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(71) Applicant: **Siemens Aktiengesellschaft Berlin und München**
Wittelsbacherplatz 2
D-8000 München 2(DE)

(72) Inventor: **Lekholm, Anders**
Gnejsvaegen 4
S-16139 Bromma(SE)
Inventor: **Amundson, David C.**
Lillaengsgatan 25
S-16152 Bromma(SE)

(54) A cardiac pacer for pacing a human heart.

(57) A cardiac pacer, which generates pacing pulses at a predetermined pacing rate comprises a device (7) for processing the pacing pulses according to an impedance measurement in a manner that a respiratory signal is obtained. The predetermined pacing rate is then varied dependent on the respiratory signal.

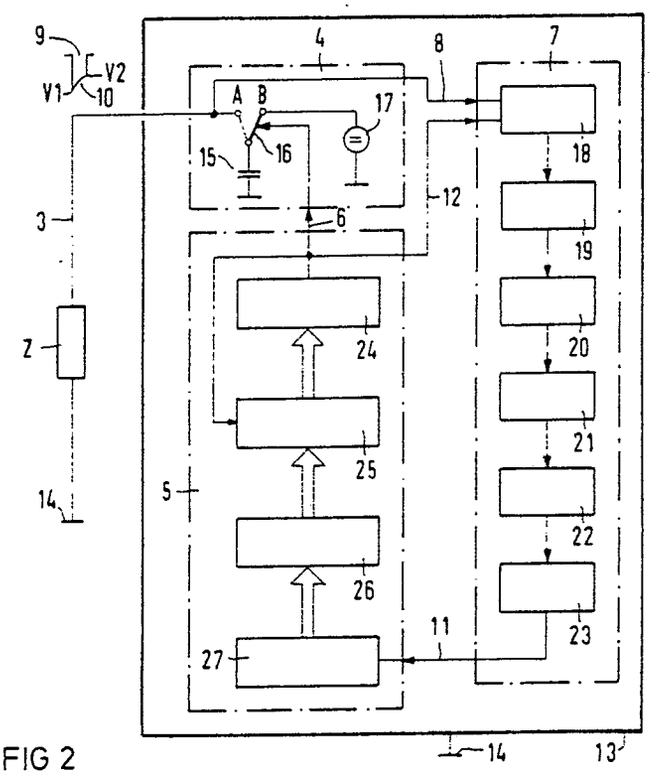

FIG 2

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A CARDIAC PACER FOR PACING A HUMAN HEART

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a cardiac pacer for pacing a human heart, wherein the pacing rate is controlled by the respiration of the patient.

Description of the Prior Art

Conventional cardiac pacers usually comprise a pacing electrode and an indifferent electrode. The pacing electrode is placed in the human heart by means of a pacing lead. The conductive (metallic) housing of the cardiac pacer defines the indifferent electrode.

The US Patent 3,593,718 describes such a conventional cardiac pacer which in addition utilizes an impedance pneumograph for obtaining a respiratory signal from thoracic impedance variations. The impedance pneumograph comprises a first and a second impedance measuring electrodes each connected with a separate first and second leads, respectively. Both impedance measuring electrodes of the impedance pneumograph are placed on the surface of the patient's chest.

The European Patent Application 0 089 014 depicts a conventional cardiac pacer which also employs an impedance pneumograph for obtaining a respiratory signal. Again the impedance pneumograph comprises first and a second impedance measuring electrodes. However, only the first impedance measuring electrode is connected to a lead while the second electrode is defined by the conductive (metallic) housing which contains the cardiac pacer and the impedance pneumograph. Furthermore, the first impedance measuring electrode and, since the conductive (metallic) housing is implanted, the second electrode are subcutaneously placed in the thorax. Under the circumstances the complete pacing and impedance measuring system comprises a pacing electrode on a first lead, a first impedance measuring electrode on a second lead and the metallic housing as both the indifferent electrode of the cardiac pacer and the second electrode of the impedance pneumograph. Finally the current impulses generated and utilized for impedance measurement are at a higher rate than those of the ventilation rate. Under the circumstances the pacer needs an unnecessary high amount of energy.

SUMMARY OF THE INVENTION

Objects

It is an object of this invention to provide for an improved cardiac pacer for pacing a human heart wherein the pacing rate is controlled by the respiration rate of the patient, and wherein the number of necessary electrodes and therefore also the number of necessary leads for obtaining a respiratory signal from thoracic impedance variations is reduced to a minimum. Furthermore the amount of energy necessary to activate the respiration rate measuring means should be reduced to a minimum.

