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(54) FAST RECOVERY OF ECG SIGNAL METHOD AND APPARATUS

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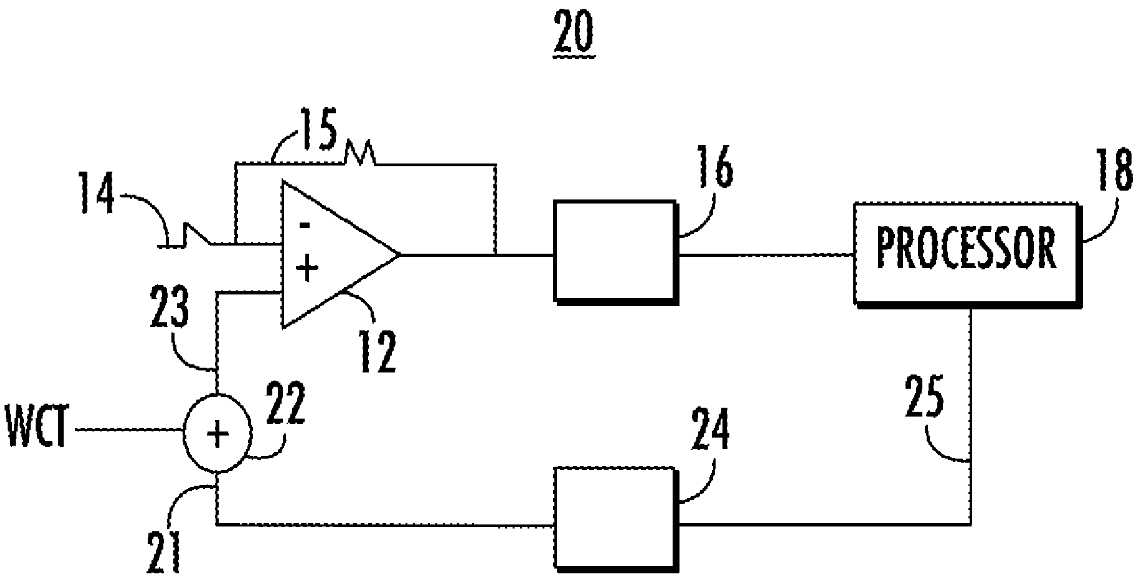
(57) **ABSTRACT**

Fast recovery electrocardiogram (ECG) signal method and apparatus are provided. In one embodiment, an ECG apparatus includes an input for receiving a biometric cardiogram signal, such as a Wilson Central Terminal (WCT) signal, and a combiner, such as an adder, for producing a compensated signal. Processing circuitry produces an ECG reflective of the compensated signal and also outputs a signal corresponding to high frequency response of the compensated signal to compensate for low response of the biometric cardiogram signal to high frequency spikes. A resultant ECG is produced by the processing circuitry having pacing signal contribution within the biometric cardiogram signal cancelled.



