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(54) **Title:** MOVEMENT DETECTOR FOR DETECTING THE MOVEMENT OF A BREATHING ACTIVITY

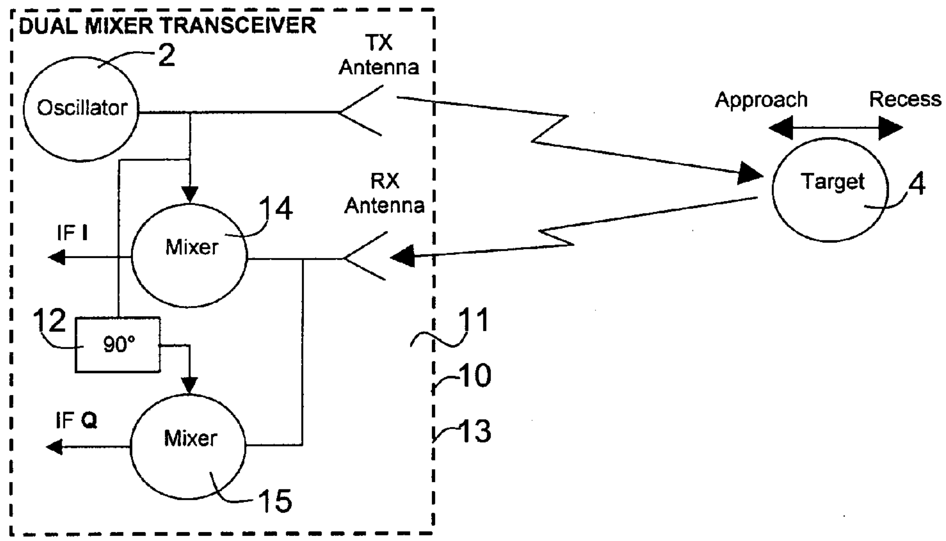

Fig. 6

(57) **Abstract:** To enhance a movement detector for detecting the movement of a body breathing or heartbeat activity comprising a Doppler sensor (11) with a microwave oscillator (2) and at least one mixer (14) in such a manner, that the detector is on the one hand efficient and save with respect to a baby breathing or heartbeat detection and on the other hand a low cost solution, the sensor (11) is performed as sensor unit (13) with a volume less than 100 cm^3 and a sending energy lower than 10 mW.

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Movement detector for detecting the movement of a breathing activity

The present invention relates to a movement detector for detecting the movement of heartbeat or body breathing activity comprising a dual mixer Doppler sensor with a microwave oscillator and with a phase shifting means.

BACKGROUND OF THE INVENTION AND PRIOR ART

Radar sensors are well known for being able to detect movements, such as automatic door motion or speed measurement apparatus by the police. Those sensors use the Doppler radar principle. The amplitude of these movements is quite large. Problems arise due to application of this kind of sensors for breathing movement activity, because this amplitude is relatively small. Another problem is the potential hazard of illumination by radio waves, especially if the respiration rate of a baby is to be measured.

The US 4,085,740 discloses a method of measuring physiological reaction like heartbeat rate and respiration rate. The technique of this method comprises the use of a remote measuring radar technique to detect the body movement. A radar signal is being sent by a sending antenna. Thereby the reflected energy from the body of the person undergoing examination is received by receiving antenna and is split by a shunt tee into a first and a second path of equal energy magnitude. The first path is connected to a first hybrid junction while the signal of the second path is transmitted to a second hybrid function which is receiving a 90° phase shifted signal from a phase shifter. Furthermore, an oscillator outputs a modulated signal of 1,000 cps with an operating frequency of around 10,000 mega cps. This signal is used on the one hand to feed the sending antenna and on the other hand to feed a second shunt tee, which splits the oscillator signal directly to the first hybrid function and to the phase shifter. This circuit provides a first mixed signal and a second mixed signal, which is 90° phase shifted. Movements caused either by respiration or heartbeat of the subjects affect the receiving signal since such movements change the length of the path over which the transmitted and received signal travels.

This enhanced radar sensor enables the use in a lie detector but is a high cost solution and sends hazardous microwaves. Since the lie examination is performed during a relative short time period the radiation of these waves is acceptable. The sensor according to this solution is quite voluminous and can only be used for the application with respect to lie detectors and not to permanent baby breathing activity detection, due to high radiation. Furthermore, this system is complicated involving a lot of different components.

The US 5,766,208 illustrates a non-acoustic pulse-echo radar monitor to detect movement of heart or lungs in medical field, whereby a large number of reflected pulses are averaged to produce a voltage that modulates an audio oscillator. The antenna used in this monitor comprises two flat copper foils, thus permitting the antenna to be housed in a substantially flat housing. The monitor converts the detected voltage to an audible signal with both amplitude modulation and Doppler effect. The frequency used is 1 MHz and is lower than the frequency disclosed in US 4,085,740. Due to the simplicity of the sensor it can be produced inexpensively. The circuit can be integrated onto a single low cost silicon chip based on a 2 micron CMOS process.

The US 4,958,638 discloses a FMCW sensor as a microwave distance sensor and monitors the variation of the reflection distance to detect the movement of breathing and heart rate. This apparatus measures without electrodes or other sensors to the body. A beam of frequency modulated continuous waves is directed to an infant to indicate a case of infant death syndrome. The system is operating at 3 GHz and 10 GHz. The reflected signal contains phase information representing the movement of the surface of the body. The reflected phase modulated energy is received and demodulated by the apparatus using synchronous quadrature detection. Furthermore, the system comprises only one antenna for transmitting a signal and receiving the return signal.

However, in the solutions according to the previous documents radio frequency or hazardous microwaves are used.

Other known solutions avoiding microwaves and radio frequency signals are shown in the FR 1 570 640, US 6,062,216, US 5,309,921, WO 2005 020815 A1 and US 5,853,005.

The technology of the FR 1 570 640 and US 6,062,216 is based on a light source.

A light beam from an optical source comprising a lens, which is used according to the FR 1 570 640, is sent to the body of a new born baby embedded in an incubator. The light beam is reflected by a reflecting element fixed at the body of the baby. If the baby is breathing the angle of the reflected beam changes. Near to the reflected beam an optical sensor is arranged. The sensor is performed as dark chamber with a lens and a photoelectric cell changing the resistance in dependence of the reflected beam position and breathing rhyme. The resistance is measured by a current measuring device. The advantage of this method is that it is save and not dangerous. Since the position of the light sending and receiving apparatus must be arranged in a very exact position the detector device can be only used in a hospital and with respect to an incubator. Furthermore a non comfortable reflecting element arranged at the body of the baby is necessary.

The system according to the US 6,062,216 comprises an apnea monitor in conjunction with an alarm performed for a hospital or a clinic. Thereby, a detection beam from a light source is reflected by a surface of a patient and returned light is analysed to develop a signal indicative of the external motion of the patient upper body. In contrast to the previous solution, a laser illumination beam generated by a laser is reflected along a fixed optical axis. The system performs a Doppler measurement to detect the breathing motions. Since the method is based on the Doppler effect, no reflecting means arranged to the body of a person are necessary. This is advantageous and comfortable for the patient. On the other hand, an expensive laser light sending source and a laser light detector are necessary for this method. This detector provides a prompt or stimulus to restore breathing regularity without requiring the intervention of a parent in domestic situation. But the laser light could be dangerous if it is send to a position near to the eyes of the patient. Therefore medical personal is necessary to operate the system.

The documents US 5,309,921, WO 2005 020815 A1 disclose systems with infrared sensors.

In US 5,309,921 the description relates to an infrared sensor to detect the presence or concentration of specific breathing gas like CO_2 during normal breathing operation. The sensor is connected to an electronic processing system. Various wavelengths of infrared light emitted from a patient in a detection region are identified. This solution is save but requires expensive components.

The system according to WO 2005 020815 A1 is suitable to adults, new bornes as well as veterinary medicine. The system uses also an infrared sensor technology to detect the movement of the breathing and the heat flow corresponding to the exhaust of breathing gas. The system relates more specially to an amount of respiratory motion detectors which are arranged above the bed of a baby to observe the respiratory motion of the baby. The detectors are based on PIR-technology (passive infra red motion detector: PIR). Furthermore, the detectors are arranged to a long supporting arm and electrically connected to a control comprising an alarm. In the event of a prolonged respiratory arrest of the baby, the electronic system can be used to trigger a local and/or remote alarm.

Another well known technology uses sensors to detect the breathing or heartbeat sound.

The US 5,853,005 as an example, relates to a system based on acoustic sensors to detect breathing and heartbeat activity. A transducer in communication with fluid in a pad held in close contact against a sound or movement source monitors the acoustic signals transferred into the fluid. The system may be applied to home baby monitoring.

OBJECT OF THE INVENTION

Object of the invention is to provide a movement detector for detecting the movement of a heartbeat or body breathing or heartbeat which is on the one hand efficient and save with respect to a baby breathing or heartbeat detection and on the other hand a low cost solution and practicable for a home use.

