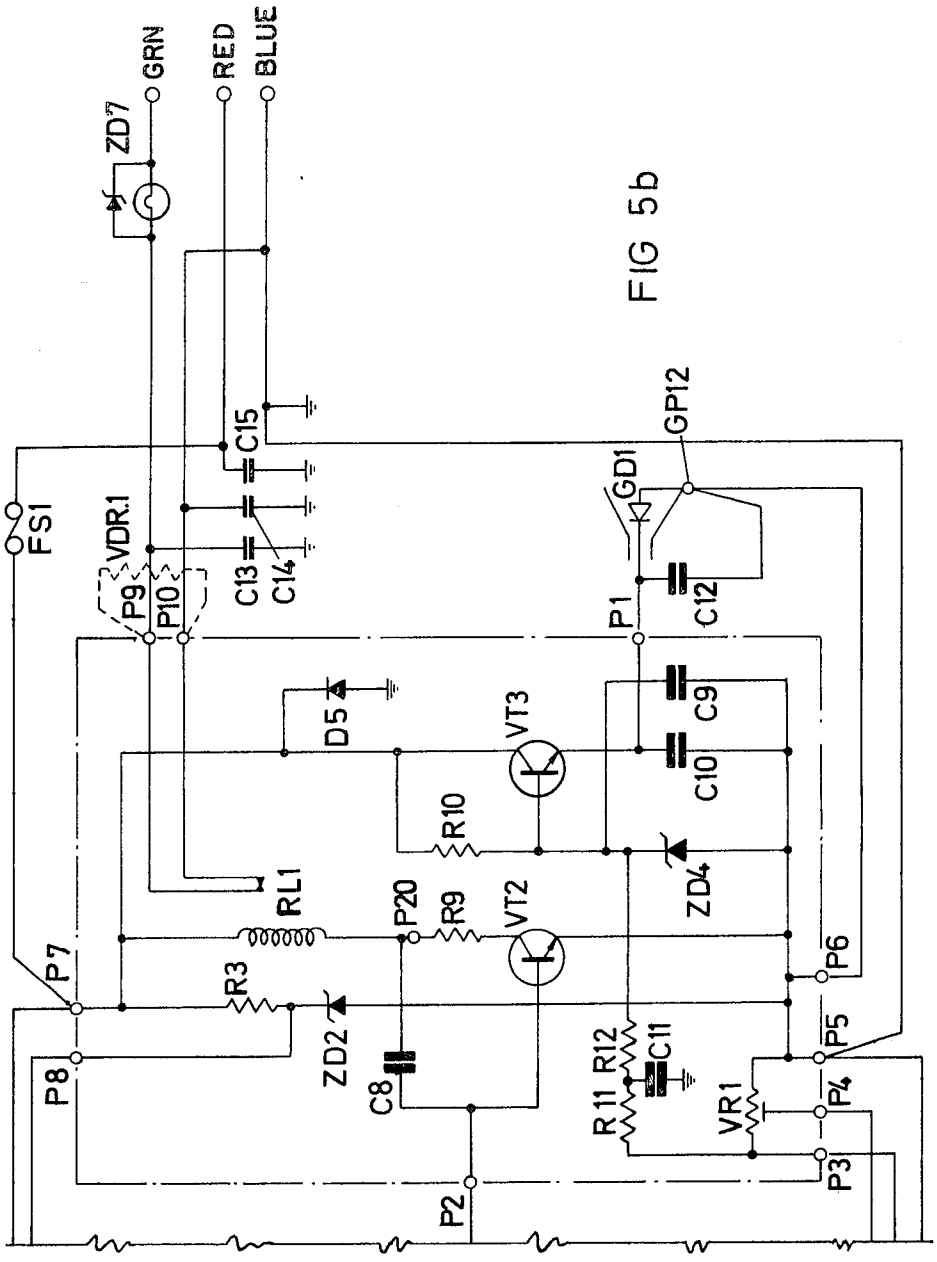

GRN
RED
BLUE
ZD7
C15
GP12
GD1
FS1
VDR1
P9
P10
C13
C14
P1
C12
D5
VT3
C9
C10
R10
ZD4
RL1
P20
R9
VT2
P7
P6
R3
ZD2
P5
P8
C8
R12
C11
R11
VR1
P4
P3
P2