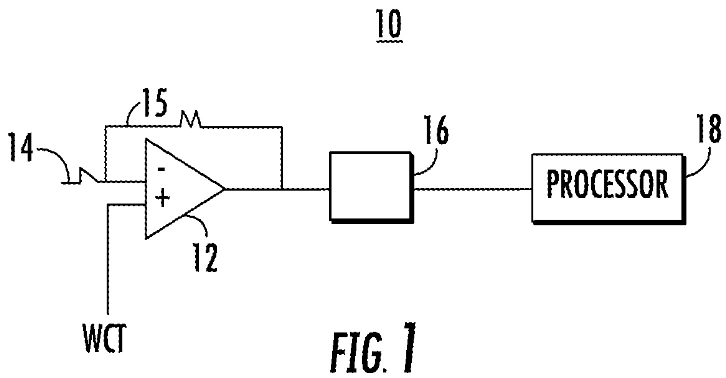

10
15
14
16
18
PROCESSOR
12
WCT

FIG. 1

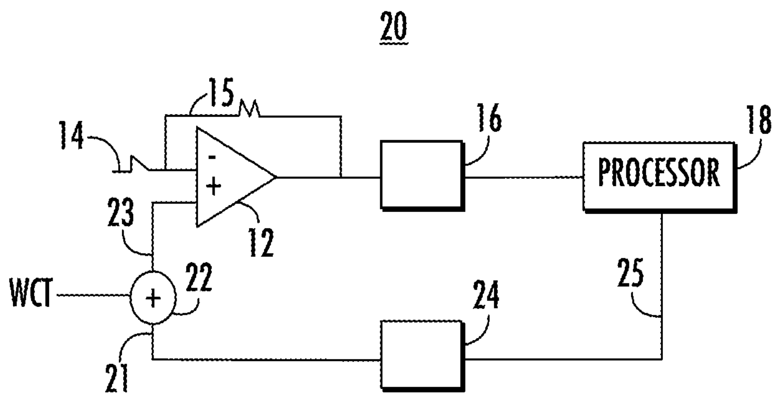

20
15
14
16
18
PROCESSOR
23
12
WCT
22
24
25
21

FIG. 2

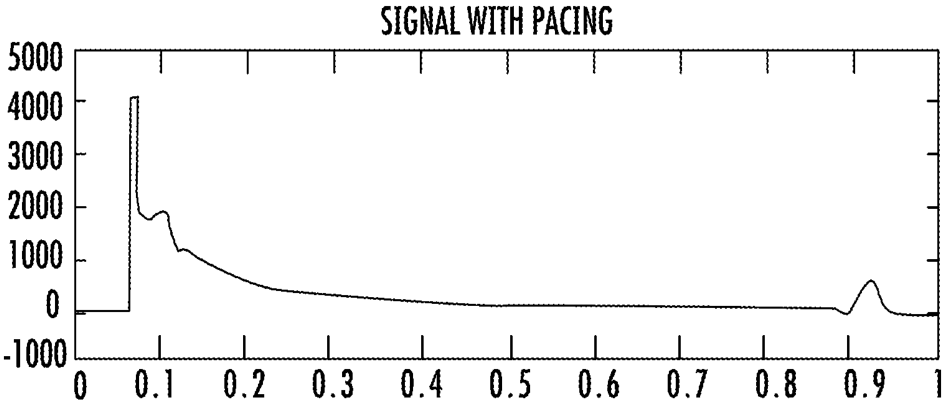


FIG. 3A

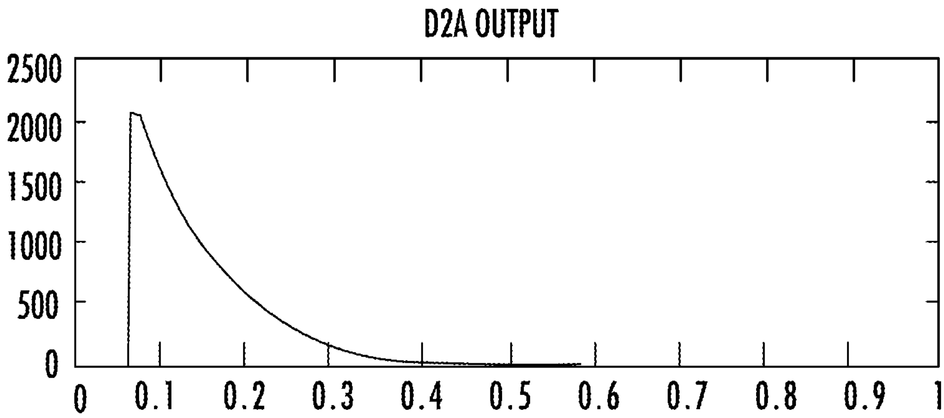


FIG. 3B

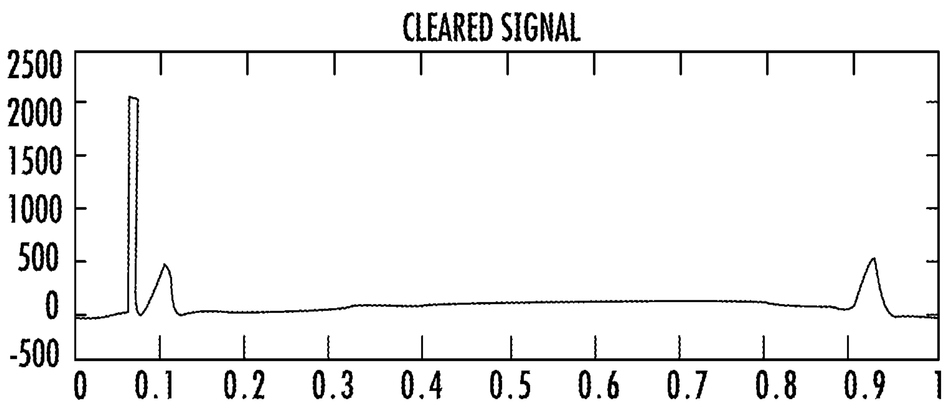


FIG. 3C

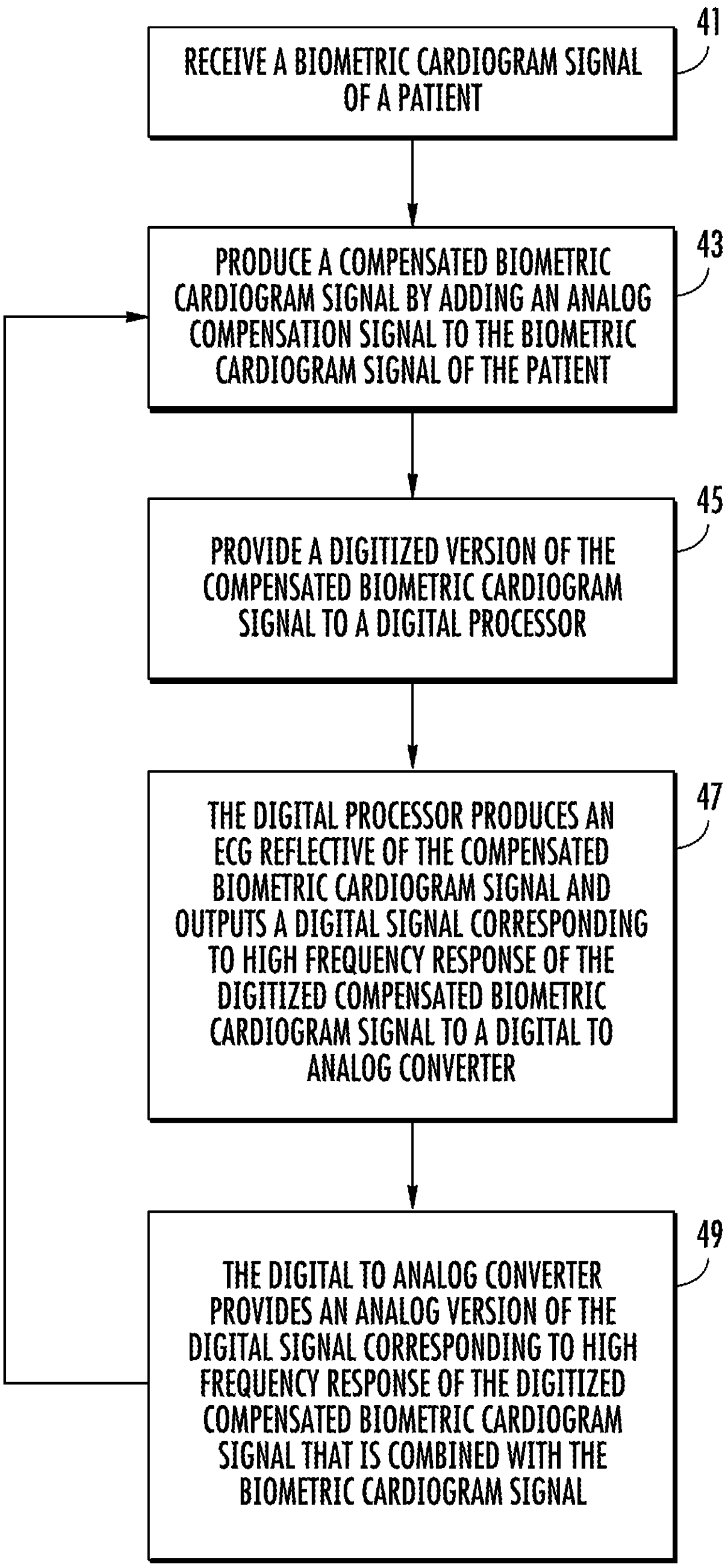

RECEIVE A BIOMETRIC CARDIOGRAM SIGNAL OF A PATIENT
41
PRODUCE A COMPENSATED BIOMETRIC CARDIOGRAM SIGNAL BY ADDING AN ANALOG COMPENSATION SIGNAL TO THE BIOMETRIC CARDIOGRAM SIGNAL OF THE PATIENT
43
PROVIDE A DIGITIZED VERSION OF THE COMPENSATED BIOMETRIC CARDIOGRAM SIGNAL TO A DIGITAL PROCESSOR
45
THE DIGITAL PROCESSOR PRODUCES AN ECG REFLECTIVE OF THE COMPENSATED BIOMETRIC CARDIOGRAM SIGNAL AND OUTPUTS A DIGITAL SIGNAL CORRESPONDING TO HIGH FREQUENCY RESPONSE OF THE DIGITIZED COMPENSATED BIOMETRIC CARDIOGRAM SIGNAL TO A DIGITAL TO ANALOG CONVERTER
47
THE DIGITAL TO ANALOG CONVERTER PROVIDES AN ANALOG VERSION OF THE DIGITAL SIGNAL CORRESPONDING TO HIGH FREQUENCY RESPONSE OF THE DIGITIZED COMPENSATED BIOMETRIC CARDIOGRAM SIGNAL THAT IS COMBINED WITH THE BIOMETRIC CARDIOGRAM SIGNAL
49

FIG. 4

FAST RECOVERY OF ECG SIGNAL METHOD AND APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. patent application Ser. No. 15/827,007, filed Nov. 30, 2017, which is incorporated by reference as if fully set forth.

SUMMARY

[0002] Fast recovery electrocardiogram (ECG) signal method and apparatus are provided. In one embodiment, an ECG apparatus includes an input for receiving a biometric cardiogram signal of a patient and a compensation signal combiner for selectively producing a compensated biometric cardiogram signal of the biometric cardiogram signal of the patient.