SOLUTION, ADVANTAGES AND PREFERRED EMBODIMENTS

This object is solved by a movement detector for detecting the movement of a heartbeat or body breathing activity comprising a Doppler sensor with a microwave oscillator and at least one mixer, whereby the sensor is performed as sensor unit with a volume less than 100 cm^3 and a sending energy lower than 10 mW.

The invention enables the use of microwaves without danger for the baby because the detector radiates a very small amount of energy. The sensor is performed as low cost sensor according to the inventive detector. Furthermore the detector is reliable and is easily adaptable into existing applications like baby phones, nursing systems and hospital monitoring circuits. The very small sensor unit can be easily hold in the palm of a hand.

The use of a dual mixer Doppler sensor transceiver is a very cost effective solution to solve the problems of the state in the art. The transmitted microwave signal is easy to retrieve and gives a reliable detection in long term. The inventive detector is performed as non voluminous planar or waveguide assembly.

Using the microwave sensor according to the invention the microwaves are able to go through the cloths and detect only the movement of the body behind. This is not dependant on the drapery colours as well. It is also detecting the movements of the body during displacement which means that the person is alive.

According to a another preferred embodiment of the invention a sending antenna is connected to the oscillator and a receiving antenna is connected to a first mixer providing a first receiving signal and is connected to a second mixer providing a second receiving signal, whereby the oscillator is connected to the first mixer and to the second mixer through a phase shifter and such that the microwave output signal from the oscillator is split to the sensing antenna and into the mixers. This solution avoids complicated circuits and does not involve a lot of different components. Furthermore signal processing by a microprocessor is possible.

The phase shifting means could be a 90° phase shifter.
According to a preferred embodiment of the invention a microcontroller is provided to generate a sending pulse signal to the oscillator and to monitor the first and second receiving signals via two channels.

Especially both channels are each connected to a sample and hold means.

A further embodiment of the invention using only a single mixer, but the oscillator can be switched to slightly different frequencies, to achieve an optimal detection condition. Preferably then a microcontroller is used to control the oscillator frequency, to generate a sending pulse signal to the oscillator and to monitor the receiving signal from the single channel.
According to another preferred embodiment of the inven-

tion the volume of the sensor is less than 50 cm^3. This makes an application in baby phones or the like possible.

If the sending energy of the sensor transmitted by the sending antenna is lower than 5 mW no danger arises to babies or new bornes. This transmitting energy of the inventive system can also be applied to incubators.

According to another advantageous embodiment of the invention the sensor unit is performed as planar sensor unit. Those planar sensor units are inexpensive and can be easily embedded in transportable devices and are optimal for domestic use.

In another preferred embodiment of the invention a microcontroller is used to generate a sending pulse signal to an oscillator from the sending antenna and to monitor the first and second receiving signals via two channels. The use of the microcontroller is advantageous to generate all the timings into the sensor and to monitor both channels and to perform the detection algorithm. A low cost RISC processor has the capability of generating the control signals, processing the received signals and supporting the necessary algorithm for the detection. This makes the sensor very low cost.

To enable a high performance both channels of the processor are each connected to a sample and hold means. In order to operate the sensor in pulse mode sample and hold circuits are arranged to sample the mixer signals during the pulses and hold this value in between two pulses. The reconstructed signal ca be amplified and easily fed to the microcontroller.

In a further preferred embodiment of the invention the radiation frequency is higher than around 10 GHz, especially around 24 GHz. The sensor is used in pulse mode with transmissions of bursts of a frequency cycle, especially less than 1%. The pulsing of the oscillator could reduce dramatically the mean output power and then the risk of the radio frequency radiation of the body. Although 24 GHz is considered as very save, because the radio waves do not pass through the body very deep it is of advantage that the transmitted power is more reduced. Therefore the mean power level of the sensor is less than 0,1 mW, specially about 0,05 mW. The low output power of 5 mW or less than 5 mW is normally exempt from any danger to the health. Since some people are very sensitive to this kind of microwaves the very low output power of 0,1 mW enables a sure application of the invention. In order to minimise the microwave radiated power to this value it is advantageous to use the sensor in pulsed mode with a pulse duration of around or lower than 100 µs. A pulse frequency of around 100 Hz is advantageous with respect to the relative low breathing and heartbeat rates. Thus, the detection can be performed with a high accuracy reducing white noise effects in save manner.

It is furthermore advantageous to give information to medical hospital or parents in cases of dangerous states. This can be reached by an alarm which is triggered in the absence of a presence of a breathing or heartbeat signal for a period exceeding a predetermined or programmable time, of specially 10 to 20 sec.

To distinguish if an alarm is caused by the failure of breathing activity or by a fault in the electronic circuit in a preferred embodiment of the invention a complete failure of a mixer signal is detected, whereby the sensor triggers a fault condition if this failure condition continues for a predetermined time.

The inventive detector can be used with respect to paediatric applications. It can be used for a detection of a baby heartbeat or breathing or activity, especially in a baby phone device. The detector can be coupled inside a cover of the baby phone. Such a system could be easily installed at the edge of a cage type bed. The sensor can be pointed towards the baby. The combination of the detector and the baby phone is ideal because the alarm transmitter of the baby phone can be used to send an alarm to the parents in case of the absence of movement. This system replaces mats or other means to detect baby movement with a more reliable that can be fit inside a single casing. This solution avoids an irregular performance and is independent from a body configuration. The invention also can be used to prevent Sudden Infant Death Syndrome. The system can also generate an audible tone to the baby to wake him up. The detector can also be embedded inside a baby toy, like a bear, to make it more familiar.

The invention is also useful in geriatric applications. Since population is growing or becomes older an electronic geriatric nurse can help to solve future problems. In this case the goal could be to detect if a person has left his bed or detect a possible stop of breathing and send an alarm to a nurse dispatching.

The invention is also helpful with respect to hospital applications. An internal monitoring system with the detector in a hospital can send several real time measurements of life parameters to the nurse dispatching. The radar sensor can generate signals having the same bandwidth and being readily available for such remote monitoring.

The detection of breath or heartbeat movement with the inventive detector is also very important in veterinary applications to monitor the anaesthesia of wild animal or the like or to detect the presence of animal in a given area.

For security applications, there is a need to detect the presence of a person in a given closed area. The detector can solve this problem. For example, the detector could be used to monitor the presence of a prisoner into his cell. The detector can be easily hidden behind a pavement wall and be protected against destruction. Using the detector it could be possible to determine if there is a person breathing or heaving some heartbeat in the area, like a man trap, which is to be observed.

Further features and advantages of the invention become apparent upon consideration of the following detailed explanation of specific embodiments of the invention and with reference to the drawings accompanying this specification.

DESCRIPTION OF THE DRAWINGS

In the figures is shown:

Fig. 1 a block diagram of a single mixer Doppler radar sensor.

Fig. 2 a vectorial representation of signals of a sensor according to fig. 1.

Fig. 3 a vectorial representation of signals according to fig. 2 and in case of small movements.

Fig. 4 a vectorial representation of signals according to fig. 3 in case that an oscillation vector in parallel situation.

Fig. 5 a vectorial representation of signals according to fig. 3 in case that an oscillation vector in perpendicular situation.

Fig. 6 a block diagram of a dual mixer Doppler radar sensor according to the invention.

Fig. 7 a vectorial representation of signals of the inventive sensor according to fig. 6.

Fig. 8 a more detailed block diagram of the dual mixer Doppler radar sensor according to the invention.

Fig. 9 a sensor output diagram monitored from the inventive sensor during quite breathing period.

Fig. 10 a sensor output diagram monitored from the inventive sensor during more agitated breathing period compared with fig. 9.

Fig. 11 a sensor output diagram monitored from the inventive sensor with levels from a first channel of the sensor that are higher than a second channel of the sensor.

Fig. 12 a sensor output diagram monitored from the inventive sensor with levels from the second channel of the sensor that are higher than the first channel of the sensor.

Fig. 13 a sensor output diagram monitored from the inventive sensor during a long term measurement of 100 s.

Fig. 14 a sensor output diagram monitored from the inventive sensor during a long term measurement of 500 s.

Fig. 15 a sensor output diagram monitored from the inventive sensor with signals without a baby in bed.

Fig. 16 a view of the detector embedded in a case with a bear design.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is based on the radar Doppler effect. To illustrate this effect with respect to a target moving in more than one direction the Doppler effect is explained with reference to fig. 1.

Fig. 1 shows a block diagram of a single mixer radar sensor. Although the invention uses a dual mixer Doppler sensor it is helpful first to understand the phenomenon of the classical Doppler effect.

The classical single mixer transceiver 1 shown in fig. 1 comprises a sending antenna TX and a receiving antenna RX and an oscillator 2 with a microwave frequency, specially of 24 GHz. The oscillator 2 is connected to the sending antenna TX and to a mixer 3, such that the oscillator signal is split to both components. The mixer 3 is fed by the receiving signal from the receiving antenna RX and outputs a signal IF which gives the information of the target movement. Furthermore, the mixer 3 comprises a non shown mixer diode in well know art.