FIG 5b

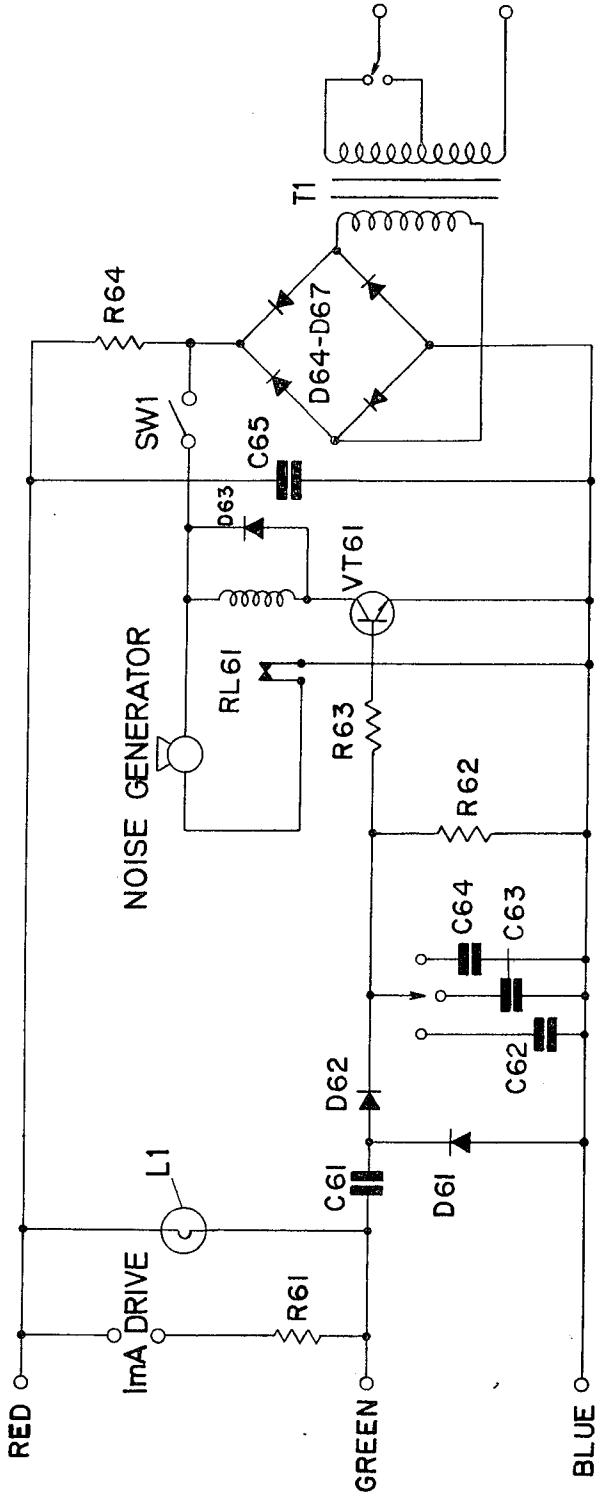

T1
R64
D64-D67
SW1
C65
D63
VT61
NOISE GENERATOR
RL61
R63
R62
C64
C63
C62
D62
D61
C61
L1
1mA DRIVE
R61
RED
GREEN
BLUE

FIG.6.

MOVEMENT MONITORING APPARATUS

The present invention concerns improvements in the monitoring of patients, and is more particularly concerned with apparatus suitable for monitoring movements of a patient and indicating when the degree of movement is such as to require attention.

Existing patient monitoring methods, as far as the applicants are aware, all require some form of physical contact with the patient. For example, some systems use thermistors attached to the nostrils of the patient, photo electric systems attached to the ear lobes, and electrodes fixed to the patient's chest to monitor cardiac activity. One form of movement-monitoring system employs a pressure-sensitive mattress on which the patient is placed, movements of the patient disturbing the pattern of flow of a pressure fluid through conduits in the mattress, such pressure variations being monitored to provide an indication of the degree of movement of the patient. In such systems, the patient has to be disturbed in order to commence monitoring, and often the freedom of movement of the patient is considerably reduced. In many situations it may be distinctly unwise to disturb the patient, when his physiological condition is already critical. For example, it may be unwise to transfer a patient from an ordinary bed to one provided with a pressure-sensitive mattress when his condition is such that movement could prove damaging.