[0003] Processing circuitry is provided that includes an analog to digital converter, a digital processor and a digital to analog converter. The analog to digital converter provides a digitized version of the compensated biometric cardiogram signal to the digital processor. The digital processor produces an ECG reflective of the compensated biometric cardiogram signal and also outputs a digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal to the digital to analog converter. The digital to analog converter provides an analog version of the digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal to the compensation signal combiner to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes. A resultant ECG is produced by the digital processor having pacing signal contribution within the biometric cardiogram signal cancelled.

[0004] Preferably, the input is configured to receive a Wilson Central Terminal (WCT) biometric cardiogram signal of a patient. Also, the compensation signal combiner is in one embodiment an adder. The compensated biometric cardiogram signal of the biometric cardiogram signal of the patient can be combined via an operational amplifier with an intra cardiac signal in a differential amplifier configuration as the input to the analog to digital converter. The processor can be configured to produce the ECG reflective of the compensated biometric cardiogram signal in a graph form reflecting microvolts of signal over time in tenths of seconds.

[0005] In another embodiment, a method of producing an electrocardiogram (ECG) is provided. A biometric cardiogram signal of a patient is received. A compensated biometric cardiogram signal of the biometric cardiogram signal of the patient is selectively produced. A digitized version of the compensated biometric cardiogram signal is provided to a digital processor. The digital processor produces an ECG reflective of the compensated biometric cardiogram signal and outputs a digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal to a digital to analog converter. The digital to analog converter providing an analog version of the digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal that is combined with the biometric cardiogram signal to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes. A resultant ECG is produced by the digital processor having pacing signal contribution within the biometric cardiogram signal cancelled.

[0006] Preferably, a Wilson Central Terminal (WCT) biometric cardiogram signal is received as the biometric cardiogram signal of the patient. Also, the analog version of the digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal is in one embodiment added to biometric cardiogram signal produce the compensated biometric cardiogram signal.

[0007] The compensated biometric cardiogram signal of the biometric cardiogram signal of the patient can be combined via an operational amplifier with an intra cardiac signal in a differential amplifier configuration as the input to an analog to digital converter which provides the digitized version of the compensated biometric cardiogram signal to the digital processor. The processor can produce the ECG reflective of the compensated biometric cardiogram signal in a graph form reflecting microvolts of signal over time in tenths of seconds.

[0008] Other object and advantages of the invention will be apparent to those skilled in the art from the drawings and following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a schematic illustration of an ECG system based on conventional teachings.

