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(54) **METHOD AND APPARATUS FOR TRANSMITTING POWER AND DATA USING THE HUMAN BODY**

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(52) **U.S. Cl.** **455/100**; 455/95; 455/41
(58) **Field of Search** 455/40, 41, 95, 455/100, 106; 340/333; 379/55.1; 341/33

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,755,816	A	*	7/1988	DeLuca	340/7.37
5,796,827	A	*	8/1998	Coppersmith et al.	713/182
6,104,913	A	*	8/2000	McAllister	455/41
6,118,882	A	*	9/2000	Haynes	381/374
6,211,799	B1	*	4/2001	Post et al.	341/33
6,223,018	B1	*	4/2001	Fukumoto et al.	455/41
6,282,407	B1	*	8/2001	Vega et al.	455/41.1
6,424,820	B1	*	7/2002	Burdick et al.	455/41.1

OTHER PUBLICATIONS

"Bio/Analogics Technology Resources"; downloaded from: http://www.bioanalogics.com/technology,htm on Apr. 26, 2000, 2 pages.

"Bio Analogics Technology —Body Compositions Techniques"; downloaded from: *http://www. bluetooth.com/text/bluetoothguide/intro/intro.asp* on Apr. 26, 2000, 1 page.

"The Official Bluetooth SIG Website —Text"; INTRO downloaded from: http://www.bluetooth.com/text/bluetoothguide/intro/into.asp on Apr. 26, 2000, 1 page.

"The Official Bluetooth SIG Website —Text, Mobile Phone"; Bluetooth Introduction downloaded from: http://www.bluetooth.com/text/bluetoothguide/intro/intro.asp?action=bt4u&sort=mobphone on Apr. 26, 2000, 1 page.

"Wireless connections made easy"; Specification of the Bluetooth System, Specification vol. 1, Core, Dec. 1st 1999, pp. 1–32.

"Popular Mechanics Technology Watch: Walking Powers Electronics"; downloaded from: http://popularmechanics.com/popmech/sci/tech/9903TUEEDM.html on Apr. 26,2000, 1 page (Mar. 1999).

"Personal Area Networks: Near–field intrabody communication"; IBM Systems Journal, vol. 35, No. 3&4, 1996 — MIT Media Lab, 11 pages.

* cited by examiner

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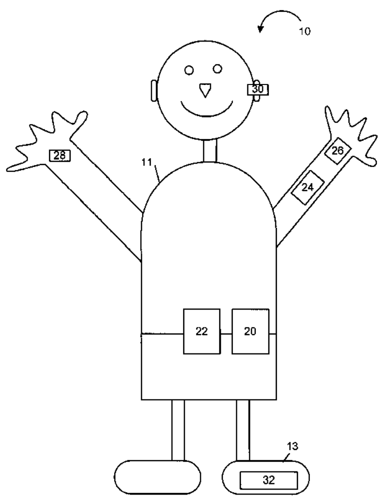
(57) **ABSTRACT**

Methods and apparatus for distributing power and data to devices coupled to the human body are described. The human body is used as a conductive medium, e.g., a bus, over which power and/or data is distributed. Power is distributed by coupling a power source to the human body via a first set of electrodes. One or more devise to be powered, e.g., peripheral devices, are also coupled to the human body via additional sets of electrodes. The devices may be, e.g., a speaker, display, watch, keyboard, etc. A pulsed DC signal or AC signal may be used as the power source. By using multiple power supply signals of differing frequencies, different devices can be selectively powered. Digital data and/or other information signals, e.g., audio signals, can be modulated on the power signal using frequency and/or amplitude modulation techniques.

