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(54) SYSTEM FOR INTERROGATING IMPLANTED PASSIVE RESONANT-CIRCUIT DEVICES

SYSTEM ZUR ABFRAGUNG EINER IMPLANTIERTEN PASSIVEN RESONANZSCHALTUNGSVORRICHTUNG

SYSTEME D'INTERROGATION DE DISPOSITIFS IMPLANTES A CIRCUITS RESONANTS PASSIFS

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Description

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to medical devices and more particularly to systems for measuring intracranial pressure by interrogating an implanted passive resonant circuit.

[0002] Numerous patents have been issued disclosing various means for monitoring intracranial pressure by means of an implanted, passive, resonant electronic circuit that is interrogated by an external device.

[0003] U.S. Patent No. 3,943,915 (Severson) discloses an intracranial pressure monitoring device that incorporates a lumped-constant tuned circuit. The typical Q of such a circuit is on the order of 50. The Q value ("quality factor") basically corresponds to the width of the response curve in the frequency domain for a resonant circuit. The quantity Q can be defined as 2π x maximum energy stored in the resonant circuit divided by the total energy lost per period from the resonant circuit.

[0004] U.S. Patent No. 4,026,276 (Chubbuck) discloses an intracranial pressure monitoring device with a lumped-constant tuned circuit. The typical Q of such a circuit is on the order of 50.

[0005] U.S. Patent No. 4,114,606 (Seylar) discloses a monitoring device for implanted resonant circuits. They are not able to even estimate the signal-to-noise ratio, but use a "grid-dip meter" approach, i.e., the detector voltage "dips" whenever the interrogating circuit sweeps by the resonant frequency of the implanted resonant frequency circuit.

[0006] U.S. Patent No. 4,265,252 (Chubbuck) discloses an intracranial pressure monitoring device with a lumped-constant tuned circuit.

[0007] U.S. Patent No. 4,354,506 (Sakaguchi) discloses an intracranial pressure monitoring device with a lumped-constant tuned circuit, and purposed using a "grid-dip meter" monitoring system.

[0008] U.S. Patent No. 5,873,840 (Neff) discloses an intracranial pressure sensor with a microwave cavity resonator. The preferred embodiment discussed includes a reflected energy measurement approach.

[0009] However, all of these devices suffer from poor signal-to-noise ratios. Thus, there remains a need for an implanted resonant circuit that provides for a response signal with good signal-to-noise ratio when interrogated.

OBJECTS OF THE INVENTION

[0010] Accordingly, it is the object of this invention to provide a system for determining the resonant frequency of a circuit, lumped-constant or other, implanted in a person.

[0011] It is further the object of this invention to provide a system that can work over a wide range of frequencies, and uses commercially available components.

[0012] It is further the object of this invention to provide a system with a high signal-to-noise ratio, which allows it to work without direct contact with the patient.

[0013] It is further the object of this invention to provide a system that exposes the patient to acceptable levels of irradiation, suitable for continuous monitoring.

[0014] It is still yet a further object of this invention to provide a system whose performance is much less sensitive to path loss.

[0015] It is even still another object of this invention to provide a system that it is completely insensitive to dispersion (frequency-dependent reflection, absorption, and transmission characteristics) of the tissue.

SUMMARY OF THE INVENTION

[0016] These and other objects of the instant invention are achieved by providing a system for monitoring the pressure within the cranium of a living being. The system comprises: a resonant frequency circuit that in use is implanted within the cranium; a remotely-located transmitter (e.g., a voltage-controlled YIG oscillator) and a remotely-located receiver coupled through alternation means (e.g., a pair of MMIC switches) that operates the transmitter and receiver in alternation such that when the transmitter is transmitting an interrogation signal to the resonant frequency circuit, the remotely-located receiver is de-activated and when the receiver is listening to a response signal from the resonant frequency circuit the transmitter is de-activated; signal generator means for generating high frequency electromagnetic excitation waves (e.g., 3.8 - 3.82 Ghz) wherein one of the excitation waves causes the resonant frequency circuit to resonate at an altered resonance frequency corresponding to the pressure within the cranium; the remotely-located receiver detects the altered resonance frequency in the response signal; and a display, coupled to the remotely-located receiver, displays the pressure within the cranium corresponding to the detected altered resonance frequency. Preferred embodiments of the invention are defined in the dependent claims.

DESCRIPTION OF THE DRAWINGS

[0017] Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 a block diagram of the present invention;
Fig. 2 is a timing diagram of the transmitter and receiver MMIC switches;
Fig. 3A is a circuit schematic of the timing circuit and the voltage sweeper/pressure display; and
Fig. 3B is a circuit schematic of the receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] The present invention is an improvement of the intercranial pressure monitoring system of U.S. Patent No. 5,873,840 (Neff)

[0019] This document discloses a system for monitoring the pressure within the cranium of a living being, said system comprising:

a resonant frequency circuit that in use is implanted within the cranium;
a *remotely-located* transmitter, said transmitter transmitting an interrogation signal to said resonant frequency circuit;
a remotely-*located* receiver, said receiver listening to a response signal from said resonant frequency circuit;
a signal generator means for generating high frequency electromagnetic excitation waves wherein one of said excitation waves causes said resonant frequency circuit to resonate at an altered resonance frequency corresponding to the pressure within the cranium;
said remotely-located receiver detecting said altered resonance frequency in said response signal; and
a display, coupled to said *remotely-located* receiver, for displaying the pressure within the cranium corresponding to said detected altered resonance frequency.

[0020] Referring now in detail to the various figures of the drawing wherein like reference characters refer to like parts, there is shown at 320 in Fig. 1, a system for interrogating an implanted resonant circuit 322 (e.g., the cavity resonator unit 22 of U.S. Patent No. 5,873,840 (Neff)) that is embedded below the scalp of a patient (not shown). The system 320 comprises a transmitter 332, a receiver 334, a transmit MMIC (monolithic microwave integrated circuit) switch 380, a receive MMIC switch 382, a timing circuit 384 and a voltage sweeper/pressure display (hereinafter referred to as VSPD) 386. The probe 324 comprises a stripline transmit antenna 388 and a stripline receiver antenna 390. When activated, as discussed below, the transmitter MMIC switch 380 permits the transmitter 332 to transmit a signal 333 through the stripline transmit antenna 338; similarly, when the receiver MMIC switch 382 is activated, the receiver MMIC switch 382 permits the receiver 334 to receive a return signal 335 from the implanted resonant frequency circuit 322.