The present invention is intended to provide apparatus suitable for monitoring patients in which no physical contact with the patient is required, so that monitoring can be commenced at will without any disturbance to the patient.

In accordance with the invention there is provided apparatus suitable for monitoring movements of a patient and indicating when the degree of movement is such as to require attention, comprising a scanner arranged in use to provide a movement-sensitive field enveloping at least part of the patient, circuitry for monitoring variations in the field, and indicator circuitry controlled by the monitoring circuitry to provide the indication that attention to the patient is required.

The monitor system thus operates on a principle which may be called the "field disturbance principle" in which a steady electro-magnetic field, is set up in a region to be kept under surveillance, and the disturbances in the field caused by movement therein are monitored.

This principle is used in microwave intruder detection systems, such as those described in U.S. Pat. No. 3,512,155 and U.S. Pat. No. 3,691,556, both of which are assigned to the same assignee as is this application and, the contents of which are hereby inserted in this application by reference.

The scanner of the present monitoring system is suitably one of the microwave radar scanners described in these two U.S. patents with the monitor circuitry thereof modified in accordance with the teaching of this invention.

In U.S. Pat. No. 3,512,155 the radar unit consists of a transmitter and receiver and operates on the Doppler principle. A beam is transmitted and reflections from objects in the beam path return to the receiver. In the absence of movement in this field, there is no frequency difference in the transmitted and reflected signals. When movement occurs in the field, however a

frequency change or Doppler shift occurs, and this is monitored to provide an indication of movements in the field of surveillance. In U.S. Pat. No. 3,691,556 the radar unit is a transmitter only and movements in the field of surveillance dusturb the pattern radiated and cause load impedance variations at the transmitter. These are monitored by an auxiliary oscillator circuit to provide the movement indicator.

The apparatus of this invention is particularly, but not exclusively, suitable for use as a respiration monitor or apnea detector, registering the patient's respiration by means of the movements of the chest wall. Apnea is the cessation of respiration and is a common condition in premature babies (Apnea Neonatorum). Provided apnea is detected quickly enough, it is generally possible to restimulate respiration.

The detection of apnea is achieved by reversing the role of the intruder detector, in that an alarm is given in the absence of movement as opposed to the appearance of movement in the field of surveillance. In addition, by suitably modifying the circuit values of the intruder detector circuitry, sensitivity to people in the near vicinity of the patient being monitored can be greatly reduced.

The monitoring system will now be described in more detail, by way of example only, and with reference to the accompanying diagrammatic drawings, in which:

FIG. **1** is a plan view of the scanner of the monitoring system as used for monitoring the respiration of babies in an infant ward;

FIG. **2** is an elevation of the scanner;

FIG. **3** is a plan view of the scanner in use in an adult ward, showing two possible positions of the scanner;

FIG. **4** shows the two possible positions of the scanner in elevation;

FIG. **5** covers two sheets of drawing designated FIG. *5a* and FIG. *5b*, respectively, and shows the monitor circuitry of the system; and

FIG. **6** shows the system power supply and indicator circuitry in the form of an alarm.

Referring to FIG. **1** and **2**, the scanner **1** is mounted for pivotal movement about a vertical axis at the free end of a horizontal arm **2** pivoted to a wall as at **3**. The scanner is downwardly directed. The mounting at **3** provides for adjustment of the height of the scanner **1** above the floor.

As shown in FIG. **1**, as many scanners **1** may be provided in an infant ward as is appropriate to the capacity of the ward. It will be appreciated that it is unlikely that all babies in the infant ward will require to be monitored at any particular time, unless the ward is specialized to the care of such infants.

The infants **4** to be monitored are placed in cots or incubators **5** beneath the respective scanners **1**. The scanners are arranged to provide a radiation pattern whose shape is as shown by the dotted outline **6** in FIG. **1**. It will be seen that this outline is generally elliptical, and the scanner **1** is preferably arranged so that the longer axis of the ellipse lies along the length of the infant's body.

It will be seen from FIG. **1** that the mounting of the scanners **1** on the horizontal arms **2** allows for the cots or incubators **5** to be situated in various positions, and any particular scanner can be hinged away against the wall when not in use, as shown in dotted outline in the central sketch of FIG. **1**, so as to take up less room.