Summary

According to this invention an improved cardiac pacer is provided which comprises

a) means for generating pacing pulses at a predetermined pacing rate;

b) means for transmitting the pacing pulses to the human heart for pacing;

c) means for processing the pacing pulses for obtaining a respiratory signal according to an impedance measurement; and

d) means for varying the predetermined pacing rate dependent on the respiratory signal.

By utilizing the pacing pulses for obtaining a respiratory signal the amount of energy to activate the respiration measuring means is reduced to a minimum. Furthermore it is possible to manage with only two electrodes and one lead for both pacing and measuring the impedance variations, namely the pacing electrode connected to the pacing lead and the metallic housing containing the pacer and the impedance pneumograph. Under the circumstances the invention provides for a minimum number of electrodes and leads for pacing and impedance measurement. Since the pacing pulse itself is processed for obtaining a respiratory signal no additional current for impedance measurement has to be supplied.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

Brief Description of the Drawings

Fig. 1 shows the invention in a schematic block diagram; and

Fig. 2 illustrates the invention in a more detailed block diagram.

Description of the Preferred Embodiment

In Fig. 1 a human heart which has to be paced is generally designated with 1. A pacing electrode 2 is inserted in the human heart 1 in a manner and position that the heart can most efficiently be paced. The pacing electrode 2 is connected through a pacing lead 3 with a pacing pulse generator 4. A time base unit 5 controls the pacing rate of the pacing pulse generator 4 through line 6. An impedance pneumograph 7 is connected with the pacing pulse generator 4 through line 8 for processing the pacing pulses 9 in a manner that a respiratory signal is obtained from the pacing pulses 9 when evaluating the amplitude decays 10 of pacing pulses 10. The amplitude decay 10 changes according to alternating body impedance during respiration.

Alternatively, the impedance measurement can be done by the simultaneous measurement of voltage and its associated current and an analog or digital division of voltage and current.

The impedance pneumograph 7 controls the time base unit 5 through line 11 in a manner that a predetermined basic pacing rate of the pacing pulse generator 4 is varied dependent on the respiratory signal. The line 12 is a control line from the time base unit 5 to the impedance pneumograph 7.

In Fig. 1 the pacing pulse generator 4, the time base unit 5 and the impedance pneumograph 7 are all encapsuled in an implantable conductive (metallic) housing 13 which is the housing of the cardiac pacer according this invention. The metallic housing 13 defines both the indifferent electrode for pacing and the second electrode for impedance measurement as indicated in Fig. 1 with reference numeral 14. Under the circumstances the cardiac pacer according to this invention manages with only two electrodes and one lead, namely electrodes 2 and 14 and lead 3 for both pacing and impedance measurement. Since the pacing pulse itself is processed for obtaining a respiratory signal no additional current for impedance measurement has to be supplied. Therefore the amount of energy necessary for activating impedance measurement is reduced to a miniumum.

Fig. 2 depicts the schematic block diagram of Fig. 1 in more detail. The complete impedance including the heart is designated with Z. The pacing pulse generator 4 comprises an output capacitor 15 which is switchable by means of switch 16 between battery 17 (switch position A) and pacing lead 3 (switch position B). In switch position A the output capacitor 15 is charged by the battery 17 to a voltage V1. In switch position B the output capacitor 15 is discharged through pacing lead 3 as pacing pulse 9. The amount of discharge depends on the impedance variations of the patient 's thorax during respiration. According to Fig. 2 the pacing pulse 9 discharges from V1 to V2 (amplitude decay 10).

The impedance pneumograph 7 includes a sample and hold circuitry 18, a difference former 19, a filter 20, a non-linear amplification (e.g. squaring) circuitry 21, an integrator 22 and a voltage to pulse rate converter 23. The sample and hold circuitry samples and holds the voltages V1, V2 of output capacitor 15. The difference former 19 supplies the difference V1 - V2 through the filter 20 to the non-linear amplification circuitry 21. The non-linear amplification circuitry 21 amplifies the output signal of filter 20 in a manner that signal portions having higher amplitudes are more amplified than signal portions having lower amplitudes. Under the circumstances interesting signal portions including the respiration signal are enhanced with respect to low amplitude noise for further processing. Non-linear amplification circuitries of this kind are well known in the art. They do not need described in more detail. The output signal of the non-linear amplification circuitry 21 is integrated in integrator 22 over a period of time, e. g. in the range of 5 to 30s. By integrating, high-frequency noise is significantly reduced. The voltage to pulse rate converter converts the integrated signal into a pulse rate according to the breathing rate.