[0021] It should be understood that the resonance frequency of the implanted resonant frequency circuit 322 is changed as a function of the patient's cranium pressure. See U.S. Patent No. 5,873,840 (Neff). Thus, depending upon the cranium pressure, the resonance frequency will change. Furthermore, embedded in the return signal 335 is a peak value signal that corresponds to the resonant frequency, which may be designated "altered resonant wave".

[0022] The transmitter 332 (e.g., a voltage-controlled YIG (Yitrium iron garnet) oscillator such as the Micro Lambda MLPB-0406 or MLPB-0204) and the receiver 334 are swept in frequency over the range of possible resonant frequencies of the implanted resonant circuit 322. The output signal 333 of the transmitter 332 and the return signal 335 to the receiver 334 are switched synchronously using monolithic GaAs FET MMIC RF switches 380 and 382, respectively, (e.g., Alpha Industries ASO18R1-00). This synchronous switching effectively disconnects the transmitter 332 when the receiver 334 is on, and effectively disconnects the receiver 334 while the transmitter 332 is on (see Fig. 2). The switches 380/382 are keyed from an oscillator/counter/demultiplexing timing circuit 384 that compensates for the 3 nanosecond switching time of the MMIC switches 380 and 382. The connection between the transmitter 332 and the receiver 334 is loosely coupled (i.e., the transmitter 332/receiver 334 and the implanted resonant frequency circuit are displaced from each other over a finite distance, in addition to the scalp of the patient acting as a lossy dielectric) to the implanted resonant frequency circuit 322.

[0023] In particular, the transmitter 332 is slowly swept across the resonant frequency of the implanted resonant frequency circuit 322. The timing circuit 384 alternatively switches the receiver 334 and the transmitter 332 in and out of the system 320. During each pulse from the transmitter 332, the receiver 334 is "off" , i.e., disconnected at >80dB attenuation by the receiver MMIC switch 382. Similarly, during each period when the receiver 334 is "listening," the transmitter 332 is "off." With the transmitter 332 off, the receiver 334 amplifies and detects only the decay of the energy stored in the implanted resonant frequency circuit 322. This energy decay is defined as:

$$e^{\frac{-ft}{Q}}$$

where

f = frequency in Hertz; and

Q = Q factor of implanted resonant frequency circuit 322.

Typical operating values of the system 320 are as follows:

- Operating frequency of transmitter 332: 3.8-3.82 Ghz
- Q of implanted resonant frequency circuit 322: 8000
- Keying waveform for transmitter 332: 10 ns pulses spaced 20 ns
- Keying waveform for receiver 334: 10 ns pulses spaced 20 ns, synchronized 15 ns behind transmitter
- Total path loss (including coupling to implanted resonant frequency in tissue): 70 dB
- Minimum discernable signal of receiver: -110 dBm
- Transmitter 332 output: + 10 dBm.

[0024] With these values, the implanted resonant frequency circuit 322 decay is approximated as:

$$(10\ \text{dBm} - 70\ \text{dB}) \cdot e^{\frac{-ft}{Q}}$$

$$= -60\ \text{dBm} \cdot e^{\frac{-t}{2.1\times10^{-6}}} \qquad (\text{with t in nanoseconds})$$

In other words, it will take approximately 2.1 μsec for the decay to reach 36.8% (i.e., at $t = 2.1 \times 10^{-6}$ sec, the decay is given by $e^{-1} = 0.368$) of its initial value (-60 dBm). This means that with the transmitter 332 clocked at 100 MHz (10ns), very little decay occurs during the next 10ns when the receiver 334 is "connected." Therefore, the received energy at the start of the receiver MMIC switch 382 "on-time" is -60 dBm, well above the minimum discernable signal (-110 dBm) of the receiver 334. During the "off-time" of the receiver 334, the leakage input from the transmitter 332 is:

-70 dBm - (coupling between transmitter antenna 388 and receiver antenna 390).

Conservatively estimating the coupling of the two parallel stripline antennas 388/390 is at -20 dB, the final value of -90 dBm is 30 dB below the desired signal.

[0025] The result of the system 320 is that rather than looking for a small change in a large signal, as the grid-dip method requires, the "pulse-detector" operation of the system 320 only provides an output when at the resonant frequency of the circuit 322. In particular, as will be discussed later, the system 320 detects the peak value in the return signal 335 which corresponds to the resonant frequency of the implanted resonant frequency circuit 322. The pressure in the patient's cranium that corresponds to that frequency is then displayed to the operator via a display DIS (Fig. 3A).

[0026] In comparison, if the "grid-dip" approach, (i.e., without the alternate transmitter/receiver switching) were used, and applying the operating values listed above, the input to the receiver from the transmitter is -10 dBm (in a classic, grid-dip meter the receiver and transmitter are the same circuit, but this does not change the physics). The input from the implanted resonant frequency circuit 322 is -60 dBm, (and even smaller when off-resonance). Thus, the receiver is attempting to detect a change that is 50 dB smaller than the signal itself, or .001% of the signal strength. Although it is possible to do this in the laboratory, routine clinical use of such a device is not realistic.

[0027] Figs. 3A-3B show an exemplary implementation of the timing circuit 384, the VSPD 386 and the receiver 334.

[0028] The timing circuit 384 (Fig. 3A) comprises a 100 MHz crystal oscillator (e.g., JDR Microdevices #OSC100.0 oscillator) whose output is fed to inverters I1 and 12 (e.g., Fairchild Semiconductor 74VHC04 Hex inverter). The output of inverter 11 is fed into the receiver MMIC switch 382. The output of inverter I2 is fed to the VSPD 386 and to another inverter 13 (e.g., Fairchild Semiconductor 74VHC04 Hex inverter). The output of the inverter 13 is fed to the transmitter MMIC switch 380.

