US 20050288727A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0288727 A1**

Penner (43) **Pub. Date: Dec. 29, 2005**

(54) **WIRELESS SENSING DEVICES FOR EVALUATING HEART PERFORMANCE**

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(21) Appl. No.: **11/140,267**

(22) Filed: **May 26, 2005**

Related U.S. Application Data

(60) Provisional application No. 60/576,145, filed on Jun. 1, 2004.

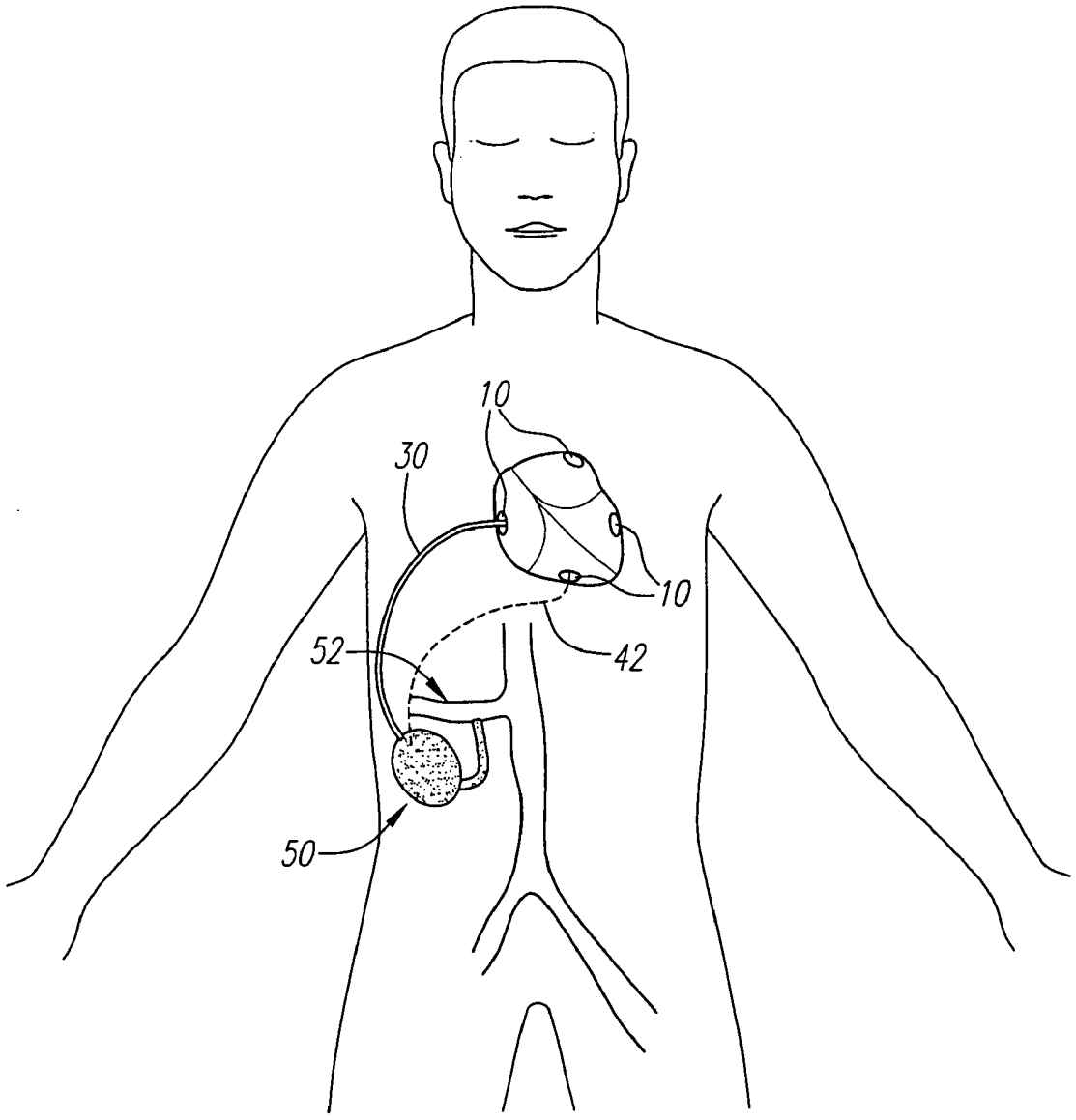
Publication Classification

(51) **Int. Cl.**[7] **A61N 1/362**

(52) **U.S. Cl.** **607/32**; 607/9; 600/509

(57) **ABSTRACT**

A system for monitoring heart performance comprises a plurality of sensing devices configured to attach to a patient's heart tissue and a controller. Each sensing device comprises a sensor configured to detect physiological data relating to heart contractility and a wireless transmitter configured to transmit data detected by the sensor. The controller comprises a receiver configured to receive the detected data transmitted by the plurality of sensing devices and a processor configured to analyze the received data.



