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(54) IMPLANTABLE MEDICAL DEVICE WITH SENSOR

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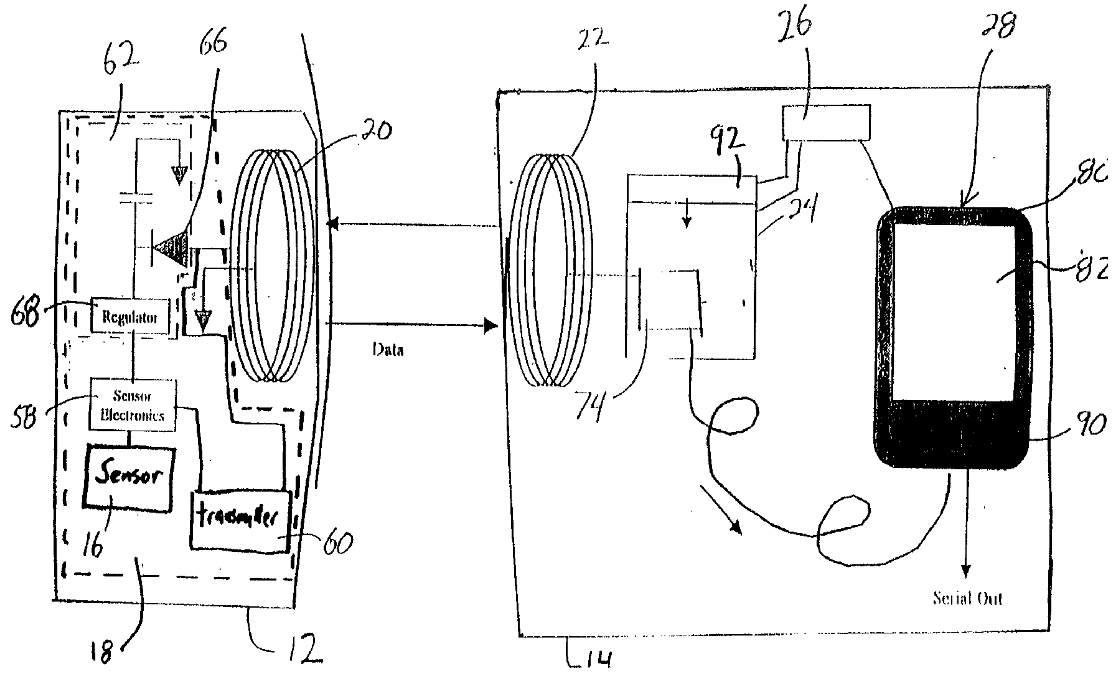
(52) U.S. Cl. **600/300**; 128/903

(57) **ABSTRACT**

A device and method for measuring and communicating parameters of a brain, tissue or other organs is disclosed. The invention includes a sensor to sense the parameter of interest and then communicate the sensed parameter to an activation system. The activation system may cause the parameter to be displayed, processed or cause action to be taken. The activation system may be entirely or partially implanted or entirely external to the patient.



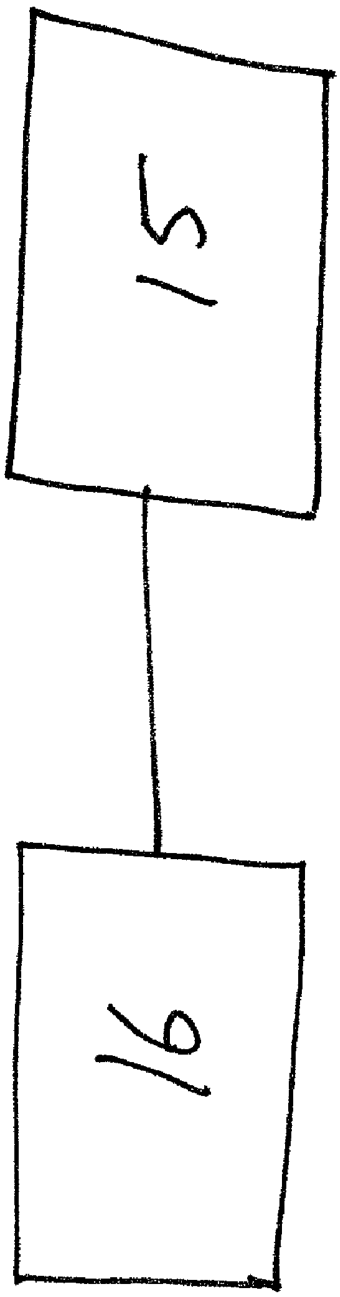


Fig. 1

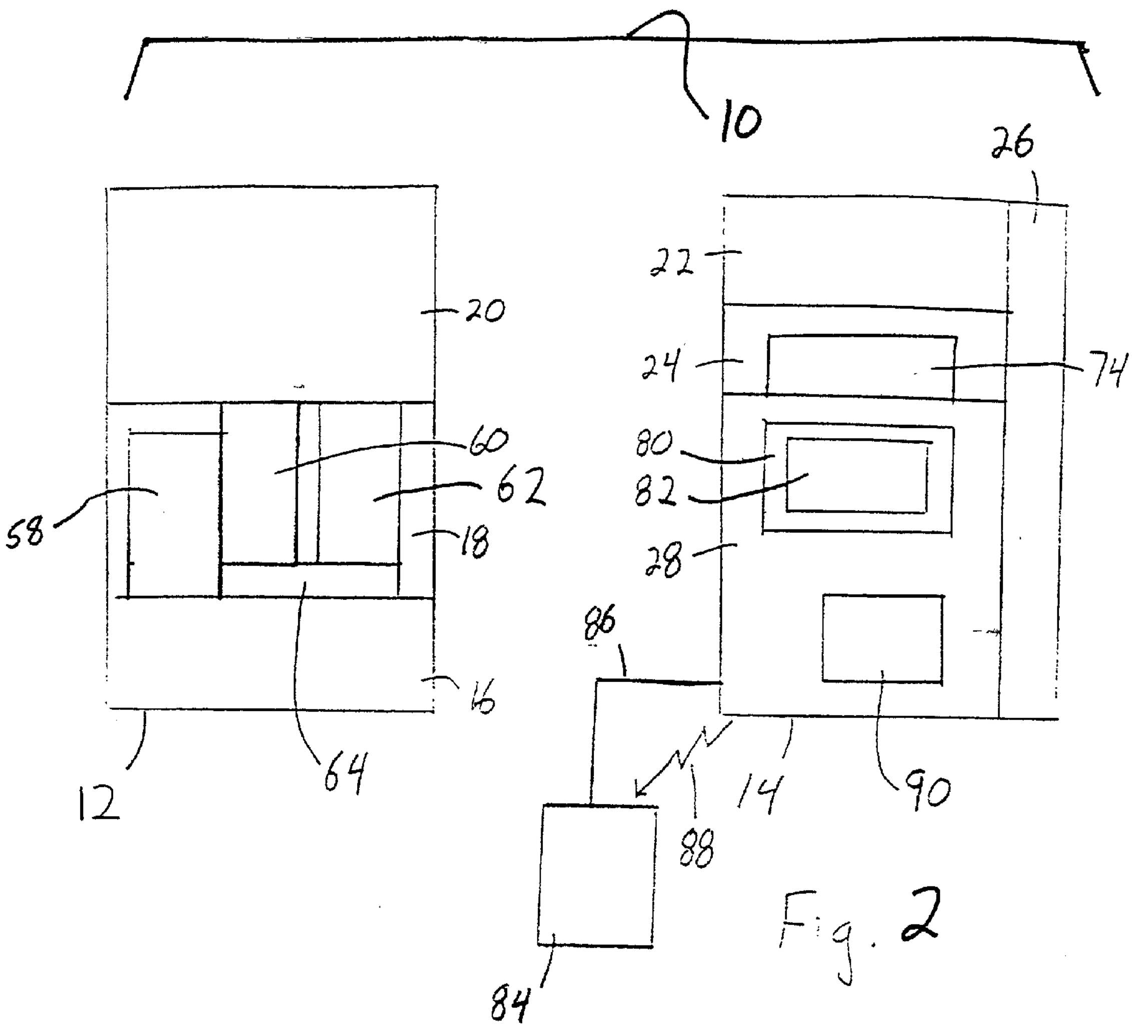


Fig. 2

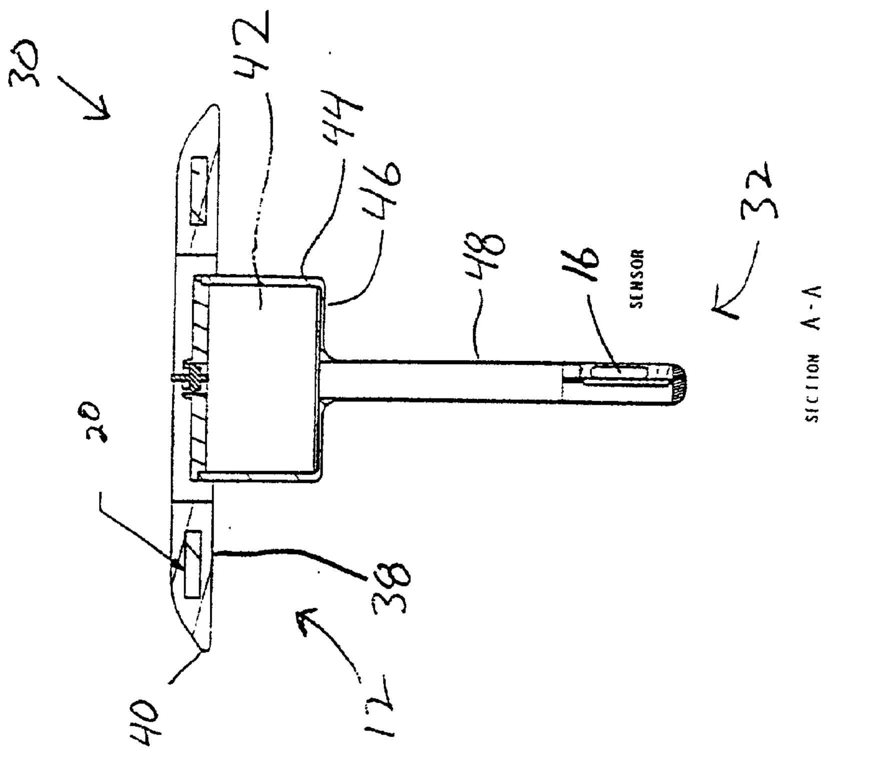

30
42
44
46
20
48
16
SENSOR
32
SECTION A-A
38
40
12

Fig 4

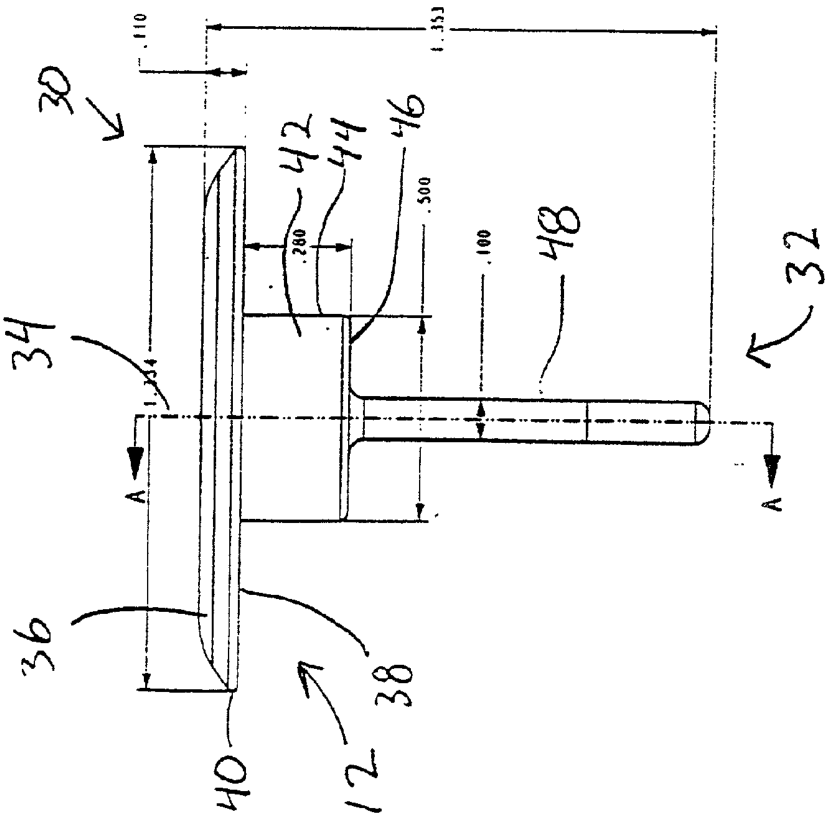
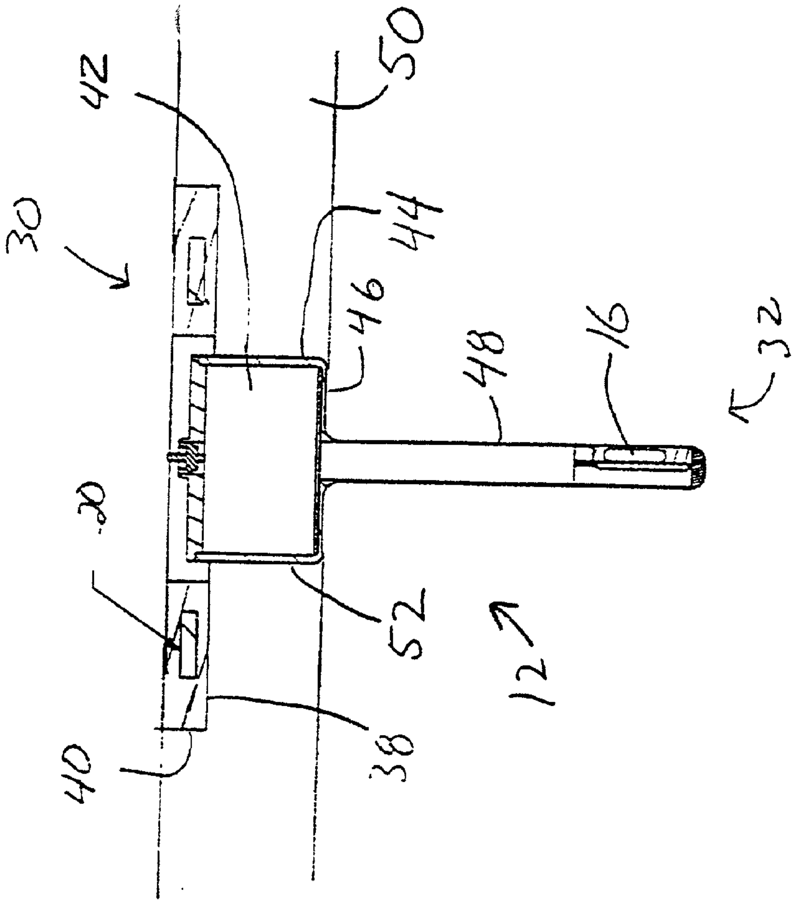