[0029] The VSPD 386 receives its input from the inverter I3. A pair of 4-bit binary counters BC1 and BC2 (e.g., Fairchild Semiconductor 74VHC93) are incremented by the 100 MHz crystal oscillator signal, from inverter 12, in 256 (2^8) increments. The digital incrementation is converted by an 8-bit digital/analog converter (e.g., JDR #DAC-0800) and resistor/capacitor network RC into an analog ramp voltage signal that is used to sweep the oscillator of the transmitter 332 through the pertinent frequency range, e.g., 3.8-3.82 GHz.

[0030] The ramp voltage signal (see Fig. 3A) exhibits linearly-increasing portions and substantially-vertical re-trace portions. The digital incrementation is simultaneously fed to a clocked frequency display DIS which converts the frequency into the corresponding cranial pressure in the range from 0 - 30 Torr (mmHg). When the resonant frequency of the implanted circuit 322 is detected by the receiver 334, a latch input signal LI from the receiver 334 (to be discussed below) is transmitted to the display DIS which latches the frequency value supplied from the binary counters BC1/BC2 and the display DIS then displays the pressure corresponding to that latched frequency value.

[0031] The receiver 334 (Fig. 3B) comprises three MMIC amplifiers U1, U2 and U3 (e.g., ERA-3 MMIC amplifiers) connected in series through 1 pF coupling capacitors. Input to amplifier U1 is controlled by the receiver MMIC switch 382. Thus, when the receiver MMIC switch 382 is active, the received signal 335 is passed to the input of amplifier U1. The output of amplifier U3 is fed through a peak detector formed by a half-wave rectifier, a DC amplifier U4 and a differentiator circuit U5. The half-wave rectifier comprises a diode D1 (e.g., Hewlett-Packard 5082-2835 diode) coupled to ground through a capacitor. The output of the half-wave rectifier is fed to a DC amplifier U4 (e.g., LM301 op amp) which in turn is fed to a differentiator circuit U5 (e.g., LM301 op amp).

[0032] The differentiator circuit U5 provides a zero output under two conditions: (1) when the received signal 335 is at the resonant frequency of the implanted resonant frequency circuit 322 (i.e., at the peaks of the return signal 335); and (2) when the ramp voltage, generated by the VSPD 386, is re-tracing, i.e., the vertical portion of the ramp is occurring. In order for the system 320 to operate properly, it is necessary to distinguish between these two conditions such that the display DIS only displays under condition (1) and not under condition (2). To that end, the output of the differentiator circuit U5 is fed as one input to a receiver NAND gate U6. The other input to the receiver NAND gate U6 is a carry out (sync) signal from binary counter BC2 that corresponds to the re-trace portion of the ramp voltage. Thus, the output of the NAND gate U6 is asserted (i.e., permits latching to the display DIS) only when the differentiator circuit U5 output is zero (which corresponds to a peak in the received signal 335 which corresponds to the received signal 335 being at the resonant frequency) and the ramp voltage is not experiencing a re-trace.

[0033] A further advantage of this system 320 and method is that the performance is much less sensitive to path loss. In the exemplary embodiment discussed above the receiver 334 could easily be placed a small (line-of-sight) distance from the patient

[0034] A further advantage of this system and method is that it is completely insensitive to dispersion (frequency-dependent reflection, absorption, and transmission characteristics) of the tissue. Only the implanted resonant frequency circuit 322 provides a signal during the time the receiver 334 is "on."

[0035] Without further elaboration, the foregoing will so fully illustrate my invention that others may, by applying current or future knowledge, readily adopt the same for use under various conditions of service.

Claims

1. A system for monitoring the pressure within the cranium of a living being, said system comprising:

   a resonant frequency circuit (322) that in use is implanted within the cranium;
   a remotely-located transmitter (332) and a remotely-located receiver (334) coupled through an alternation means (380, 382) that operates said transmitter and receiver alternately such that when said transmitter (332) is transmitting an interrogation signal to said resonant frequency circuit (322) said remotely-located receiver (334) is de-activated and when said receiver (334) is listening to a response signal (335) from said resonant frequency circuit (322) said transmitter (332) is de-activated;
   a signal generator means for generating high frequency electromagnetic excitation waves wherein one of said excitation waves causes said resonant frequency circuit (322) to resonate at an altered resonance frequency corresponding to the pressure within the cranium; said remotely-located receiver (334) detecting said altered resonance frequency in said response signal (335); and
   a display (386), coupled to said remotely-located receiver (334), for displaying the pressure within the cranium corresponding to said detected altered resonance frequency.

2. The system of Claim 1 wherein said alternation means comprises:

a timing circuit (384);
a first switch (380) coupled between said timing circuit (384) and said remotely-located transmitter (332), said first switch having a first closed state that activates said transmitter (332) and a first open state that de-activates said transmitter (332);
a second switch (382) coupled between said timing circuit (384) and said remotely-located receiver (384), said second switch (382) having a second closed state that activates said receiver (334) and a second open state for de-activating said receiver (334); and
said timing circuit (384) closing said first switch (380) in said first closed state while opening said second switch (382) in said second open state and then opening said first switch (380) in said first open state while closing said second switch (382) in said second closed state.

3. The system of Claim 2 wherein said first closed state is approximately 10 nanoseconds and said first open state is approximately 20 nanoseconds.

4. The system of Claim 2 wherein said second closed state is approximately 10 nanoseconds and said second open state is approximately 20 nanonseconds.

5. The system of Claim 3 wherein said first switch (380) is a monolithic microwave integrated circuit.

6. The system of Claim 4 wherein said second switch (382) is a monolithic microwave integrated circuit.

7. The system of Claim 1 wherein said transmitter (332) comprises a voltage-controlled oscillator VCO and wherein said system further comprises a voltage sweeper, said voltage sweeper (386) controlling said VCO to generate said high frequency electromagnetic excitation waves.