When the incident radio wave reflects on the moving target 4, its frequency is shifted proportionally to the relative speed of the target 4.

This effect takes its origin in the change of the reflected signal phase when the distance between the transceiver 1 and the target 4 varies. The received signal is then frequency shifted due to the linear phase change generated by the distance variation.

The Doppler detector according to fig. 1 is based on a Homodyne approach. The transceiver 1 is performed as breathing detecting sensor 5 which sends a micro-wave frequency of around 24 GHz, specially 24.125 GHz. This microwave signal is reflected back inside the transceiver 1. The mixer 3 detects the incoming microwave signal and the outgoing signal at the same time.

Fig. 2 illustrates a vectorial representation of the sensing signal TX and the receiving signal RX reach-ing the mixer diode. At the mixer diode level, the signal is the sum of the long TX vector and the tar-get 4 received short RX vector. The mixer diode can then be considered as an amplitude detector, giving a rectified voltage proportional to the amplitude of the vector resulting to the addition of TX and RX vectors.

When there is no movement, both vectors TX, are turn-ing at the same rotation speed determined by the transmitter frequency and no variation is detected. Then the mixer diode will give a DC signal.

When the target 4 is approaching the transceiver 1, the phase of the RX signal moves as indicated on fig. 2 relative to the TX signal. Every time the target 4 moves by half a wavelength towards the transceiver 1, the RX vector makes a full rotation along the dot circle. On target approach it turns counter clockwise and on target 4 recess it will turn clockwise.

When there is a movement the resultant vector will experience an amplitude variation coming from the addition of the TX and rotating RX vectors. As a consequence an AC rectified signal at the output of the mixer 3 whose amplitude will be depending on the RX signal and whose frequency will be strictly proportional to the target speed follows the formula :

$$F_{Doppler} = 2 \,.\, F_{Carrier} \,.\, V / c$$

Where c is the speed of light and $F_{Carrier}$ is the carrier frequency of 24.125 GHz. This means that for a target 4 moving at a speed V of 1 m/s, the Doppler frequency will be 160Hz.

In case of small body movements like breathing movements a vectorial representation according to fig. 3 is representative.

In the particular application of breathing movement or heartbeat movement detection the amplitude of the movement of the thoracic cage can be as low as fractions of millimetres. Furthermore, the movement is oscillatory and not directed all the time in a same direction. Then, the received vector will no longer turn around the circle, but only crosses a little part of it and oscillate between the two extremes points a and b, as illustrated in fig. 3. When the body is moving, these two points will be turning around the circle to reach another steady position around witch it will oscillate.

This means that in this case, the frequency of the rectified Doppler signal will no longer be dependant on the speed of the movement, but on the frequency of the breathing movement. Furthermore, there is a problem of detection associated with this approach.

If the target 4 moves with little movement amplitudes following cases are possible:

Fig. 4 illustrates a first case, whereby the oscillator vector is parallel to the TX vector. In this case the amplitude of the detected signal will be maximal and the detection will be ideal.

Fig. 5 illustrates a second case, whereby the oscillator vector is perpendicular to the TX vector. In this case the amplitude of the detected signal will be zero and the detection will fail using a single mixer transceiver according to fig 1. This means that according to the relative mean position of the body in front of the transceiver 1, there could be an important variation of the detection signal due to this reason.

In order to improve the reliability of the detection a dual mixer is used according to the invention, illustrated in fig. 6, by which the movement detector 10 for detecting the movement of a body breathing activity comprises a dual mixer Doppler sensor 11 with a microwave producing means and with a phase shifting means 12.

Another way of avoiding any loss of signal due to the cancellation effect described in the preceding paragraphs, is to change the frequency of the transmitter by a small amount that will change the relative phase condition inside the mixer. A single mixer approach could then be used in this case, with a transmitter sending several different frequencies around 24.125 GHz, typically within a bandwith of less than 200 MHz, in order to cope with the existing spectrum regulations.

According to the invention the sensor 11 is performed as sensor unit 13 with a volume less than 100 cm^3 and a sending energy lower than 10 mW. This enables that the sensor 11 is performed as low cost sensor unit 13 with relatively low output energy and relatively small size. Thus it can be used for a save measuring the breathing or heartbeat activity of a new born or a baby without high power levels of microwave energy and can be easily embedded in baby phones or the like. The combination with the dual mixer solution results in a very high measuring accuracy.

Although solutions with only one sending and receiving antenna are possible, the inventive detector 10 comprises in the shown embodiment a sending antenna TX connected to the oscillator 2 and a receiving antenna RX connected to mixer 14 and mixer 15. The first mixer 14 provides a first receiving signal IF I from the RX signal and the TX signal. A second mixer 15 provides a second receiving signal IF Q from the RX signal and a phase shifted TX signal

The TX signal sent to mixer 15 is phase shifted by a 90° phase shifter 12. The oscillator 2 is connected in such a way that the microwave output signal from the oscillator 2 is split into the sensing antenna TX and into the mixers 14 and 15.

Fig. 7 represents the vectorial situation of the TX and the RX signals reaching the mixer diodes of both mixers 14 and 15. The two TX signals are now 90° phased and the RX signals have the same phase on both channels I and Q.

If a minimum of signal on channel I is reached, a maximum on channel Q is reached and vice versa.

Fig. 8 illustrates a further preferred embodiment of the invention. A microcontroller 16 is connected to the oscillator 2 to generate a sending pulse signal P to the oscillator 2. This pulse signal P produce a short burst of microwaves to the TX antenna. Thus microwaves are only transmitted to the human body only for a short time. Furthermore the microcontroller 16 monitors the first and second receiving signals IF I and IF Q via two channels I and Q.

Both mixers 14 and 15 are connected to sample and hold circuits SH1 and SH2 to hold the correspondent output value between two pulses. Each sample and hold circuit comprise a semiconductor switch S1, S2, a capacitances C1, C2 and an amplifier V1, V2 in known art. Both channels I and Q from the controller 16 are each connected to the sample and hold circuits SH1 and SH2.

In this preferred embodiment of the invention the microprocessor is a low cost RISC processor generating control signals, processing the receiving signals and supporting an algorithms for the detection.

Important is that the radiation frequency generated by the oscillator 2 is higher than around 10 GHz, preferably around 24 GHz and more specially 24,125 GHz. At this frequency, the skin reflectivity is superior and this also minimizes the penetration of radiation inside the body, reducing further the risk.

The sensor 11 is used in pulsed mode with transmissions of bursts of a frequency signal with a duty cycle less than 1%. The burst frequency is around 100 Hz and the pulse duration around 100 μs. Thus the mean power level of the sensor can be reduced to less than 0,05 mW.

The microcontroller 16 is able to process both channels I and Q and optimise the sensitivity of the detector 10 and avoid any misdetection.

Preferably, an alarm is triggered in the absence of a presence of a breathing signal for a period exceeding a predetermined or programmable time, of specially 10 to 20 sec. This method of detecting the body movement is based on the use of a dual channel microwave Doppler sensor according to fig. 8. The microcontroller 16 performs following algorithm:

- The microcontroller detect the presence of a breathing signal and trigger an alarm in the absence of such a signal on both I and Q channels for a period exceeding a programmable time, typically 10 to 20 sec.
- The signal processing retriggers a delay every time that a movement is detected.
- If no movement is detected during 20 s then an alarm is sent.

Possible is that in case of a complete failure of a mixer signal the sensor triggers a fault condition signal. This failure signal is only triggered if this failure condition continues for a predetermined time.

Fig. 9 to 15 show different monitored signals from the detector 10.

Fig. 9 illustrates the situation when the baby is quite sleeping. The breathing movements are regular. The amplitude of the monitored signal is small, but above a first limit value. If the monitored signal falls under this first limit value for a predetermined time period an alarm is automatically triggered.

Furthermore, it is possible to perform a sensitivity level adjustment to adjust properly the sensitivity of the sensor 11 according to the situations. The signal processing in the microprocessor is able to retrigger a delay every time that no breathing movement is available. If no movement is detected during 20 s then an alarm should be sent.

Fig. 10 illustrates when the baby is not sleeping. During the first time period the baby is moving. The correspondent breathing signal is irregular. This indicates that the baby changes his body position. During the second time period the baby is agitated but his body does not move. Than the magnitude of the signals are higher than according to the situation of fig. 9. A second limit value higher than the first limit value can be used to trigger an information signal that indicates that the baby is not sleeping and/or is breathing more agitated.

Fig. 11 and 12 illustrates positioning situations of both channels I and Q with different amplitudes with respect to the channels. While the magnitude of amplitudes of the I channel in fig. 11 reaches higher levels than the magnitude of the Q channel amplitude because a bad positioning on the Q channel is existing, the magnitudes changes vice versa according to fig. 12 due to a bad positioning on the I channel.