The scanner 1 may be as described in our U.S. Pat. No. 3,512,155. This particular form of scanner is a two-aerial doppler device employing interaerial coupling to feed microwave energy from the transmitter horn directly to the receiver horn.

Microwave radiation from the transmitter horn is reflected from, for example, the moving chest wall of the patient to the receiver horn. The frequency of the reflected radiation is varied because of the movement of the chest wall, and the difference in frequency between the transmitted and received waves is seen after amplification as a signal voltage of one cycle for every half wavelength of relative movement. The particular scanner under discussion operates at a transmission wavelength of 3cm, so that the signal voltage is of one cycle for every 1.5cm of chest movement.

If the respiratory excursion of the chest wall is considerably greater than 1.5cm, several cycles of doppler signal will be generated. According to the teaching of this invention the signal is rectified and smoothed in such a way that a resulting signal is produced representing the instantaneous velocity of the chest wall at any point of the respiratory cycle. If this signal voltage falls below a certain level and this condition persists for longer than a preselected interval, an alarm sounds to indicate cessation of breathing. During this interval, an adequate movement on the part of the patient restores the instrument to its normal operating mode, cancelling the alarm. Movement by the patient once the alarm is sounding also has the effect of cancelling the alarm. These processes will shortly be described in more detail.

If the chest wall movement is less than 1.5cm, a useful output signal will still be generated as a result of the phase shift of the reflected signal.

It has been found that this type of scanner will operate effectively without the inter-aerial coupling. At the short ranges involved in the patient-monitoring application, the intensity of the reflected signal varies with the chest position to a sufficient extent to provide efficient monitoring.

The maximum microwave energy level at the transmitter antenna aperture is 50 μW per cm^2. Legs 5cm in length have been added to the front of the scanner so that it cannot be brought closer than 5cm to a patient, and at this distance from the antenna aperture the maximum energy level drops to 10 μW per cm^2. A minimum working distance of one foot is recommended for infant-monitoring applications, at which distance the energy level is only 1 μW per cm^2. This is below the upper permissible level for this frequency range by a factor of thousands. With adults, because of the large amplitude of chest movement, satisfactory operation is obtained with the unit some 3 or 4 feet from the chest wall.

FIG. 3 shows two positions of the scanner for monitoring an adult patient.

In the left-hand sketch the scanner is near the foot of the bed and directs a fan-shaped radiation curtain giving wide coverage of the patient's head and shoulder region. In the right-hand sketch, the scanner is placed directly above the patient's chest and directed downwardly, to provide a radiation pattern similar to that used for monitoring infants. The coverage provided is more narrow, but monitoring is more sensitive with the scanner in the position shown in the right-hand sketch.

FIG. 4 shows these two positions of the scanner in elevation, indicating the height adjustment facility provided by the scanner's support.

FIG. 5 (appearing on two sheets of drawing designated *5a* and *5b*) shows the monitor circuitry.

The receiver diode D1 is located in the receiver aerial, and has its cathode connected to the aerial which is grounded. Its anode is connected to ground through a decoupling capacitance and through an electrolytic capacitance C1. This is shunted by a pre-set potentiometer VR1 with which the response range of the circuitry may be adjusted and whose adjustable center tap is connected through an electrolytic capacitance C3 to the input 1 of an amplifier A1. A supply connection 2 of the amplifier A1 is connected to ground through an electrolytic capacitance C2 and to a supply terminal P13 through a resistance R2. The amplifier output 3 is connected to the terminal P13 through a resistance R5. It is also connected to ground through the series-connected combination of a resistance R6 and an electrolytic capacitance C4. The junction of resistance R6 and capacitance C4 is connected to the amplifier input 1 through a feedback resistance R4. The series-connected combination of resistance R6 and capacitance C4 is shunted by an electrolytic capacitance C5.

The amplifier's output 3 is connected through an electrolytic capacitance C6 to the base of a first NPN transistor VT1. The base of this transistor is also connected to the cathode of a diode D3 whose anode is connected to earth. The emitter of transistor VT1 is connected to ground and its collector to a terminal P12 through a resistance R7. The collector is also connected to ground through an electrolytic capacitance C7, and to the anode of a diode D6. The cathode of the diode D6 is connected to a terminal P11. The components so far described, with the exception of the receiver aerial, receiver diode and its decoupling capacitance, and the pre-set potentiometer VR1 are mounted on a first printed circuit board.