8. The system of Claim 1 wherein said high frequency electromagnetic excitation waves are in the range of 3.8 - 3.82 GHz.

9. The system of Claim 7 wherein said high frequency electromagnetic excitation waves are in the range of 3.8 - 3.82 GHz.

10. The system of Claim 7 wherein said receiver (334) comprises a peak detector (inter-alia U4, U5)for detecting said altered resonant frequency in said response signal.

11. The system of Claim 10 wherein said peak detector (U4, U5) comprises a half-wave rectifier, a direct current (DC) amplifier (U4) and a differentiator (U5) coupled together in series.

12. The system of Claim 11 wherein said voltage sweeper (386) generates a ramp voltage for controlling a voltage controlled oscillator (VCO1), said ramp voltage comprising linearly increasing portions and substantially vertical re-trace portions.

13. The system of Claim 12 wherein said receiver (334) further comprises logic means (U1 to U6) having a first input coupled to the output of said differentiator (U5) and a second input coupled to said voltage sweeper (386), said logic means (U6) having an output coupled to said display (386) and wherein said logic means (U1 to U6) decouples said receiver from said display during said re-trace portions of said ramp voltage while permitting said display (386) to display the pressure within the cranium when said altered resonance frequency is detected by said receiver (334).

Patentansprüche

1. System zum Beobachten des Drucks innerhalb des Schädels eines Lebewesens, wobei das System umfasst
einen Reeonanzfrequenzkreis (322), der bei Gebrauch im Inneren des Schädels implantiert ist;
einen beabstandet angeordneten Sender (332) und einen beabstandet angeordneten Empfänger (334), die durch ein Wechselmittel (380, 382) gekoppelt sind, das den Sender und den Empfänger abwechselnd betätigt, so dass, falls der Sender (332) ein Abfragesignal an den Resonanzfrequenzkreis (322) sendet, der beabstandet angeordnete Empfänger (334) deaktiviert ist, und, wenn der Empfänger (334) auf ein Antwortsignal (335) von dem Resonanzfrequenzkreis (322) hört, der Sender (332) deaktiviert ist;
ein Signalerzeugungamittel zum Erzeugen hochfrequenter elektromagnetischer Erregerwellen, wobei eine der

Erregerwellen den Resonanzfrequenzkreis (322) dazu veranlasst, bei einer veränderten Resonanzfrequenz in Resonanz zu schwingen, die dem Druck innerhalb des Schädels entspricht; wobei der beabstandet angeordnete Empfänger (334) die veränderte Resonanzfrequenz in dem Antwortsignal (335) erfasst; und
eine Anzeige (386), die mit dem beanstandet angeordneten Empfänger (334) gekoppelt ist, zum Anzeigen des Drucks innerhalb des Schädels entsprechend der erfassten veränderten Resonanzfrequenz.

2. System nach Anspruch 1, wobei das Wechselmittel umfasst
einen Zeitablaufschaltkreis (384);
einen ersten Schalter (380), der zwischen den Zeitablaufschaltkreis (384) und den beabstandet angeordneten Sender (332) geschaltet ist, wobei der erste Schalter einen ersten geschlossenen Zustand, der den Sender (332) aktiviert, und einen ersten geöffneten Zustand, der den Sender (332) deaktiviert, aufweist;
einen zweiten Schalter (382), der zwischen den Zeitablaufschaltkreis (384) und den beabstandet angeordneten Empfänger (384) geschaltet ist, wobei der zweite Schalter (382) einen zweiten geschlossenen Zustand, der den Empfänger (334) aktiviert, und einen zweiten geöffneten Zustand zum Deaktivieren des Empfängers (334), aufweist; und
der Zeitablaufschaltkreis (384) den ersten Schalter (380) in den ersten geschlossenen Zustand schließt, während er den zweiten Schalter (382) in den zweiten geöffneten Zustand öffnet, und dann den ersten Schalter (380) in den ersten geöffneten Zustand öffnet, während er den zweiten Schalter (382) in den zweiten geschlossenen Zustand schließt.

3. System nach Anspruch 2, wobei der erste geschlossene Zustand annähernd 10 Nanosekunden währt und der erste offene Zustand annähernd 20 Nanosekunden währt.

4. System nach Anspruch 2, wobei der zweite geschlossene Zustand annähernd 10 Nanosekunden währt und der zweite offene Zustand annähernd 20 Nanosekunden währt.

5. System nach Anspruch 3, wobei der erste Schalter (380) ein monolithischer integrierter Mikrowellenschaltkreis ist.

6. System nach Anspruch 4, wobei der zweite Schalter (382) ein monolithischer integrierter Mikrowellenschaltkreis ist.

7. System nach Anspruch 1, wobei der Sender einen spannungsgesteuerten Oszillator (voltage controlled oscillator) VCO umfasst und wobei das System ferner ein Kippspannungselement (386) umfasst, wobei das Kippspannungselement (386) den VCO steuert, um die hochfrequenten elektromagnetischen Erregerwellen zu generieren.

8. System nach Anspruch 1, wobei die hochfrequenten elektromagnetischen Erregerwellen in dem Bereich von 3,8 bis 3,82 Gigahertz liegen.

9. System nach Anspruch 7, wobei die hochfrequenten elektromagnetischen Erregerwellen in dem Bereich von 3,8 bis 3,82 Gigahertz liegen.

10. System nach Anspruch 7, wobei der Empfänger (334) einen Spitzendetektor (u.a. U4, U5) zum Erfassen der veränderten Resonanzfrequenz in dem Antwortsignal umfasst.

11. System nach Anspruch 10, wobei der Spitzendetektor (U4, U5) einen Halbwellengleichrichter, einen Gleichstrom-(DC)-Verstärker (U4) und ein Differenzierglied (U5) umfasst, die in Reihe geschaltet sind.