.110
1.353
30
42
44
46
.280
.500
.100
48
34
A
A
32
36
38
40
12

Fig 3



30
42
50
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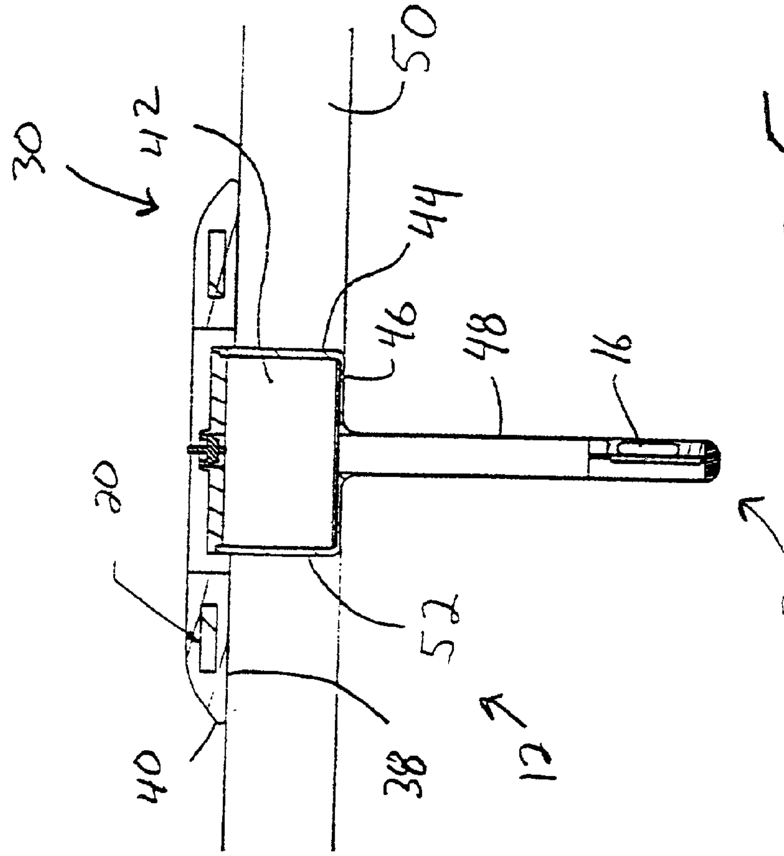
46
48
16
32
20
52
12
40
38

Fig 6



30
42
50
44
46
48
16
32
20
52
12
40
38

Fig. 5

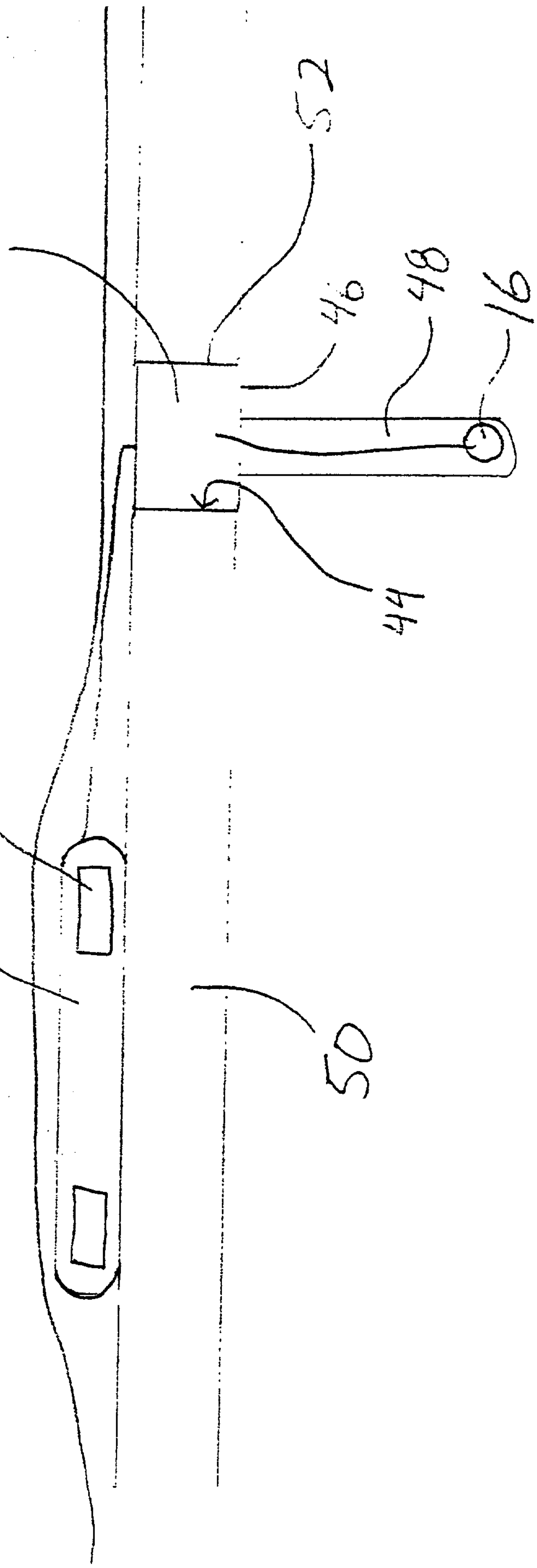
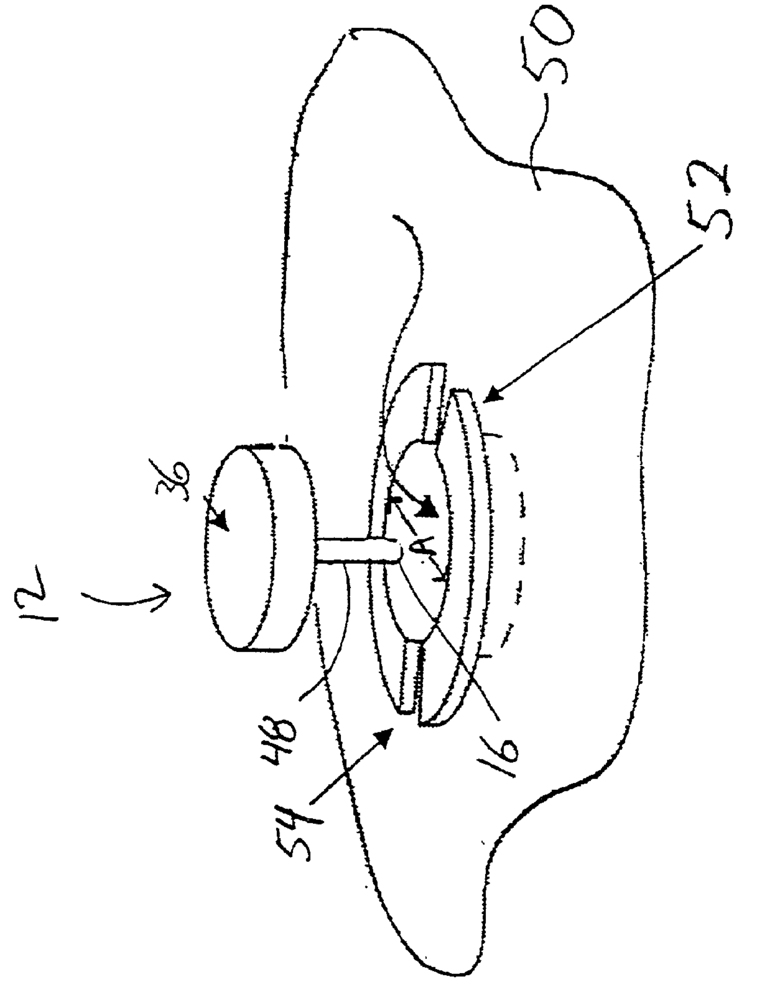