53 Claims, 6 Drawing Sheets



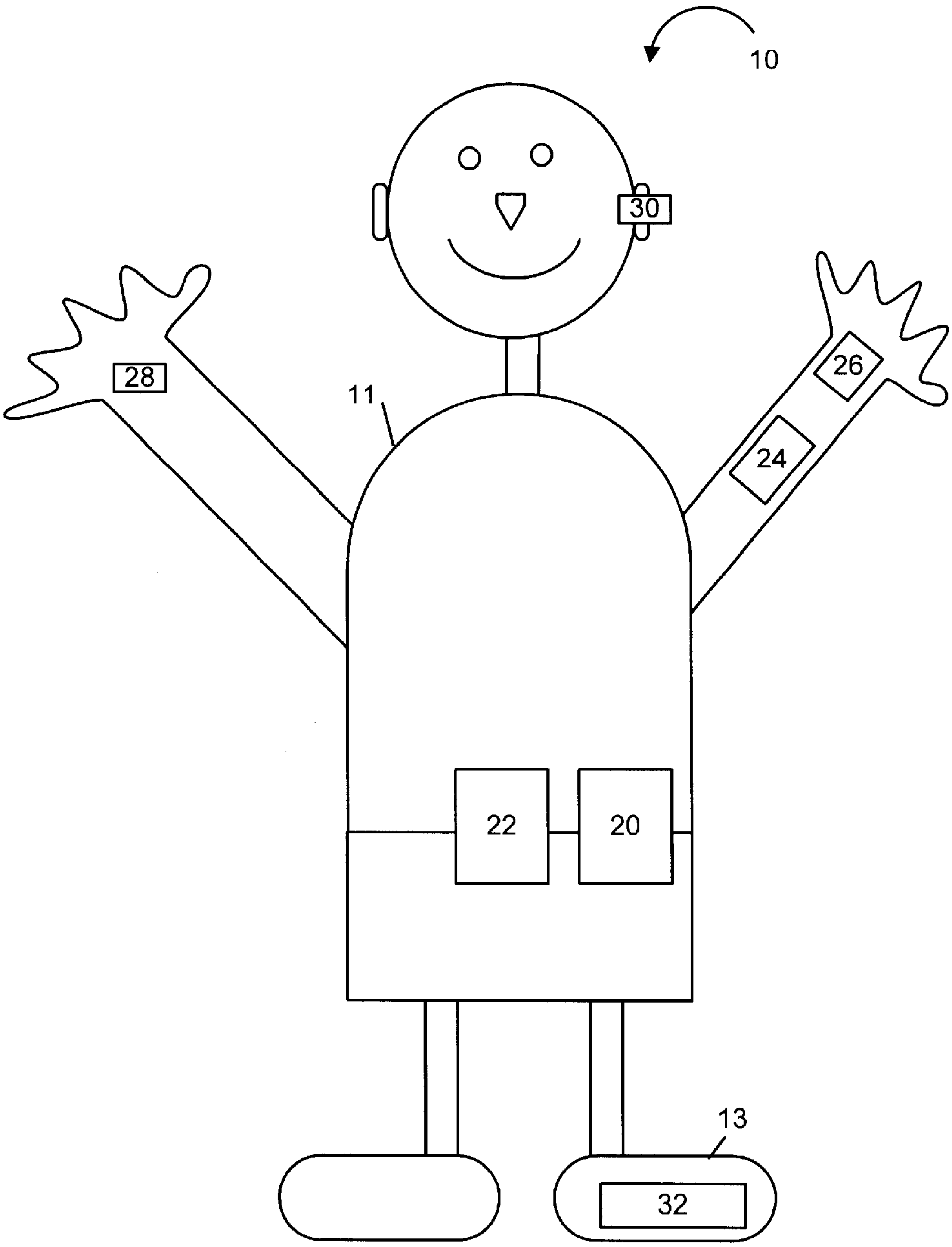


Fig. 1

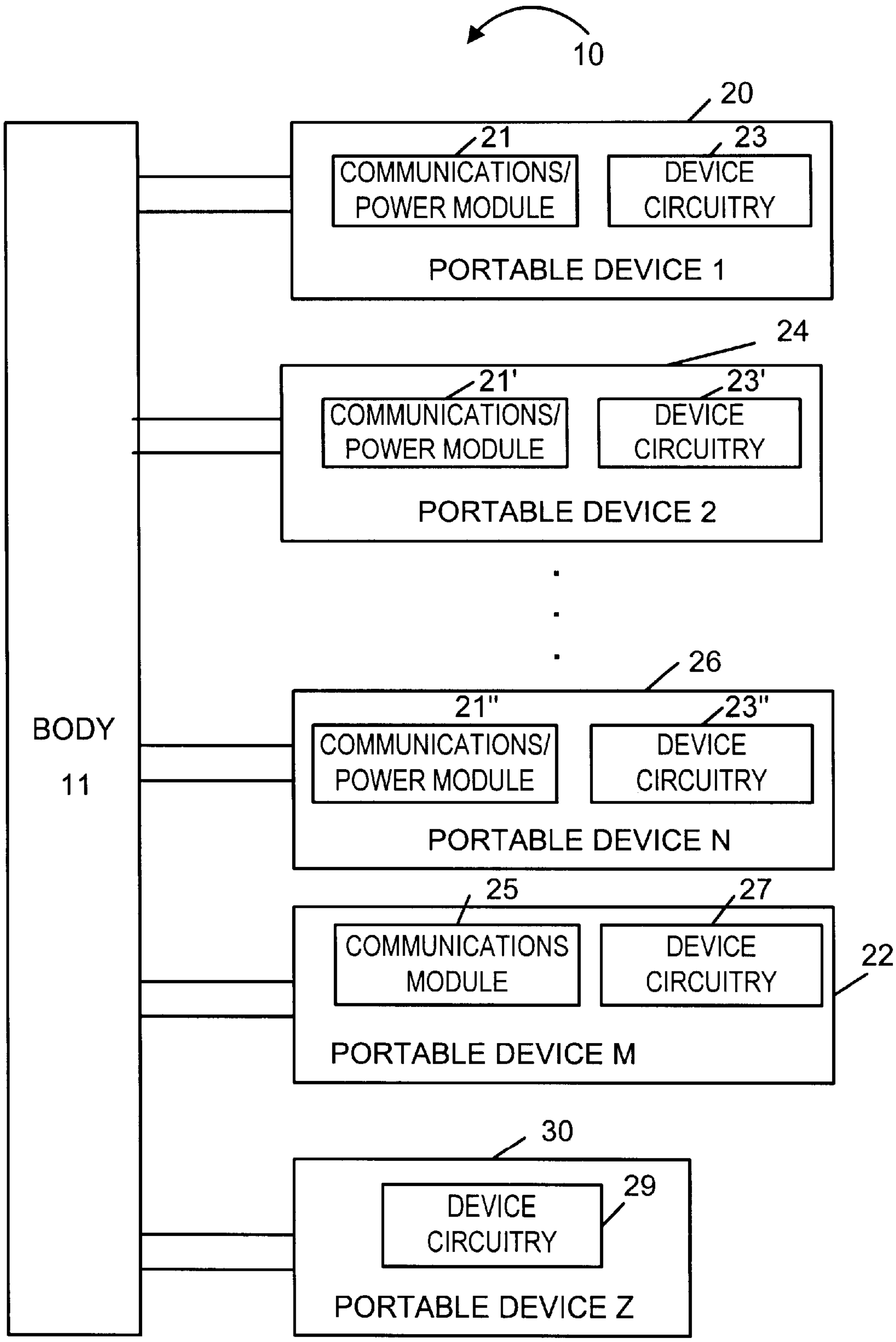

10
20
21
23
COMMUNICATIONS/ POWER MODULE
DEVICE CIRCUITRY
PORTABLE DEVICE 1
24
21'
23'
COMMUNICATIONS/ POWER MODULE
DEVICE CIRCUITRY
PORTABLE DEVICE 2
26
21"
23"
BODY
11
COMMUNICATIONS/ POWER MODULE
DEVICE CIRCUITRY
PORTABLE DEVICE N
25
27
COMMUNICATIONS MODULE
DEVICE CIRCUITRY
22
PORTABLE DEVICE M
30
29
DEVICE CIRCUITRY
PORTABLE DEVICE Z

Fig. 2

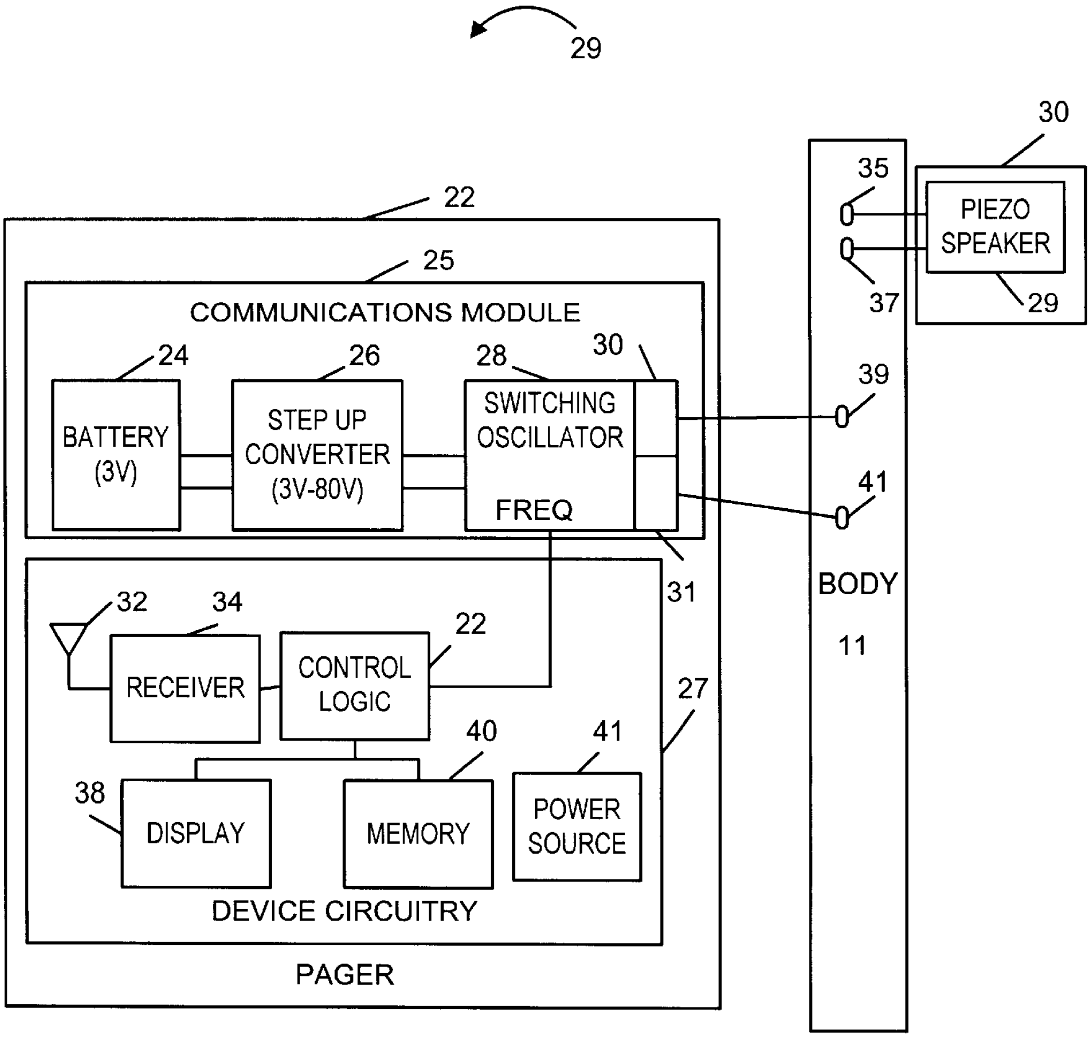
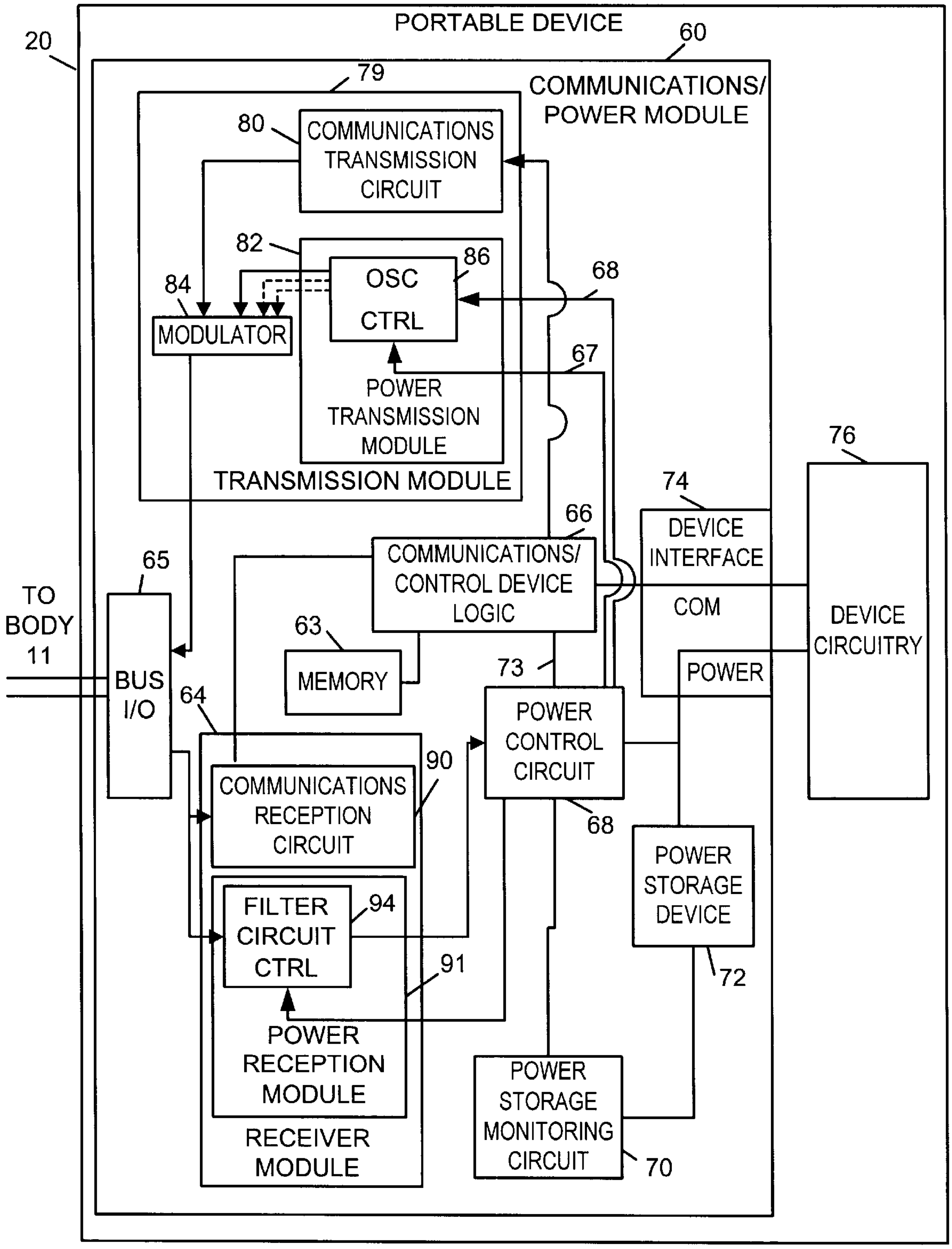