12. System nach Anspruch 11,. wobei der Kippspannungsgenerator (386) eine Durchfahrspannung zum Steuern des spannungsgesteuerten Oszillators (VCO1) erzeugt, wobei die Durchfahrspannung linear anwachsende Abschnitte und im Wesentlichen senkrecht rücklaufende Abschnitte aufweist.

13. System nach Anspruch 12, wobei der Empfänger (334) ferner Logikmittel (U1 bis U6) umfasst, die einen ersten Eingang aufweisen, der an den Ausgang des Differenzierglieds (U5) angeschlossen ist, und mit einem zweiten Eingang versehen ist, der an den Kippspannungsgenerator (386) angeschlossen ist, wobei das Logikmittel (U6) einen Ausgang aufweist, der an die Anzeige (386) angeschlossen ist, und wobei das Logikmittel (U1 bis U6) den Empfänger während der Rücklaufabschnitte der Durchfahrspannung von der Anzeige entkoppelt, während es der Anzeige (386) erlaubt, den Druck innerhalb des Schädels anzuzeigen, wenn die geänderte Resonanzfrequenz von dem Empfänger (334) erfasst wird.

Revendications

1. Système pour surveiller la pression à l'intérieur du crâne d'un être vivant, ledit système comprenant :

un circuit de fréquence de résonance (322) qui en utilisation est implanté à l'intérieur du crâne ;
un transmetteur situé à distance (332) et un récepteur situé à distance (334) couplés par l'intermédiaire d'un moyen d'alternance (380, 382) qui fait fonctionner ledit transmetteur et ledit récepteur de manière alternée de telle sorte que lorsque ledit transmetteur (332) transmet un signal d'interrogati on audit circuit de fréquence de résonance (322) ledit récepteur situé à distance (334) est désactivé et lorsque ledit récepteur (334) écoute un signal de réponse (335) depuis ledit circuit de fréquence de résonance (322) ledit transmetteur (332) est désactivé ;
un moyen de génération de signal destiné à générer des ondes d'excitation électromagnétiques de haute fréquence dans lequel une desdites ondes d'excitation entraîne le fait que ledit circuit de fréquence de résonance (322) résonne à une fréquence de résonance altérée correspondant à la pression à l'intérieur du crâne ;
ledit récepteur situé à distance (334) détectant ladite fréquence de résonance altérée dans ledit signal de réponse (335) ; et
un affichage (386) couplé audit récepteur situé à distance (334) pour afficher la pression à l'intérieur du crâne correspondant à ladite fréquence de résonance altérée détectée.

2. Système selon la revendication 1 dans lequel ledit moyen d'alternance comprend :

un circuit de réglage (384) ;
un premier interrupt eur (380) couplé entre ledit circuit de réglage (384) et ledit transmetteur situé à distance (332), ledit premier interrupteur ayant un premier état fermé qui active ledit transmetteur (332) et un premier état ouvert qui désactive ledit transmetteur (332) ;
un deuxième interrupteur (382) couplé entre ledit circuit de réglage (384) et ledit récepteur situé à distance (384), ledit deuxième interrupteur (382) ayant un deuxième état fermé qui active ledit récepteur (384) et un deuxième état ouvert pour désactiv er ledit récepteur (334) ; et
ledit circuit de réglage (384) fermant ledit premier interrupteur (380) dans ledit premier état fermé tout en ouvrant ledit deuxième interrupteur (382) dans ledit deuxième état ouvert et ensuite ouvrant ledit premier interrupteur (380) dans ledit premier état ouvert tout en fermant ledit deuxième interrupteur (382) dans ledit deuxième état fermé.

3. Système selon la revendication 2 dans lequel ledit premier état fermé est approximativement 10 nanosecondes et ledit premier état ouvert est approximativement 20 nanosecondes.

4. Système selon la revendication 2 dans lequel ledit deuxième état fermé est approximativement 10 nanosecondes et ledit deuxième état ouvert est approximativement 20 nanosecondes.

5. Système selon la revend ication 3 dans lequel ledit premier interrupteur (380) est un circuit intégré à micro - ondes monolithiques.

6. Système selon la revendication 4 dans lequel ledit deuxième interrupteur (382) est un circuit intégré à micro - ondes monolithiques.

7. Système selon la revendication 1 dans lequel ledit transmetteur (332) comprend un oscillateur traducteur de tension VCO et dans lequel ledit système comprend en outre un analyseur panoramique de tension, ledit analyseur panoramique de tension (386) contrôlant ledit oscillateur VCO afin de générer lesdites ondes d'excitation électromagnétiques à haute fréquence.

8. Système selon la revendication 1 dans lequel lesdites ondes d'excitation électromagnétiques à haute fréquence sont comprises dans la plage de 3,8 à 3,82 G Hz.

9. Système selon la revendication 7 dans lequel lesdites ondes d'excitation électromagnétiques à haute fréquence sont comprises dans la plage de 3,8 à 3,82 G Hz.

10. Système selon la revendication 7 dans lequel ledit récepteur (334) comprend un déte cteur de pic (entres autres U4, U5) destiné à détecter ladite fréquence de résonance altérée dans ledit signal de réponse.

11. Système selon la revendication 10 dans lequel ledit détecteur de pic (U4, U5) comprend un rectificateur de demi-onde, un amplificateur de courant continu (DC) (U4) et un différenciateur (U5) couplés ensemble en série.

12. Système selon la revendication 11 dans lequel ledit analyseur panoramique de tension (386) génère une tension de rampe pour contrôler un oscillateur traducteur de tension (VCO1) ladite tension de rampe comprenant des parties augmentant de façon linéaire et des parties de retraçage sensiblement verticales.

13. Système selon la revendication 12 dans lequel ledit récepteur (334) comprend en outre des moyens de logique (U1 à U6) ayant une première entrée couplée à la sortie dudit différenciateur (U5) et une deuxième entrée couplée audit analyseur panoramique de tension (386), lesdits moyens de logique (U6) ayant une sortie couplée audit affichage (386) et dans lequel lesdits moyens de logique (U1 à U6) découplent ledit récepteur dudit affichage au cours desdites parties de retraçage de ladite tension de rampe tout en permettant audit affichage (386) d'afficher la pression à l'intérieur du crâne lorsque ladite fréquence de résonance altérée est détectée par ledit récepteur (334).