Fig. 7

Fig. 8



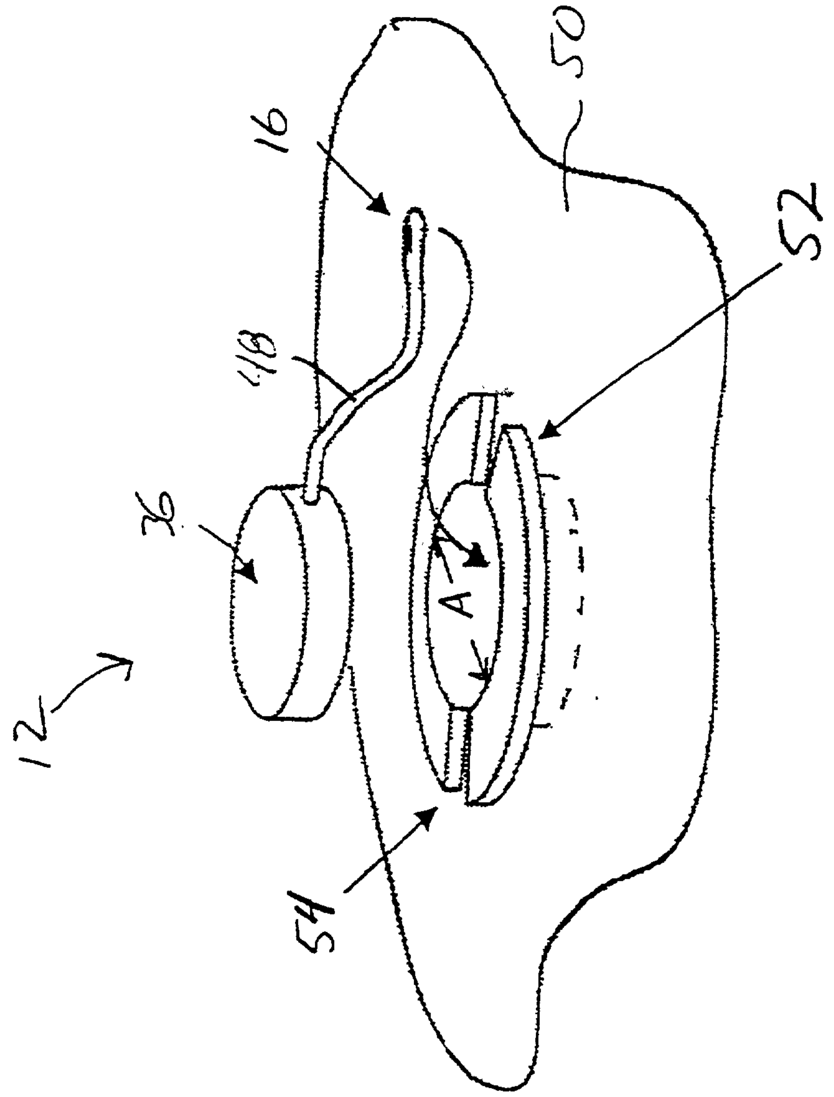


Fig. 9

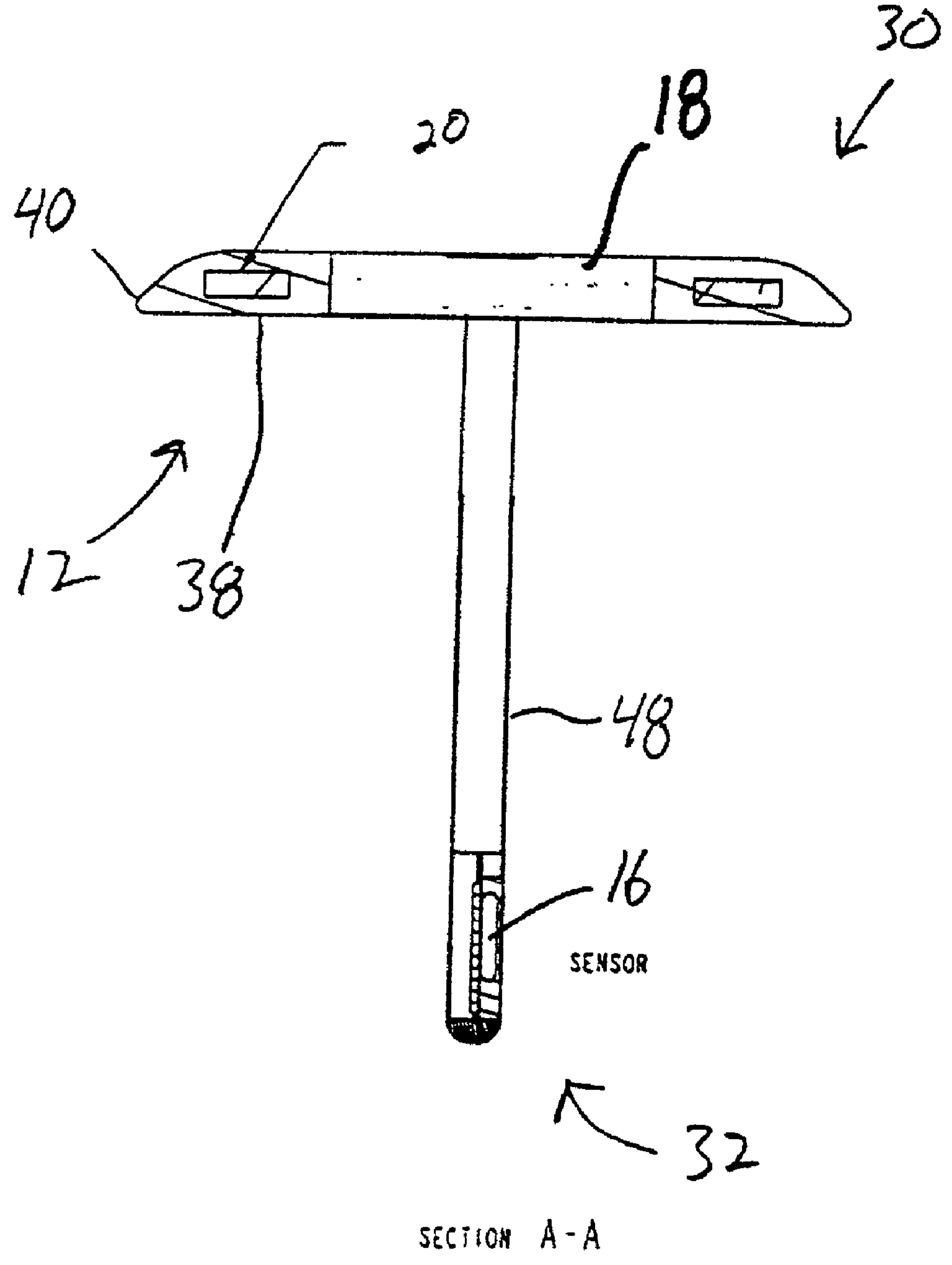


Fig. 10

Fig. 11

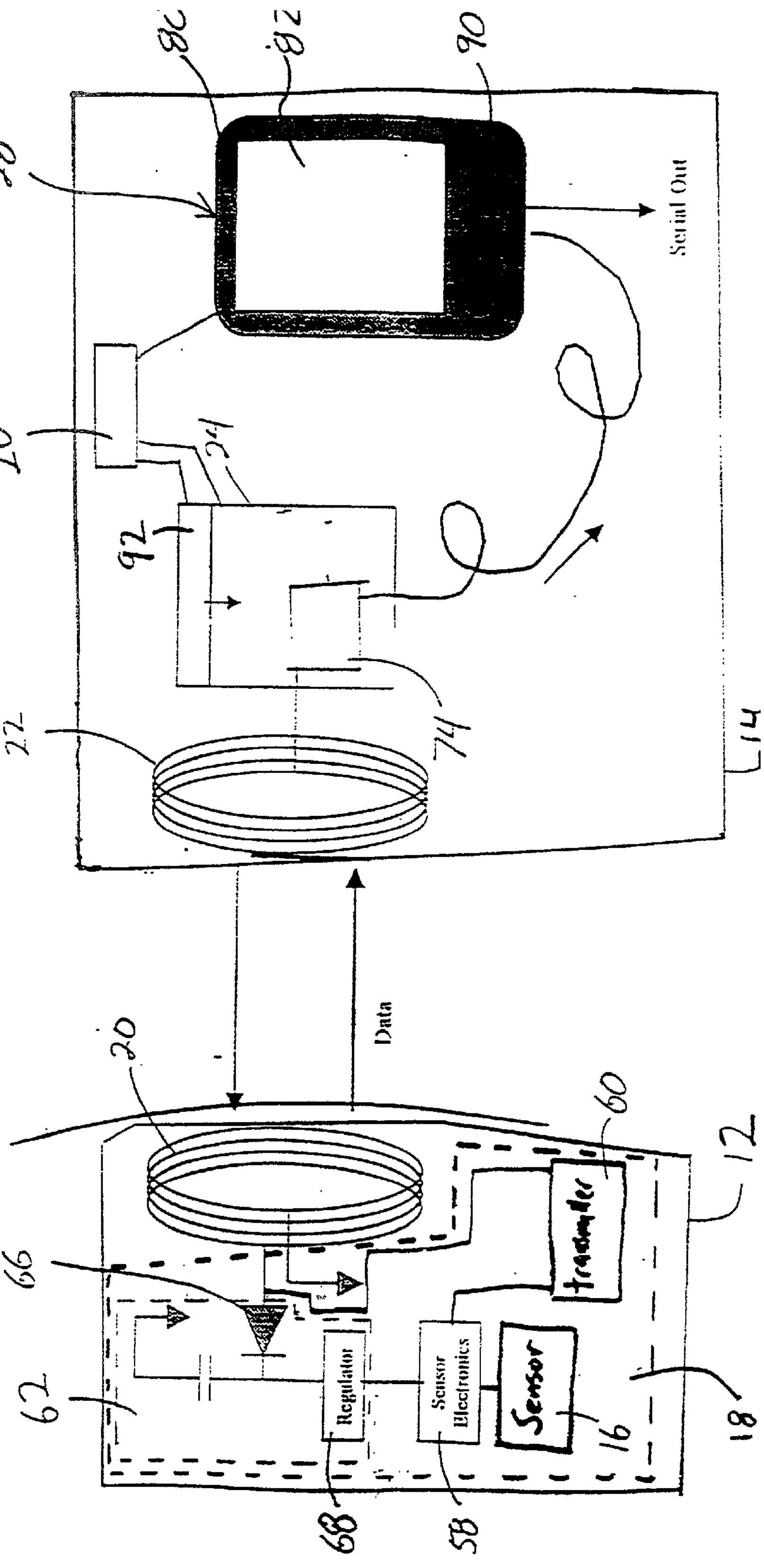
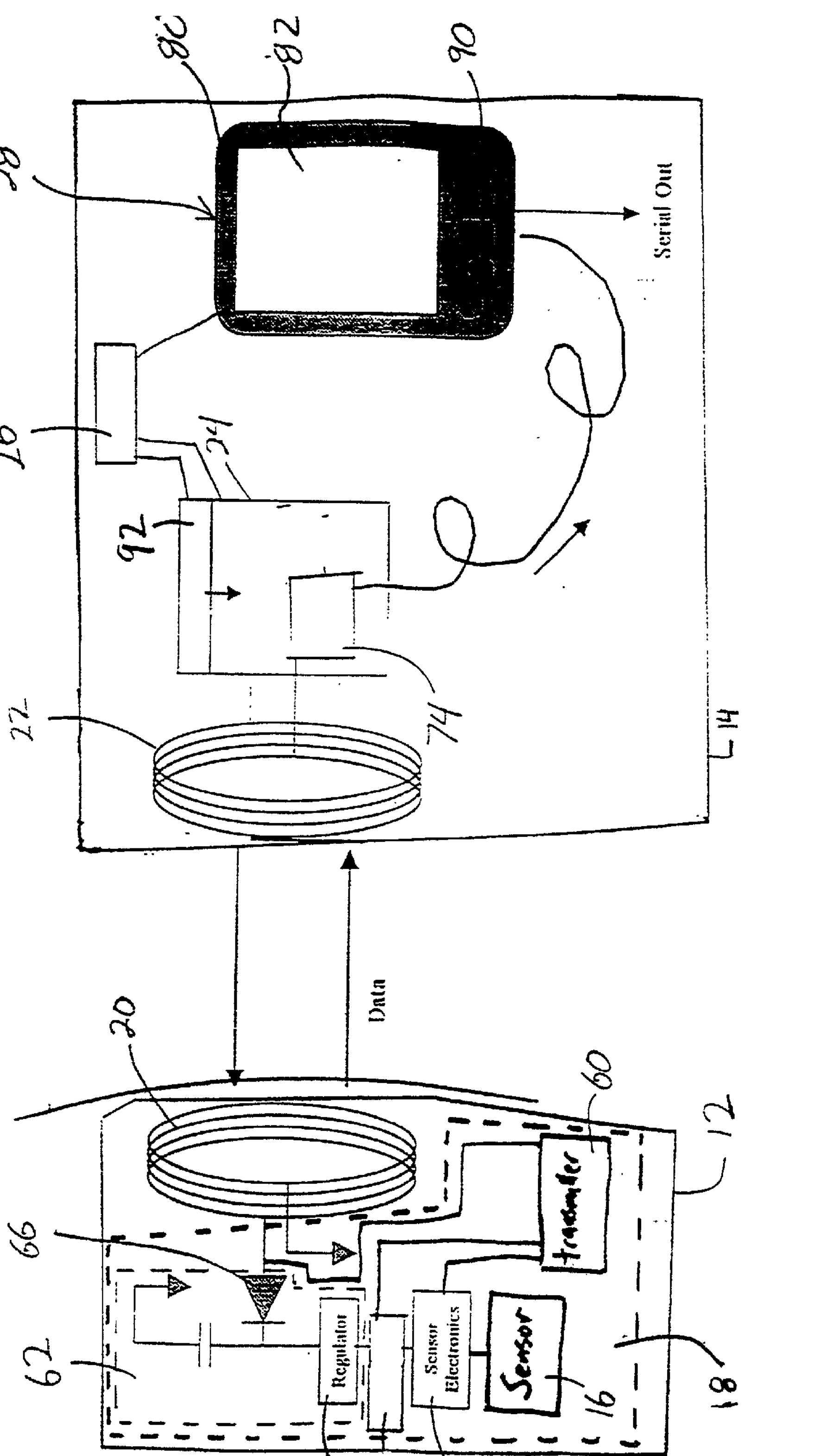

28
80
82
90
26
24
92
74
22
14
Serial Out
Data
20
60
12
66
62
68
58
16
18
Regulator
Sensor Electronics
Sensor
transmitter

Fig. 12


28
82
90
Serial Out
26
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74
22
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Data
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60
12
66
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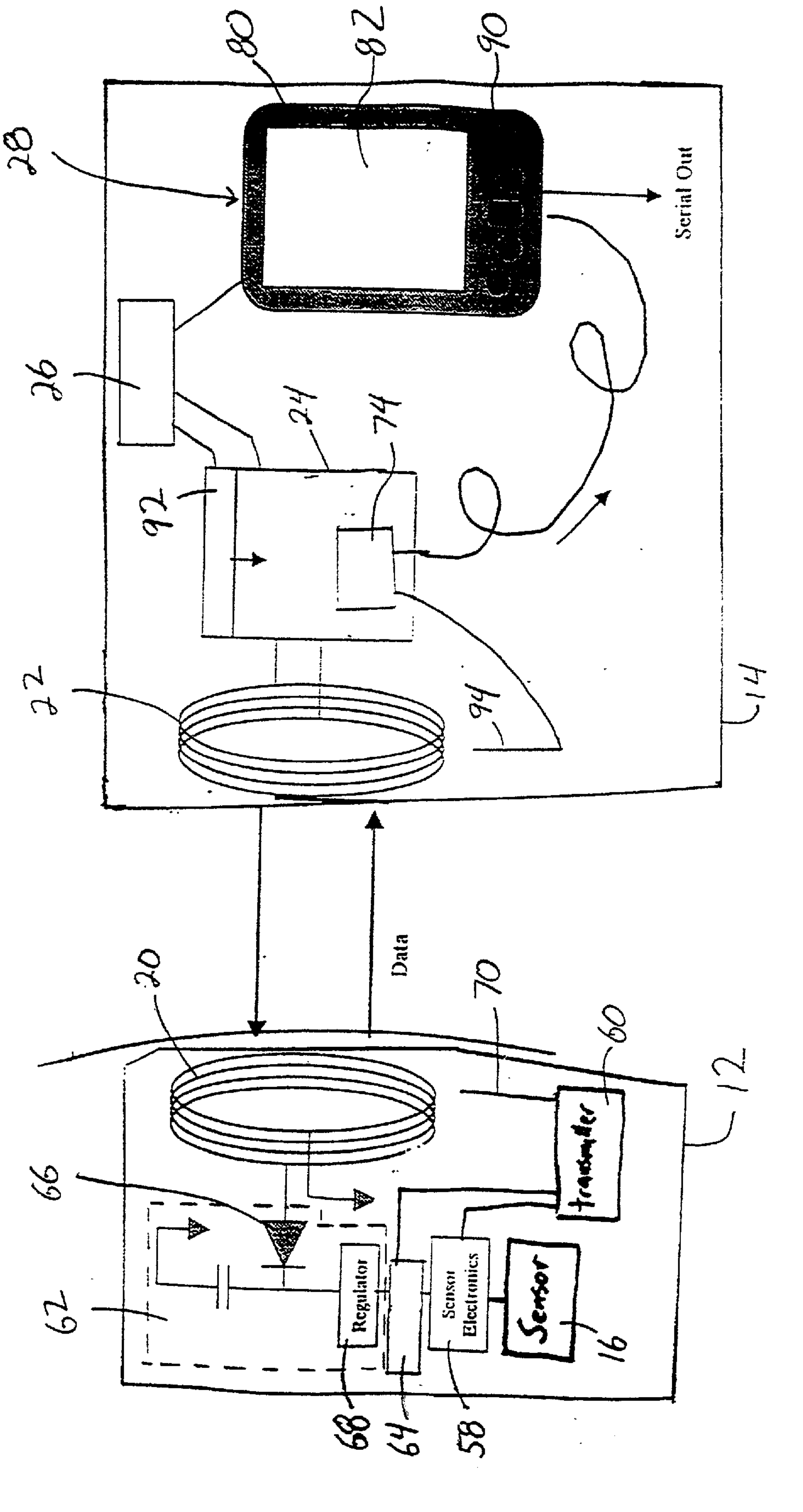
Regulator
Sensor Electronics
Sensor
transmitter
16
18
68
64
58

Fig. 13


80
82
90
28
Serial Out
26
24
74
92
22
94
14
Data
20
70
60
12
transmitter
66
62
Regulator
Sensor Electronics
Sensor
16
68
64
58