29
30
35
PIEZO
SPEAKER
37
29
22
25
COMMUNICATIONS MODULE
24
26
28
30
39
BATTERY
(3V)
STEP UP
CONVERTER
(3V-80V)
SWITCHING
OSCILLATOR
FREQ
41
31
BODY
11
32
34
22
RECEIVER
CONTROL
LOGIC
27
40
41
38
DISPLAY
MEMORY
POWER
SOURCE
DEVICE CIRCUITRY
PAGER

Fig. 3



PORTABLE DEVICE
20
60
79
COMMUNICATIONS/
POWER MODULE
80
COMMUNICATIONS
TRANSMISSION
CIRCUIT
82
86
OSC
CTRL
68
84
MODULATOR
67
POWER
TRANSMISSION
MODULE
TRANSMISSION MODULE
76
74
66
DEVICE
INTERFACE
COMMUNICATIONS/
CONTROL DEVICE
LOGIC
65
TO
BODY
11
COM
DEVICE
CIRCUITRY
63
MEMORY
73
POWER
BUS
I/O
64
POWER
CONTROL
CIRCUIT
90
COMMUNICATIONS
RECEPTION
CIRCUIT
68
POWER
STORAGE
DEVICE
FILTER
CIRCUIT
CTRL
94
72
91
POWER
RECEPTION
MODULE
POWER
STORAGE
MONITORING
CIRCUIT
RECEIVER
MODULE
70

Fig. 4

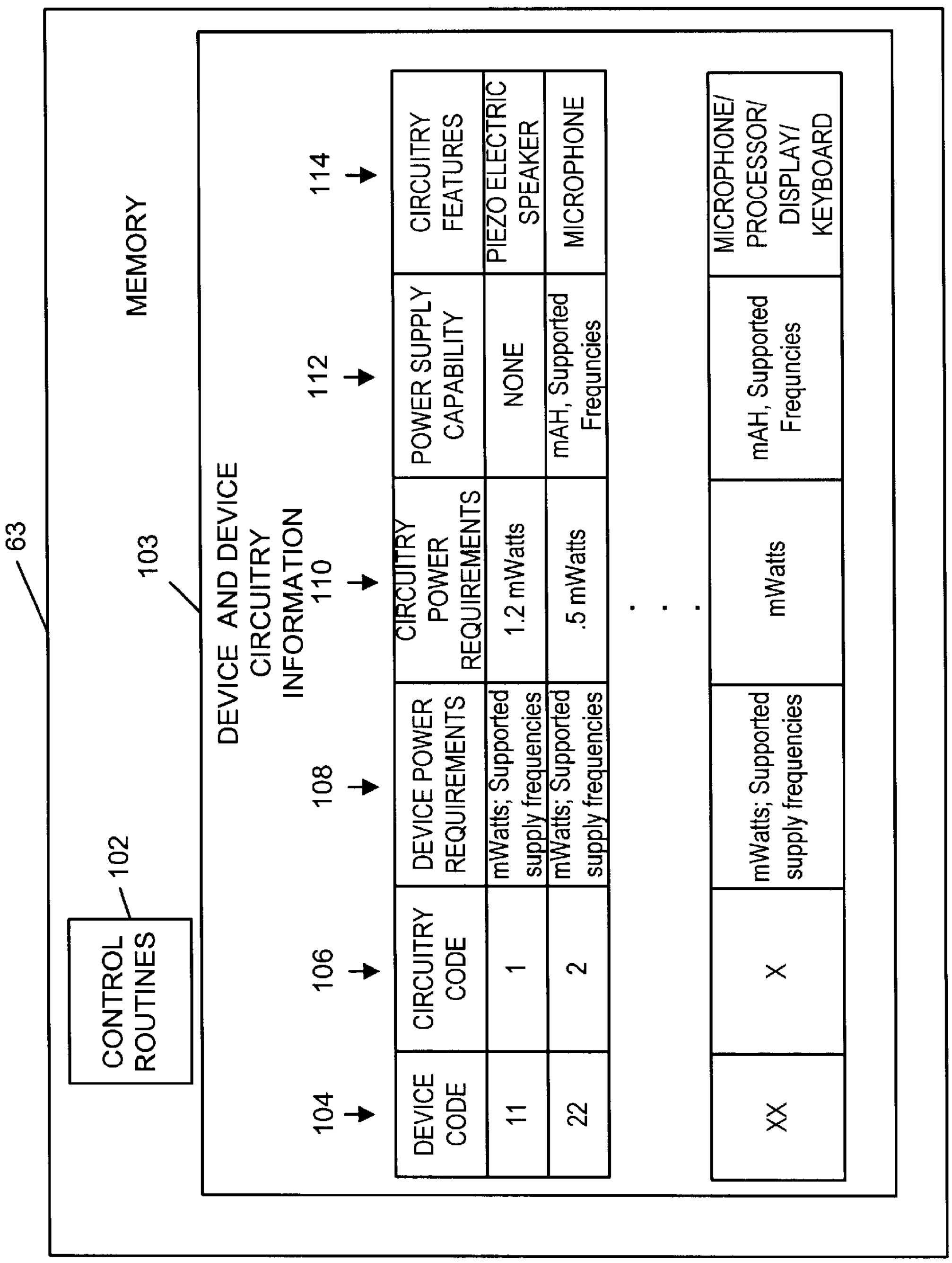

63
MEMORY
CONTROL ROUTINES
102
103
DEVICE AND DEVICE CIRCUITRY INFORMATION
104
106
108
110
112
114
DEVICE CODE
CIRCUITRY CODE
DEVICE POWER REQUIREMENTS
CIRCUITRY POWER REQUIREMENTS
POWER SUPPLY CAPABILITY
CIRCUITRY FEATURES
11
1
mWatts; Supported supply frequencies
1.2 mWatts
NONE
PIEZO ELECTRIC SPEAKER
22
2
mWatts; Supported supply frequencies
.5 mWatts
mAH, Supported Frequncies
MICROPHONE
XX
X
mWatts; Supported supply frequencies
mWatts
mAH, Supported Frequncies
MICROPHONE/ PROCESSOR/ DISPLAY/ KEYBOARD