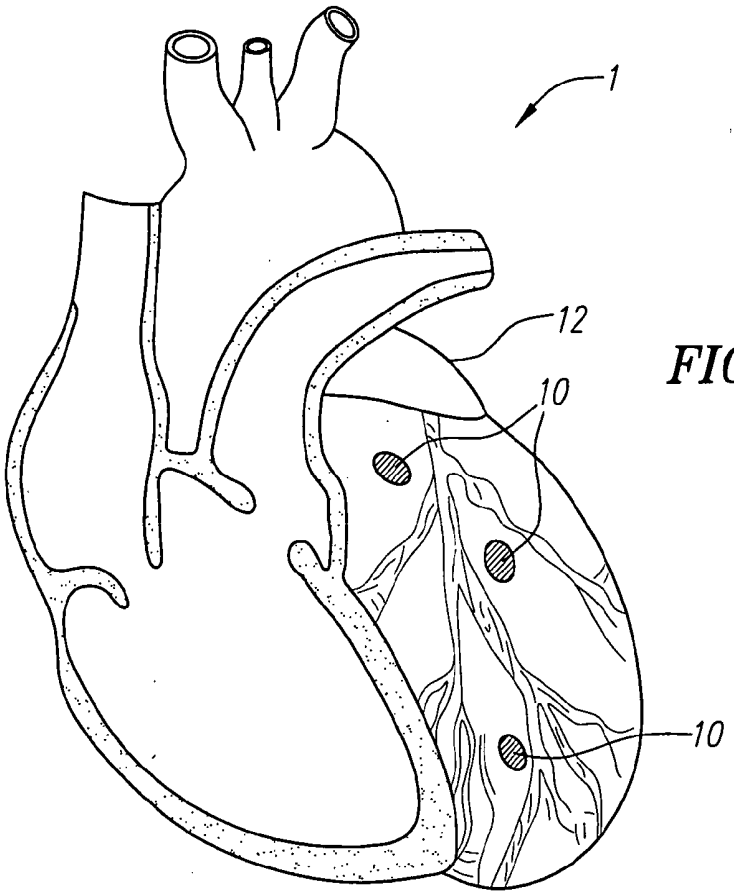


FIG. 1

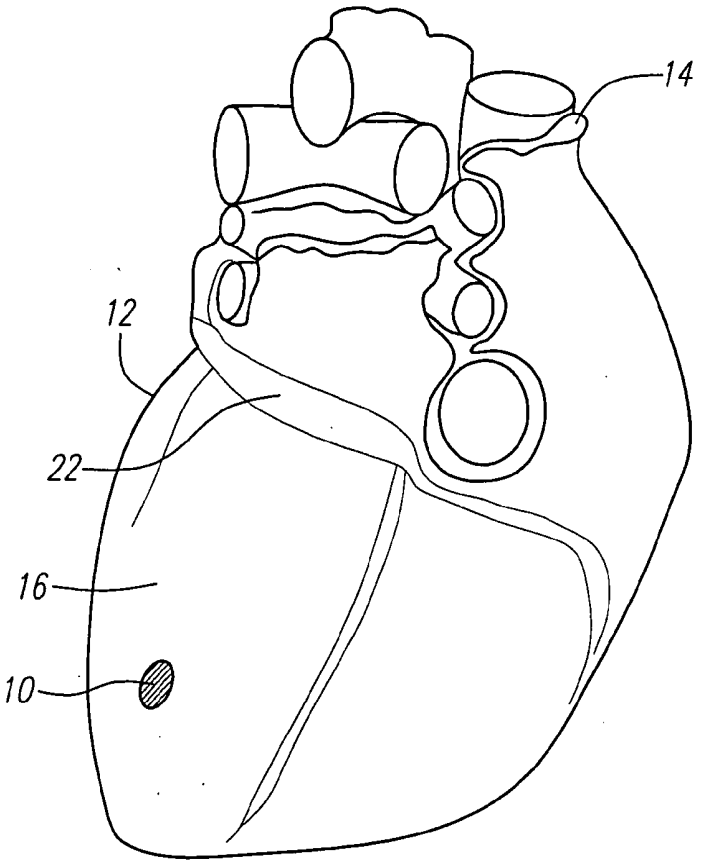


FIG. 2

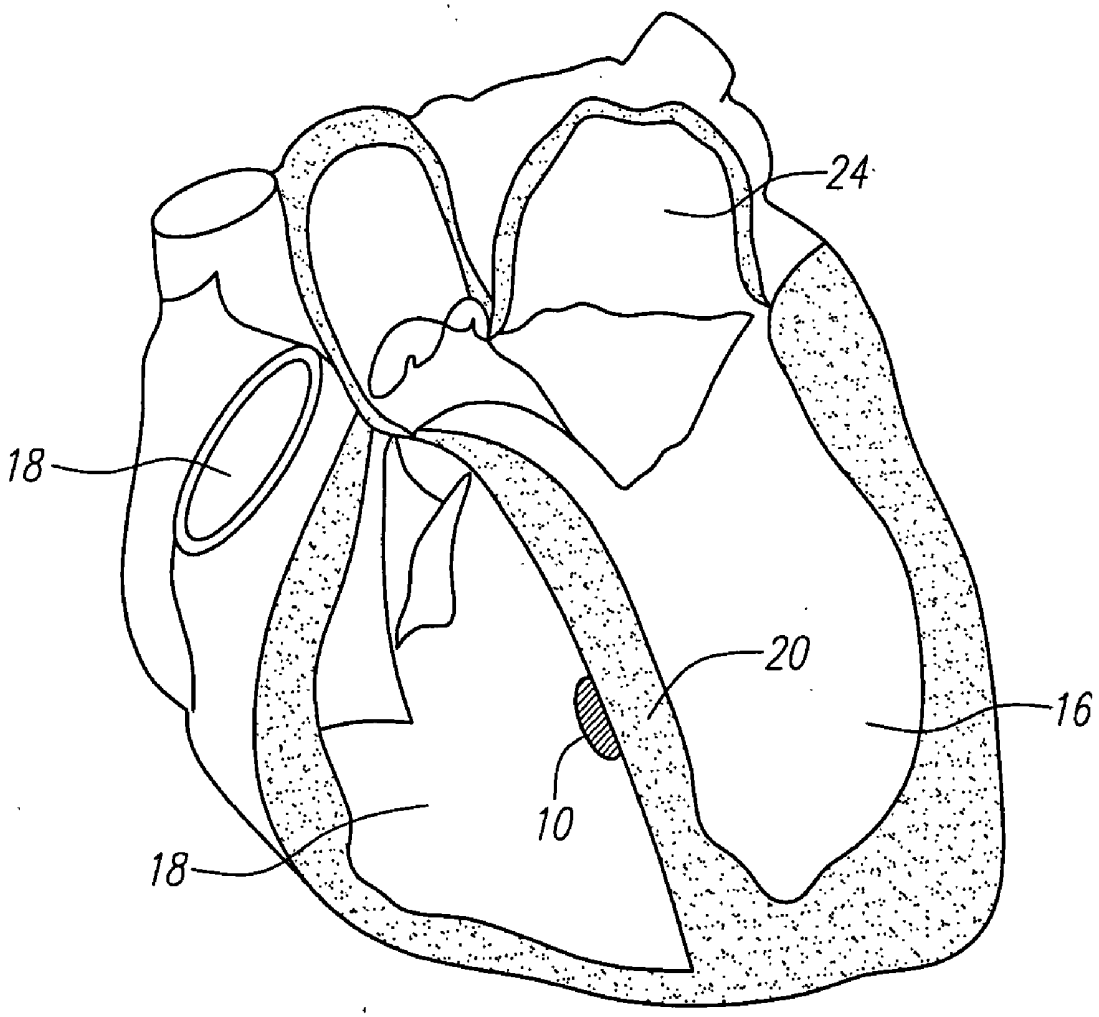


FIG. 3

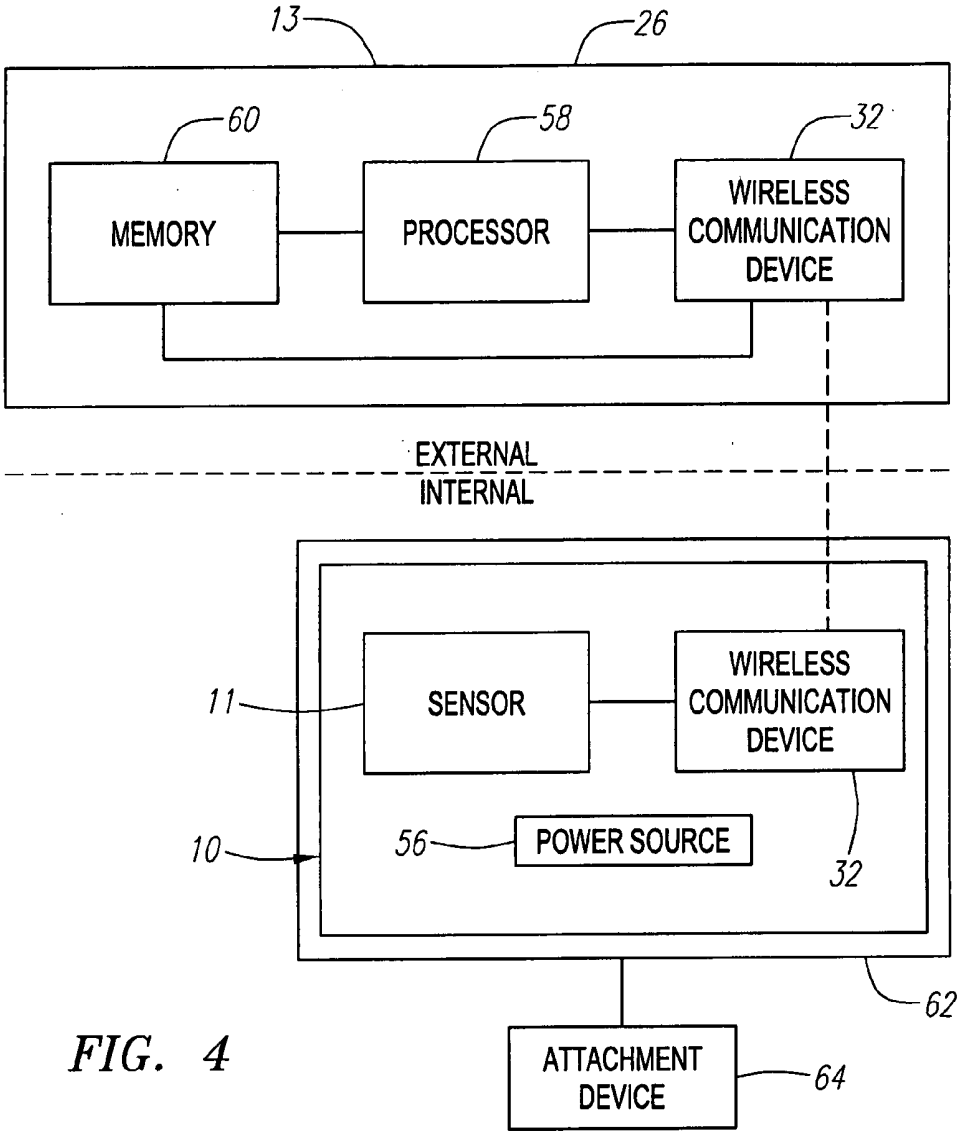

13
26
60
58
32
MEMORY
PROCESSOR
WIRELESS COMMUNICATION DEVICE
EXTERNAL
INTERNAL
11
SENSOR
WIRELESS COMMUNICATION DEVICE
10
56
POWER SOURCE
32
62
ATTACHMENT DEVICE
64