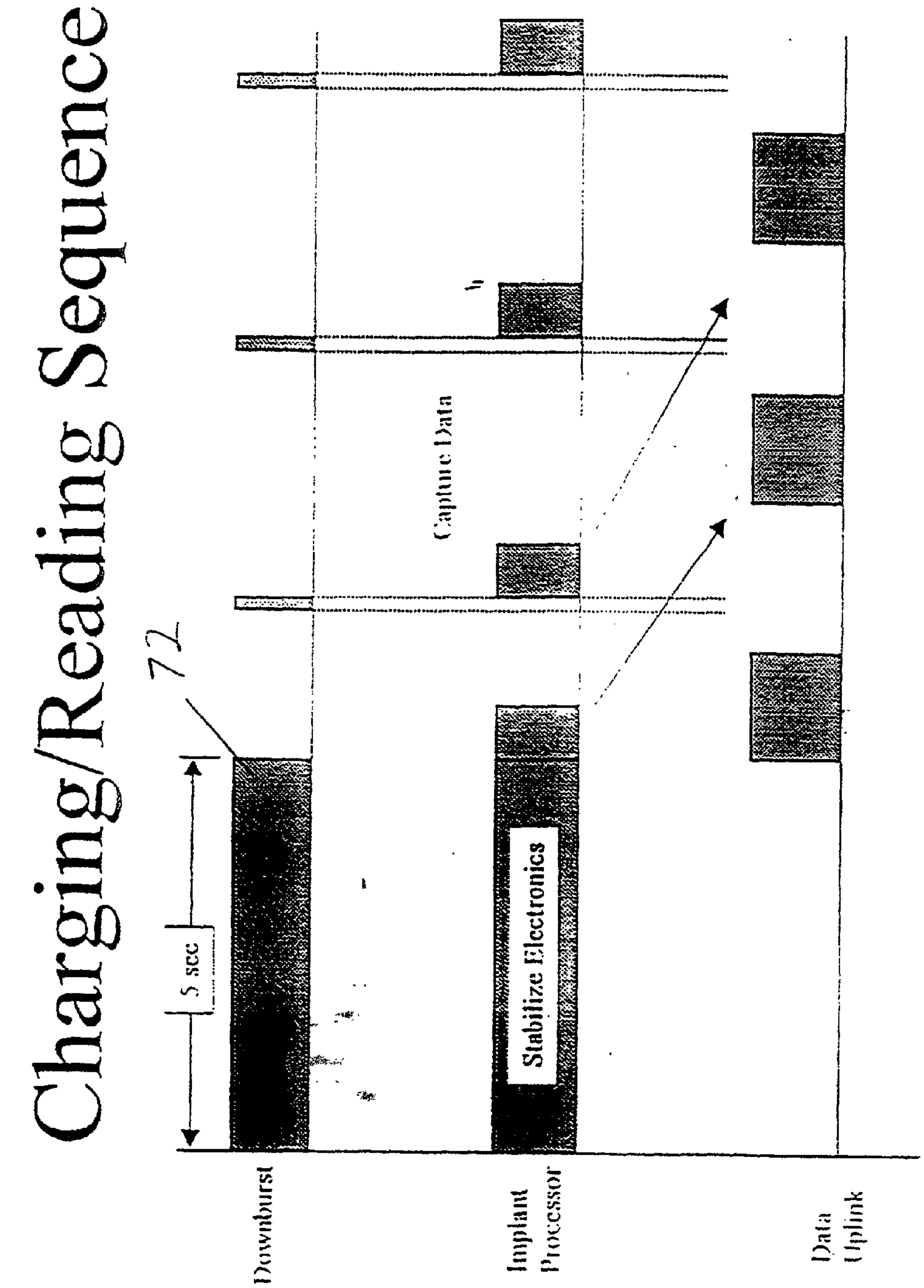
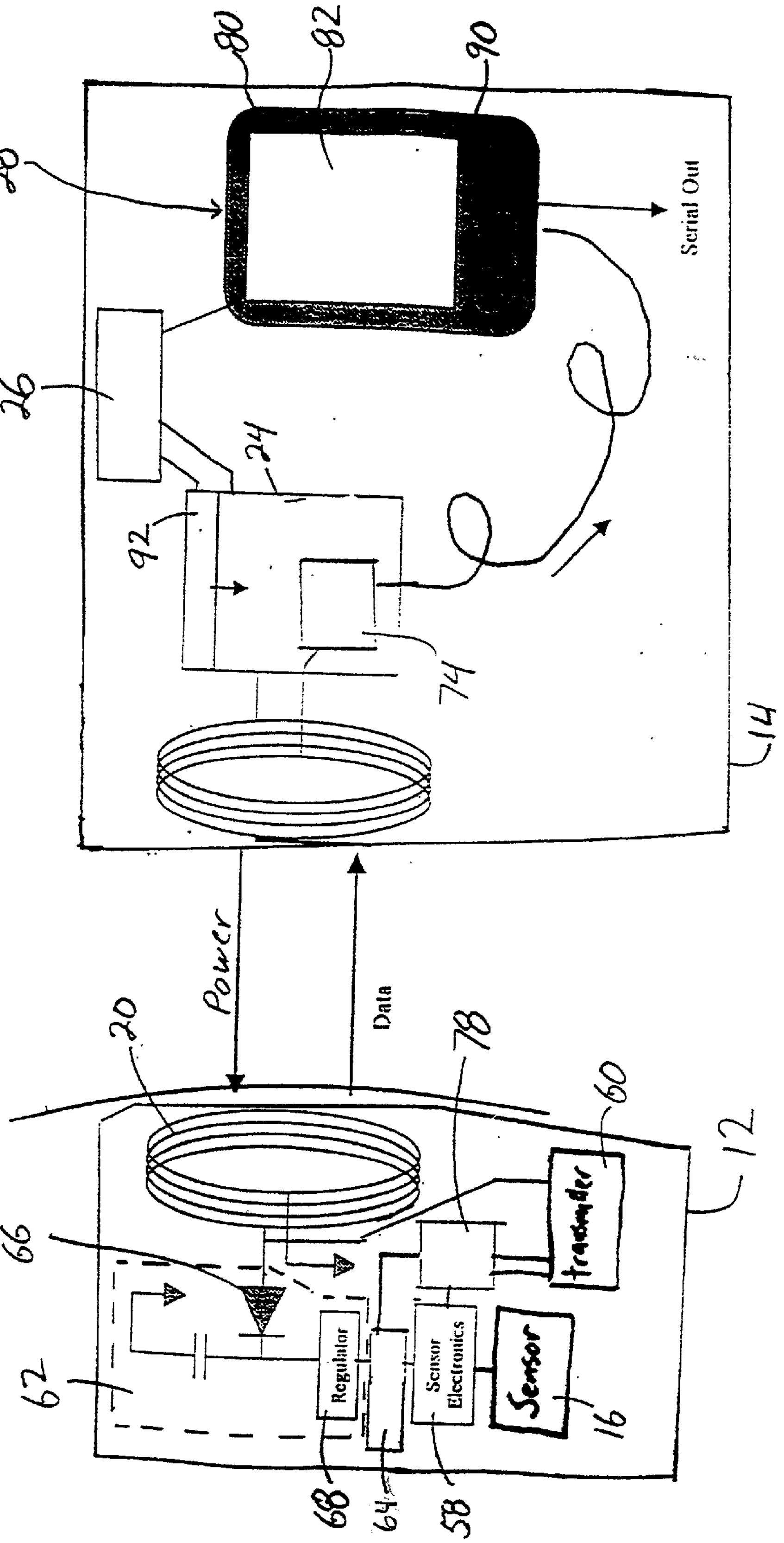

Charging/Reading Sequence
72
5 sec
Stabilize Electronics
Capture Data
Downburst
Implant Processor
Data Uplink

Fig. 14

Fig. 15


80
82
90
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Serial Out
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24
92
74
14
Power
Data
20
78
60
12
66
transmitter
62
Regulator
Sensor Electronics
Sensor
16
68
64
58

Fig. 16

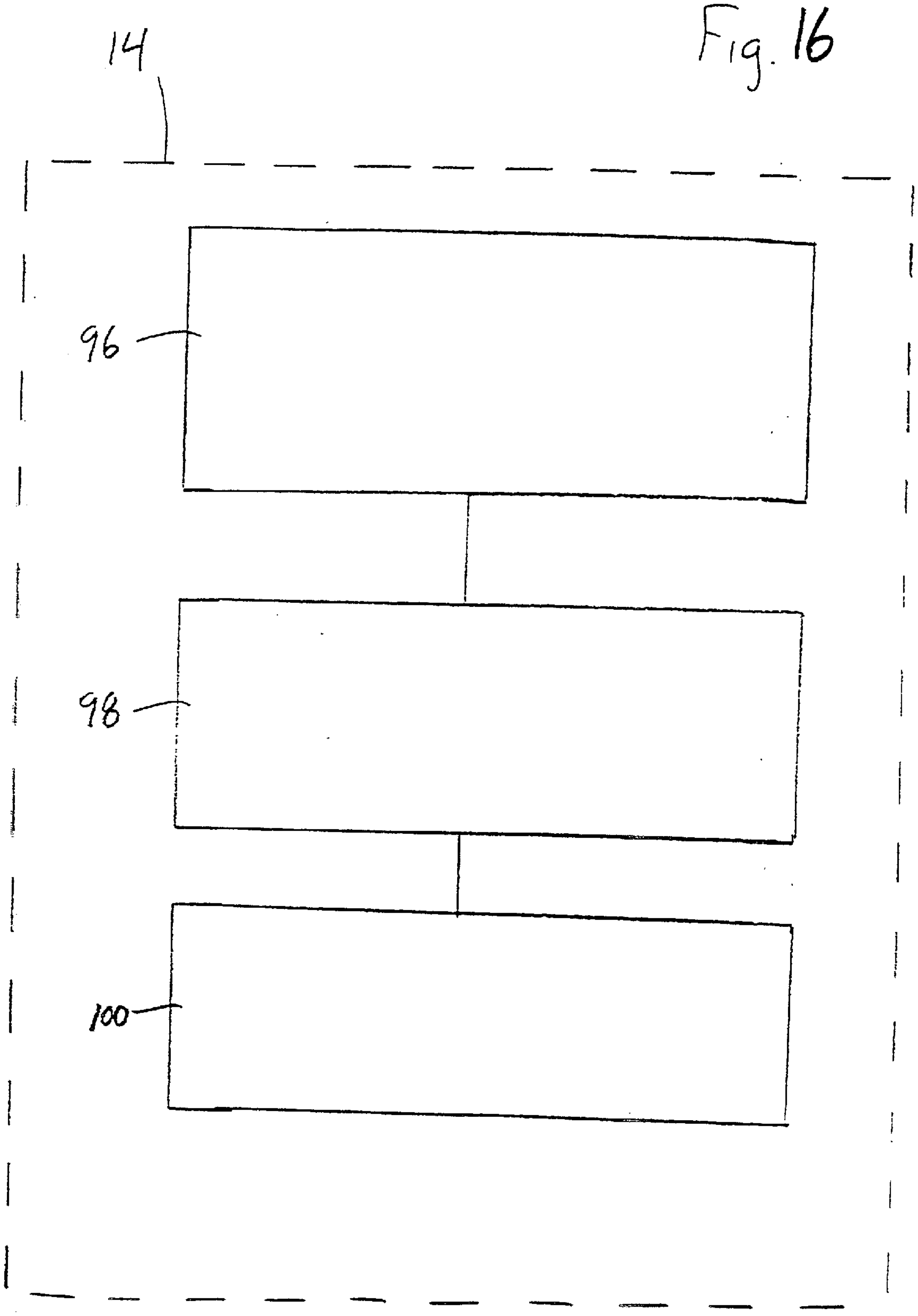
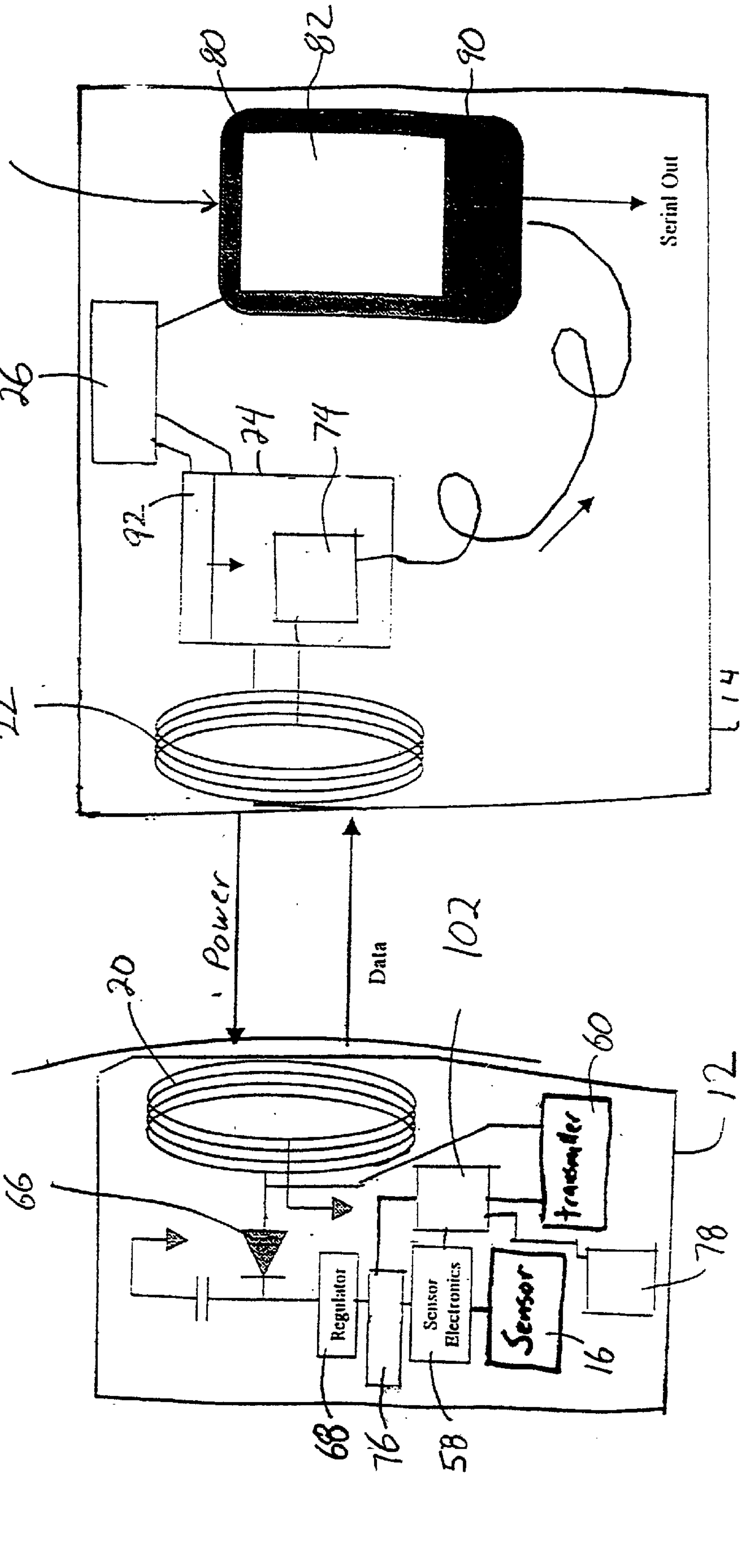


Fig. 17


Serial Out
Power
Data
Regulator
Sensor Electronics
Sensor
transmitter
80
82
90
28
26
24
74
92
22
14
20
102
60
12
66
78
16
68
76
58

IMPLANTABLE MEDICAL DEVICE WITH SENSOR

FIELD OF THE INVENTION

[0001] The present invention relates to a device for measuring and communicating parameters of a brain, tissue or other organs.