Fig. 5

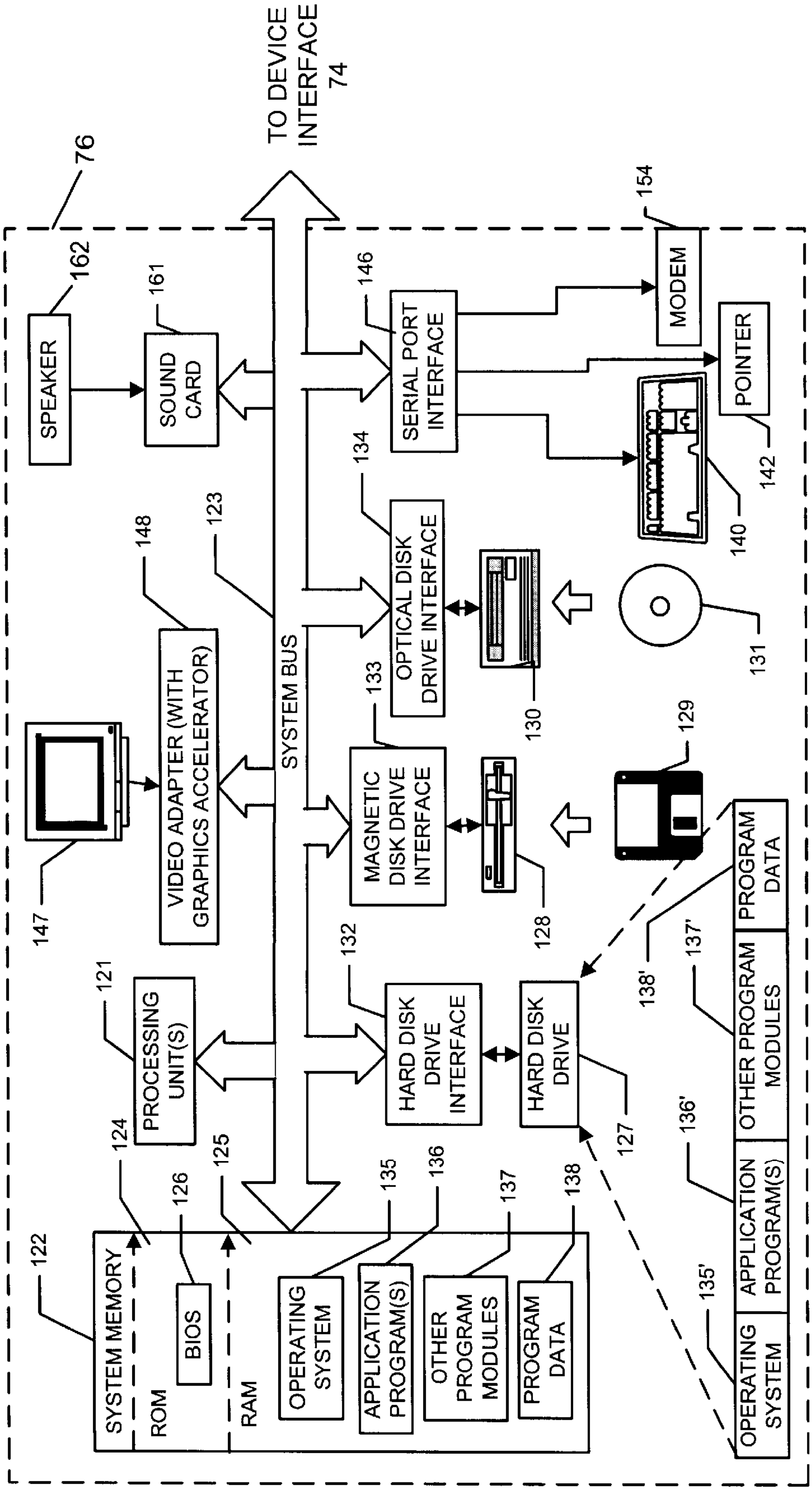

TO DEVICE INTERFACE 74
76
SPEAKER
162
SOUND CARD
161
SERIAL PORT INTERFACE
146
MODEM
154
POINTER
142
140
VIDEO ADAPTER (WITH GRAPHICS ACCELERATOR)
148
147
123
SYSTEM BUS
OPTICAL DISK DRIVE INTERFACE
134
130
131
MAGNETIC DISK DRIVE INTERFACE
133
128
129
PROCESSING UNIT(S)
121
HARD DISK DRIVE INTERFACE
132
HARD DISK DRIVE
127
SYSTEM MEMORY
122
124
ROM
BIOS
126
RAM
125
OPERATING SYSTEM
135
APPLICATION PROGRAM(S)
136
OTHER PROGRAM MODULES
137
PROGRAM DATA
138
OPERATING SYSTEM
135'
APPLICATION PROGRAM(S)
136'
OTHER PROGRAM MODULES
137'
PROGRAM DATA
138'

FIG. 6

METHOD AND APPARATUS FOR TRANSMITTING POWER AND DATA USING THE HUMAN BODY

FIELD OF THE INVENTION

The present invention relates to methods and apparatus for transmitting power and data, and more particularly, to methods of powering devices coupled to the human body and communication information between the devices.

BACKGROUND OF THE INVENTION

Small portable electronic devices are commonplace today. Small portable devices commonly used by people today include wristwatches, radios, communications devices, e.g., pagers and cell phones, and personal data assistants (PDAs) to name but a few exemplary devices. As electronics manufacturing techniques have improved, weight and power consumption requirements of many small portable devices have decreased. At the same time, the capabilities of the devices have increased. As a result, it is now possible to power many small electronic devices including watches, audio players, personal data assistants, portable computers, etc. with relatively little power.

Given the small size and portable nature of many of today's portable electronic devices, people have begun wearing them on their bodies. For example, wristwatches are worn on people's arms, pagers and PDAs are worn on people's belts, and small displays are sometimes worn mounted on headgear.

As a result of carrying multiple portable electronic devices, there is often a significant amount of redundancy in terms of input/output devices included in the portable devices used by a single person. For example, a watch, pager, PDA and radio may all include a speaker. In order to reduce the redundancy in input/output devices, networking of portable electronic devices has been proposed. By exchanging data, e.g., as part of a network, a single data input or output device can be used by multiple portable devices, eliminating the need for each of the portable devices to have the same input/output device.

Various approaches have been taken in an attempt to network portable devices. The uses of radio (RF) signals, infrared (IR) communications signals, and near field intrabody communication signals are examples of various signals that have been suggested for use in networking portable devices. Radio signals between devices can cause interference. In addition radio devices can be expensive to implement and tend to consume relatively large amounts of power. In addition, decoding another person's transmitted information and controlling another person's device is plausible using RF, raising the concern for security and privacy. IR communications signals present similar privacy concerns to those of RF signals while further being subject to additional limitations in terms of the tendency for many objects, e.g., opaque objects, to block the transmission of IR signals. Near field intrabody communication signals represent a relatively new and still largely undeveloped field of signal communications.

In the case of one near field intrabody communications system, information is exchanged between electronic devices on or near the human body by capacitively coupling picoamp currents through the human body of a person.

While some work has been done to minimize the redundancy that exists in data input/output devices, in portable

devices frequently used by a single individual, there still remains room for improvements in the way information is communicated between portable devices. In addition, some wearable devices are not big enough to have any kind of interface at all; e.g. earrings.

There remains significant room for improvement with regard to how portable devices are powered. Portable electronic devices frequently rely on power supplied by batteries to operate. Batteries have a limited energy storage capability. As a result, batteries periodically need to be replaced or, assuming they are rechargeable, recharged. The need to replace or recharge batteries posses a serious limitation on known portable battery powered devices. Battery replacement normally involves physically removing a current set of batteries and replacing them with a new set of batteries. Recharging of batteries normally involves plugging the portable device into a battery charger thereby limiting the devices portability until the re-charging is complete or, alternatively, swapping a charged battery pack for a battery pack including the batteries, which need to be recharged.

The swapping of battery packs, replacement of batteries, and/or recharging of batteries by plugging in a portable device represents an inconvenience in terms of time involved with a user performing a battery replacement operation or recharging operation. In many cases it also represents an interruption in service, i.e., often during the battery swapping or recharging operation, the device cannot be used or its portability is limited.

Until the present invention, the focus with regard to portable device power issues has been largely on improving the quality of batteries, reducing the amount of power required by a portable device to operate, and/or in providing backup power sources, e.g., to permit the swapping of batteries without causing an interruption in operation.

While recent improvements in batteries and device power consumption has increased the amount of time portable devices can operate before needing the batteries to be recharged or replaced, the need to periodically recharge or replace batteries in portable devices remains an area where improvements can be made. In particular, there is a need for making recharging of batteries easier to perform, preferably without requiring an interruption in device operation or for backup batteries inside the device. There is also a need for eliminating batteries in at least some portable devices, thereby reducing the weight of the portable devices making them easier to wear for extended periods of time.

SUMMARY OF THE PRESENT INVENTION

The present invention is directed to methods and apparatus for distributing power to devices coupled to the human body. The invention is also directed to methods and apparatus for communicating information, e.g., data and control signals, to devices coupled to the human body.

In accordance with the present invention the human body is used as a conductive medium, e.g., a bus, over which power is distributed. Information, e.g., data and control signals, may also be distributed over the human body in accordance with the present invention. To avoid the need for digital circuitry, e.g., in audio output devices, some of the communicated signals may be analog signals. For example, analog audio signals may be transmitted to a speaker using the human body as the communications media by which the audio signal is transmitted.