Fig. 13 and 14 illustrate quite sleep and agitated sleep periods over long term measurements of 100 s and 500 s.

The correspondent noise signal without the baby in bed using a scale of 200mV/div is shown in fig. 15.

Furthermore, a method of detecting failure of the microwave transceiver and sensor 11 can be applied. As an example, in case of complete failure of the dual diode mixer the signal will be absent and then the sensor should trigger a fault condition. If this condition continues for more than a predetermined time or long period like 1 hour a permanent alarm suggesting the repair of the sensor could be triggered. If the diode failure has as a consequence to generate a higher level of noise than shown fig. 15 for example, the microcontroller program could be performed in such a way that it is able to detect the difference between white noise and low frequency oscillating signal.

Since the need for a low bandwidth in the amplifiers V1, V2 could increase its set time, with capacitances C1, C2 in the range of 10 - 100 μF like 22 μF and non shown amplifier resistors in the range of 1 - 100 kΩ like 10 kΩ at the input of the amplifier, the correspondent set up time is for example 50 s. To decrease this set up time during the sensor 11 is not able to detect it is possible to use analogue gates to short circuit series resistors and speed up the charging of the capacitances C1, C2 up to their normal state values. After a brief period of time, the analogue gates are set to OFF state.

Fig. 16 illustrates a toy or case 17 designed as bear for babies. This toy comprises a baby phone device with the detector 10. As shown, the detector 10 comprises a planar sensor for a detection of a baby breathing or heartbeat activity.

Although the detector 10 is performed as dual mixer Doppler radar sensor one or more features of the description and/or the drawings are inventive using a single mixer Doppler radar sensor according to fig. 1.

LIST OF REFERENCE SIGNS

1	transceiver
2	oscillator
3	mixer
4	target
5	sensor
10	movement detector
11	dual mixer Doppler sensor
12	phase shifter
13	sensor unit
14	first mixer
15	second mixer
16	microcontroller
17	case
TX	sending antenna
RX	receiving antenna
SH1	first sample & hold means
SH2	second sample & hold means
P	pulse signal
C1	first capacitance
C2	second capacitance
S1	first semiconductor switch
S2	second semiconductor switch
V1	first amplifier

V2 second amplifier

CLAIMS

1. Movement detector (10) for detecting the movement of a heartbeat or body breathing activity comprising a Doppler sensor (11) with a microwave oscillator (2) and at least one mixer (14) **characterized in that** the sensor (11) is performed as sensor unit (13) with a volume less than 100 cm^3 and a sending energy lower than 10 mW.

2. Movement detector according to claim 1, **characterized by** a sending antenna (TX) connected to the oscillator (2) and a receiving antenna (RX) connected to a first mixer (14) providing a first receiving signal (IF I) and connected to a second mixer (15) providing a second receiving signal (IF Q), whereby the oscillator is connected to the first mixer (14) and to the second mixer (15) through a phase shifter (12) and such that the microwave output signal from the oscillator is split into the sensing antenna (TX) and into the mixers (14 and 15).

3. Movement detector according to claim 2, **characterized in that** the phase shifting means (12) is a

90° phase shifter.

4. Movement detector according to anyone of the previous claims, **characterized by** a microcontroller (16) to generate a sending pulse signal to the oscillator (2) and to monitor the first and second receiving signals via two channels (I, Q).

5. Movement detector according to claim 4, **characterized in that** both channels (I, Q) are each connected to a sample and hold means (SH1, SH2).

6. Movement detector according to anyone of the previous claims, **characterized by** using only a single mixer, but the oscillator can be switched to slightly different frequencies, to achieve an optimal detection condition.

7. Movement detector according to claims 6, **characterized by** a microcontroller (16) to control the oscillator frequency, to generate a sending pulse signal to the oscillator (2) and to monitor the receiving signal from the single channel (I).

8. Movement detector according to anyone of the previous claims, **characterized in that** its volume is less than 50 cm^3.

9. Movement detector according to anyone of the previous claims, **characterized in that** the sending energy is lower than 5 mW.

10. Movement detector according to anyone of the previous claims, **characterized in that** the sensor unit is a planar sensor unit (13).

11. Movement detector according to claim 4 or 7, **characterized in that** the microcontroller (16) is a RISC processor generating control signals, processing the receiving signals and supporting an algorithm for the detection.

12. Movement detector according to anyone of the previous claims, **characterized in that** the radiation frequency is higher than around 10 GHz.

13. Movement detector according to claim 12, **characterized in that** the radiation frequency is around 24 GHz.

14. Movement detector according to anyone of the previous claims, **characterized in that** the sensor is used in a pulsed mode with transmissions of bursts of microwave signal with a duty cycle.

15. Movement detector according to claim 14, **characterized in that** the duty cycle is less than 1%, specially around 100 Hz and a pulse duration specially around 100 μs.

16. Movement detector according to claim 14 or 15, **characterized in that** the mean power level of the sensor (11) is less than 0,1 mW, specially about 0,05 mW.

17. A method of detecting a body movement with a detector (10) according to anyone of the previous claims, **characterized by** which an alarm is triggered in the absence of a breathing signal for a period exceeding a predetermined or programmable time, of specially 10 to 20 sec.

18. A method of detecting a failure of the detector according to anyone of the previous claims, **characterized by** which a complete failure of a mixer signal is detected, whereby more especially the sensor (11) triggers a fault condition if this failure condition continues for a predetermined time.

19. Use of a detector according to anyone or the previous claims and/or of a method according to claims 17 or 18 in a device for a detection of a baby breathing or heartbeat activity.

20. Use of a detector according to claim 19 and/or a method according to claim 17 in a baby phone device.

21. Use of a detector according to claim 19 or 20 and/or method according to claim 17 or 18 inside a baby toycase.

22. Use of a detector and/or method according to anyone of the previous claims for a geriatric nurse or a hospital use or for a veterinary application or for security applications, especially for monitoring the presence of a person in a closed area.

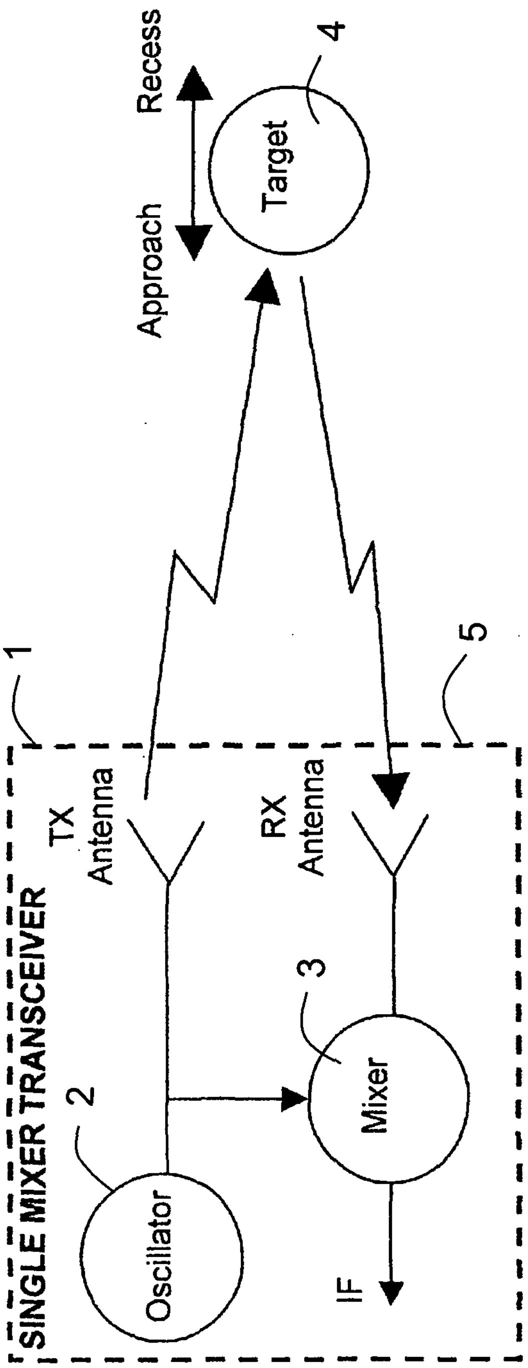

SINGLE MIXER TRANSCEIVER
Oscillator
Mixer
TX Antenna
RX Antenna
IF
Target
Approach
Recess
1
2
3
4
5