BRIEF DESCRIPTION OF RELATED ART

[0002] It is often desirable to measure and communicate parameters of a brain, tissue or other organs. For example, many people have a condition called hydrocephalus. Hydrocephalus is a condition of excessive accumulation of CSF in the ventricles or brain cavities. Hydrocephalus can result from congenital conditions interfering with normal CSF circulation or as the result of a problem with CSF reabsorption. A typical adult has a total of about 120-150 cc of (cerebrospinal fluid) CSF with about 25 cc in the ventricles in the brain. A typical adult also produces about 500 cc/day of CSF, all of which is reabsorbed into the blood stream on a continuous basis.

[0003] Different conditions can cause the CSF pressure to vary, often in an increasing and dangerous manner. Excessive accumulation of CSF due to hydrocephalus causes increased pressure upon the brain. Whatever the cause, over time, this increased CSF pressure causes damage to the brain tissue. It has been found that shunting the excess CSF to another area of the body is therapeutically beneficial and generally allows the patient to lead a full and active life. Both on a short and long term basis, many physicians believe that it is desirable to measure and read the CSF fluid pressure.

[0004] Further, many physicians believe it is desirable to monitor both the physiologic parameters associated with various medical conditions but also the reaction of various organs and tissue to treatments administered or directed by the physicians. Unfortunately, there has not been many devices or methods available to physicians to monitor physiologic parameters, particularly on a continuing basis. What systems that are available often require wires or tubes running from sensors within the patient's body to the outside world. These wires and tubes increase the likelihood of infection and irritation. Therefore, there is a need for a system whereby implantable sensors may communicate with the outside world without requiring wires, tubes or the like to pass from within the patient's body to outside the patient's body.

SUMMARY OF THE INVENTION

[0005] A device and method for measuring and communicating parameters of a brain, tissue or other organs is disclosed. The invention includes a sensor to sense the parameter of interest and then communicate the sensed parameter to an activation system where the parameter may be displayed, processed or cause action to be taken. The activation system may include an external device. The present invention allows chronic and stable measurement and communication of parameters, including parameters, to be made.

[0006] In an embodiment, the device measures and communicates parameters of a brain, tissue or other organs. The invention includes a sensor. The sensor in one embodiment is located at the distal end of a probe and is preferably placed in the area of the brain, tissue or other organ where a measurement is desired. In another embodiment, the sensor is co-located with an implanted device in the tissue or organ of interest. In a further embodiment, the sensor is located in or near the tissue or organ of interest.

[0007] In one embodiment, the sensor is part of a passive system that allows parameter measurements to be made and communicated to an attending practitioner when the passive system receives power from an external source. The part of the passive system that receives power from the external source and communicates pressure measurements is preferably located on or next to the skin of the patient while the sensor is located near or at the area where a measurement is desired to be made.

[0008] The passive system couples to an external device that provides power to the passive system. This power is used to power the sensing operation of the sensor and to upload the sensed information from the passive system to an external device, if desired. As a result, when coupled to the external power source, the passive system is able to measure and uplink measured parameters from the sensor to an external device or to power the operation of an implanted device.

[0009] In an alternate embodiment, the sensor is part of a system having a long-term energy source and storage system that allows parameter measurements to be taken periodically or upon demand, stored and then communicated to an attending practitioner as desired. The part of the system that provides power, stores parameter measurements and communicates the parameter measurements is preferably located on or next to the skin of the patient or may be embedded in the bone of the patient such as in the skull or pelvis.

[0010] The long-term energy source may be rechargeable. This power from the long-term energy source is used to power the sensing operation of the sensor, store the parameter measurements and to upload the sensed parameter information from the system to an external device or to an implanted device.

[0011] In an alternate embodiment of the invention, the sensed parameter is used to control a medical device such as a pump or valve in a CSF drainage system, a drug delivery system or an electrical stimulation device. These medical devices may be wholly or partially implanted.

[0012] It is an object of one embodiment of the invention to provide a system for measuring a parameter that does not require a continuous source of power such as a battery or power capacitor.

[0013] It is another object of one embodiment of the invention to provide a device that communicates a sensed parameter to an external device.

[0014] In another embodiment of the invention, it is an object of the invention to provide a system that stores sensed parameter measurements to be uploaded to an external device at a later time.

[0015] In a further alternate embodiment of the invention, it is an object of the invention to provide a system that actively responds to a sensed parameter to take an action.

[0016] In another alternate embodiment of the invention, it is an object of the invention to provide a sensor of parameters that requires the tissue of interest to be exposed only once during implantation for implantation of the sensor and is thereafter not exposed while providing long-term monitoring of the parameter of interest.

[0017] It is an object of the invention in another embodiment of the invention to provide an implantable device that provides information about a parameter of interest which does not depend on a battery to operate and therefore does not depend on the battery life to remain in operation.

[0018] These and other objects of the invention will be clear from the description of the invention contained herein and more particularly with reference to the Figures. Throughout the description, like elements are referred to by like reference numbers. Further, it is clear that to changes to the description contained herein may occur to those skilled in the art and still fall within the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] **FIG. 1** is a block diagram of the invention.

[0020] **FIG. 2** is a block diagram of one embodiment of the invention.

[0021] **FIG. 3** is a side view of one embodiment of the invention.

[0022] **FIG. 4** is a side cross-sectional view of the embodiment of **FIG. 3**.

[0023] **FIG. 5** is a side cross-sectional view of the embodiment of **FIG. 3** in place in a skull.

[0024] **FIG. 6** is a side cross-sectional view of an alternate embodiment of the invention in place in a skull.

[0025] **FIG. 7** is a side cross-sectional view of an alternate embodiment of the invention in place on a skull.

[0026] **FIG. 8** is a perspective view of an alternate embodiment of the invention.

[0027] **FIG. 9** is a perspective view of another alternate embodiment of the invention.

[0028] **FIG. 10** is a side cross-sectional view of another alternate embodiment of the invention.

[0029] **FIG. 11** is a schematic drawing of one embodiment of the invention.

[0030] **FIG. 12** is a schematic drawing of another embodiment of the invention.

[0031] **FIG. 13** is a schematic drawing of another embodiment of the invention.

[0032] **FIG. 14** is a chart showing the charging and transmitting sequence of one embodiment of the invention.

[0033] **FIG. 15** is a schematic drawing of another embodiment of the invention.

[0034] **FIG. 16** is a block diagram of an alternate embodiment of the invention.

[0035] **FIG. 17** is a schematic drawing of another embodiment of the invention.

[0036] **FIG. 18** is a schematic drawing of another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0037] The device embodying the present invention is shown in **FIG. 1** generally labeled **10**. The device **10** includes a sensor **16** and an activation system **15** connected to and responding to sensor **16**. Sensor **16** is implanted in the body of a patient. In one embodiment, activation system **15** includes an external device **14** that is located outside the body of the patient. In another embodiment, activation system **15** and sensor **16** are co-located in the body of the patient. In a further embodiment, activation system **15** and sensor **16** are both implanted in a patient but are not co-located.

[0038] Activation system **15** preferably includes a user communication system **28**. User communication system **28** may be entirely implanted within the patient of may have a portion that is located in external device **24**. In the embodiment where activation system **15** includes an external device **14**, external device **14** may include a portion of the user communication system **28** that includes an external coil **22**, external electronics **24** and a power source **26**.

[0039] User communication system **28** is in communication with sensor **16** and may communicate information from or about sensor **16** or may communicate alarms or other information based on the values that sensor **16** detects. Further, user communication system **28** may communicate information that is processed from information provided by sensor **16** such as trends in the sensed parameters from sensor **16**.

[0040] In one embodiment, user communication system **28** includes a receiver **74**. User communication system **28** preferably includes a display system **80** that displays or otherwise communicates the parameter information received from a transmitter **60** by receiver **74** to a user. User communication system **28** may include a display screen **82** that displays the parameter information to the physician or other user. Alternately, user communication system **28** may pass the parameter information from the external device **14** to an external computer **84**, the internet or through a modem by direct connection **86** or through telemetry **88** as is well understood in the art. Computer **84** can display the parameter information on its display screen **82**, record the information or further process the information. If the information is passed through the internet or through a modem, the information may be remotely used, processed or displayed as desired.

[0041] User communication system **28** may also include an alarm **90** that is part of the external device **14** or the external computer **84** that is triggered to alert the user to a parameter that is outside of a pre-determined range. The alarm **90** can also take the form of an audible or visible warning such as a warning chime or a flashing visual display panel, a physical warning such as a vibrating alarm or other means of alerting the user or emphasizing the status as will occur to those skilled in the art.

[0042] Activation system **15** may also direct components to take action based on the information from or about sensor **16** or processed from information provided by sensor **16**. For example, activation system **15** may direct a drug pump to provide a certain amount of a drug to the patient or may direct an electrical stimulation device to stimulate the patient.

[0043] All or part of activation system **15** may be implanted in the patient or may be entirely located outside the patient. Where activation system **15** includes at least a part outside the patient, the outside part of activation system **15** is an external device **14**.

[0044] Sensor **16** may be of the type that can detect any or all of the following, as is well understood in the art. Examples of such sensors **16** are given below. However, it is to be understood that the descriptions below are not intended to limit the type of sensor **16** or the specific structure of sensor **16**. It is clear that sensors **16** of the types listed below are well understood to those skilled in the art and the specific types and uses of sensors **16** will be immediately clear to those skilled in the art. It is also clear that the form or structure of the sensor **16** is not critical to the instant invention so long as such sensor **16** can be implanted and used as is described herein.