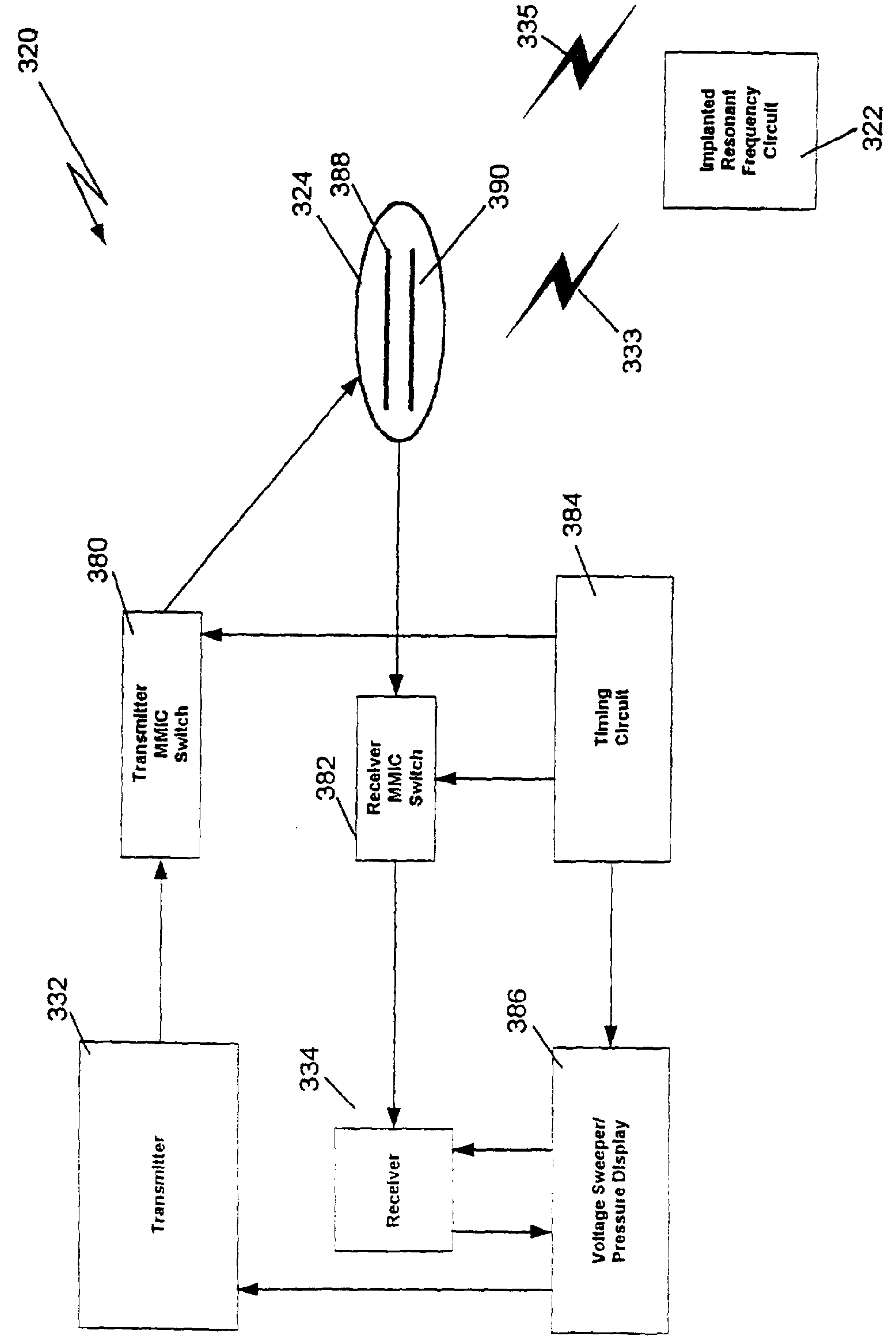

320
335
Implanted Resonant Frequency Circuit
322
324
388
390
333
380
Transmitter MMIC Switch
384
Receiver MMIC Switch
382
Timing Circuit
332
Transmitter
334
Receiver
386
Voltage Sweeper/ Pressure Display