A terminal P2 on a second printed circuit board is linked to terminal P11 on the first board. Terminal P2 is connected to the base of a second NPN transistor VT2. The emitter of this transistor is connected to ground. Its collector is connected to its base through the series-connected combination of a resistance R9 and an electrolytic capacitance C8. The junction of the resistance R9 and the capacitance C8 is connected to one end of the energisation winding of a relay RL1. The other end of the energisation winding is connected to a terminal P7 to which is connected one end of a resistance R3 whose other end is connected to the cathode of a Zener diode ZD2. The anode of this Zener diode is connected to earth. The cathode is also connected to a terminal P8, which is linked to terminal P13 on the first printed circuit board.

Terminal P7 is connected to the cathode of a diode D5 whose anode is connected to ground. The cathode is also connected to the collector of a third NPN transistor VT3, this collector being connected to the base through a resistance R10.

The base of transistor VT3 is connected to the cathode of a Zener diode ZD4 whose anode is connected to ground. The cathode is also connected through the series-connected combination of resistances R11 and R12 to that end of the potentiometer VR1 which is not grounded. The junction of those resistances R11 and R12 is connected to ground through an electrolytic ca-

pacitance C11. The Zener diode ZD4 is shunted by an electrolytic capacitance C9.

The emitter of transistor VT3 is connected to ground through a capacitance C10 and to the cathode of the Gunn diode GD1 of the transmitter aerial. The anode of the Gunn diode GD1 is connected to the aerial and to ground. The diode is shunted by a capacitance C12.

The contacts of relay RL1 are connected to terminals P9 and P10. These are connected to ground through respective capacitances C13 and C14.

Terminal P7 is linked to terminal P12 on the first printed circuit board and is connected to ground through a fuse FS1 and a capacitance C15.

Terminal P9 is connected through a lamp shunted by a Zener diode ZD7 to an output terminal labelled GRN.

Terminal P10 is connected to an output labelled BLUE, which is connected to ground.

The junction of fuse FS1 and capacitance C15 is connected to an output labelled RED.

Referring to FIG. 6, a main transformer T1 has its primary winding connected to the AC main supply. The primary winding is center-tapped to provide for dual-voltage operation, a voltage selector switch being provided as shown.

The transformer secondary winding provides 12 volts AC which is rectified by a bridge rectifier comprising diodes D64 to D67. The rectifier output is smoothed by a resistance R64 and capacitance C65. The smoothed output across capacitance C65 is applied to inputs labelled RED and BLUE, connected to the similarly labelled outputs of the circuitry of FIG. 5.

A lamp L1 is connected between the input labelled RED and an input labelled GREEN which is connected to the output labelled GRN of the circuitry of FIG. 5. A 1mA drive is available from a pair of terminals, one of which is connected to the input labelled RED and the other which is connected through a resistance R1 to the input labelled GREEN.

The input labelled GREEN is connected through an electrolytic capacitance C61 to the cathode of a diode C61 whose anode is connected to the input labelled BLUE. It will be recalled that the similarly labelled output of the circuitry of FIG. 5 is connected to ground. The cathode of the diode D61 is connected to the anode of a diode D62 whose cathode is connected to earth through a resistance R62. The resistance R62 is shunted by a selected one of three electrolytic capacitances C62, C63 and C64.

The cathode of diode D62 is also connected through a resistance R63 to the base of an NPN transistor VT61 whose emitter is connected to ground. Its collector is connected to one end of the energisation winding of a relay RL61, the other end of this winding being connected to the unsmoothed supply through a switch SW1. The energisation winding is shunted by a diode D63 whose anode is connected to the collector of transistor VT61.

That end of the energisation winding remote from transistor VT61 is connected through a noise generator to one of the relay RL61 contacts, the other of which is connected to ground.

The operation of the circuitry will now be described with reference to FIGS. 5 and 6.