[0010] FIG. **2** is a schematic illustration of an ECG system in accordance with the teachings of the present invention.

[0011] FIGS. **3**(A)-**3**(C) are illustrations of ECG related signals.

[0012] FIG. **4** is a flow diagram of a method of producing an electrocardiogram (ECG) in accordance with the teachings of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0013] The present invention is related to ECG systems and methods. The inventors have recognized that electrophysiology physicians require an enhanced ECG system that compensates for the interfering signals caused by pacing.

[0014] ECG monitoring systems that include pace pulse detection are known in the art. For example, see U.S. Pat. No. 5,682,902 (Herleikson). Such standard ECG input systems utilize analog to digital signal processing. Pacing signals can be detected through the analysis of the digital signals. In conventional ECG systems, such as Herleikson, pace pulse signals can be removed though replacement with a selected flat signal for a specified or calculated time. The inventors have recognized that electrophysiology physicians can benefit from an enhanced ECG system that more accurately compensates for the interfering signals caused by pacing.

[0015] Consistent with the conventional methodology, an ECG system **10** can be constructed, for example, to process Wilson Central Terminal ("WCT") ECG signals of a patient that average three active limb electrode voltages measured with respect to a return ground electrode. As illustrated in FIG. **1**, a WCT signal can be combined via an operational amplifier **12** with an intra cardiac signal **14** in a differential amplifier configuration **15** as the input to an analog to digital converter **16**. The digital output of the analog to digital converter **16** is then processed by a processor **18** in a conventional manner, such as corresponding to the processing taught by Herleikson, to produce an ECG corresponding to the WCT signal.

[0016] When the WCT signal includes a pacing charge, however, the ECG produced by the system **10** that uses conventional processing of the digitized signal, is partially skewed due to conventional processing of the pacing signal.

[0017] The present invention provides an improved ECG system that implements a digital to analog compensation value to cancel out the pacing charge such that a more accurate ECG is produced. Referring to FIG. **2**, an example fast-recovery ECG input system **20** is provided that utilizes an analog to digital converter **16** and associated processor **18** to detect pacing, similar to the system **10** of FIG. **1**. However, the processor **18** of the FIG. **2** modified system **20** is configured to process the WCT signal after being combined with an added DC value signal **21** that cancels out the pacing charge when the WTC signal includes a pacing charge.

[0018] Applicants have recognized that when a pacing signal is applied, the WTC signal will include both significant low and high frequency components that arise from the electronic pacing pulse. As illustrated in FIG. **2**, the WTC signal is passed through an adder **22** which adds the cancellation signal **21** to compensate for the low response of the WTC signal to high frequency spikes. The post-adder "compensated" WTC signal **23** is provided to the analog to digital converter **16** via the operational amplifier **12** with an intra cardiac signal **14** in a differential amplifier configuration **15**. The digital output of the analog to digital converter **16** is then provided to a digital processor **18**.

[0019] The digital output of the analog to digital converter **16** is processed by the processor **18** in a conventional manner, such as corresponding to the processing taught by Herleikson, to produce an ECG corresponding to the compensated WCT signal. Additionally, however, a high frequency response of the digital signal received from the analog to digital converter **16** is used by the processor **18** to create a digital compensation signal **25**. The digital compensation signal **25** is passed through a digital to analog converter **24** to provide the analog signal **21** which is added to the WTC signal. The result of adding the cancellation signal **21** to the WTC signal causes the processor **18** to produce an ECG having the pacing signal contribution within the biometric cardiogram signal cancelled since the ECG is based on the compensated WTC signal **23**.

[0020] The high frequency response of the WTC signal, which is significant when the WTC signal includes a pacing pulse, is determined by the processor **18** to produce the digital compensation signal **25** that is fed to the digital to analog converter **24** to provide the compensation signal **21** which is added to the WTC signal. Once a pacing artifact is detected by the processor **18**, a short averaging window can be used to keep the signal always without an offset. The digital compensation signal **25** input to the digital to analog converter **24** is smoothed to avoid steps.

[0021] The resultant ECG signal graphs both with and without having the cancellation signal applied are illustrated in FIGS. **3**A and C. FIG. **3**A reflects the WTC signal without cancellation and FIG. **3**C illustrates the resultant ECG that utilizes the pace pulse cancellation of the fast-recovery ECG input system **20**. For reference, FIG. **3**B is provided that reflects an ECG channel response to a pace pulse signal within the WTC signal. The graphs reflect microvolts (μVs) of signal over one second of time.