In accordance with the invention, power is distributed by coupling a power source to the human body via a first set of electrodes. One or more devices to be powered, e.g., periph-

eral devices, are also coupled to the human body via additional sets of electrodes. The devices may be, e.g., a speaker, display, watch, keyboard, etc. A pulsed DC signal or AC signal may be used as the power source. By using multiple power supply signals of differing frequencies, different devices can be selectively powered. For example, a 100 Hz signal may be used to power a first device while a 150 Hz signal may be used to power a second device. Digital data and/or other information signals, e.g., audio signals, can be modulated on the power signal using frequency and/or amplitude modulation techniques. The power source and peripheral devices can interact to form a complete computer network where the body serves as the bus coupling the devices together. Devices can include optional batteries, one or more CPUs, transmit/receive circuitry, and/or input/output circuitry. In one particular exemplary network implementation the first device to be placed on the body operates as a master device, e.g., bus master, with subsequently added devices working as slaves. In accordance with the invention power and/or communication signals may also be transmitted from one body to another by touch.

The proposed methods of the present invention enable the use of a whole new class of wearable devices. These devices do not have a direct interface, but are instead used as relays for collecting and transmitting information to the user. For example earrings, which can be used to measure the persons pulse rate or even deliver sound to the ear via a phone worn on the person's belt. To program the earring directly would be a quite cumbersome task; however, the earrings parameters could be set via another device that is large enough and has the appropriate user interface to enter data. The user could use this device to control the volume of the earrings or to control other function of this device. This concept could be extended to many other such devices that are worn on the body: jewelry, watches, and eyeglasses to name a few.

Because the devices of the present invention are networked, they can be recharged and powered by other devices on the network. Kinetic to power converters can be used in this network to sustain this network's power. Kinetic converters in shoes and on wrist watches can be used to convert the kinetic energy of the user to electrical power and distribute that power to the rest of the network. This is yet another property that distinguishes devices of the present invention from other networks such as RF or IR.

Numerous additional features and advantages of the present invention will be discussed in the detailed description, which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an exemplary system of the present invention wherein the body of a person is used as a bus for distributing power and information between various devices coupled to the person's body.

FIG. **2** is a block diagram illustration of the exemplary system illustrated in FIG. **1**.

FIG. **3** illustrates two of the devices shown in FIG. **2** in greater detail.

FIG. **4** illustrates an exemplary portable device implemented in accordance with the present invention.

FIG. **5** illustrates the contents memory included in a communications/power module implemented in accordance with the present invention.

FIG. **6** illustrates device circuitry, which may be used to implement a portable computer system coupled to a body in accordance with the present invention.

DETAILED DESCRIPTION

As discussed above, the present invention is directed to methods and apparatus for distributing power to devices coupled to the human body. The invention is also directed to methods and apparatus for communicating information, e.g., data and control signals, to devices coupled to the human body.

FIG. **1** illustrates a system **10** implemented in accordance with the present invention. The system **10** comprises a plurality of portable devices **20**, **22**, **24**, **26**, **28**, **32**, and **30**, which are coupled together by the human body **11**. The portable devices include a portable computer device **20**, a pager device **22**, a keyboard **24**, a display **26**, an audio input device **28**, an audio playback device **30** and a power supply **32**. Each of the devices is coupled to the human body by a pair of electrodes. Normally, the electrodes are placed in physical contact with the skin with some space between each of the electrodes in an electrode pair.

Power and/or information may be transmitted between the portable devices **20**, **22**, **24**, **26**, **28**, **32**, and **30** by using the body **11** as a conductive medium. Communicated signals may include analog as well as digital signals. Analog signals can be particularly useful for communicating.audio information, e.g., to audio playback device **30**. As will be discussed below, audio playback device **30** may be implemented as a piezo electric speaker which can directly convert received audio frequency signal into acoustic audio signals.

As illustrated in FIG. **1**, portable devices implemented in accordance with the present invention can be mounted on the body in a wide range of locations. They can be implemented so as to appear as common objects if desired.

Portable computer device **20** is shown mounted on the waist. The portable computer device **20** can be implemented as a common personal data assistant (PDA) if desired. Pager device **22** is also shown as a waist mounted device. Given the common wearing of pagers on the waist, pager **22** can be designed to appear as an ordinary pager device.

Audio playback device **30** is shown mounted in an ear. Alternatively, it can be mounted on the skin near the ear or on another portion of the body. Thus, audio playback device **30** can be designed to take on the appearance of a modern hearing aid.

Keyboard **24** is shown being mounted on the arm. This position makes it easy to reach by the hand on the other arm. It can also be easily concealed by a shirt cuff or sleeve. Display device **26** is conveniently mounted on the wrist. Display device **26** can be implemented using an LCD and mounted in a housing with a wristband. The housing may be similar in size and shape to common watch housings in use today. In this manner display device **26** can be made to appear as an ordinary watch if desired. Audio input device **28**, which includes, e.g., a microphone, is also implemented as a wrist mounted device in the FIG. **1** embodiment. The audio input device **28** may be implemented as part of, e.g., a bracelet, if desired.

Power supply **32** is shown mounted on foot **13**. The power supply can be mounted in the sole of a pair of shoes or a boot. Accordingly, power supply **32** can also be implemented in an easy to conceal manner. The weight associated with batteries used in a power supply designed to power multiple devices can make the feet or waist good locations for mounting power supply devices. In a foot mounted implementation, a mere change of footwear can serve to replace the power source for the various devices **20**, **22**, **24**, **26**, **28**, **30**.

In accordance with the present invention, the portable devices mounted on a person's body interact to form a complete personal network. Such a network, and the devices which make up the network, will now be discussed in further detail with regard to FIG. **2**.

As illustrated in FIG. **2**, body **11** serves as a bus to couple portable devices **20**, **22**, **24**, **26**, and **30** together. Portable devices, in accordance with the present invention, can transmit and receive power and transmit and receive information, e.g., communications signals. For cost reasons, it may be desirable to implement some devices with a limited subset of these capabilities. For example, it may be cost effective to design an audio device so that it only receives information signals. Alternatively, it may be desirable to implement a device that can draw power from the bus **11** but otherwise not interact with the other devices in the network.

In FIG. **2**, the first through Nth portable devices, e.g., devices **20**, **24**, **26**, each include a communications/power module **21**, **21**', **21**" and device circuitry **23**, **23**', **23**". Communications/power module **21** is responsible for interfacing with other devices in the network **10**, communicating with them, and receiving/sending power over the bus **11**. Device circuitry **23**, **23**', **23**" is circuitry which implements the specific functions the portable devices **20**, **24**, **26** are designed to support. By segmenting the communications/power functions from the other device functions a standard communications/power module can be designed to support many different types of device circuitry. Furthermore, the device circuitry manufacturer can be isolated from issues relating to the design of the communications/power module. A device interface can thus be standardized with the device circuitry manufacturers merely having to comply with the interface requirements without concerning themselves with the manner in which power is ultimately supplied or the manner in which signals are communicated over the bus **11**.

Portable device M **22**, e.g., a pager device, is an example of a device which can be implemented so that it does not support the receipt or transmission of power signals over the network but which includes a communications module **25** for communicating information over the bus **11**. Device circuitry **27** may include a power source, e.g., battery or solar cell, for powering the portable device M.

Portable device Z, e.g., audio output device **30**, is an example of a network device that is capable of receiving signals and using the received signals without a communications/power module. Device circuitry **29** may be a piezo electric speaker with leads coupled directly to the bus **11**. Electrical signals, e.g., audio frequency signals, transmitted over the bus **11** are converted directly into acoustic audio signals by the piezo electric element of speaker **30** without the need for additional interface circuitry. Thus, speaker **30** can be implemented as a very small device, having very little weight. Audio frequency signals may be transmitted to the speaker **30** as analog as opposed to digital signals.

FIG. **3** illustrates a portion **29**, of the system **10**, that includes the portable pager **25** and audio output device **30**. The system portion **29** illustrates how information, e.g., audio signals, can be communicated to an audio playback device **30**, which does not include an internal power source, over the body **11**.

In FIG. **3**, the audio playback device **30** comprises a piezo electric speaker **29**, coupled to bus **11**, via two electrodes **35**, **37**.