It will be recalled that the Doppler frequency shift is seen, after amplification, as a voltage. This voltage is the output voltage of amplifier A1. The amplifier A1 is frequency selective, and is tuned to an optimum frequency by means of the feedback resistance R4 and associated component values. It has been found that the optimum response frequency for monitoring of respiration is 1Hz.

The output voltage of the amplifier A1 is applied to the capacitance C7, which acts as a store, through the pump circuit provided by transistor VT1. The voltage across capacitance C7 is applied to the base of transistor VT2 which acts as a relay driver.

So long as the voltage across capacitance C7 exceeds a preselected value, the relay RL1 is kept energised, and the normally closed contacts connected between terminals P9 and P10 are open.

A circuit may be traced from one pole of the smoothed supply, that is one plate of capacitance C65, through lamp L1, the lamp shunted by Zener diode ZD7, the contacts of relay RL1, to the other pole of the smoothed supply, that is the other plate of capacitance C65.

Thus, so long as the Doppler output voltage exceeds a predetermined value, and the relay contacts are held open, these two lamps are not lit.

If this voltage falls below that level, the voltage at the base of transistor VT2 drops to such an extent that the relay RL1 drops out. The normally closed contacts therefore close to complete the lamp energisation circuit, and both lamps therefore glow.

Lamp L1 is situated at an alarm station remote from the scanner and the other lamp is situated on the scanner, but appropriately situated so as to be invisible to the patient being monitored.

As the patient breathes, the voltage across capacitance C7 continually varies, passing above and below the limit value at the respiration rate. The two lamps consequently blink on and off at the same rate.

The sensitivity may be adjusted by means of potentiometer VR1 so that if the degree of chest excursion falls below a particular amount, more particularly if breathing stops altogether, the relay RL1 is no longer energised, the normally closed contacts remaining continuously closed. Consequently both lamps shine continuously.

While the patient was breathing normally, the intermittent operation of the relay RL1 was supplying pulses to the GREEN input of the alarm circuitry. These passed through diode D62, negative pulses being shunted to ground by diode D61, to be aggregated in the selected one of the capacitances C62, C63 and C64. The selected capacitance is maintained charged by these pulses, so that transistor VT61 remains conducting. The relay RL61 driven by this transistor therefore remains energised, and its contacts are held open to inhibit operation of the noise generator.

When relay RL1 becomes continuously de-energised, activating the contacts thereof, on cessation of breathing, no further pulses reach the selected one of capacitances C62, C63 and C64, which therefore discharges through resistance R62. The values of capacitances C62, C63 and C64 are chosen to give respective delay times of 10, 20 and 30 seconds. The result is that 10, 20 or 30 seconds after relay RL1 becomes continuously de-energised, activating the contacts thereof, the voltage on the base of transistor VT61 drops below a limit value, the relay RL61 is de-energised and its contacts close to activate the noise generator to sound an alarm.

It will be appreciated that for the alarm circuitry to operate the switch SW1 must be closed. The function of the switch will be described shortly.

The transistor VT3 is a series-current regulator for the Gunn diode GD1. The capacitances C13, C14 and C15 decouple any RF present at terminals P9, P10 or P7, due for example to X-ray equipment operating in the vicinity of the monitor.

The Zener diode ZD7 shunting the second lamp is intended to maintain circuit continuity in the event of lamp failure.

Should the lamp L1 fail the selected capacitance C62, C63 or C64 discharges to sound the alarm. In the event of failure of the radar devices or the amplifier A1, both relays will open to sound the alarm. The device will become inoperative if there is a failure of the main supply, but provision could be made to keep the unit operating for a few hours from a 12 volt battery.

The 1mA drive terminals may be connected to a recording instrument such as a chart recorder, to provide a permanent record of the patient's respiration. As well as providing a suitable pulse record of the respiration rate, it is envisaged that the output of the amplifier A1 must be brought out to an external connection from which a record of the respiration waveform could be obtained. Heart-beat waveforms are of great assistance in diagnosing various forms of cardiac complaint, and it is thought that respiration waveforms might provide similarly useful information regarding respiratory complaints.