Fig. 1

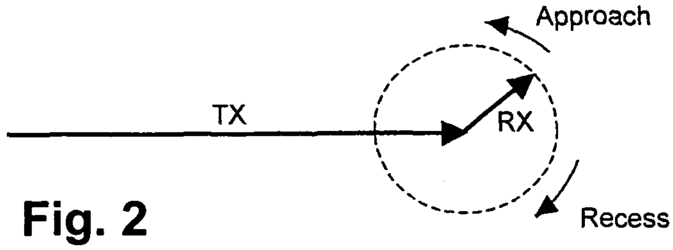


Fig. 2

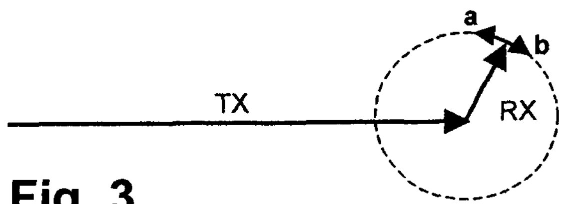


Fig. 3

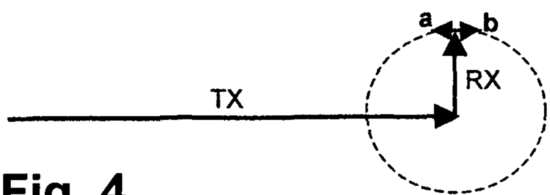


Fig. 4

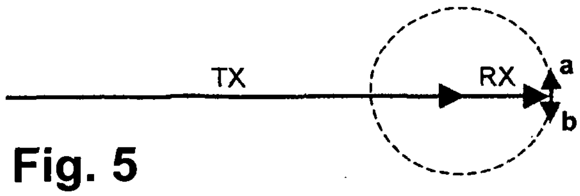


Fig. 5

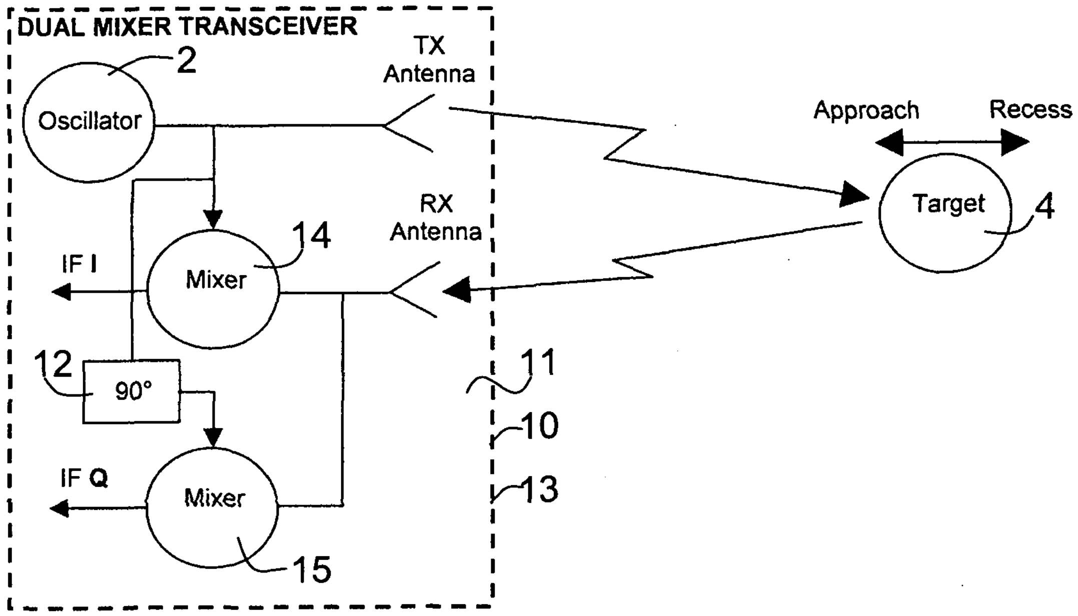

DUAL MIXER TRANSCEIVER
2
Oscillator
TX
Antenna
Approach
Recess
Target
4
RX
Antenna
Mixer
14
IF I
12
90°
11
10
IF Q
Mixer
13
15

Fig. 6

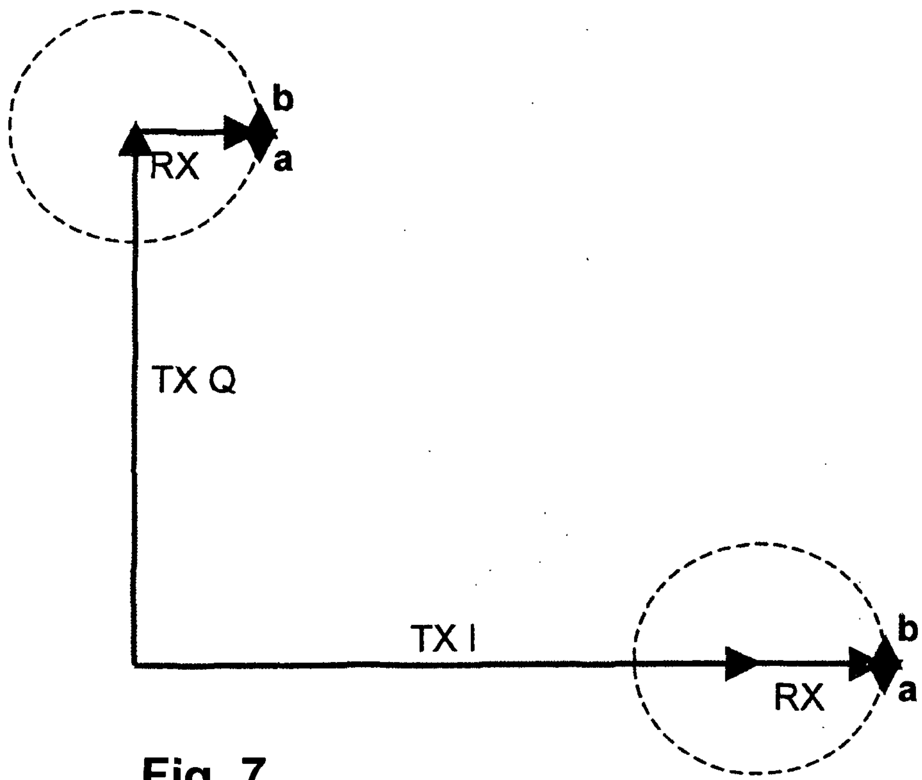
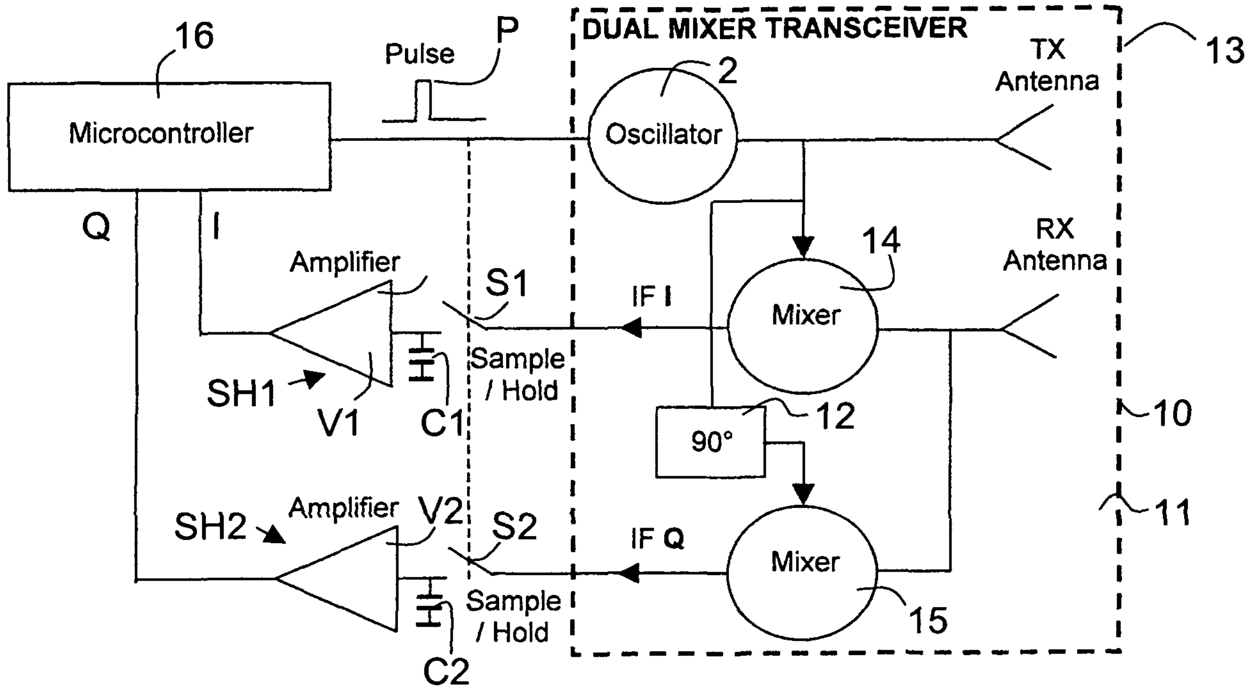


Fig. 7



16
Microcontroller
Pulse
P
DUAL MIXER TRANSCEIVER
2
Oscillator
TX
Antenna
13
Q
I
Amplifier
S1
IF I
14
Mixer
RX
Antenna
Sample
/ Hold
SH1
V1
C1
12
90°
10
SH2
Amplifier
V2
S2
IF Q
Mixer
11
Sample
/ Hold
C2
15