The time base unit 5 comprises a zero decoder 24, a down counter 25, a time base register 26 and an analog signal to digital control word converter 27. The latter one converts the analog pulse rate signal of the voltage to pulse rate converter 23 into a digital control word. This digital control word is supplied to the time base register 26. It controls the time base register 26 in a manner that a basic pacing rate, e.g. 60 beats/min., is varied dependent on the respiration rate. When the breathing rate increases the time base register 26 increases the counting speed of down counter 25 so that it reaches zero faster than at basic rate. Under the circumstances the zero decoder 24 generates switching signals at higher rates, so that the output

capacitor 15 of the pacing pulse generator 4 charges and discharges at higher rates. As a result the pacing rate increases dependent on increasing breathing rate as desired.

Having thus described the invention with particular reference to the preferred forms thereof, it will be obvious to those skilled in the art to which the invention pertains, after understanding the invention, that various changes and modifications may be made therein without departing from the spirit and scope of the invention as defined by the claims apended hereto.

Claims

1. A cardiac pacer for pacing a human heart comprising

a) means (4) for generating pacing pulses (9) at a predetermined pacing rate;

b) means (2, 3) for transmitting the pacing pulses (9) to the human heart (1) for pacing;

c) means (7) for processing the pacing pulses (9) for obtaining a respiratory signal according to an impedance measurement; and

d) means (5) for varying the predetermined pacing rate dependent on the respiratory signal.

2. The cardiac pacer according to claim 1, further comprising

a) means (21) for non-linearly amplifying the respiratory signal in a manner that signal portions having higher amplitudes are more amplified than signal portions having lower amplitudes;

b) means (22) for integrating the non-lineary amplified respiratory signal over a period of time, e.g. 5 to 30 s; and

c) means (5) for varying the predetermined pacing rate dependent on the integrated signal.

3. The cardiac pacer according to claim 1 or 2, further comprising means (18) for measuring the amplitude (V1) of a pacing pulse (9) at the beginning and the amplitude (V1) of the same pacing pulse (9) at the end of the pacing pulse and means (9) for obtaining a measure for the decay (10) between the two amplitudes (V1, V2) which is a measure for the respiration.

4. The cardiac pacer according to claim 3, wherein said means (18) for measuring the amplitudes (V1, V2) comprises a sample and hold circuitry.

5. The cardiac pacer according to claim 3 or 4, wherein said means (19) for obtaining a measure for the decay (10) comprise a difference former for the amplitudes (V1, V2).

6. The cardiac pacer according to one of the preceding claims 2 to 8, wherein said means (7) for processing the pacing pulses further comprising a voltage to pulse rate converter (23) for the integrated signal.

7. The cardiac pacer according to claim 6, wherein said means (5) for varying the predetermined pacing rate comprises an analog signal to digital control word converter (27) for the output signal of the voltage to pulse rate converter (23), a time register (26) for the output signal of the analog signal to digital control word converter (27), a down counter (25) which is set to higher zero counting speed when the respiration rate increases and a zero decoder (24) at the output of the down counter (25), said zero decoder (24) being connected with and controlling the pacing pulse generator (4) in a manner that a pacing pulse is generated at each zero count.