If the instrument has been disconnected from the main supply for some time a "warm-up" period of about 3 minutes is required before it will function. This is because of the long time constant circuits employed in the apparatus. If the switch SW1 is closed during this period, the detector will remain insensitive to movement, the monitor lamps will glow continuously, and the alarm will sound. As this will be rather inconvenient, the switch SW1 is opened while the unit is allowed to warm up, so disabling the alarm circuit. When the "warm-up" period is complete, the detector becomes sensitive to movement, the monitor lamps begin to blink at the respiration rate, and the switch may be closed to ready the alarm. This "warm-up" period may be obviated by keeping the instrument permanently connected to the main supply, switch SW1 being held open until the unit is required for use.

When the unit is to be used, the detector is positioned so as to observe the patient's respiratory movements, the appropriate alarm delay time of 10, 20 or 30 seconds is selected, and the detector is adjusted for optimal sensitivity.

A delay time of 10 seconds has been found to be the most appropriate for detecting apnea in infants, but longer periods may be used for adults, depending on the illness or complaint concerned.

Optimal sensitivity is obtained by gradually advancing the detector sensitivity control from a minimum position, while observing the monitor lamps. The optimal setting is considered to be that in which the on and off phases of the monitor lamps are of approximately equal duration. If sensitivity is too low, the lamps will be on most, or all of the time, If the sensitivity is too high, the lamps will be off most or all of the time, and with too low sensitivity the instrument is liable to give an alarm even when breathing is only shallower than normal. If sensitivity is too high, however, there will be a great risk of extraneous movements in the vicinity of the patient exciting the instrument.

The sensitivity setting required will depend on the distance between the detector and the patient, the amplitude and frequency of breathing, and the presence of an interposed material, such as the roof of an incubator in the case of premature babies. In all cases, sensitivity should be held low as possible whilst compatible with detecting respiration.

The instrument has been made rather insensitive to movements at frequencies higher than those likely to be encountered in breathing, that is to say of the order of 80 cycles per minute. This lessens the likelihood of the device being activated by movements extraneous to the patient.

It should be noted that a large amplitude movement by the patient will paralyse the circuitry for 1 or 2 seconds, rendering it temporarily insensitive to respiratory movement. Consequently, the instrument cannot be relied upon for an entirely accurate record of the respiratory rate, as such record is liable to be frequently interrupted by a restless patient. Of course, if a record of the degree of restlessness of the patient is required, this factor is of considerable usefulness.

The apparatus can moreover, be adapted to give the alarm if the patient is unduly restless.

The alarm is given when there is insufficient movement in the field when a signal voltage drops below a threshold (in FIG. 6 when capacitance C62, C63 or C64 becomes sufficiently discharged). By arranging that the alarm is given when the voltage exceeds a further and higher threshold, the undue restlessness indication may be given.

The system has been used to monitor respiration in several normal newborn infants. In each case the scanner was arranged approximately 1 foot above the baby, and tests were made with the long axis both parallel to and perpendicular to the baby's height. Better results were obtained in the latter case. The alarm signal was duly given when one infant subject to periodic breathing suffered apnea lasting more than 10 seconds. The alarm is also given when, to test the instrument, the infant was removed from the cot. The presence of persons standing within a foot or two of the cot did not appear to interfere with the operation of the detector, provided that its sensitivity was appropriately regulated.

Newborn infants in incubators have also been monitored with the device, the detector being held approximately 5cm above the upper surface of the incubator. The alarm signal was given reliably in the case of two premature babies subject to frequent attacks of apnea. A third infant was not subject to apnea but had shallow breathing at a rate of approximately 60 cycles per minute. The monitor lamps flashed at a rate closely corresponding to this. The alarm duly sounded with the scanner situated over an empty incubator, even with persons standing closeby.

It is considered that the detector should not be placed against the side wall of an incubator, since the infant may come close to this wall and thereby increase the energy level received, and the detector is then liable to be activated by reflections from individuals standing close to that side of the incubator.

Tests have been carried out on adult patients in a normally crowded hospital ward, with the scanner situated in both positions illustrated in FIGS. 3 and 4. The

alarm was duly given when the patient held his breath and otherwise remained motionless. The presence of staff along the side of the bed and of patients in adjacent beds caused no interference in operation.

The instrument conveniently consists of two units, the wall mounted or free-standing scanner and the alarm unit. The scanner is connected to the alarm unit by a cable carrying the 12 volts supply and the alarm and monitor lamp signals. This cable need only have three cores, linking the GREEN, RED and BLUE terminals of the circuits of FIGS. **5** and **6.**

The alarm unit may be placed adjacent or remote from the patient. Where it is located adjacent the patient, it may be advantageous to set up a slave alarm at a remote station.