Fig. 8

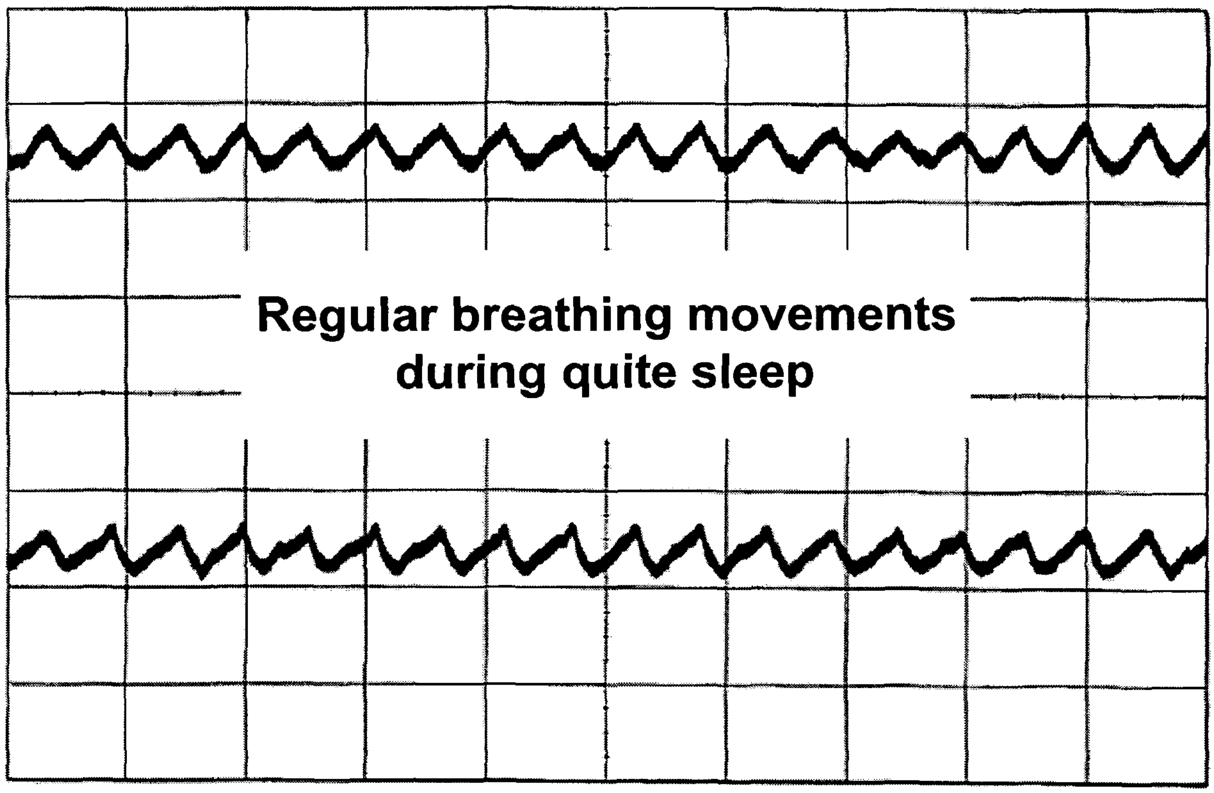


Fig. 9

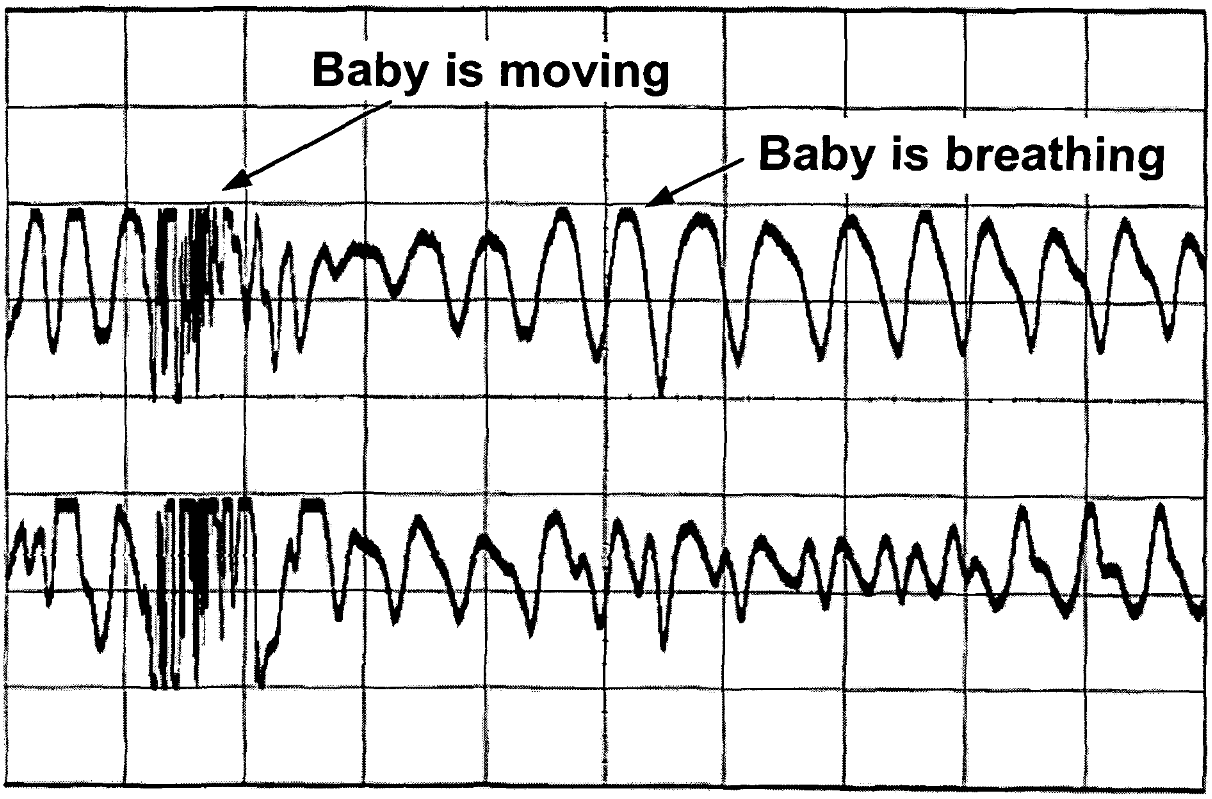


Fig. 10

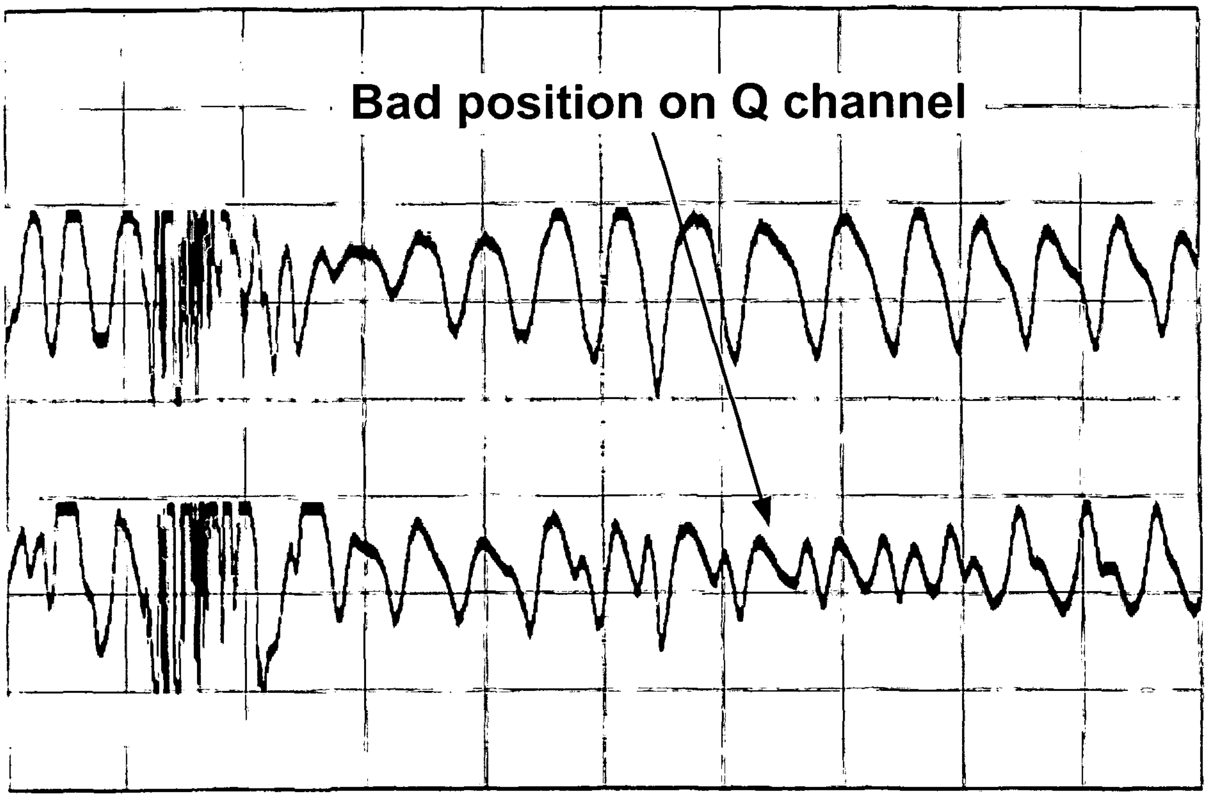


Fig. 11

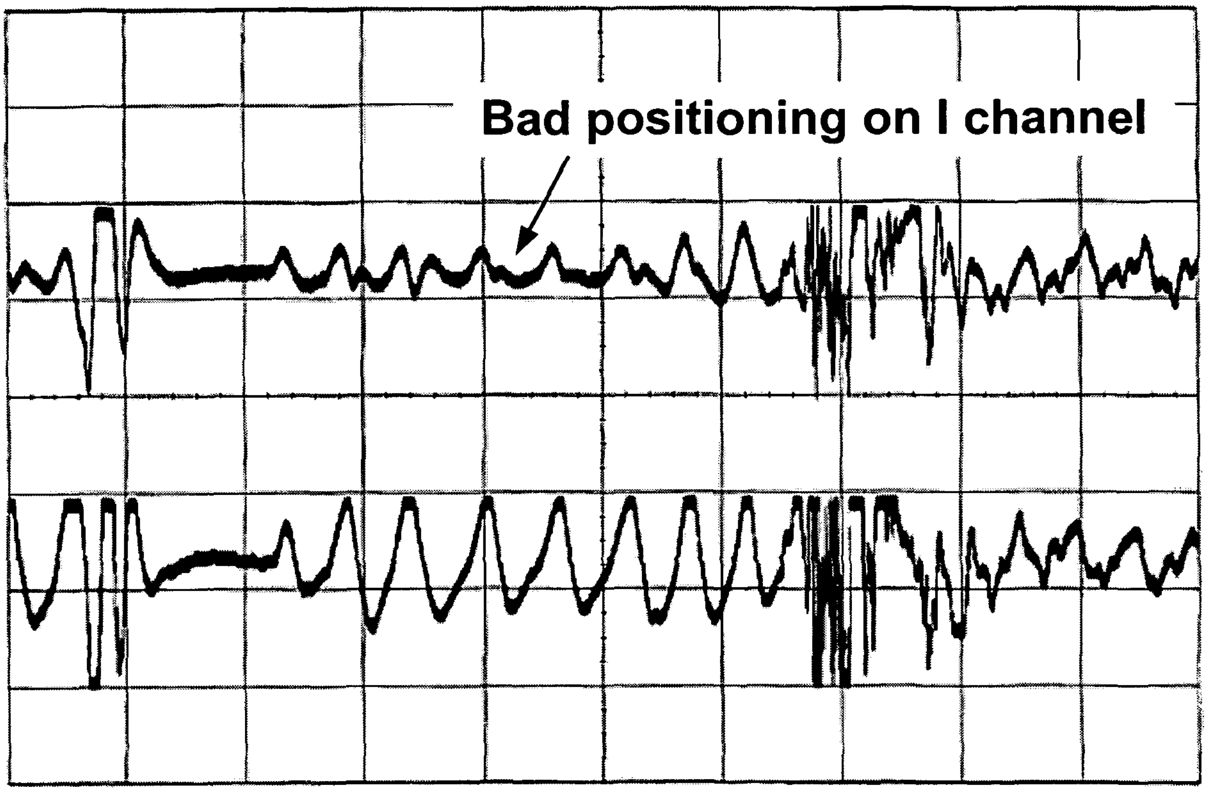


Fig.-12

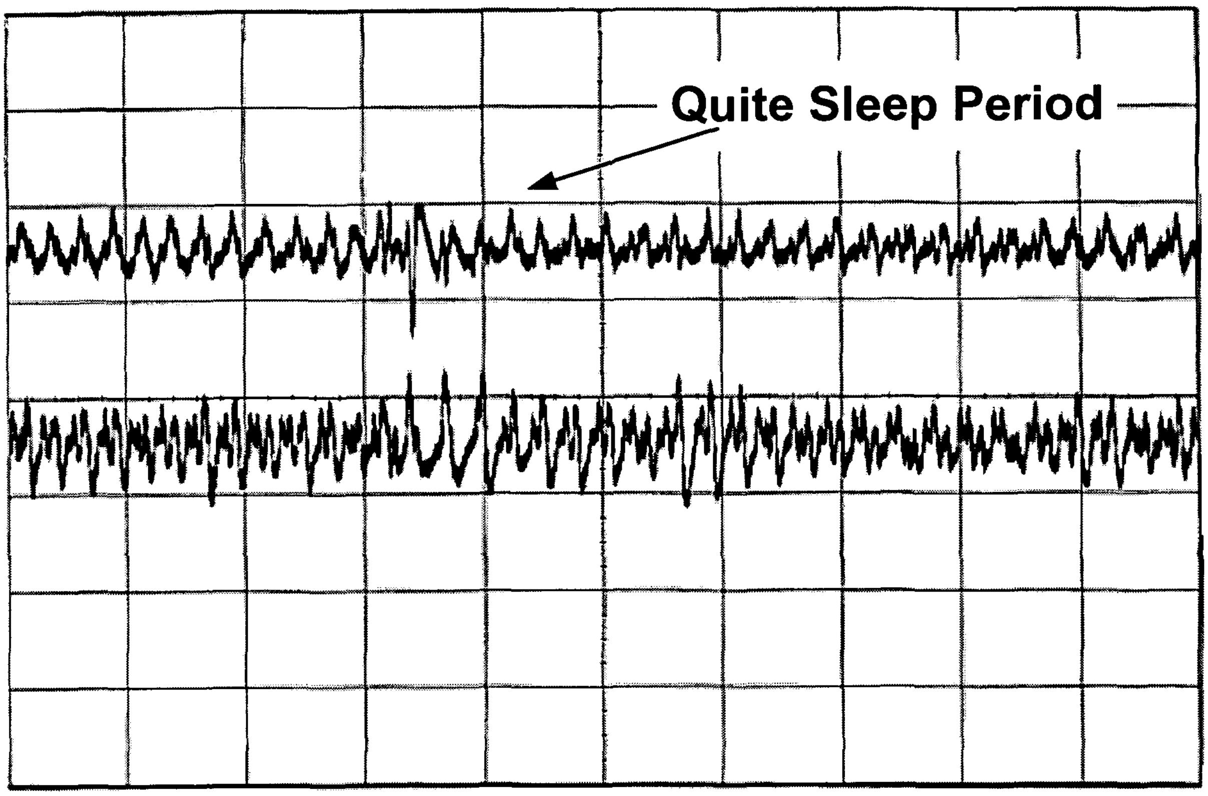


Fig. 13

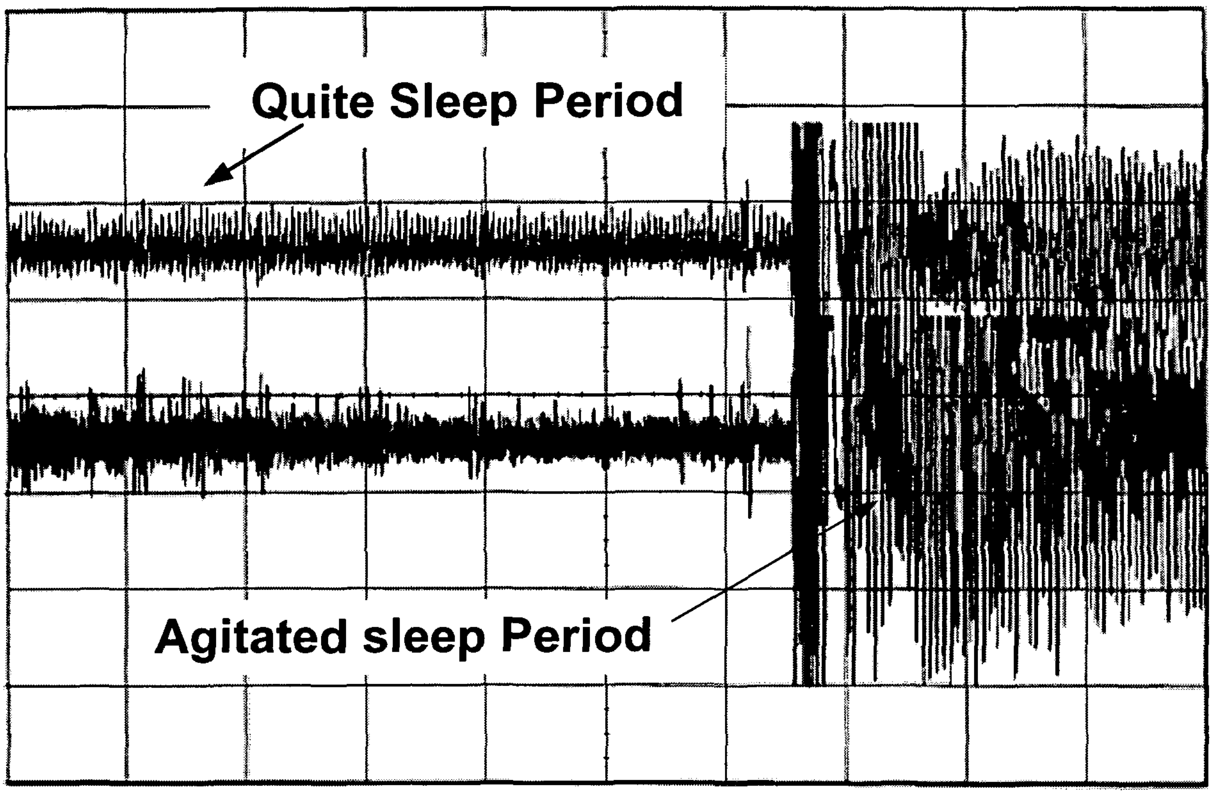


Fig. 14

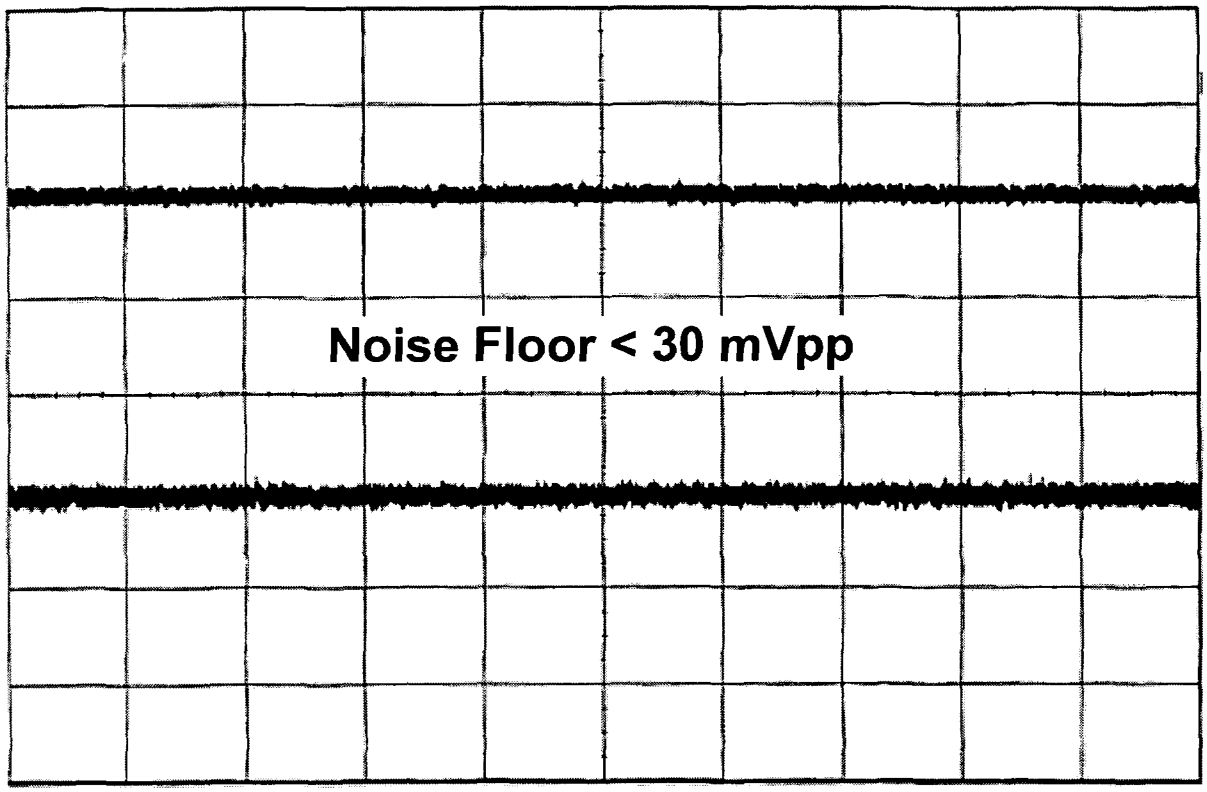


Fig. 15

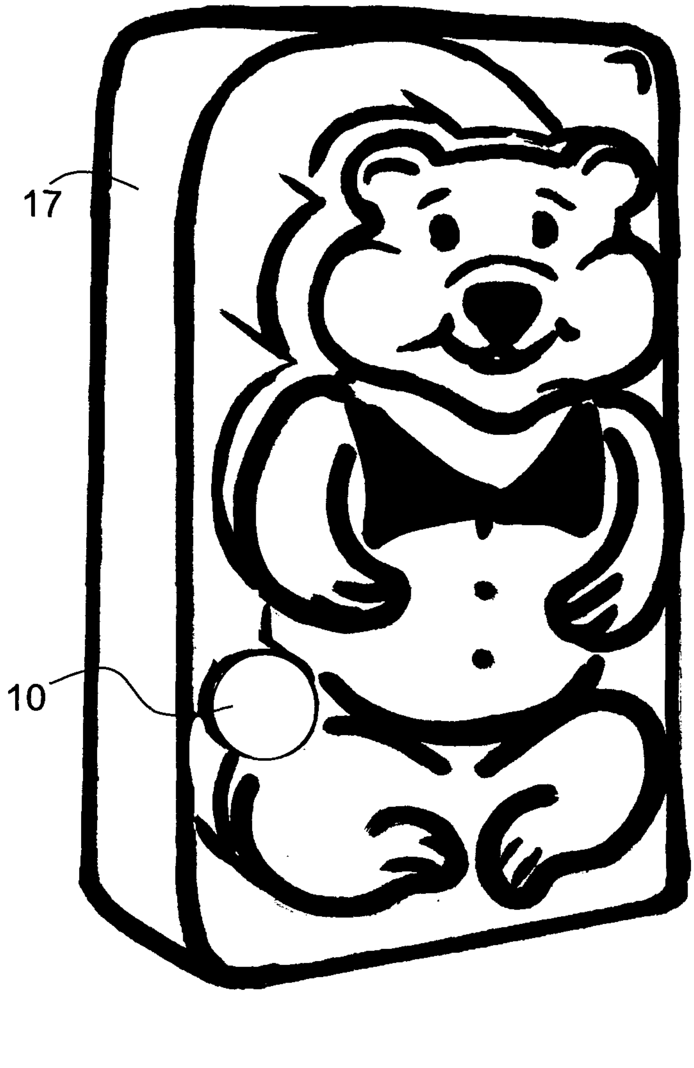


Fig. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/011438

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01S13/50

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)
G01S A61B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/073424 A1 (RUOSS HANS-OLIVER [DE] ET AL RUOSS HANS-OLIVER [DE] ET AL) 7 April 2005 (2005-04-07) figures 1,3,5,7,8 paragraph [0032] - paragraph [0033] paragraph [0036] paragraph [0046] paragraph [0052] claim 4	1-22