Fig. 1

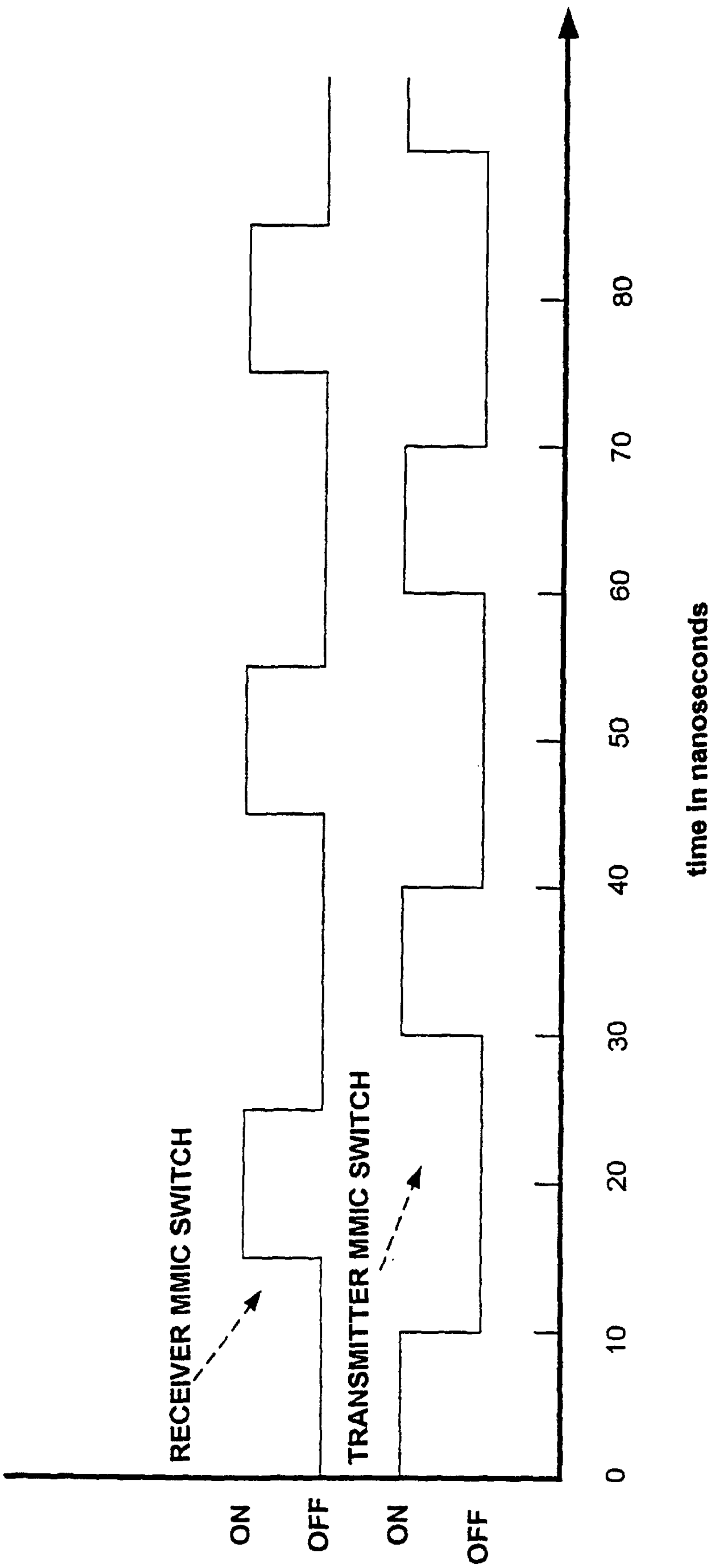
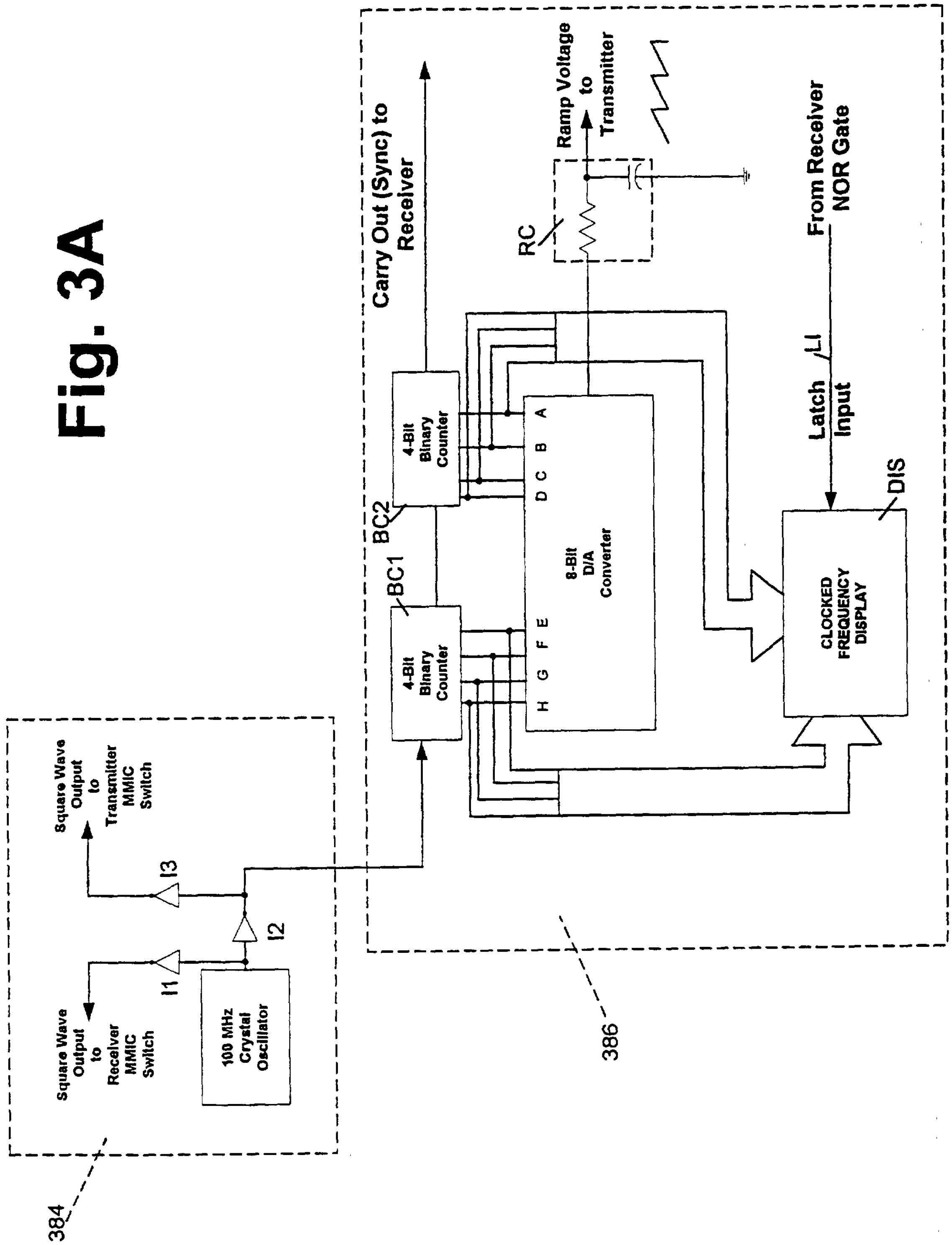

RECEIVER MMIC SWITCH
TRANSMITTER MMIC SWITCH
ON
OFF
ON
OFF
0
10
20
30
40
50
60
70
80
time in nanoseconds