[0022] With reference to FIG. **4**, An example method of producing the ECG depicted in FIG. **3**C is provided. In step **41**, a biometric cardiogram signal of a patient is received. In step **43**, a compensated biometric cardiogram signal is produced by adding an analog compensation signal to the biometric cardiogram signal of the patient. In step **45**, a digitized version of the compensated biometric cardiogram signal is provided to a digital processor. In step **47**, the digital processor produces an ECG reflective of the compensated biometric cardiogram signal and outputs a digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal to a digital to analog converter. In step **49**, the digital to analog converter provides an analog version of the digital signal corresponding to high frequency response of the digitized compensated biometric cardiogram signal that is combined with the biometric cardiogram signal in step **43** to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes whereby an ECG is produced by the digital processor having pacing signal contribution within the biometric cardiogram signal cancelled.

[0023] All references cited in this application are incorporated by reference herein as if fully set forth. It will be apparent to one of ordinary skill in the art that many changes and modifications can be made to the embodiments described without departing from the spirit or scope of the invention as set forth herein.

What is claimed is:

1. An electrocardiogram (ECG) apparatus comprising:

an input configured to receive a Wilson Central Terminal (WCT) biometric cardiogram signal of a patient;

a compensation signal combiner for selectively producing a compensated biometric cardiogram signal of the biometric cardiogram signal of the patient; and

processor circuitry configured to receive the compensated biometric cardiogram signal and to produce an ECG reflective of the compensated biometric cardiogram signal and to output a signal corresponding to high frequency response of the compensated biometric cardiogram signal to the compensation signal combiner to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes whereby an ECG is produced by the processor circuitry having pacing signal contribution within the biometric cardiogram signal cancelled.

2. The ECG apparatus according to claim **1** wherein the compensation signal combiner is an adder.

3. The ECG apparatus according to claim **2** wherein the compensated biometric cardiogram signal of the biometric cardiogram signal of the patient is combined via an operational amplifier with an intra cardiac signal in a differential amplifier configuration to produce a combined compensated biometric cardiogram signal that is received by the processor circuitry.

4. The ECG apparatus according to claim **3** wherein the processor circuitry is configured to produce the ECG reflective of the compensated biometric cardiogram signal in a graph form reflecting microvolts of signal over time in tenths of seconds.

5. The ECG apparatus according to claim **3** wherein the processor circuitry includes:

an analog to digital converter configured to receive the combined compensated biometric cardiogram signal;

a digital processor coupled to the analog digital converter and configured to produce the ECG reflective of the compensated biometric cardiogram signal; and

a digital to analog converter coupled to the digital processor and configured to output the signal corresponding to high frequency response of the compensated biometric cardiogram signal.

6. An electrocardiogram (ECG) apparatus comprising:

an input configured to receive a biometric cardiogram signal of a patient;

a compensation signal combiner for selectively producing a compensated biometric cardiogram signal of the biometric cardiogram signal of the patient; and

processor circuitry configured to produce an ECG reflective of the compensated biometric cardiogram signal and to output a signal corresponding to high frequency response of the compensated biometric cardiogram signal to the compensation signal combiner to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes whereby an ECG is produced by the processor circuitry having pacing signal contribution within the biometric cardiogram signal cancelled;

wherein the compensated biometric cardiogram signal of the biometric cardiogram signal of the patient is combined via an operational amplifier with an intra cardiac signal in a differential amplifier configuration to produce a combined compensated biometric cardiogram signal that is received by the processor circuitry.

7. The ECG apparatus according to claim **6** wherein the compensation signal combiner is an adder.

8. The ECG apparatus according to claim **7** wherein the processor circuitry is configured to produce the ECG reflective of the compensated biometric cardiogram signal in a graph form reflecting microvolts of signal over time in tenths of seconds.

9. The ECG apparatus according to claim **7** wherein the processor circuitry includes:

an analog to digital converter configured to receive the combined compensated biometric cardiogram signal;

a digital processor coupled to the analog digital converter and configured to produce the ECG reflective of the compensated biometric cardiogram signal; and

a digital to analog converter coupled to the digital processor and configured to output the signal corresponding to high frequency response of the compensated biometric cardiogram signal.

