TRANSDERMAL COMMUNICATION SYSTEM AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

Copending U.S. patent application Ser. No. 08/549,375, entitled "System and Method to Monitor the Heart of a Patent", filed Oct. 27, 1995, which is a continuation-in-part application of U.S. patent application Ser. No. 08/545/306, entitled "System and Method to Measure to the Condition of a Patent's Heart", filed Oct. 19, 1995, both assigned to the assignee of the present invention, are incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a transdermal communication system having an internal communication device and an external communication device, and more particularly, to a transdermal communication system wherein data stored in the body is transferred to the external communication device by modulating a carrier signal, transmitted by the external communication device, with the data by either reflecting the carrier signal or not reflecting the carrier signal, and recovering the data at the external communication device by detecting when the carrier signal is either reflected or not reflected.

2. Background Art

With recent advances in the field of microelectronics, it is now common to subdermally implant semiconductor chips and related circuitry into the body of a patient. The chips and circuitry are used to control a variety of bodily functions, and/or monitor anyone of a number of physiological attributes of a patient. For example, U.S. Pat. No. 5,391,190 entitled "Variation in Cardiac Chamber Volume or Pressure as a Controlling Parameter" issued to Pederson on Feb. 21, 1995, discloses the use of a cardiac pacemaker system that uses a subdermally implanted microprocessor to control the heart beat rate of the patient based on a heart and respiratory measurement. In yet another example, Carney in U.S. Pat. No. 5,368,040 entitled *"Apparatus and Method for Determining A Plurality of Hemodynamic Variables From A Single Chronically Implanted Absolute PressureSensor"*, issued Nov. 29, 1994, discloses a telemetry system wherein circuitry subdermally implanted into a patient is used to transmit blood pressure measurements to a receiver external to the body.

One problem confronting bio-medical engineers developing transdermal communication devices is providing electrical power to the chronically implanted circuitry inside the body. The majority of implanted devices are powered using a battery. The power of the battery eventually drains, and needs to be replaced. The most common way to replace the battery is through surgery. Prior to the expiration of the battery, an operation is performed on the patient and either the battery is replaced, or a new device is implanted into the patient. Surgery, however, is usually a major ordeal for the patient, is costly, and is generally undesirable. Another way to provide power to an implanted device is through the use of a split transformer, where one coil of the transformer is located underneath the skin and the other coil is positioned outside the skin. The transformer is used to replenish power to an implanted power supply, such as a battery, when needed. See for example the above referenced Carney patent. The problem with transformers is that they require a coil to be implanted under the skin. The implanted coil is typically bulky, and the spilt transformer provides relatively little power transfer to the internal device.

Another problem confronting biomedical engineers is providing two-way communication through the skin of the patient. It is known to surgically implant wires through the skin of the patient. While this approach facilities two-way communication, it is generally undesirable. Chronically implanted wires piercing the skin tend to be uncomfortable for the patient, are unsanitary, and may cause infection. Radio telemetry is another known approach for communicating between an implanted device and an external device. With radio telemetry, data is transmitted either into or out of the body using radio waves. The problem with radio telemetry is that a transmitter/receiver is needed inside the body of the patient. These transmitter/receivers tend to be very sophisticated and expensive. Furthermore, the transmitter/receiver inside the body consumes a relatively large amount of power, particularly during broadcasting. In battery powered radio telemetry transdermal communication devices, the frequent broadcasting of data from the body to an external receiver tends to significantly reduce the life of the battery.

U.S. Pat. No. 5,387,259 entitled *"Optical Transdermal Linking Method for Transmitting Power and Receiving an Internal Data Stream While Receiving a Second Data Stream,"*, issued to Davidson on Feb. 7, 1995, discloses an optical transdermal system. The system of Davidson provides an internal module implanted underneath the skin of a patient, and an external module. The internal module includes a photodetector, a preamplifier, a clock recovery circuitry for detecting an incoming optical signal, a laser diode and driver for transmitting an optical signal, and a photo-cell for providing power to the internal module. The external module includes one or more laser diodes for transmitting an optical signal to the internal module, and a photodetector for receiving an optical signal from the internal module. Davidson teaches two ways in which power can be provided to the internal module. One way is to provide the external module with an unmodulated laser diode which is dedicated for power transmission and a second laser diode dedicated for data transmission. Alternatively, a single laser diode can be used for both power transmission and data transmission. Regardless of the number of laser diodes used in the external module, the photo-cell of the internal module absorbs light transmitted through the skin of the patient by the laser diode of the external module. The light energy is then converted to electrical energy for powering the internal module.

A problem associated with the system of Davidson is that it requires the transmission of a relatively high power optical energy signal into the body to provide and replenish power to the internal module. The internal module also requires a photo-cell to convert the light energy into electrical energy. This process is generally inefficient, particularly through the skin and tissue of the patient. The internal module is also required to drive its own laser diode when transmitting data external to the body. Laser diodes consume a relatively large amount of power, which tends to drain the power of the photo-cell. Consequently, the Davidson device is less than ideal because the patient would be required to repeatedly replenish the photo-cell of the internal module.

U.S. Pat. No. 4,571,589 entitled *"Biomedical Implant with High Speed, Low Power Two Way Telemetry"*, issued to Slocum on Feb. 18, 1986 discloses a transdermal communication system that relies on an external coil and an internal coil implanted under the skin of a patient. During data transmission from inside to outside of the body, the external