Y	US 6 703 965 B1 (MING SU GUANG [SG] ET AL) 9 March 2004 (2004-03-09) figures 6-9 column 5, line 12 - column 6, line 30	1-22

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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
16 October 2008	23/10/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Niemeijer, Reint

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 5 766 208 A (MCEWAN THOMAS E [US]) 16 June 1998 (1998-06-16) cited in the application figure 3 column 11, line 60 - column 12, line 4	1,17-22
A	WO 2007/136610 A (UNIV HAWAII [US]; BORIC-LUBECKE OLGA [US]; HOST-MADSEN ANDERS [US]; LU) 29 November 2007 (2007-11-29) paragraph [0058]; figure 2A	1,17-22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2007/011438

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			DE	10259522	A1	01-07-2004
			EP	1590685	A1	02-11-2005
			JP	2006510880	T	30-03-2006
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			EP	1222479	A1	17-07-2002
			WO	0125818	A1	12-04-2001
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			TW	448305	B	01-08-2001
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			CA	2197063	A1	22-02-1996
			CN	1155236	A	23-07-1997
			DE	69530848	D1	26-06-2003
			DE	69530848	T2	22-01-2004
			EP	0774918	A1	28-05-1997
			JP	10504976	T	19-05-1998
			JP	3720053	B2	24-11-2005
			WO	9604845	A1	22-02-1996
			US	5573012	A	12-11-1996
WO 2007136610	A	29-11-2007	US	2008074307	A1	27-03-2008
			US	2008119716	A1	22-05-2008
			US	2008077015	A1	27-03-2008