Sensor Type	Examples:
Respiration	(1) Piezoelectric activity sensors: U.S. Pat. No. 4,485,813 issued to Anderson et al.; 4,576,179, 3,782,368, 4,169,462, 4,185,621 and 4,443,730. These typically describe the use of piezo transducers that are sensitive to body breathing motions as well as impacts or forces incident from various directions. (2) U.S. Pat. No. 5,195,529, issued Mar. 23, 1993 to Lauri Malkamaki entitled "SENSOR FOR MONITORING RESPIRATION (3) U.S. Pat. No. 6,064,910 issued May 16, 2000 entitled "RESPIRATOR RATE/RESPIRATION DEPTH DETECTOR AND DEVICE FOR MONITORING RESPIRATORY ACTIVITY EMPLOYING SAME" to Jonas Andersson, Johan Lidman and Carolina Bigert
Electrolyte concentration	U.S. Pat. No. 5,234,567 entitled "Gas Sensor" issued Aug. 10, 1993 to Bryan S. Hobbs and Yat S. Chan and U.S. Pat. No. 5,746,898 issued May 5, 1998 to Walter Preidel.
O_2	U.S. Pat. No. 6,267,724 entitled "Implantable Diagnostic Sensor" issued on July 31, 2001 to David W. Taylor and U.S. Pat. No. 6,201,980 entitled "Implantable Medical Sensor System" issued on March 13, 2001 to Christopher B. Darrow, Joe H Satcher, Jr., Stephen M. Lane, Abraham P. Lee and Amy W. Wang.
PH	As is understood in the art
glucose	U.S. Pat. No. 4,703,756 issued Nov. 3, 1987 entitled "Complete Glucose Monitoring System with an Implantable, Telemetered Sensor Module" to David A Gough, Joseph Y. Lucisano, Jon C. Armour and Brian DMcKean;
Blood pressure	As is understood in the art
Intra-cranial Pressure	(1) U.S. Pat. No. 4,984,567 issued Jan. 15, 1991 entitled "APPARATUS FOR MEASURING INTRACRANIAL PRESSURE" to Naoki Kageyama, Hiroji Kuchiwaki, Junki Ito, Nobumitsu Sakuma, Yukio Ogura; U.S. Pat. No. 4,971,061 issued Nov. 20, 1990 entitled "APPARATUS FOR RECORDING INTRACRANIAL PRESSURE" to Naoki Kageyama, Hiroji Kuchiwaki, Nissincho Aichi-gun, Junki Ito, Nobumitsu Sakuma, Yukio Ogura, Eiji Minamiyama,
Heart rate	(1) ECG MONITORS--require at least two electrodes to be attached to the body, as described in U.S. Pat. Nos. 4,630,614 and 4,269,195. (2) ULTRASOUND--Must be attached to the chest. (3) ACOUSTIC--Must be attached to the chest, or nostril as in U.S. Pat. Nos. 4,421,113 4,281,651. (4) INFRARED--Which is attached to the finger. Nothing is known of the remote (detached) passive heart rate monitors. (5) A sensor that detects air flow through the nostril. As in U.S. Pat. No. 4,036,217. (6) A strap that is stretched across the chest to detect the chest movements during respiration. As in U.S. Pat. Nos. 3,802,419 and 4,540,002. (7) A device attached to the mattress U.S. Pat. No. 3,325,799. As in U.S. Pat. Nos. 4,146,885; 4,066,072; 3,631,438; and France PV No. 43858 No. 1,480,160; (8) A CO2 sensor that is attached to the breathing system. (9) A Thermistor sensor that is attached to the breathing system. (10) Ultrasound or microwave Doppler radar (invasive due to radiation). As in U.S. Pat. Nos. 3,875,929; 3,796,208. (11) Inductance change respiratory electrodes. As in U.S. Pat. Nos. 3,911,899; 3,658,052.
temperature	(a) U.S. Pat. No.: 5,596,995 issued Jan. 28, 1997 entitled "BIOMEDICAL DEVICE HAVING A TEMPERATURE SENSING SYSTEM" to Marshall L. Sherman, Thomas M. Castellano, Jose J. Moya, (b) thermocouple
activity/posture	U.S. Pat. No. 5,593,431 entitled "Medical service employing multiple DC accelerometers for patient activity and posture sensing and method" issued Jan. 14, 1997 to Todd J. Sheldon and U.S. Pat. No. 5,031,618 entitled "Position-responsive neuro stimulator" issued July 16, 1991 to Keith R. Mullett.
eeg	(a) January 1973 edition of Popular Electronics magazine at pages 40–45. (b) U.S. Pat. No.: 5,215,086 issued Jun. 1, 1993 entitled "THERAPEUTIC TREATMENT OF MIGRAINE SYMPTOMS BY STIMULATION" by Reese S. Terry, Jr., Joachim F. Wernicke, Ross G. Baker, Jr., (c) U.S. Pat. No. 4,744,029 issued May 10, 1988 entitled "BRAIN ELECTRICAL ACTIVITY ANALYSIS AND MAPPING" to Gabriel Raviv, Gil Raviv, (d) U.S. Pat. No.: 4,753,246 issued Jun. 28, 1988 entitled "EEG SPATIAL FILTER AND METHOD" by Walter J. Freeman (e) U.S. Pat. No. 4,974,602 issued Dec. 4, 1990 entitled "ARRANGEMENT FOR ANALYZING LOCAL BIOELECTRIC CURRENTS IN BIOLOGICAL TISSUE COMPLEXES" to Klaus Abraham-Fuchs Gerhard Roehrlein, Siegfried Schneider,
ecg	As is understood in the art
emg	(a) U.S. Pat. No.: 4,753,246 issued Jun. 28, 1988 entitled "EEG SPATIAL FILTER AND METHOD" to Walter J. Freeman

[0045] In use, sensor **16** is preferably placed in or in contact with the tissue, organ or other part of the body where parameter information may be sensed. For example, sensor **16** may be placed in or in contact with the spinal column, organs of the body such as the liver, kidneys, the heart, the bladder, tumors or growths, body tissue, joints, cavities, sinuses or spaces between organs or tissue or other areas as will occur to those skilled in the art.

[0046] Sensor **16** may be part of a probe **12** that includes sensor **16**, probe electronics **18** and a probe coil **20**.

[0047] In one embodiment, device **10** has a single sensor **16**. However, device **10** may also have multiple sensors **16** sensing the same or different parameters at a single or at multiple locations. Where sensor **16** senses parameters other than physiological, probe may include sensors that sense non-parameters in addition to or in any combination with the sensors to sense parameters.

[0048] In the embodiment of the invention shown in **FIGS. 3 and 4**, probe **12** has a proximal end **30** and a distal end **32** and a central axis **34**. Sensor **16** is preferably located at the distal end **32**.

[0049] A probe head **36** is located at the proximal end **30**. In one embodiment, probe head **36** is roughly discoid in shape and includes an embedded probe coil **20**. Probe coil **20** is an inductive coil. In the embodiment shown in **FIGS. 3 and 4**, probe coil **20** is wound around axis **34** in the plane of probe head **36**. Probe head **36** includes an underside **38** and an outer edge **40**.

[0050] In the embodiment of **FIGS. 3 and 4**, the probe electronics **18** are stored in an electronics case **42**, attached to the underside **38** of probe head **36**. The electronics case **42** has a periphery **44** and an underside **46**. Electronics case **42** is preferably cylindrical with a smaller diameter around axis **34** than has probe head **36**.

[0051] As shown in **FIGS. 3 and 4**, sensor **16** is separated from electronics case **42**. This is preferably accomplished by locating sensor **16** at the distal end of a body **48** connected to the underside **46** of electronics case **42**. Body **48** may be made of a stiff material such as titanium or a rigid body-compatible plastic like polyurethane. Alternately, body **48** may be made of a flexible material such as a flexible body-compatible plastic such as polyurethane that is inherently flexible by its composition or designed to be flexible by its structural design. In either the rigid or flexible case, the material of body **48** may be any metal, plastic, ceramic or other material that is body-compatible and is as flexible or rigid, in varying degrees, as desired as is well understood in the art.

[0052] In the embodiment where body **48** is rigid, sensor **16** will be located at a fixed location relative to the electronics case **42**. Where body **48** is flexible, such as in the embodiment shown in **FIG. 9**, sensor **16** may be placed where desired in the brain, tissue or in other organs wherever in the body. In particular, where body **48** is flexible, sensor **16** may be placed where the distance from sensor **16** to the electronics case **42** varies as, for example, with movement.

[0053] In addition, where body **48** is flexible, sensor **16** may be placed on or in areas where it would be difficult to place sensor **16** where body **48** to be rigid. For example, where body **48** is flexible, sensor **16** may be "slid" between the dura and the skull to a desired position between the dura and the skull. Other locations to locate the sensor will occur to those skilled in the art.

[0054] In a further alternate embodiment, sensor **16** may be connected to electronics case **42** through a system known as a "body bus". The "body bus" is a telemetry system where the patient's own body provides the interconnection between the sensor **16** and the electronics case **42**. An example of such a "body-bus" communication system is given in U.S. Pat. Nos. 4,987,897 and 5,113,859, issued to Hermann D. Funke on Jan. 29, 1991 and May 19, 1992, entitled "Body Bus Medical Device Communication System" and "Acoustic Body Bus Medical Device Communication System" respectively, the teachings of which are incorporated herein by reference in its entirety. Alternately, a radio frequency telemetry approach as described in U.S. Pat. No. 5,683,432 to Goedeke may be used to link sensor **16** to electronics case **42**.

[0055] The sensor **16** is preferably calibrated at the manufacturing site by comparing its measurements with measurements from a standardized sensor. Calibration coefficients, which are unique to each sensor **16**, are computed and stored in the external device **14**, probe electronics **18**, storage device **78** or microprocessor **102** for the purpose of post-measurement processing to achieve an accurate report of the parameters measured by sensor **16**.

[0056] Because probe **12** will be inserted into the body, probe **12** should be hermetically sealed to prevent the intrusion of body fluids into probe **12**.

[0057] In the embodiment shown in **FIGS. 3 and 4**, the proximal end **30** is located either immediately outside of or incorporated into the skull **50** of the patient or in other bony places such as the pelvis, sternum, scapula, to name but a few places that will occur to those skilled in the art. This is preferably accomplished by making the probe head **36** with a larger diameter around axis **34** than the electronics case **42** has. Then, for example, to place the probe **12** in the skull **50**, a hole **52** is drilled in skull **50** having a diameter about the same as the diameter of electronics case **42** (**FIG. 5**). Hole **52** should go entirely through the skull **50** and have the same diameter as the diameter of electronics case **42**. The sensor **16** and body **48** of probe **12** is placed through the hole **52** until the electronics case **42** contacts hole **52**. Electronics case **42** is then aligned with hole **52** and pushed through hole **52** until the underside **38** of probe head **36** contacts the skull **50**. Electronics case **42** should be dimensioned so as not to extend entirely through hole **52**.

[0058] Alternately, screw threads may be placed around the periphery **44** of electronics case **42**. In this embodiment, hole **52** is a threaded hole with threads matching the threads of electronics case **42**. Electronics case **42** is brought into contact with hole **52** as described above. However, instead of pushing electronics case **42** through hole **52**, electronics case **42** is threaded into hole **52**.

[0059] In a further alternate embodiment shown in **FIG. 6**, screw threads are placed on the outer edge **40** of probe head **36**. Hole **52** is dimensioned to have a diameter approximately the same as the diameter of probe head **36**. In this embodiment as well, hole **52** has threads corresponding to the threads on probe head **36**. To place the probe **12**, the sensor **16**, body **48** and electronics case **42** of probe **12** is placed through the hole **52** until the outer edge **40** of probe head **36** contacts hole **52**. Probe head **36** is then aligned with hole **52** and threaded through hole **52** until probe head **36** has a desired orientation, such as flush with the skull **50**. In this embodiment, electronics case **42** may or may not have the same diameter as probe head **36**.

[0060] In another embodiment shown in **FIG. 7**, probe head **36** is separated from, although connected to, electronics case **42**. In this embodiment, electronics case **42** is mounted through a hole **52** bored in, for example, the skull **50**, and body **48** with sensor **16** is still attached to electronics case **42** in all the variants described herein. But, in this embodiment, probe head **36** with probe coil **20** is implanted underneath the patient's skin but above or in the skull **50**. Probe head **36** may be attached to the patient's skull **50** by screws, adhesives or other means that will occur to those skilled in the art. Alternately, a separate hole from hole **52** may be bored into the skull **50** to receive the probe head **36**. Where probe head **36** is located in the separate hole, probe head **36** may have screw threads placed on the outer edge **40** of probe head **36** and the separate hole is dimensioned to have a diameter approximately the same as the diameter of probe head **36** with threads corresponding to the threads on probe head **36**. In this embodiment, to place the probe **12**, the sensor **16**, body **48** and electronics case **42** of probe **12** is placed through the hole **52**. Probe head **36** is then attached to the skull **50** as described above.

[0061] In a further embodiment shown in **FIGS. 8 and 9**, a burr-hole ring **54** having an opening **56** with a diameter "A" is placed in a hole **52** in skull **50**. Burr-hole ring **54** may be screwed into the bone of the skull **50** or otherwise attached to the skull **50** in a fashion well known for burr-hole rings. In this embodiment, probe head **36** has a diameter about equal to the diameter "A" of the opening **56** of burr-hole ring **54**. Probe head **36** is placed in the opening **56** where it may be held in place by means such as friction, body-compatible adhesive or other means that will occur to those skilled in the art.

[0062] In the embodiment of **FIG. 8**, the body **48** is rigid so that sensor **16** is located a fixed distance from and at a fixed relationship to the probe head **36**. In the embodiment of **FIG. 9**, body **48** is flexible. In this embodiment, the sensor **16** is placed through the opening **56** to a desired location.

[0063] In a further embodiment shown in **FIG. 10**, the probe head **36** may contain all or part of the probe electronics **18**. In this embodiment, there may be no need to have an electronics case **42**. Therefore, the sensor **16** may be attached directly to probe head **36** through a rigid or flexible body **48**. In use, for example to place the device in the head, a hole **52** is drilled through skull **50** and sensor **16** placed through hole **52** to a desired location. Then, probe head **36** may be attached to the skull **50** as described above.

[0064] In a variant of this embodiment, the probe head **36** may be located a distance from the hole **52**. For example, the probe head **36** may be located under the skin near the clavicle or in the abdomen at sites common for placing RF powered implantable neurological stimulators. In this embodiment, it may be necessary to use a burr-hole ring **54** to position the body **48** at the skull **50** so that sensor **16** will not move with respect to the hole **52**. Further, the probe electronics may also be located in total or in part in the body **48** in any of the embodiments described herein.

[0065] Probe electronics **18** includes sensor electronics **58** and a transmitter **60**. Sensor electronics **58** is connected to sensor **16** and provides power to sensor **16**, directs sensor **16** to take measurements, processes the sensed measurement signal from sensor **16** and converts the sensed signal to a digital signal. This digital signal is preferably passed to transmitter **60**.

[0066] Transmitter **60** is connected to sensor electronics **58** and probe coil **20**. Probe coil **20** acts as an antenna as will be explained hereafter. Transmitter **60** and probe coil **20** communicate parameter information determined by sensor **16** to the external device **14** by telemetry. Examples of telemetry systems are shown in U.S. Pat. No. 5,683,432 entitled "Adaptive, Performance-Optimizing Communication System for Communicating with an Implanted Medical Device", issued on Nov. 4, 1997 to Steven D. Goedeke, Gregory J. Haubrich, John G. Keimel and David L. Thompson, U.S. Pat. No. 5,752,976 entitled "World Wide Patient Location and Data Telemetry System for Implantable Medical Devices", issued on May 19, 1998 to Edwin G. Duffin, David L. Thompson, Steven D. Goedeke and Gregory J. Haubrich, U.S. Pat. No. 5,843,139 entitled "Adaptive, Performance-Optimizing Communication System for Communicating with an Implanted Medical Device", issued on Dec. 1, 1998 to Steven D. Goedeke, Gregory J. Haubrich, John L. Keimel and David. L. Thomson and U.S. Pat. No. 5,904,708 entitled "System and Method for Deriving Relative Physiologic Signals", issued on May 18, 1999 to Steven D. Goedeke, the teachings of which are incorporated herein in their entireties by reference. Other alternate means of communication between the probe **12** and the external device **14** include amplitude shift keying (ASK), binary phase shift key (BPSK) or quadrature phase shift key (QPSK) to name but a few choices.