FIG. 4

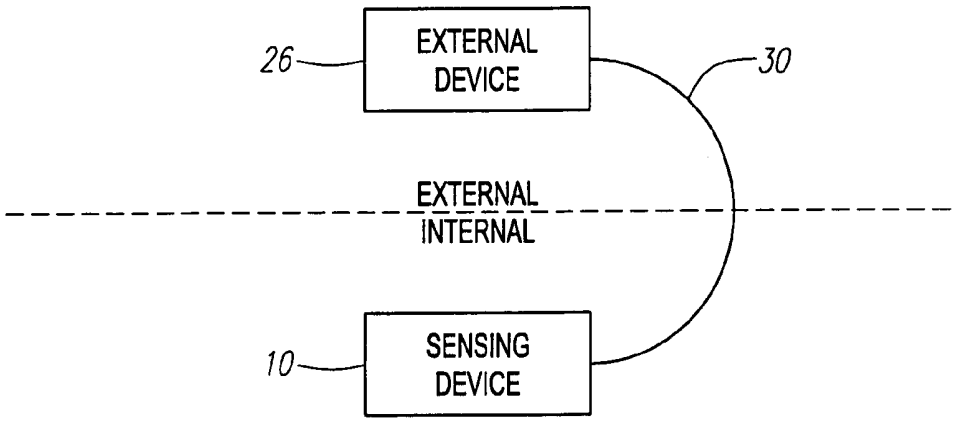

26
EXTERNAL DEVICE
30
EXTERNAL
INTERNAL
10
SENSING DEVICE

FIG. 5

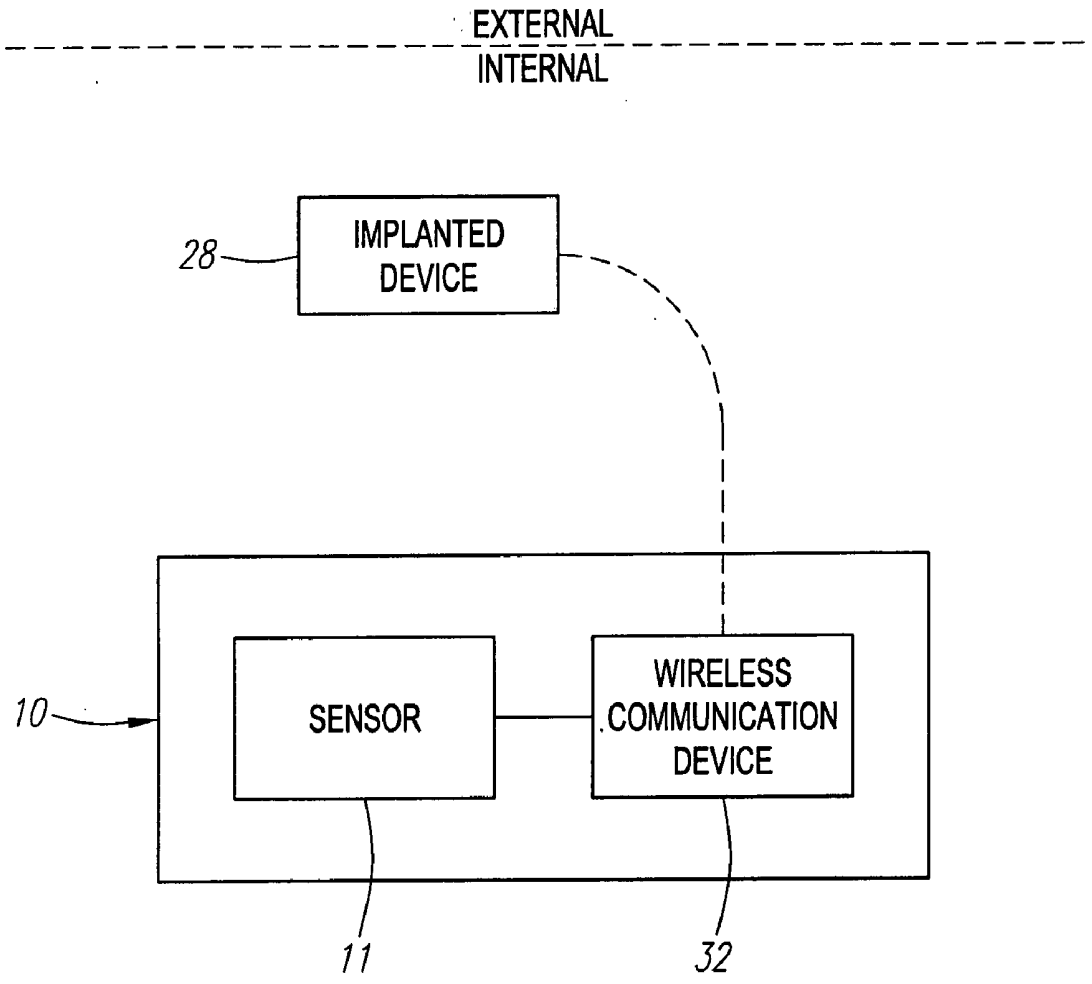

EXTERNAL
INTERNAL
28
IMPLANTED DEVICE
10
SENSOR
WIRELESS COMMUNICATION DEVICE
11
32

FIG. 6

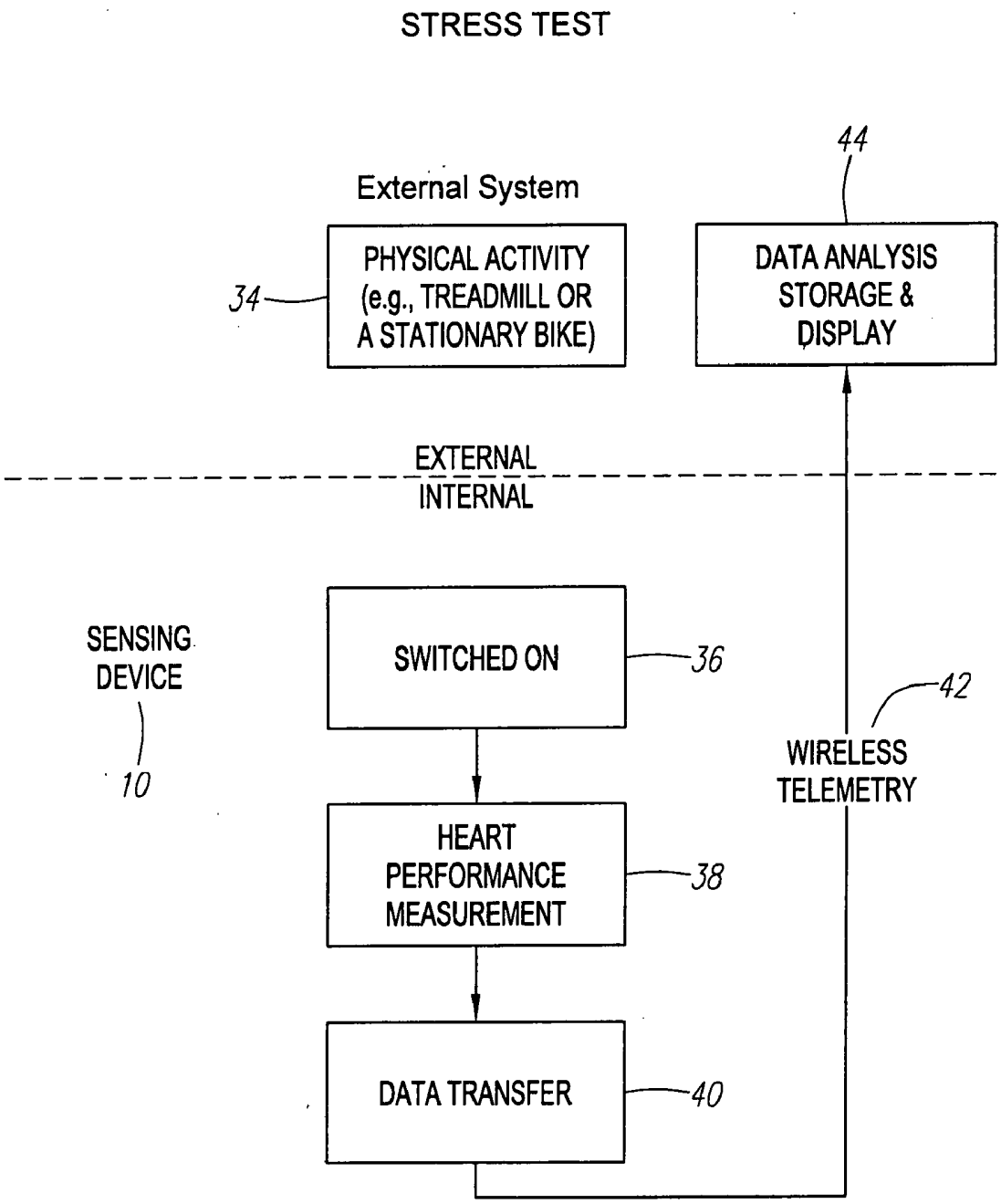

STRESS TEST
External System
44
PHYSICAL ACTIVITY (e.g., TREADMILL OR A STATIONARY BIKE)
34
DATA ANALYSIS STORAGE & DISPLAY
EXTERNAL
INTERNAL
SENSING DEVICE
10
SWITCHED ON
36
42
WIRELESS TELEMETRY
HEART PERFORMANCE MEASUREMENT
38
DATA TRANSFER
40