The pager device **22** comprises a communications module **25** and device circuitry **27**. The communications model **25** includes a battery **24**, step up converter **26**, and switching oscillator **28**. The battery **24** serves as a power source for the communications module **25**. The battery **24** may be, e.g., a small watch type battery with a relatively low output voltage, e.g., 1–5 volts. Step up converter **26** is used to step up the voltage provided by battery **24** to a level that is high enough to be used to transmit signals over the body **11**. In the illustrated example, a 3V signal is stepped up to 80 volts. The 80 volt signal is supplied to the input of switching oscillator **28**. The switching oscillator **28** outputs, depending on the embodiment, either a square wave signal or sinusoidal signal, having a frequency determined by a frequency control input signal. In the FIG. **3** embodiment, the frequency range of the oscillator **28** corresponds to a part of the audible frequency range. The frequency control input is supplied by pager device circuitry **27**.

The pager device circuitry **27** includes an antenna **32**, a receiver **34**, control logic **22**, a display **38**, memory **40**, and a power source, e.g., battery **41**. In various implementations, the same battery **41** or **24** is used to power both the communications module **25** and device circuitry **27**.

The pager **22** receives messages, e.g., telephone numbers and/or other short text messages via antenna **32**. The signals received by the antenna **32** are filtered and demodulated/decoded by receiver **34**. The messages are then supplied to control logic **22**. Control logic **22** may be implemented, e.g., as a CPU operating under instructions, e.g., control routines, stored in memory **40**. Memory **40** may also include a pager number used to identify messages corresponding to the particular pager device.

When the control logic receives a message which includes the pager number stored in memory **40**, it displays the message, e.g., telephone number, on display **38**. In addition, or alternatively, it sends a signal to switching oscillator **28** causing the oscillator **28** to output one or more audio signals. The audio signals generated by oscillator **28** may simply be a tone indicating the receipt of a message or, alternatively, an audio version of the message. The electrical signals generated by switching oscillator **28** are supplied to the body **11** via output transistors **30**, **31** and electrodes **39**, **41**.

The piezo electric speaker **30** is responsive to electrical signals in part of the audio frequency range. Thus, the electrical audio frequency signals applied to the body **11** via the pager **22** are converted into acoustic signals which a user of the system **10** can hear. Since the electrical audio signals are transmitted via the body to the speaker **29**, the signals cannot be easily intercepted or detected by people or devices located nearby. Furthermore, by mounting the speaker **29** in or near the user's ear, the possibility of acoustic audio signals being overheard is also minimized. Accordingly, the system of the present invention allows a user to receive and hear audio messages in a manner which is difficult to detect by nearby individuals and which therefore can be used even during meetings.

FIG. **4** is a block diagram of the first portable device **20**, wherein the components of the communications power module are shown in detail. As previously discussed, the portable device **20** includes a communications/power module **60** and device circuitry **76**.

The communications/power module includes a transmission module **79**, a receiver module **64**, bus interface circuit **65**, memory **63**, communications/control device logic **66**, device interface **74**, power control circuit **68**, power storage device **72**, and power storage monitoring circuit **70**.

The bus interface **60** is responsible for interfacing between the body **11** that is used as a power and communications bus, and the circuitry of the communications/power module **60**. Accordingly, both power and information signals are transmitted and received through the bus interface **65**. Device interface **74** is responsible for coupling components of the communications/power module to device circuitry **76**. The device interface **74** includes both an information, e.g., communications (COM) interconnect and a power interconnect. Device interface **74** may be standardized, e.g., using a common connector, to allow a plurality of different device circuits **76** to be used with the same device interface **74**.

Communications/control device logic **66** may be implemented using a CPU that executes one or more control routines. The control routines and other data are stored in memory **63** that is coupled to the device logic **66**.

In addition to being coupled to memory **63**, the device logic **66** is coupled to the transmission module **79**. By way of the transmission module **79**, the device logic can transmit signals via the bus **11**. The device logic **11** is also coupled to the receiver module **64**, power control circuit **68**, and the communication port of the device interface **74**. The connection to the receiver module **64** allows the device logic **66** to receive signals from the bus **11**. Such signals may be identification, control signals and/or other information transmitted by another portable device coupled to the bus **11**. The connection to the power control circuit **68** allows the device logic **68** to receive power consumption information, power storage status information, and power requirement information from the power control circuit **68** and to send signals to the power control circuit **68** regarding charging information and power transmission information. For example, the device logic can indicate to the power control circuit the time period during which the power storage device **72** is to be charged from power obtained via the bus **11** and the frequency at which the power signal will be transmitted. Similarly, when being used to supply power to the bus **11**, the control device logic **66** can indicate to the power control circuit **68** the time period in which power is to be supplied to the bus **11** and the frequency of the signal to be used to supply the power.

Through the connection with the device interface **74**, communications/control logic **66** can receive and exchange information and other signals with the device circuitry **76**. Thus, communications/control logic **66** can be used to oversee the exchange of information between device circuitry **76** and other devices coupled to the bus **11**.

The power control unit **68** is coupled to the communications control device logic **66**, power storage monitoring circuit **70**, power storage device **72**, power port of device interface **74**, and control inputs of the transmission module **79** and receiver module **64**.

Power usage and battery status is monitored by the power storage monitoring circuit **70**. Information relating to power usage and battery status is then supplied by the power storage monitoring circuit **70** to the power control circuit **68**. From this information, the power control circuit **68** can determine when the power storage device **72** will need to be recharged and/or when there is sufficient power in the power storage device **72** to power other devices coupled to the bus **11**.

Power control circuit **68** is coupled to power storage device **72**. Thus, power can be supplied from the power storage device **72** to the power control circuit **68**, e.g., for purposes of powering other devices or attached circuitry. In addition, power control circuit **68** can supply power to the power storage device **72**, e.g., to recharge batteries included in the power storage device **72**.

Power control circuit **68** has power outputs coupled to the power terminal of device interface **74** and to a power input of the transmission module **79**. Accordingly, power control circuit **68** can supply power to the device circuitry **76**, coupled to device interface **74** and/or to transmission module **79** for transmission via bus **11** to other devices.

An information and control line **73** couples the communications/control device logic **66** to the power control circuit **68**. Via line **73**, power consumption availability and other power related information can be supplied to the device logic **66**. In addition, communications/control device logic can instruct the power control circuit **68** when, and at what transmission frequency, power is to be supplied to one or more devices coupled to the bus **10**. The communications/control device logic **66** can also instruct the power control circuit **68** when, and at what transmission frequency, power is to be received via the bus **11**, e.g., for purposes of recharging power storage device **72** and/or for powering device circuitry **76**.

Power control circuit **68** has a receiver control signal output coupled to the receiver module for transmitting a control signal used to indicate the frequency at which power is to be supplied to the portable device **20** via bus **11**. Power control circuit **68** also has a power transmission control signal output, coupled via bus **67**, to the transmission module for transmitting a frequency control signal used to indicate the frequency at which power is to be supplied to one or more portable devices coupled to the bus **11**.

Transmission module **79** comprises a communications transmission circuit **80** and a power transmission module **82**. The power transmission module **82** is a signal generator circuit capable of producing one or more power supply signals of different frequencies with signals of different frequencies being used to supply power to different devices coupled to the bus **11** during the same or different time periods. In order to generate the power supply signals, the power transmission module includes one or more controllable oscillators **86**. Each oscillator **86** is responsive to the frequency control signal supplied by the power control circuit **68** to generate a signal have a frequency specified by the control signal. Power is supplied to an input of the controllable oscillator **86** is by the power control circuit **68** via bus **75**. The input voltage to OSC **86** may be a DC voltage in the range of, e.g., 3–200 volts. While relatively high voltages can be safe assuming low currents, they can be felt by the user of the system. Accordingly, in order to minimize the sensation resulting form the transmission of signals over the body, power supply and communication signals may be limited to under 100 volts. The oscillator **86** generates either a pulsed DC signal or an AC signal having a frequency determined by the received frequency control signal.

In the case of a pulsed DC signal, power control circuit **68** can also supply a period duration signal indicating the duration of a pulse is to be asserted, e.g., "on", during the signal period determined by the frequency control signal. Thus, pulse duration, e.g., duty cycle, can be used to finely adjust the amount of power supplied to a device coupled to the bus **11**, while the frequency of the power signal can be used to control which device or devices will be supplied with power during a given time period. The power signal generated by the oscillator **86** is supplied to a first input of the modulator **84**.

Communications transmission circuit **80** receives from the communications/control device logic information to be transmitted to other devices coupled to the bus **11**. The information may include, e.g., power supply information, initialization information, and/or information to be used by device circuitry included in one or more devices on the bus **11**. The communications transmission circuit **80** places the information to be transmitted into a format that is used for transmission of data over the bus **11**. The formatted information is then supplied to a second signal input of modulator **84**. Modulator **84** modulates the information to be transmitted onto the power transmission signal output by the power transmission module **82**. In the event that a power transmission signal is not being supplied to the bus, or as an alternative to modulating the information signal on the power signal, the information signal output by the communications transmission circuit may be supplied directly to bus **11**.