The instrument is simple to operate, and can be arranged as a permanent monitoring station to which patients to be monitored are brought. Where the patients cannot be moved, portable scanners on free-standing supports may be used.

No apparatus need be attached to the patient, and neither the patient nor his bed need be especially prepared for monitoring to begin. The inconveniences which may arise if monitoring apparatus has to be attached to or otherwise placed in contact with the patient are eliminated. These inconveniences include restriction of breathing or other movement, skin irritation, accidental disconnection of links, and interference with normal medical care. As the apparatus is not in contact with the patient, it requires no special cleaning or sterilisation. The scanner may be quickly moved to one side of there is urgent need for access to a patient, for example an infant in an incubator subject to apnea.

As has already been mentioned, the energy level at the patient is reduced to an extremely small value which is below that regarded as the upper permissible level by a factor of thousands.

It is not thought that the instrument will interfere with the taking of ECG records, in view of the high frequency used.

The instrument may find extensive applications in labor wards, in special neonatal units, and in children's wards. It may also be useful in casualty cubicles, in adult medical and surgical wards, in anaesthetic or recovery rooms. It will be used for monitoring patients suffering from drug overdose, or head injuries, and for monitoring patients on respirators to ensure that there is actually movement of the chest. The instrument will be of particular assistance in monitoring patients in side rooms or private wards where close nursing supervision may be difficult.

I claim:

1. Movement monitoring apparatus comprising:

a. microwave radar means providing a limited movement-sensitive field of microwave radiation;

b. monitor circuit means monitoring disturbances of said field and providing at its output a pulsed signal indicative of the degree of field disturbance;

c. aggregating circuit means coupled to the output of said monitor circuit means to aggregate said pulsed signal to provide at its output a signal voltage the level of which is indicative of said degree of field disturbance;

d. threshold circuit means defining a predetermined threshold voltage and coupled to the output of said aggregating circuit means to receive said signal voltage;

e. trigger circuit means coupled to the output of said threshold circuit means to be activated thereby when said signal voltage is below said predetermined threshold voltage;

f. delay circuit means coupled to the output of said trigger circuit means and providing a predetermined delay between the appearance at its input of an input signal caused by activation of said trigger circuit means and the appearance at its output of a corresponding output signal; and

g. alarm circuit means connected to the output of said delay circuit and activated by said output signal thereof.

2. Apparatus as set forth in claim **1,** in which said microwave radar means is a doppler radar unit and said pulsed signal is indicative of the doppler frequency shift in the output signal of said unit.

3. Apparatus as set forth in claim **1,** in which said microwave radar means is a microwave radar transmitter and said pulsed signal is indicative of variations in the impedance loading of said transmitter due to said field disturbances.

4. Apparatus as set forth in claim **1,** in which said monitor circuit means includes a filter which responds only to frequencies lower than a predetermined upper limit, whereby said pulsed signal is not indicative of field disturbances at frequencies above said upper limit.

5. Apparatus as set forth in claim **4,** in which said upper frequency limit is 80 Hz.

6. Apparatus as set forth in claim **1,** in which said trigger circuit means includes terminals for connection to a recording instrument to provide thereto said voltage signal, whereby a record of the degree of field disturbance may be obtained.

7. Apparatus as set forth in claim **1** wherein said trigger circuit means and said alarm circuit means include means for returning to their de-activated state when said signal voltage is returned to said threshold voltage.

8. Apparatus as set forth in claim **1** including means wherein said alarm circuit means is activated by failure of said other means thereof.

9. Apparatus as set forth in claim **4** constructed as respiration monitoring apparatus including means wherein said field is adapted to envelop at least the chest of a patient; said predetermined threshold voltage is produced by normal respiration of said patient, and said upper limit of frequencies corresponds to movements of the chest wall of said patient characteristic of normal respiration.

10. Apparatus as set forth in claim **1** wherein said alarm circuit includes a switch means for deactivation thereof.

11. Apparatus as claimed in claim **1** including means wherein said predetermined delay provided by said delay circuit means is restored to its full value upon disappearance of said input signal at said input of said delay circuit means.

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