FIG. 7

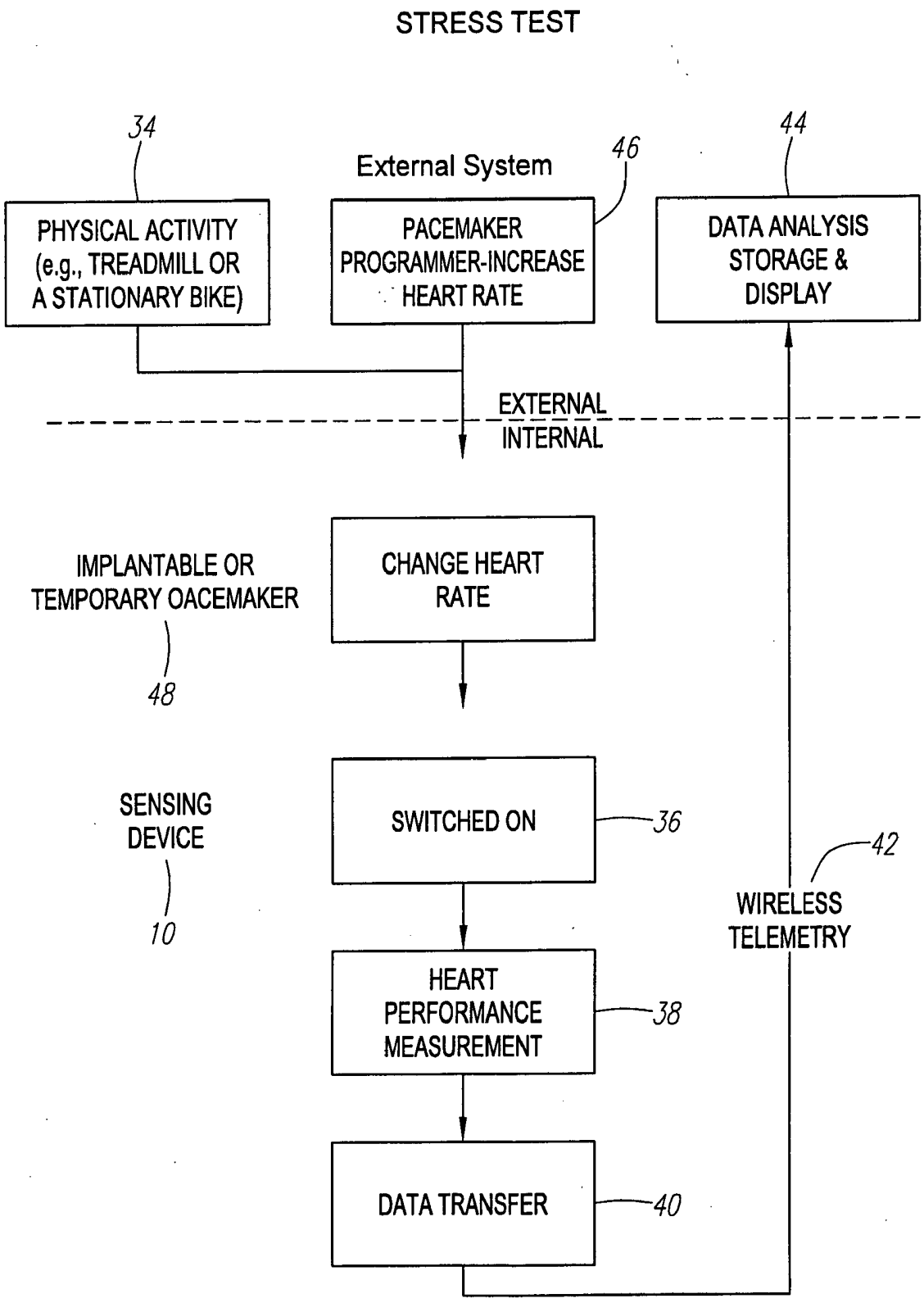

STRESS TEST
34
External System
46
44
PHYSICAL ACTIVITY (e.g., TREADMILL OR A STATIONARY BIKE)
PACEMAKER PROGRAMMER-INCREASE HEART RATE
DATA ANALYSIS STORAGE & DISPLAY
EXTERNAL
INTERNAL
IMPLANTABLE OR TEMPORARY OACEMAKER
48
CHANGE HEART RATE
SENSING DEVICE
10
SWITCHED ON
36
42
WIRELESS TELEMETRY
HEART PERFORMANCE MEASUREMENT
38
DATA TRANSFER
40

FIG. 8

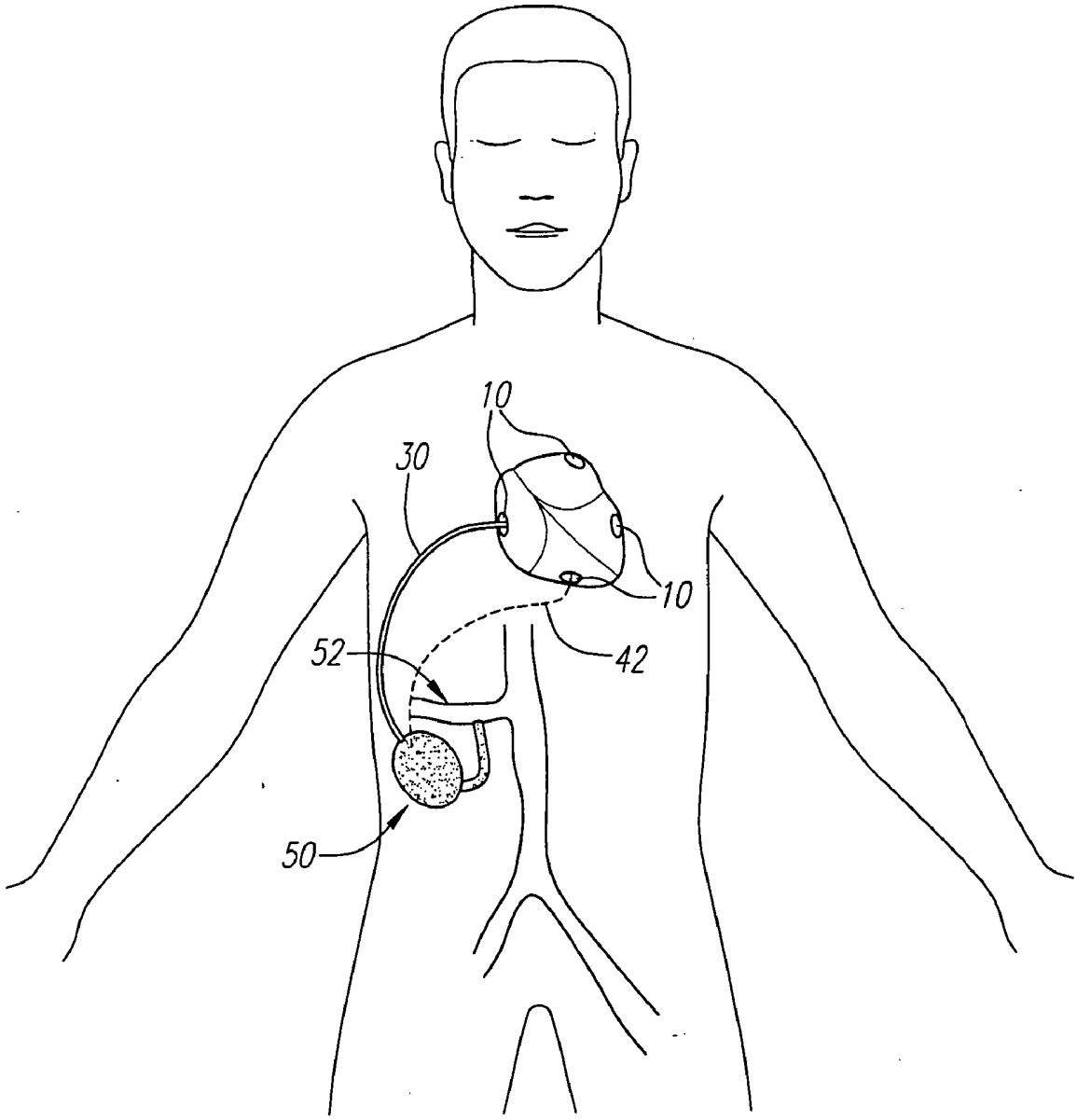


FIG. 9

WIRELESS SENSING DEVICES FOR EVALUATING HEART PERFORMANCE

RELATED APPLICATION DATA

[0001] This application claims the benefit under 35 U.S.C. §119 of U.S. provisional application Ser. No. 60/576,145, filed Jun. 1, 2004.

FIELD OF INVENTION

[0002] The present invention generally relates to the field of medical devices, and more specifically, to the use of wireless sensing devices for evaluating the performance and status of a heart muscle.

BACKGROUND

[0003] A heart attack occurs when the blood supply to part of the heart muscle is severely reduced or stopped. The reduction or stoppage happens when one or more of the coronary arteries supplying blood to the heart muscle are blocked. Cardiac ischemia is a condition associated with lack of blood flow and oxygen to the heart muscle. As a result of the reduced blood flow, muscle cells at the heart may suffer permanent injury and may die.

[0004] While the heart contracts (during systole), the ventricle does not contract in a linear fashion. For example, part of the ventricle shortens relatively more in one direction or in a radial fashion. The change in the shape of the ventricle is progressive along its length and involves a twisting effect that tends to squeeze out more blood. If blood flow is cut or reduced to part of the heart muscle, myocardial infraction may occur. A few minutes after the blood flow is cut or reduced, damage to the heart may result, and the optimal contraction pattern of the heart may change. If the blood flow is resumed within hours from the onset of the cardiac ischemia, the heart muscle damage can be minimized, and in some cases, even reversed.

[0005] A person may have ischemic episodes without knowing it. For example, such individual may have painless ischemia called silent ischemia, which may deteriorate to a heart attack with no prior warning. A person with angina also may have undiagnosed episodes of silent ischemia. The diagnosis of ischemia is done mainly using non-invasive means, including an exercise test, a 24-hour portable monitor of an electrocardiogram (Holter monitor), echocardiogram, and stress echocardiogram.

[0006] In order to minimize damage associated with ischemia, early detection of ischemia or detection of its manifestations is desired. However, currently available techniques may not be able to detect ischemia and its manifestations, thereby failing to provide warning to a patient. For example, a stress test, such as a stress echocardiography (stress echo), is frequently used to evaluate heart performance or to detect a heart condition (e.g., coronary heart disease). Stress echo is an echocardiogram done, before and during, or immediately after, some form of physical stress (e.g., created by riding a bicycle or performing a treadmill exercise). This requires a physical effort from the patient, as well as special equipment and an echocardiography specialist, which increase test complexity and price, thereby limiting the use of the stress test to only cases with high risk of heart pathology.