[0067] In addition, in this embodiment, probe electronics **18** includes an AC/DC conversion system **62** (**FIG. 11**). Probe coil **20** is connected to AC/DC conversion system **62**. Probe electronics **18** allows power to be transferred from the external device **14** to probe **12** to power probe **12** and at the same time allows probe **12** to uplink sensed parameters from probe **12** to external device **14**. This simultaneous power transfer and uplink of information is preferably done by a technique known as absorption modulation as is well understood in the art.

[0068] In this embodiment, AC/DC conversion system **62** includes a rectifier **66** and a regulator **68**. Probe coil **20** will be inductively coupled to an external coil **22** in the external device **14** as will be explained hereafter. This inductive coupling between probe coil **20** and external coil **22** provides power to the probe coil **20**. This power will be in the form of an alternating current. In this embodiment, this AC current has a frequency of about 175 kHz although other frequencies may be used as desired.

[0069] Rectifier **66** is connected to probe coil **20** and converts the AC power received from the probe coil **20** to DC power. Rectifier **66** is preferably a full-wave rectifier as is well understood in the art but may be other rectification systems as is also well understood in the art. The DC power is passed through the regulator **68** that ensures a relatively constant DC level despite variations in power received from the probe coil **20** due, for example, to the relative movement of the probe coil **20** to the external coil **22**. In this way, regulated DC power is provided to power the probe electronics **18**.

[0070] In an alternate embodiment (**FIG. 12**), probe electronics **18** includes the AC/DC conversion system **62** described above and in addition includes a temporary energy source **64**. Probe coil **20** is again connected to AC/DC conversion system **62**. Probe coil **20** is inductively coupled to external coil **22**.

[0071] In this embodiment, a temporary energy source **64** is connected to AC/DC conversion system **62**. Temporary energy source **64** preferably takes the form of a rechargeable battery or a power capacitor such as a "super capacitor", having for example a small capacity such as 1 μf, although larger or smaller capacities may be used as desired and non-rechargeable batteries may also be used.

[**0072**] Inductive coupling between probe coil **20** and external coil **22** provides power to the probe coil **20** and through AC/DC conversion system **62**, charges up the temporary energy source **64**. Temporary energy source **64** then provides the energy to power the probe electronics **18**.

[**0073**] Probe coil **20**, in this embodiment (**FIG. 11**), also acts as an antenna connected to transmitter **60** to transmit information from sensor **16** to the external device **14**. In this role, probe coil **20** acts as an antenna in addition to acting as an inductive coil for receiving power from the external device **14** as described above. As described above, probe coil **20** is a coil so that when probe coil **20** acts as an antenna, probe coil **20** is a coil antenna.

[**0074**] In this embodiment, probe coil **20** performs both the function of inductively coupling with external coil **22** to receive power from external device **14** and transmitting information from transmitter **60** to external device **14**. In an alternate embodiment shown in **FIG. 13**, these two functions are separated. In this alternate embodiment, probe coil **20** performs only the function of inductively coupling with external coil **22** to receive power from external device. But, a probe antenna **70** is provided that serves the function of transmitting parameter information from the transmitter **60** to the external device **14**.

[**0075**] In the embodiment of **FIG. 12**, as shown in **FIG. 14**, when probe coil **20** is inductively coupled to external coil **22**, probe coil **20** receives a downburst of energy **72** from the external device **14** through the external coil **22**. The downburst of energy **72** preferably lasts for a specified time period to allow the temporary energy source **64** to be charged, for example, about 5 seconds, although more or less time may be used as desired. This downburst of energy **72** is converted to a regulated DC voltage by rectifier **66** and regulator **68** and charges the temporary energy source **64** to provide temporary energy to the probe electronics **18** as described above.

[**0076**] When the probe coil **20** is inductively coupled to the external coil **22** and the probe **12** is receiving power from the external device **14** or after the temporary energy source **64** is charged, sensor electronics **58** directs sensor **16** to sense the parameter and communicate the sensed parameter to the sensor electronics **58**. Sensor electronics **58** processes the sensed parameter information and passes it to the transmitter **60** where the parameter information is converted into a form capable of being sent via telemetry from the transmitter **60** to the external device **14**. The parameter information is then sent from the transmitter **60** and either the probe coil **20** acting as an antenna or the probe antenna **70**, to the external device **14**. External device **14** receives the transmitted parameter information through the external coil **22** acting as an antenna or the external device antenna **94**, and a receiver **74**, preferably located within external device **14**.

[**0077**] This process of sensing parameters and transmitting it to the external device **14** may be continued for as long as the probe **12** receives power from the external device **14** or as long as the temporary energy source **64** has power or for a lesser time if desired. If sufficiently many occurrences of sensing parameters and communicating the sensed parameters are desired so that the power capacity of the temporary energy source **64** is or will be exceeded, power may again be downloaded from the external device **14** as described above. As a result, the temporary energy source **64** will be recharged and the sensing and transmitting process continued as described above.

[**0078**] The embodiment of probe **12** is a passive system without a long-term power source on the probe **12**. As a result, probe **12** is a relatively low-cost device for measuring and communicating parameters. This embodiment allows a "real time" snapshot of the parameter of interest.

[**0079**] Alternately, as shown in **FIG. 15, a** long-term power source **76** may be provided to power the probe electronics **18**. Long-term power source **76** may take the form of a battery that may or may not be rechargeable or a power capacitor such as a "super-capacitor" as is well understood in the art. Long-term power source **76** must have a capacity sufficient to power the probe **12** for a relatively long time. Where the long-term power source **76** is used, the temporary energy source **64** is replaced with the long-term power source **76**. Where a storage device **78** is present, as will be explained hereafter, long-term power source **76** may also provide power to storage device **78** as well.

[**0080**] In this embodiment (**FIG. 11**), external device **14** includes an external coil **22**, external electronics **24**, a power source **26**, and a user communication system **28**. Power source **26** provides power to operate the external electronics **24** and user communication system **28** and provides power to external coil **22** that will be passed to probe **12** through inductive coupling with probe coil **20**. Power source **26** may be either a battery or ordinary line current that has been adapted to provide power by such means as rectifying and filtering line AC power to produce a DC voltage as is well understood in the art.

[**0081**] External electronics **24** preferably contains a receiver **74** although the receiver **74** may be a separate component connected to the external device **14**. Receiver **74** receives and processes the parameter information transmitted by transmitter **60** and received by external coil **22** acting as an antenna.

[**0082**] External device **14** may also include an ambient parameter sensor **92**. Ambient parameter sensor **92** measures ambient parameters such as pressure, temperature and humidity. Where ambient parameter sensor **92** is a barometer, barometer **92** measures the atmospheric pressure. This measured atmospheric pressure is then subtracted from the pressure measured by sensor **16** and transmitted from probe **12** to external device **14** to produce the "gauge" pressure. This "gauge" pressure is independent of the ambient atmospheric pressure, which is influenced by weather systems and altitude. Of course, where ambient parameter sensor **92** measures temperature or humidity, ambient parameter sensor **92** will be a thermometer or a hygrometer as is well understood in the art. Further ambient parameters will occur to those skilled in the art and are intended to be included in the scope of the ambient parameter sensor **92**. This ambient parameter information may be displayed directly, used to calibrate the sensor **16** or processed with parameter information from sensor **16**.

[**0083**] In one embodiment, external coil **22** serves both to couple with the probe coil **20** to provide power to the probe **12** and as an antenna to receive information transmitted by probe **12** from transmitter **60**. As such, external coil **22** is connected to receiver **74**.

[0084] Alternately, an external device antenna **94** may be present, separate from external coil **22**. In this embodiment, external device antenna **94** is connected to receiver **74** and communicates with probe antenna **70** or probe coil **20** to receive information transmitted from transmitter **60**. In this embodiment, external coil **22** is not connected to receiver **74**.

[0085] To use the device **10** to measure a parameter of the body, the first step is cut through the skin and place the sensor **16**. For example, if the device **10** is to be mounted on a skull **50** and the sensor **16** placed inside a head, after the skin is opened and the skull exposed, a hole **52** is preferable drilled in the skull **50** to allow the sensor **16** to be placed in the head. The probe **12** is then implanted as described above. Thereafter, the patient's skin is closed so that the probe **12** is entirely contained within the patient's skin.

[0086] The external device **14** is brought near the probe **12** so that the probe coil **20** is inductively coupled to the external coil **22** and power is transferred from the external device **14** to the probe **12**.

[0087] The hole **52** is then sealed with the probe **12** in place. Thereafter, the patient's skin is re-connected over the probe **12** where the wound will heal. This will seal the probe **12** underneath the patient's skin.

[0088] When a measurement of a parameter is desired, the external device **14** is placed with its external coil **22** over the probe coil **20**. The probe **12** is powered by transmitting a downburst of energy **72** from the external device **14**. In this embodiment, the initial downburst of energy **72** after power-up lasts about 5 seconds. This allows the probe electronics **18** to stabilize and set up such things as internal clocks, etc. Subsequent downbursts of energy **72** are preferably about 2 ms long.

[0089] In one embodiment, the probe **12** does not have an on-site battery. Therefore, on power-up the probe electronics **18** performs an autocalibration operation to ensure that the parameter measurements by sensor **16** will fall within the range of the probe electronics **18**. Whenever the falling edge of the downburst of energy **72** is detected, the probe **12** uplinks its sensed parameter measurements to the external device **14**. The uplink continues for as long as the external device **14** sends downbursts of energy **72** to the probe **12**. The frequency of uplink is controlled by the external device **14** and cannot exceed the rate of downburst of energy **72**. It is also possible to periodically uplink the stored calibration coefficients to the external device **14** or to uplink the stored calibration coefficients to the external device **14** with every uplink of sensed parameters.

[0090] In one embodiment, each uplink of the sensed parameter measurements is transmitted from probe **12** to external device **14** multiple times, for example thrice, to compensate for telemetry or processing errors. In a continuous mode, when the external device **14** intermittently sends downbursts of energy **72** to provide essentially continuous power to probe **12** and receives uplinked parameter measurements.

[0091] In addition, as explained above, calibration coefficients for sensor **16** may be stored in the probe **12** in the probe electronics **18**, storage device **78** or microprocessor **102**. Where these calibration coefficients are stored in probe **12**, these coefficients may be uplinked from the probe **12** to the external device for the purpose of post-measurement processing to achieve to achieve an accurate report of the parameters measured by sensor **16**. These coefficients may be uplinked to external device **14** when probe **12** is first powered up or may be uplinked with every uplink of sensed parameters.

[0092] Further, data such as the serial number or model number of the probe **12** may be stored in probe **12** in the probe electronics **18**, storage device **78** or microprocessor **102** or in the external device **14**. Where such serial number or model number is stored in probe **12**, this information may be uplinked to external device **14** when probe **12** is first powered up or may be uplinked with every uplink of sensed parameters.

[0093] In one embodiment, external device **14** is a single unit that includes the components of an external coil **22**, external electronics **24**, a power source **26**, user communication system **28** and an external device antenna **94**, if present. However, external device **14** may be two or more separate devices. For example, as shown in **FIG. 16**, one device **96** may provide power to the probe **12** through inductive coupling between the probe coil **20** and external coil **22**, a second device **98** may receive the parameter information transmitted by transmitter **60** and a third device **100** may display the parameter information received by the second device **98**.

[0094] In one embodiment where probe **12** includes a passive system **24**, it is critical that probe coil **20** and external coil **22** be coupled to allow power to be passed from the external device **14** to the probe **12** and for parameter information to be passed from probe **12** to external device **14**. It may be desirable to have an audible confirmation that probe coil **20** and external coil **22** are coupled. This may be accomplished by probe **12** uploading a signal to external device **14** indicating that probe coil **20** and external coil **22** are inductively coupled. This signal may be used by the external device **14** to trigger an audible signal indicating that the probe **12** and the external device **14** are inductively coupled.

[0095] Alternately, the loading of the external coil **22** caused by the inductive coupling with the probe coil **20** can be detected by the external device **14** and used to determine coupling efficiency. This loading can be detected by monitoring the power passed through the external coil **22**. As the inductive coupling between the external coil and probe coil **20** increases, the power passing through the external coil **22** to the probe coil **20** will increase. By monitoring this power and comparing instantaneous power measures, trends in power transmission (i.e., increasing or decreasing) or a relative maximum power transmission amount may be determined. This information can be used to determine whether increasingly efficient coupling positions between external coil **22** and probe coil **20** are being reached or that the optimum coupling position has been reached.

[0096] Further, it may be desirable to store sensed parameter information from the sensor **16** to be transmitted from transmitter **60** at a later time. This may be accomplished by having a storage device **78** attached to sensor **16** and transmitter **60** (**FIG. 17**). Storage device **78** may be of the type disclosed in U.S. Pat. No. 5,817,137 entitled "Compressed Patient Narrative Storage In and Full Text Reconstruction from Implantable Medical Devices", issued on Oct.

6, 1998 to William F. Kaemmerer or U.S. Pat. No. 5,549,654 entitled "Interactive Interpretation of Event Markers in Body-Implantable Medical Devices" issued to Richard M. Powell on Aug. 27, 1996, both assigned to the assignee of the present application, the teachings of which are incorporated herein by reference in their entirety.

[0097] Storage device **78** may be located in probe head **36**, electronics case **41** or body **48** or may be located separate from but electrically connected to the probe **12**. For example, storage device **78** may be located near the clavicle in a manner similar to the placement of the Reveal® cardiac recording device manufactured and sold by Medtronic, Inc. of Minneapolis, Minn. Further, storage device **78** may be directly connected to probe **12** by wires, through the "body bus" communication system described above or other similar communication means.

[0098] In this embodiment, probe **12** requires a long-term power source **76** to provide power to the sensor **16**, sensor electronics **58** and the storage device **78**. Sensor electronics **58** would periodically direct sensor **16** to sense the parameter of interest. Alternately, sensor electronics **58** could be directed from a signal from the external device **14** to direct sensor **16** to sense parameter information.