FIG. 2

Fig. 3A


Square Wave Output to Receiver MMIC Switch
Square Wave Output to Transmitter MMIC Switch
100 MHz Crystal Oscillator
I1
I2
I3
384
386
4-Bit Binary Counter
4-Bit Binary Counter
BC1
BC2
Carry Out (Sync) to Receiver
8-Bit D/A Converter
A B C D E F G H
RC
Ramp Voltage to Transmitter
From Receiver NOR Gate
Latch Input
LI
DIS
CLOCKED FREQUENCY DISPLAY

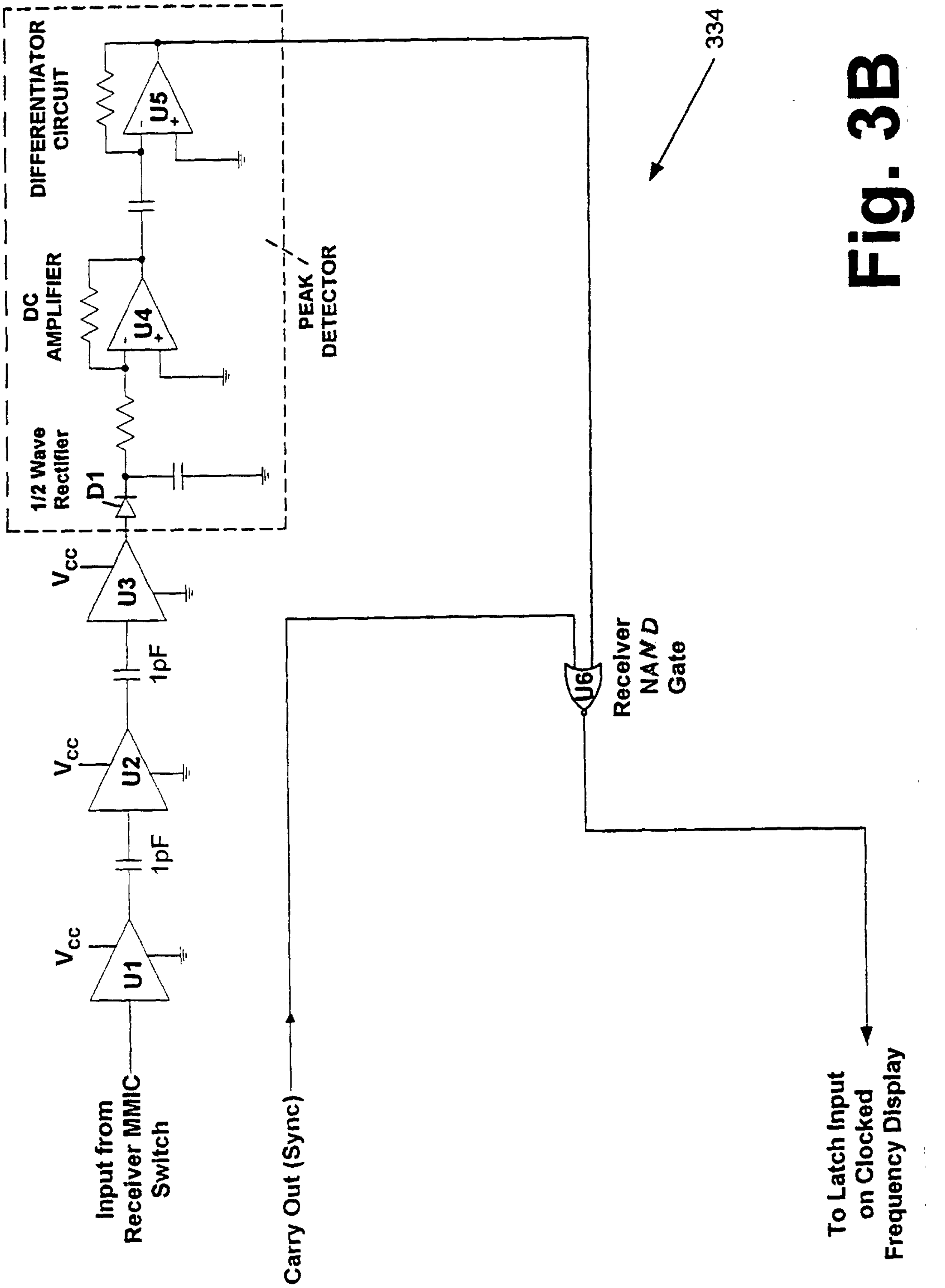

Input from Receiver MMIC Switch
Carry Out (Sync)
To Latch Input on Clocked Frequency Display
V_{cc}
U1
1pF
V_{cc}
U2
1pF
V_{cc}
U3
D1
1/2 Wave Rectifier
DC AMPLIFIER
U4
DIFFERENTIATOR CIRCUIT
U5
PEAK DETECTOR
U6
Receiver NAND Gate
334

Fig. 3B

专利名称(译)	用于询问植入的无源谐振电路器件的系统		
公开(公告)号	EP1202666B1	公开(公告)日	2005-01-19
申请号	EP2000945299	申请日	2000-07-11
[标]申请(专利权)人(译)	NEFF SAMUELř		
申请(专利权)人(译)	NEFF，塞缪尔·		
当前申请(专利权)人(译)	NEFF，塞缪尔·		
[标]发明人	NEFF SAMUEL R		
发明人	NEFF, SAMUEL R.		
IPC分类号	A61B5/00 A61B5/03		
CPC分类号	A61B5/0031 A61B5/031		
代理机构(译)	SHAW，LAURENCE		
优先权	09/354385 1999-07-14 US		
其他公开文献	EP1202666A1		
外部链接	Espacenet		

摘要(译)

描述了用于询问植入的无源谐振电路的系统和方法。通过发送一系列短脉冲然后在脉冲之间监听以检测谐振电路的输出来检测谐振频率。通过脉冲之间的适当间隔，可以获得极大改善的信噪比。

$$e^{\frac{-ft}{Q}}$$