SUMMARY OF THE INVENTION

[0007] In one embodiment, a system for monitoring heart performance comprises a plurality of sensing devices configured to attach to a patient's heart tissue and a controller. Each sensing device comprises a sensor configured to detect physiological data relating to heart contractility and a wireless transmitter configured to transmit data detected by the sensor. The controller comprises a receiver configured to receive the detected data transmitted by the plurality of sensing devices and a processor configured to analyze the received data.

[0008] In another embodiment, a method for evaluating heart performance, comprises attaching a plurality of sensing devices to a patient's heart tissue, detecting, with the sensing devices, physiological data relating to heart contractility, wirelessly transmitting the detected data from the sensing devices to a controller, and analyzing the detected data at the controller to determine a contractility of the patient's heart.

[0009] In yet another embodiment, a system for monitoring heart performance comprises a plurality of sensing devices configured to attach to a patient's heart tissue, a controller, and a therapeutic medical device in which the controller is incorporated. Each sensing device comprises a sensor configured to detect physiological data relating to heart contractility and a wireless transmitter configured to transmit data detected by the sensor, wherein the sensing devices are configured to acoustically transmit the detected data to the controller. The controller comprises a receiver configured to receive the detected data transmitted by the plurality of sensing devices and a processor configured to analyze the received data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In order to better understand and appreciate the invention, reference should be made to the drawings and accompany detailed description, which illustrate and describe exemplary embodiments thereof. For ease in illustration and understanding, similar elements in the different illustrated embodiments are referred to by common reference numerals. In particular:

[0011] **FIG. 1** is a cutaway perspective view of a heart with attached sensing devices in accordance with one embodiment;

[0012] **FIG. 2** is a perspective view of a heart with attached sensing devices in accordance with another embodiment;

[0013] **FIG. 3** is a cutaway perspective view of a heart with attached sensing devices in accordance with yet another embodiment;

[0014] **FIG. 4** is a schematic diagram of a system for monitoring heart performance constructed in accordance with still another embodiment;

[0015] **FIG. 5** is a schematic diagram of a system for monitoring heart performance constructed in accordance with a still further embodiment of the present invention;

[0016] **FIG. 6** is a schematic diagram of a system for monitoring heart performance constructed in accordance with yet another embodiment;

[0017] **FIG. 7** is a flow chart of a method for monitoring heart performance in accordance with still another embodiment;

[0018] **FIG. 8** is a flow chart of a method for monitoring heart performance in accordance with a further embodiment; and

[0019] **FIG. 9** is a cutaway perspective view of a patient implanted with a system for monitoring heart performance in accordance with a still further embodiment.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0020] In the following description of the illustrated embodiments, it will be understood by those skilled in the art that the drawings and specific components thereof are not necessarily to scale, and that various structural changes may be made without departing from the scope or nature of the various embodiments.

[0021] As illustrated in **FIG. 1**, in accordance with some embodiments of the invention, a system **1** includes a plurality of sensing devices **10** configured to be attached to a heart **12**. Each sensing device **10** includes a sensor **11** and a wireless communication device **32**. The sensing devices **10** are configured to measure a characteristic of the heart **12**, such as its contractility, or a variable associated with contractility of the heart **12**. From that measured characteristic, the system **1** can determine a performance of the heart **12**. As used herein, the words "heart tissue" refer to myocardium and pericardium **14**.

[0022] Various types of sensors can be used to sense one or more parameters associated with a heart condition, such as parameters that can be used as indicators for ischemia.

[0023] In some embodiments, position sensors **11** sense locations or orientations of portions of a heart **12**. The sensed locations or orientations can be used to extrapolate contractility of the heart **12**. Changes in the sensed locations or the sensed orientations can also be used to extrapolate contractility of the heart **12**. In some embodiments, the determined locations or orientations can be combined using an algorithm to form a three dimensional time dependent map of the heart **12**. In some embodiments, sensors **11** use magnetic fields to determine locations or orientations. In other embodiments, radio-opaque positioning sensing devices **10** are used to determine locations or orientations. In other embodiments, triangulation is used to determine the locations of sensing devices **10**.

[0024] In some embodiments, a sensor's velocity is calculated by taking a first derivative of the sensor's position over time. The determined velocity is used to determine the contractility of a heart **12**. In other embodiments, a sensor's acceleration is calculated by taking a second derivative of the sensor's position or a first derivative of the velocity over time. The determined acceleration is used to determine the contractility of the heart **12**.

[0025] In other embodiments, the sensors **11** are accelerometers for measuring accelerations of portions of a heart **12**. A variety of accelerometers can be used. For example, accelerometers integrated within pacemakers can be used. MEMS technology can be employed to reduce a size of the accelerator, thereby reducing a size of the sensing devices **10**. The accelerations or changes of the accelerations of the portions of the heart **12** are then used to determine the contractility of the heart **12**. In some embodiments, signals from accelerometer sensing devices **10** are integrated over time to obtain velocities, which are used to determine the contractility of the heart **12**. In other embodiments, the velocities are integrated over time to obtain distances, which are also used to determine the contractility of the heart **12**.

[0026] In other embodiments, the sensors **11** detect velocities of portions of a heart **12**. The velocities or changes of the sensed velocities can be used to determine the contractility of the heart **12**.

[0027] In other embodiments, the sensors **11** are strain gauges configured to monitor strains on portions of a heart **12** as it contracts. The detected strains or changes of the detected strains are used to determine the contractility of the heart **12**. In some embodiments, the sensors **11** are configured to detect a change, in response to damage to the heart **12**, of the strain induced by contraction of the heart **12**.

[0028] In other embodiments, the sensors **11** are tactile sensors for detecting changes in the stiffness of a heart **12**. Stiffness of the heart **12** can change due to contraction and relaxation of the heart **12**, or due to ischemic damage to the heart **12** from myocardial infractions. The detected heart stiffness or change thereof can be used to determine the contractility of the heart **12**, or to monitor the heart diastolic filling.

[0029] Also in other embodiments, sensors **11** are configured to detect an electrical impedance of a heart **12**. As cells die, the their electrical impedance changes. As such, by monitoring an electrical impedance of a portion of the heart **12**, the vitality of the cells in the portion of the heart **12** can be determined. In still other embodiments, sensors **11** are configured to detect electrical activity in a portion of a heart **12**, as in an electrocardiogram. In other embodiments, sensors **11** are configured to detect the temperature of a portion of a heart.

[0030] Sensing devices **10** can communicate in various ways with controllers **13** incorporated in other implantable devices **28** or external devices **26**. Controllers can also be incorporated in therapeutic medical devices or diagnostic medical devices. Diagnostic medical devices include devices for displaying an image of the heart to a physician in a well known fashion. In some embodiments, a wireless communication device **32** sends signals from and receives signals sent to the sensing devices **10**. The wireless communication device **32** can send and receive, an acoustic signal, a magnetic induction signal, an optical signal (e.g., UV, infrared), or an electromagnetic signal (e.g., a radio-frequency signal) to and from the sensing devices **10**. In other embodiments, the communication can be performed using a conventional wire lead **30**.