10. A method of producing an electrocardiogram (ECG) comprising:

receiving a Wilson Central Terminal (WCT) biometric cardiogram signal of a patient;

selectively producing a compensated biometric cardiogram signal of the biometric cardiogram signal of the patient;

providing the compensated biometric cardiogram signal to processor circuitry; and

the processor circuitry producing an ECG reflective of the compensated biometric cardiogram signal and outputting a signal corresponding to high frequency response of the compensated biometric cardiogram signal that is combined with the biometric cardiogram signal to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes whereby an ECG is produced by the processor circuitry having pacing signal contribution within the biometric cardiogram signal cancelled.

11. The method according to claim **10** wherein the signal corresponding to high frequency response of the compensated biometric cardiogram signal is added to biometric cardiogram signal to produce the compensated biometric cardiogram signal.

12. The method according to claim **11** wherein the compensated biometric cardiogram signal of the biometric cardiogram signal of the patient is combined via an operational amplifier with an intra cardiac signal in a differential amplifier configuration to produce a combined compensated biometric cardiogram signal that is received by the processor circuitry.

13. The method according to claim **12** wherein the processor circuitry produces the ECG reflective of the compensated biometric cardiogram signal in a graph form reflecting microvolts of signal over time in tenths of seconds.

14. The method according to claim **12** where the processor circuitry includes an analog to digital converter, a digital processor coupled to the analog digital converter, and a digital to analog converter coupled to the digital processor wherein:

the analog to digital converter receives the combined compensated biometric cardiogram signal;

the digital processor produces the ECG reflective of the compensated biometric cardiogram signal in a graph form; and

the digital to analog converter outputs the signal corresponding to high frequency response of the compensated biometric cardiogram signal.

15. A method of producing an electrocardiogram (ECG) comprising:

receiving a biometric cardiogram signal of a patient;

selectively producing a compensated biometric cardiogram signal of the biometric cardiogram signal of the patient;

providing the compensated biometric cardiogram signal to processor circuitry; and

the processor circuitry producing an ECG reflective of the compensated biometric cardiogram signal and outputting a signal corresponding to high frequency response of the compensated biometric cardiogram signal that is combined with the biometric cardiogram signal to compensate for low response of the biometric cardiogram signal of the patient to high frequency spikes whereby an ECG is produced by the processor circuitry having pacing signal contribution within the biometric cardiogram signal cancelled;

wherein the compensated biometric cardiogram signal of the biometric cardiogram signal of the patient is combined via an operational amplifier with an intra cardiac signal in a differential amplifier configuration to produce a combined compensated biometric cardiogram signal that is received by the processor circuitry.

16. The method according to claim **15** wherein the signal corresponding to high frequency response of the compensated biometric cardiogram signal is added to biometric cardiogram signal to produce the compensated biometric cardiogram signal.

17. The method according to claim **16** wherein the processor circuitry produces the ECG reflective of the compensated biometric cardiogram signal in a graph form reflecting microvolts of signal over time in tenths of seconds.

18. The method according to claim **16** where the processor circuitry includes an analog to digital converter, a digital processor coupled to the analog digital converter, and a digital to analog converter coupled to the digital processor wherein:

the analog to digital converter receives the combined compensated biometric cardiogram signal;

the digital processor produces the ECG reflective of the compensated biometric cardiogram signal in a graph form; and

the digital to analog converter outputs the signal corresponding to high frequency response of the compensated biometric cardiogram signal.

* * * * *

patsnap

专利名称(译)	快速恢复心电信号的方法和装置
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公开(公告)日	2020-01-30
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[标]申请(专利权)人(译)	韦伯斯特生物官能(以色列)有限公司
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摘要(译)

提供了一种快速恢复心电图（ECG）信号的方法和设备。 在一个实施例中，一种ECG设备包括用于接收诸如威尔逊中央终端（WCT）信号之类的生物心电图信号的输入，以及用于产生补偿信号的诸如加法器之类的组合器。 处理电路产生反映补偿信号的ECG，并且还输出与补偿信号的高频响应相对应的信号，以补偿生物体心电图信号对高频尖峰的低响应。 由处理电路产生的合成心电图具有抵消了生物心电图信号内起搏信号的作用。