Any one of a plurality of known modulation techniques may be used for this purpose. For example, frequency modulation (FM) or amplitude modulation (AM) may be used by the modulator **84**. The modulated signal, which includes the information to be transmitted, generated by the modulator **84**, is supplied to the bus **11** via bus interface **65**.

Initialization information, transmitted by the transmission module **79**, may include device identification information, power requirement information, power supply capability information, and other device capability information. Control signals may be exchanged between devices on the bus **11** whenever a device is added to the bus **11**, e.g., placed on the body, and periodically thereafter to determine when a device has been removed from the bus **11**. As part of the device initialization process, a master/slave relationship is set up between devices on the bus **11** with, e.g., one of the devices acting as the bus and power control master. In one embodiment, the first device added to the bus **11** with the communications/power module **60** required servers as the master with later added devices acting as slaves. With the removal of the master device from the bus **11**, the devices remaining on the bus repeat the initialization process and select another device to serve as the master.

Assuming at least one power source is present at any given time or the devices have sufficient stored power to operate without power from the bus **11**, devices can be added and removed from the bus **11** periodically without an interruption in device operation. Thus, new power sources can be added to replace existing power sources without any interruption in the services being provided by the devices coupled to the bus **11**.

Power and information reception by the communications/power module **60** will now be described. The receiver module **64** includes a communications reception circuit **90**, and a power reception module **91**. The communications reception circuit **90** is a demodulator circuit, which demodulates the signal received from the bus **11** to produce the transmitted information signal. The information signal generated by communications reception circuit **90** is supplied to communications/control device **66** which can identify, e.g., based on device identification information included in the information signal, information directed to the portable device **20**.

Power reception module **91** includes a controllable filter circuit **94**. The controllable filter circuit **94** may be implemented as a pass band filter which can be set to pass the frequency used to supply power to the portable device **20** while rejecting other frequencies. The filter **94** is responsive to a power reception frequency control generated by the power control circuit **68**. By setting different devices to receive power at different frequencies, different devices can be powered at the same time over the bus **11** via one or more power supply signals of different frequencies. Accordingly, multiple power supply devices and power sinks can be coupled to the bus **11** at the same time with power being supplied and received in a selective manner as a function of the frequency of the signals used to transmit the power.

FIG. **5** illustrates the memory **63** of the device **20** in greater detail. As illustrated the memory includes control routines **102**, and a set of data **103** indicating the capabilities and power requirements of various devices that may be coupled together by the bus **11**. In the data set **103**, each row corresponds to a different device. The device is identified in the first column **104** of each row by a unique device identifier. In the illustrated example, the device code is a two digit number. In the second column **106**, a circuitry code is stored indicating the type of device circuitry **60** included in the particular device identified in the first column. In the third column **108** device power requirement information is stored. The stored information includes, e.g., the power required by the device and the frequencies of a power supply signal which may be used to supply the power to the device using the body as a bus. The forth row **110** indicates the power requirements of the circuitry **60** included in the particular device. This number will normally be lower than the total device power requirements listed in column **8**. The fifth column **112** includes information on the ability of the device identified in the first column to supply power to other devices coupled to the bus **11**. As illustrated, some devices do not support the ability to supply power supply capability. For those devices that can supply power to other devices, the total amount of power available for use is listed and the frequencies of the power supply signals which can be generated by the device are listed. The last column **114** of the data **103** lists the particular features/capabilities of the device identified in column **1**. For example, device identified by code **11** has a piezo electric speaker while device XX listed in the last row of has a microphone, processor, display and keyboard.

The device power and capabilities information can be used by the communications/control device logic **66**, when operating as a master, to determine how best to supply the various devices coupled to the bus **11** with power. The use of device codes and look-up table information minimizes the amount of initialization and device identification/power requirement information that must be exchanged between the devices coupled to the bus **11**.

As discussed above, in one embodiment, the device that is coupled to the bus first serves as a master device with the later added devices serving as slaves. When a master device leaves the network, e.g., is removed from the body, another one of the devices takes over as the master insuring orderly distribution of power and communication signals.

FIG. **6** illustrates exemplary device circuitry **76** of the portable device **20** in detail. The device circuitry **76** represents circuitry used to implement a portable computer system or PDA.

With reference to FIG. **6**, it can be seen that exemplary device circuitry **76** includes a processing unit **121**, a system memory **122**, and a system bus **123** that couples various system components including the system memory **122** to the processing unit **121**. The system bus **123** may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system bus **123** is used for distributing both information and data, e.g., using one or more separate lines. The system bus **123** is coupled to device interface **74** allowing the device circuitry **76** to receive power from and communicate with communications/power module **60**.

The system memory may include read only memory (ROM) **124** and/or random access memory (RAM) **125**. A basic input/output system **126** (BIOS), containing basic routines that help to transfer information between elements within the personal computer **120**, such as during start-up, may be stored in ROM **124**. The device circuitry **76** may also include a hard disk drive **127** for reading from and writing to a hard disk (not shown), a magnetic disk drive **128** for reading from or writing to a (e.g., removable) magnetic disk **129**, and an (magneto) optical disk drive **130** for reading from or writing to a removable (magneto) optical disk **131** such as a compact disk or other (magneto) optical media. The hard disk drive **127**, magnetic disk drive **128**, and (magneto) optical disk drive **130**, may be coupled with the system bus **123** by a hard disk drive interface **132**, a magnetic disk drive interface **133**, and a (magneto) optical drive interface **134**, respectively. The drives and their associated storage media provide nonvolatile storage of machine-readable instructions, data structures, program modules and other data for the personal computer **120**. Although the exemplary environment described herein employs a hard disk, a removable magnetic disk **129** and a removable (magneto) optical disk **131**, those skilled in the art will appreciate that other types of storage media, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, random access memories (RAMs), read only memories (ROM), and the like, may be used instead of, or in addition to, the storage devices introduced above.

A number of program modules may be stored on the hard disk **127**, magnetic disk **129**, (magneto) optical disk **131**, ROM **124** or RAM **125**, such as an operating system **135**, one (1) or more application programs **136**, other program modules **137**, and/or program data **138** for example.

A user may enter commands and information into the device circuitry **76** through input devices, such as a keyboard **140** and pointing device **142** for example. Other input devices (not shown) such as a microphone, joystick, game pad, satellite dish, scanner, or the like may also be included. These and other input devices are often connected to the processing unit **121** through a serial port interface **146** coupled to the system bus. However, input devices may be connected by other interfaces, such as a parallel port, a game port or a universal serial bus (USB) or, in accordance with the present invention, through communications/power module **60** which is coupled to various devices via bus **11**. A monitor **147** or other type of display device may also be connected to the system bus **123** via an interface, such as a video adapter **148** for example. In addition to the monitor, the device circuitry may include other peripheral output devices (not shown), such as speakers and printers for example.

The circuitry **76** is designed to operate in a networked environment that defines logical connections to one (1) or more remote devices, such as remote devices **24**, **26**, **27**, **30**. In a networked environment, at least some of the program modules depicted relative to the device circuitry **76** may be stored in a remote memory storage device. The network connections shown are exemplary and other means, e.g., modems, of establishing a communications link between the device circuitry **76** and other devices may also be employed.

While the above system has been described as a network of devices coupled to a single body it is to be recognized that the network can be extended by connecting multiple bodies through physical contact, e.g., touching hands as part of a handshake. When two or more bodies are connected physically, the linked bodies form one large bus over which power and/or communications signals can be transmitted.

In addition, the physical resistance offered by the human body can be used in implementing a keypad or other input device as well as estimating distances between devices and device locations. In accordance with the present invention, by varying the distance on the skin between the contacts corresponding to different keys, different signal values can be generated representing different inputs.

The relative distances between devices coupled to a body can be estimated based on the strength of a device's transmit signals as compare to the strength of the receive signals detected by a device. If the location of the master device is known, then the master can estimate the location of peripherals on the body. This information is used in accordance with various embodiments of the present invention by the communications/control device logic when controlling the power of broadcasted signals. Broadcast signal power is reduced when the device to which the signal is being transmitted is in close proximity to the broadcasting signal source and increased when the device is relatively distant from the broadcasting signal source. Thus power usage can be optimized to minimize wastage. In one particular embodiment, the voltage of a signal transmitted by a first device and received by a second device over a body is measured by the second device to determine the strength of the received signal. The output voltage and/or duty cycle of signals transmitted from the second device to the first device are then adjusted as a function of the measured signal voltage. The power control circuit **68** of a portable device is used to perform the received signal voltage measurement and to control the output voltage/duty cycle control operation. To perform these function the control circuit **68** may include voltage measurement circuitry, e.g., volt meter, and control logic. Normally a low measured voltage, indicative of a relatively large distance between the first and second devices, will result in the second device transmitting a signal to the first device with a higher output voltage or duty cycle than when a higher voltage is measured in regard to a signal received from the first device.