[0031] Examples of implantable devices **28** include pacemakers, defibrillators, implantable cardioverter defibrillators, cardiac resynchronization therapy (CRT) pacemakers, CRT-defibrillators, and nerve stimulators. Examples of external devices **26** include external pulse generators and telemetry recording devices.

[0032] In some embodiments, as shown in **FIG. 4**, the controller **13** also has a wireless communication device **32** for receiving signals from and sending signals to the sensing

devices **10**. In some embodiments, the wireless communication devices **32** in the system **1** are transceivers and the respective controller **13** and sensing devices **10** for an acoustic communication network. In still other embodiments, the wireless communication devices **32** in the sensing devices **10** are configured to convert acoustic energy transmitted by the wireless communication devices **32** in the controller **13** into electrical energy used to operate the respective sensing devices **10**.

[**0033**] The system **1** also includes a power source **56** for the sensing devices **10**. The power source **56** can be one or more internal batteries. Alternatively, the sensing devices **10** can be powered telemetrically using energy from radio frequency, acoustic, magnetic or infrared signals.

[**0034**] In some embodiments, the system **1** also includes a processor **58** for processing signals from the sensing devices **10**. The processor **58** of some embodiments is disposed in the external device **26**, but in alternative embodiments, the processor **58** can be disposed in the sensing devices **10**. In still other embodiments, the processor **58** can be disposed both in the external device **26** and in the sensing devices **10**. In some embodiments, the system **1** also include a memory **60** for storing the data from the sensor and the processed data.

[**0035**] In some embodiments, the system **1** includes an encapsulation **62** for the sensing devices **10** and wireless communication device **32** for improving a durability of those implanted parts. The system **1** also includes attachment devices **64** for attaching the sensing devices **10** to the heart. Suitable attachment devices **64** include screws, hooks, sutures, anchors, suction devices, and clips.

[**0036**] In some embodiments, the system **1** also includes a delivering device for delivering the sensing devices **10** to target sites. Suitable delivery devices include catheters, injection needles, and cannulas. The sensing devices **10** can be attached to the pericardium **14** of the heart **12**, and preferably over the left ventricle **16**, as shown in **FIG. 2**. However, the sensing devices **10** can also be attached to other locations on the heart **12**. Various techniques can be used to attach the sensing devices **10** to the heart **12**. For examples, the sensing devices **10** can be implanted, sutured, or attached to the heart during a heart surgery, such as a coronary artery bypass surgery (CABG) or a valve replacement. This surgery can be a conventional one with incision of the sternum or a minimally invasive one, which is performed through a smaller incision on the patient's chest over the heart to gain access to the coronary arteries.

[**0037**] Alternatively, the sensing devices **10** can be implanted percutaneously in the right heart chambers **18**, preferably in the septum **20**, as shown in **FIG. 3**, or in the coronary sinus **22**. In other embodiments, the sensing devices **10** can be implanted using a trans-septal approach in the left atrium **24** or the left ventricle **16**. In other embodiments, the sensing devices **10** can be secured to other parts of the heart **12** by other conventional methods.

[**0038**] In some embodiments, as shown schematically in **FIGS. 4 and 5**, the sensing devices **10** are configured to communicate with an external device **26**. In other embodiments, as shown schematically in **FIG. 6**, the sensing devices **10** are configured to communicate with an implanted device **28** internal to a patient's body, such as an implantable pulse generator. The communication can be accomplished using conventional leads **30**, as shown in **FIG. 5**, or a wireless communication device **32**, as shown in **FIG. 4**. Wireless communication devices **32** include transmitters, receivers, and transceivers.

[**0039**] In case of ischemia, parts of the heart muscle **12** that have a reduced blood supply lose part of their ability to contract and relax after a contraction. The sensing devices **10** may be used to detect ischemia by monitoring the heart contractility or an abnormality or a change in the heart tissue movement. These changes can occur at the stage of relaxation after systole or during a contraction at the systolic phase. During ischemia, the sensing devices **10** attached to the heart **12** senses a characteristic (e.g., a contractility, or a variable associated with a contractility) of the heart **12** that is associated with a symptom of ischemia. Based on the sensed characteristic, a heart condition (e.g., existence of a blockage of artery, severity of the stenosis, etc.) can be determined. Based on the determined heart condition, a physician can determine the patient status, perform additional examinations, or provide an appropriate treatment (i.e. catheterization, drug therapy etc.).

[**0040**] In other embodiments, the sensing devices **10** can be used for evaluating a status of congestive heart failure (CHF) patients. Heart failure is generally divided into systolic and diastolic. In systolic heart failure, the heart or parts of it lose the ability to contract. Diastolic dysfunction caused by abnormalities in left ventricular filling can be a result of many pathologic conditions, including hypertrophy, infiltrative cardiomyopathies, or myocardial ischemia. Attaching sensing devices **10** to the heart **12**, and especially to the left ventricle **16**, as shown in **FIGS. 1 and 2**, can help in evaluating the status of the patient. This is true for both systolic dysfunction where the contractility can be monitored and for diastolic dysfunction where the relaxation and filling of the heart **12** can be followed.

[**0041**] In other embodiments, the sensing devices **10** can be used to monitor heart performance under a stress test, as shown in **FIG. 7**. A stress test involves performing a simple exercise (usually a treadmill or a stationary bike) while the patient is monitored using several devices. These devices may include an electrocardiograph machine (ECG), an ultrasound machine, a blood pressure cuff, and/or a mask.

[**0042**] As shown in **FIG. 7**, the process begins with the start of physical activity **34** and activation of the sensor **36**. Next, a heart characteristic associated with contractility is measured **38**. Then data is transferred **40**, via wireless telemetry **42**, to an external system, where it is analyzed, stored, and displayed **44**. In other embodiments, based on a measured heart characteristic (e.g., contractility or a variable associated with a contractility), a map of heart movement can be formed.

[**0043**] For a patient with an implantable pacemaker, the heart rate can be increased by increasing the electrical stimulation rate of the pacemaker with no physical activity by the patient, as shown in **FIG. 8**. This method is similar to that depicted in **FIG. 7**, except the test may also begin by increasing the electrical stimulation rate of the pacemaker **46**. This allows the physician to carry out the "stress test" at any location, such as the clinic, office, or the patient's home. In some cases, the stress test can be performed by remote programming of the pacemaker using a telemetric system such as the Medtronic CareLink™.

[0044] In another embodiment sensing devices **10** are used to monitor heart performance under a stress test involving a temporary pacemaker **48**. The temporary pacemaker **48** may be used to make a heart **12** beat at a normal rate after heart surgery or another life-threatening event involving the heart **12**. The temporary pacemaker **48** can be external or internal to the patient's body. Using the above-described method, a heart stress test can be performed while the patient is recovering from the heart surgery. In such cases, the sensors **11** sense a characteristic of the heart **12** (e.g., contractility or a variable associated with a contractility) and transmit a signal providing feedback to the physician.

[0045] In other embodiments, the sensing devices **10** can be used to automatically perform a heart test and use the test results to optimize an operation of a therapeutic device, such as an implantable pulse generator. Another embodiment is described in **FIG. 9**. The sensing devices **10** on the heart **12** are used for feed back regulation of a drug pump **50**. The sensors **11** can be of any type disclosed herein. For example, the sensors **11** can be an accelerometer, a velocity sensor, a position sensor, a tactile sensor, or a pressure sensor.