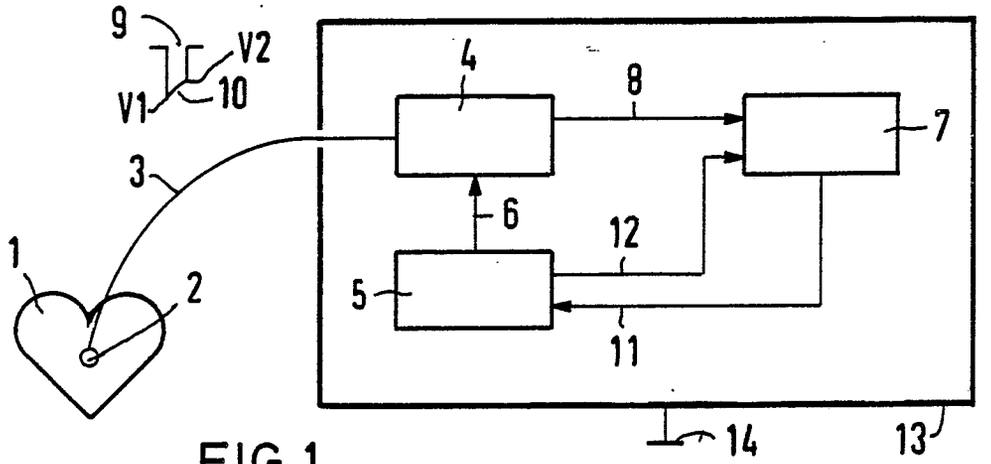
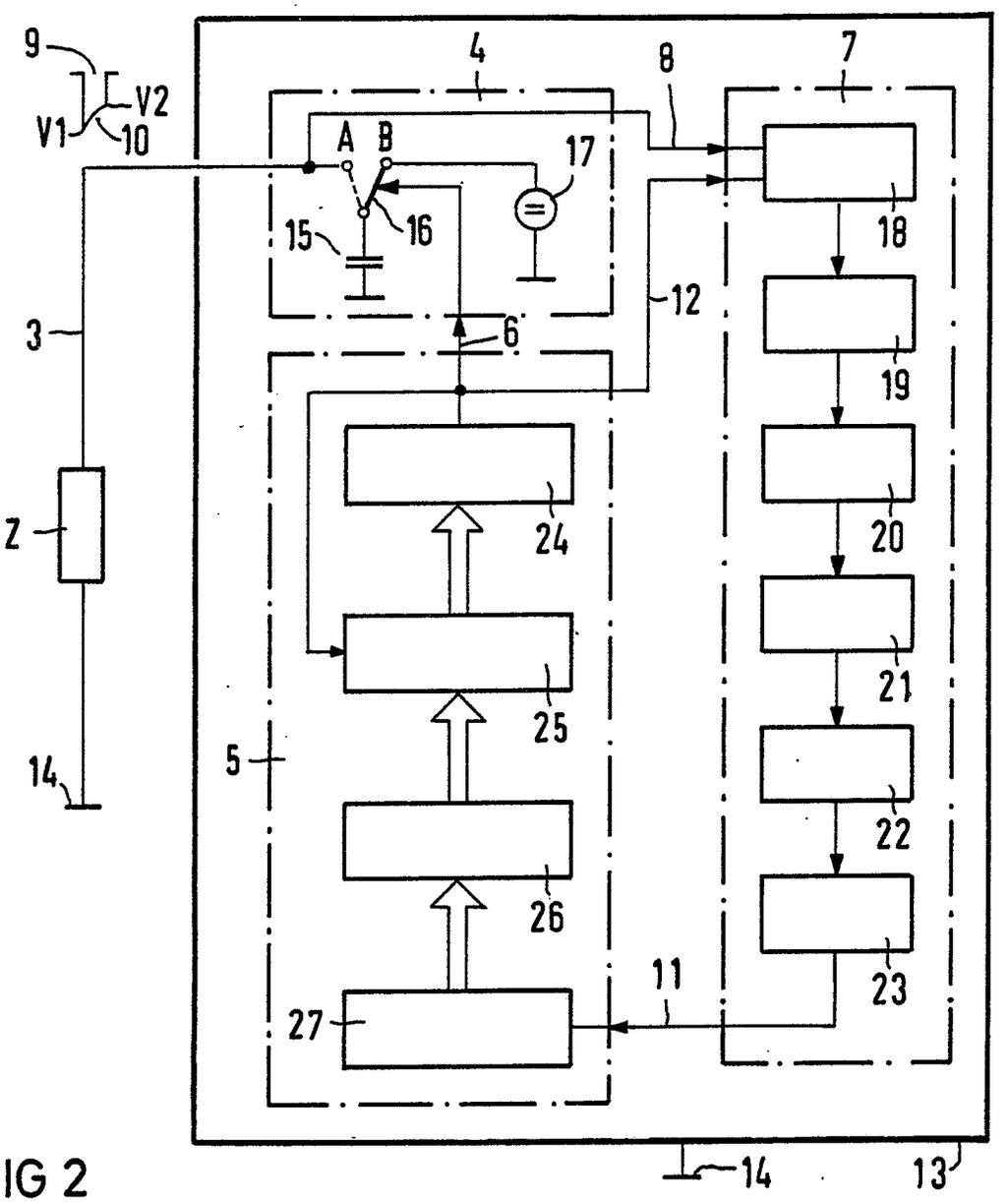

9
V2
V1
10
4
8
7
3
6
12
1
2
5
11
14
13

FIG 1


9
4
8
7
V1
V2
10
A
B
17
18
15
16
12
3
6
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24
20
Z
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14
13

FIG 2

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 10 8101

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP-A-0 135 911 (PLICCHI) * Page 3, line 21 - page 10, line 29; figures *	1,2,4-6	A 61 N 1/365
A	EP-A-0 074 126 (PURDUE RESEARCH FOUNDATION) * Page 10, line 26 - page 21, line 13; figures *	1,4-7	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

A 61 N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07-09-1987	LEMERCIER D.L.L.

CATEGORY OF CITED DOCUMENTS

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