In accordance with another feature of the present invention, devices can initialize differently depending on location. For example, a speaker located near the ear can convey its location so that it will be supplied with less power than a speaker further away from the ear, e.g., a speaker located on the waist or arm. Accordingly, the transmission of device location information as part of a device initialization process that occurs after a device is placed on the body is contemplated and implemented in various exemplary embodiments.

Various exemplary embodiments have been described above. In view of the description provided above, various modifications will be apparent to those skilled in the art without deviating from the inventive teachings described and claimed herein. For example, it will be apparent that the body may be that of a wide variety of living animals and need not be limited to being a body of a human being.

What is claimed is:

1. A network of devices comprising:

a first device for generating a first electrical signal;

a second device including first circuitry requiring an electrical signal from an external source to operate, wherein the second device generates initialization information including at least power requirement information; and a body of a living creature for coupling the first device to the second device and for conducting the electrical signal from the first device to the second device and the initialization information from the second device to the first device, wherein the first and second devices establish a master and a slave relationship there between.

2. The network of claim **1**, wherein the first device further comprises:

a first signal generator coupled to the human body for generating the first electrical signal, the first electrical signal having a first frequency.

3. The network of claim **2**,

wherein the first frequency is an audible frequency; and

wherein the first circuitry is a piezo electric speaker which is powered by said first electrical signal.

4. The network of claim **3**, wherein the first signal is an analog signal.

5. The network of claim **3**, wherein the first signal is a digital signal.

6. The network of claim **1**,

wherein the first device includes a signal generator for generating the first electrical signal, the first electrical signal having a first frequency; and

wherein the second device includes a first passband filter for passing signals in a first frequency range including the first frequency and for blocking signals outside the first frequency range.

7. The network of claim **6**,

wherein the second device further includes a power storage device coupled to the passband filter, for storing power from the first electrical signal.

8. The network of claim **6**,

wherein said signal generator is capable of generating signals of different frequencies.

9. The network of claim **8**, further comprising a third device coupled to said body, the third device including a second passband filter, for passing signals in a second frequency range which includes a second frequency, and for blocking signals of said first frequency.

10. The network of claim **9**, wherein the first device further includes:

control circuitry for controlling the signal generator to generate the first electrical signal having said first frequency during a first period of time and to generate a second electrical signal having the second frequency during a second period of time.

11. The network of claim **10**, wherein the first and second periods of time are different periods of time.

12. The network of claim **10**, wherein the first and second periods of time correspond to overlapping periods of time.

13. The network of claim **10**, wherein the third device further includes a second power storage device coupled to the second passband filter for storing power from the second electrical signal.

14. The network of claim **8**, wherein the first device further includes:

a modulator for modulating information on said first electrical signal.

15. The network of claim **14**, wherein the second device further includes:

transmitter circuitry for transmitting information to the first device over said body.

16. A network device, comprising

power storage device;

a signal generator, coupled to the power storage device, for generating an electrical signal having any one of a plurality of frequencies;

electrodes for coupling the signal generator to a body of a living creature; and

a control circuit for controlling the signal generator to generate a signal as a function of the power requirements of at least one device coupled to said body.

17. The network device of claim **16**, wherein the control circuit controls the frequency of the signal being generated by the signal generator.

18. The network device of claim **17**, wherein the control circuit further controls the duty cycle of the signal being generated by the signal generator.

19. The network device of claim **16**, further comprising:

a communications circuit for generating a communications signal for communicating information to the first device over the body.

20. The network device of claim **19**, further comprising:

a modulator for modulating the communications signal on the electrical signal generated by the signal generator.

21. The network device of claim **16**, wherein the signal generator includes means for generating a plurality of signals having different frequencies at the same time.

22. The network device of claim **20**, wherein the control circuit includes means for controlling the frequency of the signals generated by the signal generator so that at least some of the plurality of generated signals have different frequencies corresponding to the frequencies at which power is supplied to different devices coupled to the body.

23. The network device of claim **22**, further comprising:

a data storage device for storing information on the power requirements of multiple devices which can be coupled to the body.

24. The network device of claim **23**, wherein the stored information includes the frequency of signals which can be used to supply power to the devices over the body.

25. The network device of claim **23**, wherein the stored information includes device power consumption information.

26. The network device of claim **16**, further comprising:

a receiver circuit for receiving a signal transmitted using said body as a conductor; and

means for recharging the power storage device from energy included in the signal transmitted using said body.

27. The network device of claim **16**, wherein the control circuit includes:

means for measuring the voltage of a signal received from said at least one device; and

means for adjusting at least one of a voltage or duty cycle of the electrical signal as a function of a voltage measurement of said received signal.

28. A device comprising:

a receiver circuit;

electrodes for coupling the receiver circuit to the body of a living creature;

a power storage device coupled to the receiver circuit, for storing power included in a signal received from said body;

a power storage monitoring circuit coupled to the power storage device; and

means for transmitting information regarding device power requirements using said body as a transmission medium.

29. The device of claim **28**, wherein the power storage device includes a battery.

30. The device of claim **28**, wherein the receiver circuit includes a fitter for passing signals having a frequency

within a first frequency range and rejecting signals having a frequency in a second frequency range.

31. The device of claim **30**, further comprising:

a signal generator for generating a power supply signal; and

means for supplying said power supply signal to said body.

32. The device of claim **28**, further comprising:

a signal generator for generating a power supply signal; and

means for supplying said power supply signal to said body.

33. The device of claim **32**, further comprising:

a modulator coupled to said signal generator for modulating an information signal on said power supply signal.

34. The device of claim **33**, further comprising:

memory for storing information on power requirements of a plurality of devices which may be coupled to said body.

35. The device of claim **32**, wherein said signal generator generates a pulsed direct current signal.

36. The device of claim **32**, further comprising:

a control circuit for controlling the frequency of the power supply signal generated by the signal generator.

37. The device of claim **36**, wherein the signal generator includes a controllable oscillator.

38. A method of powering a device, comprising:

placing the device in contact with a body of a living creature;

operating the device to receive a power supply signal transmitted using said body as a transmission medium;

operating the device to charge a power storage device included in said device from power included in the received power supply signal;

monitoring the status of the power storage device; and

transmitting a signal including power information using said body as a transmission medium.

39. The method of claim **38**, further comprising:

operating the device from the power included in the received power supply signal.

40. The method of claim **39**, further comprising:

periodically transmitting device status information using said body as a transmission medium.

41. The method of claim **40**, further comprising:

establishing a master/slave control relationship with another device coupled to said body through the use of signals transmitted using said body as a transmission medium.

42. A method of transmitting information to a device coupled to a body of a living creature, comprising:

generating an audio signal;

applying said audio signal to the human body; and

operating the device coupled to said body to receive the audio signal.

43. The method of claim **42**, further comprising:

supplying the received audio signal to a speaker.

44. The method of claim **43**, the speaker is a piezo electric speaker placed in close proximity to an ear.

45. A digital data storage media, comprising:

computer executable instructions for controlling a device including a processor to perform the steps recited in claim **42**.

46. A method of operating a network using a body of a living creature as a bus, comprising:

placing a plurality of devices on said body;

operating a first one of the devices to transmit power to a second one of the devices using the body as a conductive medium;

using the power transmitted to the second one of the devices to power the second device; and,

establishing a master/slave relationship between a first device placed on said body and devices subsequently placed on said body, the first device placed on said body acting as a bus master.

47. The method of claim **46**, further comprising the step of:

transmitting information signals, in addition to said power signal, between the first and second devices using the body as a conductive medium.

48. The method claim **46**, further comprising:

modulating an information signal transmitted from the first device to the second device on the power signal transmitted by the first device to the second device.

49. The method of claim **48**, further comprising:

transmitting an additional power signal from the first device to a third device coupled to said body, the additional power signal being transmitted at a different frequency than said power signal transmitted from the first device to the second device.

50. A method of transmitting signals between first and second devices coupled to the body of a living creature, comprising:

measuring the voltage of a first electrical signal transmitted from the first device to the second device;

operating the second device to generate a second electrical signal having a voltage or duty cycle which is controlled by the second device as a function of the measured voltage; and

operating the second device to transmit the generated signal to the first device.

51. The method of claim **50**, wherein the second device controls the voltage of the second signal to be inversely proportional to the measured voltage.

52. The method **50**, wherein the second device controls the voltage of the second signal to be higher when the measured voltage is a first value and to be lower when the measured voltage is a second value, the second value being greater than the first value.

53. The method **50**, wherein the second device controls the duty cycle of the second signal to be longer when the measured voltage is a first value and to be shorter when the measured voltage is a second value, the second value being greater than the first value.

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