[0046] As shown in the illustrated embodiment, the sensing devices **10** are configured to communicate with a drug pump **50** using a conventional lead **30** or a wireless communicator **42**. Based on data from the sensor devices **10**, the drug pump **50** can control a dosage of medication, and optimize an amount of medication injected to the patient via an injection port **52**. In other embodiments, the communication between the sensing devices **10** and the drug pump **50** can be performed indirectly via another implantable device (not shown) such as a pacemaker, a pacemaker, an implantable cardioverter defibrillator, a cardiac resynchronization therapy (CRT) pacemaker, a CRT-defibrillator, or a nerve stimulator.

[0047] In other embodiments, heart muscle movement can be used for optimizing a CRT operation. Sensing devices **10** can be implanted in the heart wall and septum **20** to detect movement, which can then be used to optimize the biventricular delay of CRT. The optimization can be done by transferring the information to an external system and then reprogramming the CRT, or by an automatic feedback of the CRT operation using the measurements from the sensing devices **10**. For patients with pacemakers, the system can be used for feedback regulation of the pacemaker to control the pace and rate of a heart based in part of the measured heart characteristic.

[0048] Although various embodiments of the invention have been shown and described herein, it should be understood that the above description and figures are for purposes of illustration only, and are not intended to be limiting of the invention, which is defined only by the appended claims and their equivalents.

What is claimed:

1. A system for monitoring heart performance, comprising:

a plurality of sensing devices configured to attach to a patient's heart tissue, each sensing device comprising

a sensor configured to detect physiological data relating to heart contractility, and

a wireless transmitter configured to transmit data detected by the sensor; and

a controller comprising

a receiver configured to receive the detected data transmitted by the plurality of sensing devices, and

a processor configured to analyze the received data.

2. The system of claim 1, wherein at least one of the sensing devices is configured to attach to heart tissue located on an exterior of a heart.

3. The system of claim 1, wherein at least one of the sensing devices is configured to attach to heart tissue located on an interior of a heart.

4. The system of claim 1, wherein the controller is incorporated in a device configured for implantation in the patient.

5. The system of claim 1, wherein the controller is incorporated in a device configured for use external to the patient.

6. The system of claim 1, wherein the controller is incorporated in a therapeutic medical device.

7. The system of claim 1, wherein the controller is incorporated in a diagnostic medical device.

8. The system of claim 1, wherein the data is selected from the group consisting of position, velocity, acceleration, change in position, change in velocity, change in acceleration, stiffness, strain, electrical impedance, temperature, and electrical activity.

9. The system of claim 1, wherein the respective sensing device sensors are selected from the group consisting of position sensors, velocity sensors, accelerator sensors, strain sensors, tactile tensors, temperature sensors, electrocardiogram monitors, and electrical impedance sensors.

10. The system of claim 1, wherein the sensing devices acoustically transmit the detected data to the controller.

11. The system of claim 1, wherein the sensing devices transmit the detected data to the controller using a signal selected from the group consisting of acoustic, radio frequency, magnetic induction, and infrared.

12. The system of claim 6, wherein the therapeutic device comprises an implantable pulse generator selected from the group consisting of a pacemaker, a defibrillator, an implantable cardioverter defribrillator, a CRT-pacemaker, a CRT-defibrillator, and a nerve stimulator.

13. The system of claim 1, wherein the controller is incorporated in, or coupled with, an external pulse generator.

14. The system of claim 6, wherein the detected data is used for controlling an output of the therapeutic medical device.

15. The system of claim 14, wherein the medical device comprises a pump that delivers a therapeutic agent to the patient.

16. The system of claim 1, wherein the processor is configured to analyze the detected data to determine a contractility of the patient's heart.

17. The system of claim 1, wherein the sensing device transmitters comprise transceivers, the controller receiver comprises a transceiver, and the respective controller and sensing device transceivers comprise an acoustic communication network.

18. The system of claim 17, wherein the sensing device transceivers are configured to convert acoustic energy transmitted by the controller transceiver into electrical energy.

19. A method for evaluating heart performance, comprising:

attaching a plurality of sensing devices to a patient's heart tissue;

detecting, with the sensing devices, physiological data relating to heart contractility;

wirelessly transmitting the detected data from the sensing devices to a controller; and

analyzing the detected data at the controller to determine a contractility of the patient's heart.

20. The method of claim 19, wherein attaching a plurality of sensing devices to a patient's heart tissue comprises attaching at least one of the sensing devices to heart tissue located on an exterior surface of the patient's heart.

21. The method of claim 19, wherein attaching a plurality of sensing devices to a patient's heart tissue comprises attaching at least one of the sensing devices to heart tissue located on an interior surface of the patient's heart.

22. The method of claim 19, wherein the data is selected from the group consisting of position, velocity, acceleration, changes in position, changes in velocity, changes in acceleration, stiffness, strain, electrical impedance, temperature, and electrical activity.

23. The method of claim 19, wherein wirelessly transmitting the detected data comprises acoustically transmitting the detected data.

24. The method of claim 19, wherein wirelessly transmitting the detected data comprises using a signal selected from the group consisting of acoustic, radio frequency, magnetic induction, and infrared.

25. The method of claim 19, further comprising controlling an output of a therapeutic medical device based, at least in part, on the determined contractility.

26. The method of claim 19, further comprising controlling a pacing signal used to pace the patient's heart based, at least in part, on the determined contractility.

27. The method of claim 19, further comprising transmitting an acoustic signal from the controller to the plurality of sensing devices in order to activate the respective sensing device sensors.

28. The method of claim 27, further comprising converting, at the sensing devices, the acoustic signal into electrical energy.

29. The method of claim 19, wherein the controller is incorporated in a device configured for implantation in the patient.

30. The method of claim 19, wherein the controller is incorporated in a device configured for use external to the patient.

31. The method of claim 19, wherein the controller is incorporated in a therapeutic medical device.

32. The method of claim 19, wherein the controller is incorporated in a diagnostic medical device.

33. A system for monitoring heart performance, comprising:

a plurality of sensing devices configured to attach to a patient's heart tissue, each sensing device comprising

a sensor configured to detect physiological data relating to heart contractility, and

a wireless transmitter configured to acoustically transmit data detected by the sensor;

a controller incorporated in a diagnostic or therapeutic medical device comprising

a receiver configured to receive the detected data transmitted by the plurality of sensing devices, and

a processor configured to analyze the received data.

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专利名称(译)	用于评估心脏性能的无线传感设备		
公开(公告)号	US20050288727A1	公开(公告)日	2005-12-29
申请号	US11/140267	申请日	2005-05-26
当前申请(专利权)人(译)	REMON MEDICAL TECHNOLOGIES LTD		
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IPC分类号	A61B5/00 A61N1/05 A61N1/362 A61N1/365		
CPC分类号	A61B5/0031 A61N1/36514 A61N1/3627		
优先权	60/576145 2004-06-01 US		
外部链接	Espacenet USPTO		

摘要(译)

一种用于监测心脏性能的系统包括多个传感装置，其被配置为附接到患者的心脏组织和控制器。每个感测设备包括：传感器，被配置为检测与心脏收缩性相关的生理数据;以及无线发送器，被配置为发送由传感器检测的数据。控制器包括：接收器，被配置为接收由多个感测设备发送的检测数据;以及处理器，被配置为分析所接收的数据。