[0099] In either case, the sensed parameter would then be communicated to the storage device where it would be stored. Then, either periodically or when an inquiry is made from the external device **14**, parameter information would be uploaded from the storage device **78** through the transmitter **60** to the external device **14** as described above.

[0100] In an alternate embodiment (**FIG. 18**), sensor electronics **28** and storage device **78** may be connected to a microprocessor **102** as shown in **FIG. 13**. In this embodiment, parameter measurements may be processed by microprocessor **102** before being stored in storage device **78**. Alternately, microprocessor **102** may take a series of stored measurements from storage device **78** and process the series, as for example, to produce a running average of the parameter values. Such processed information may by transmitted from probe **12** to external device **14** at the time of the processing or may be stored in storage device **78** to be transmitted to external device **14** at a later time.

[0101] The sensed parameter information may also be used to control or activate a control device **104**. In this embodiment, shown schematically in **FIG. 18**, the control device **104** may control a pump or valve in a CSF drainage system, a drug delivery system or an electrical stimulation device, to name but a few examples. In the embodiment shown, the control device **104** is connected to microprocessor **102** so that microprocessor **102** controls whether the control device **104**. In use, where microprocessor **102** has determined that a parameter sensed by sensor **16** is within a predetermined range, microprocessor **102** activates the control device **104** to control the corresponding medical device. When the microprocessor **102** has determined that the sensed parameter from sensor **16** is outside the predetermined range, microprocessor **102** causes control device **104** to either cease or diminish operation of the control device **104**.

[0102] For example, as shown in the embodiment of **FIG. 18, a** drainage catheter **2** is placed in the ventricle **4** of a patient, coupled to the control device **104**. The control device **104** is preferably connected to a peritoneal or atrial catheter **8** although the control device **104** could be connected to a drainage bag. Control device **104** may be a pump or a valve connected between the drainage catheter **2** and the peritoneal or atrial catheter **8** or drainage bag. Where the control device **104** is a pump, the pump pumps CSF fluid from the ventricle **4** to the peritoneal or atrial catheter **8** where it is absorbed into the body or into a drainage bag. Where the control device **104** is a valve, the valve, when open, allows CSF fluid to drain from the ventricle **4** through the peritoneal or atrial catheter **8** or into the drainage bag.

[0103] In the embodiment shown, the control device **104** is connected to microprocessor **102** so that microprocessor **102** controls whether the pump pumps CSF fluid or the valve is open to allow the drainage of CSF fluid.

[0104] In use, where microprocessor **102** has determined that the parameter sensed by sensor **16** is outside the predetermined range, microprocessor **102** activates the control device **104** to either pump CSF fluid or to open the valve to allow the excess CSF fluid to drain from the patient's ventricle. When the microprocessor **102** has determined that the sensed parameter is within a predetermined range, microprocessor **102** causes control device **104** to either cease pumping CSF fluid or closes the valve so that CSF ceases to drain through the valve.

[0105] The control device **104** may also control the operation of, for example, an adjustable subcutaneously implantable fluid flow valve in a CSF shunt system. Such a device is the Strata® Valve Adjustable Valve manufactured and sold by Medtronic—PS Medical of Goleta, Calif. and as disclosed in U.S. Pat. No. 5,637,083 entitled "Implantable Adjustable Fluid Flow Control Valve", issued on Jun. 10, 1997 to William J. Bertrand and David A. Watson. Such an adjustable valve is useful in a physiological shunt system for controlling the flow of fluid from one part of the body to another such as from the patient's ventricle to the patient's ventricle or atrium. The control device **104**, for example, controls the movement of an external or percutaneously-applied magnetic field, to cause the valve to provide a variety of pressure or flow characteristics.

[0106] In a variant of the embodiment using the control device **104** to control a valve or pump, the control device may also control another medical device such as a pacemaker, neurological electrical stimulator or a drug pump.

[0107] In addition, in one embodiment, the probe electronics **18** are located in the electronics case **42**. In an alternate embodiment, the probe electronics **18** may be located in the body **48** or in the probe head **36**.

[0108] One advantage of the device **10** described herein is that long-term monitoring of a parameter can be conveniently performed without risk of infection since the organ or tissue of interest, for example, the brain, is exposed only once during implantation. Thereafter, the probe **12** is encased within the skin of the patient where it can measure and communicate the parameter of interest.

[0109] An advantage of one embodiment of the present invention, is that the device does not have an on-site battery. Therefore, the probe **12** must run a start-up sequence each time power is transferred to the probe **12**. In the present invention, this start-up sequence involves running an auto-calibration algorithm. This auto-calibration algorithm ensures that the pressure measurements received from the sensor **16** will always be within the desired range of the probe electronics **18**.

[**0110**] It is also clear from the description above that the invention includes a method for measuring and communicating a parameter of a brain, tissue or other organs of a body. Without further limiting such methods described above, the method, in one embodiment, comprising the steps of:

[**0111**] providing:

[**0112**] an implantable first sensor **16** capable of measuring and communicating parameters of a brain, tissue or other organs; and

[**0113**] an activation system **15** connected to and responding to sensor **16**, the activation system **15** having an external device capable of transmitting power to the sensor and receiving parameter information from the sensor;

[**0114**] cutting through the skin;

[**0115**] placing the sensor **16** at a desired location within the body;

[**0116**] closing the skin is closed so that the sensor **16** is entirely contained within the patient's skin;

[**0117**] bringing the external device **14** near the sensor **16** so that power is transferred from the external device **14** to the sensor **16**; and

[**0118**] uplinking information from the sensor **16** to the external device **14**.

[**0119**] The description contained herein is intended to be illustrative of the invention and not an exhaustive description. Many variations, combinations and alternatives to the disclosed embodiments will occur to one of ordinary skill in this art. Further, where specific values have been given, these values are intended to be illustrative of the invention and are not intended to be limiting. Further, specific anatomical locations for implanting the device have been described. These are intended to be exemplary and not limiting. The locations where the described device can be located will readily occur to those skilled in the art. All these alternatives, combinations and variations are intended to be included within the scope of the attached claims. Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims attached hereto.

1. A device for measuring and communicating parameters of a brain, tissue or other organs of a body comprising:

an implantable first sensor **16** capable of measuring and communicating parameters of a brain, tissue or other organs; and

an activation system **15** connected to and responding to sensor **16**.

2. The device of claim 1 wherein the activation system **15** includes a user communication system **28** that communicates information from or about sensor **16** or may communicate alarms or other information based on the values that sensor **16** detects.

3. The device of claim 2 wherein the activation system **15** includes an external device **14**, the external device **14** including an external coil **22**, external electronics **24** and a power source **26**.

4. The device of claim 2 wherein the external device **14** includes an ambient parameter sensor **92**.

5. The device of claim 2 wherein the user communication system **28** includes a transmitter **60** and a receiver **74**.

6. The device of claim 5 wherein the activation system **15** includes an external device **14** and wherein the receiver **74** is located in the external device **14**.

7. The device of claim 5 wherein the user communication system **28** includes a display system **80** that displays or otherwise communicates the parameter information from the sensor **16** transmitted by the transmitter **60** to the receiver **74** to a user.

8. The device of claim 2 wherein the user communication system **28** includes a display system **80** that displays the parameter information sensed by the sensor **16** to the physician or other user.

9. The device of claim 2 wherein the user communication system **28** includes an alarm **90** that is triggered to alert the user to a parameter sensed by the sensor **16** that is outside of a pre-determined range.

10. The device of claim 1 wherein the activation system **15** and sensor **16** are co-located in the body of a patient.

11. The device of claim 1 wherein the sensor **16** and at least a portion of the activation system **15** are both implanted in a patient but are not co-located.

12. The device of claim 1 further comprising a control device **104** capable of taking action to effect the body of a patient wherein the activation system **15** directs the control device **104** to take action based on the information from or about sensor **16** or processed from information provided by sensor **16**.

13. The device of claim 1 wherein the sensor **16** is chosen from the group consisting of piezoelectric activity sensors, intracranial pressure sensors, ecg sensors, ultrasound sensors, acoustic sensors, infrared sensors, air flow sensors, strap-type respiration sensors, CO_2 sensors, thermistor sensors, microwave Doppler sensors, inductance change respiratory electrodes, temperature sensors, eeg sensors, pH sensors, emg sensors, O_2, respiration sensors, electrolyte concentration, glucose sensors, blood pressures sensors, heart rate sensors, posture sensors and activity sensors.

14. The device of claim 1 further comprising a probe **12**.

15. The device of claim 14 wherein the probe **12** includes sensor **16**, probe electronics **18** and a probe coil **20**.

16. The device of claim 15 further comprising an external device **14** and wherein the probe electronics **18** transfers power from the external device **14** to probe **12** to power probe **12** and uplinks sensed parameters from probe **12** to external device **14**.

17. The device of claim 15 therein the probe electronics **18** includes an AC/DC conversion system **62**.

18. The device of claim 17 wherein the probe coil **20** is connected to the AC/DC conversion system **62**.

19. The device of claim 17 wherein the AC/DC conversion system **62** includes a rectifier **66** and a regulator **68** wherein the rectifier **66** is connected to probe coil **20** and converts AC power received from the probe coil **20** to DC power.

20. The device of claim 15 wherein the probe electronics **18** further includes a temporary energy source **64** that provides the energy to power the probe electronics **18**.

21. The device of claim 20 wherein the temporary energy source **64** is chosen from the group consisting of a rechargeable battery, a non-rechargeable battery or a power capacitor such as a "super capacitor".

22. The device of claim 15 wherein probe electronics **18** further includes a long-term power source **76** that provides the energy to power the probe electronics **18**.

23. The device of claim 22 wherein the long-term power source **76** is chosen from the group consisting of a rechargeable battery, a non-rechargeable battery or a power capacitor such as a "super-capacitor".

24. The device of claim 15 wherein the probe **12** includes an electronics case **42** and wherein the probe electronics **18** is stored in the electronics case **42**.

25. The device of claim 24 wherein the electronics case **42** has a periphery **44**, wherein screw threads are placed on the periphery **44** of the electronics case.

26. The device of claim 15 wherein the probe electronics **18** includes sensor electronics **58** and a transmitter **60** wherein the sensor electronics **58** is connected to sensor **16** and provides power to sensor **16**, directs sensor **16** to take measurements and processes the sensed measurement signal from sensor **16**.

27. The device of claim 26 wherein the transmitter **60** is connected to sensor electronics **58** and a probe coil **20** wherein the probe coil **20** acts as an antenna and wherein the transmitter **60** and probe coil **20** communicate parameter information determined by sensor **16** to an external device **14** by telemetry.

28. The device of claim 26 further comprising a microprocessor **102** and a storage device **78** and wherein the sensor electronics **28** and storage device **78** are connected to the microprocessor **102** whereby parameter measurements by the sensor **16** are processed by microprocessor **102** before being stored in storage device **78**.

29. The device of claim 28 further comprising a control device **104** connected to microprocessor **102** and wherein the sensed parameter information controls or activates the control device **104**.

30. The device of claim 29 wherein the control device **104** is chosen from the group consisting of a pump, a valve in a CSF drainage system, a drug delivery system or an electrical stimulation device.

31. The device of claim 15 wherein the probe electronics **18** further includes a temporary energy source **64** and wherein the probe coil **20** is connected to an AC/DC conversion system **62** and wherein the probe coil **20** is inductively coupled to an external coil **22** in the external device **24** and wherein the temporary energy source **64** is connected to AC/DC conversion system **62** whereby inductive coupling between probe coil **20** and external coil **22** provides power to the probe coil **20** and through AC/DC conversion system **62**, charges up the temporary energy source **64** and whereby the temporary energy source **64** then provides the energy to power the probe electronics **18**.

32. The device of claim 14 wherein the probe **12** has a proximal end **30** and a distal end **32** and a central axis **34** and wherein the sensor **16** is located at the distal end **32**.

33. The device of claim 32 wherein the probe **12** includes a probe head **36** located at the proximal end **30**, the probe head **36** having an outer edge **40**.

34. The device of claim 33 wherein the probe head **36** is roughly discoid in shape.

35. The device of claim 34 wherein the probe head **36** includes an embedded probe coil **20** and wherein the probe coil **20** is an inductive coil.

36. The device of claim 35 wherein the probe coil **20** is wound around axis **34** in the plane of probe head **36**.

37. The device of claim 33 wherein screw threads are placed on the outer edge **40** of probe head **36**.

38. The device of claim 33 further comprising a storage device **78** located in probe head **36**.

39. The device of claim 14 wherein the sensor **16** is separated from the probe **12**.

40. The device of claim 39 further comprising a body **48** having a proximal and a distal end, the proximal end of the body **48** connected to the probe **12**, wherein the sensor **16** is located at the distal end of the body **48**.

41. The device of claim 40 wherein the body **48** is rigid.

42. The device of claim 40 wherein the body **48** is flexible.

43. The device of claim 39 wherein the sensor **16** is connected to the probe **12** through a body bus.

44. The device of claim 14 wherein the probe **12** has a proximal end **30**, a distal end **32** and a central axis **34** wherein the probe **12** includes a probe head **36** located at the proximal end **30**.

45. The device of claim 44 further comprising a body **48** having a proximal and a distal end, the proximal end of the body **48** connected to the probe head **36**, wherein the sensor **16** is located at the distal end of the body **48**.

46. The device of claim 45 wherein the body **48** is rigid.

47. The device of claim 45 wherein the body **48** is flexible.

48. The device of claim 1 wherein the sensor **16** is connected to the activation system **15** through a body bus.

49. The device of claim 1 further comprising a second sensor.

50. The device of claim 1 further comprising a microprocessor **102** and a storage device **78** wherein the sensor **16** and storage device **78** are connected to the microprocessor **102** whereby parameter measurements by the sensor **16** are processed by microprocessor **102** before being stored in storage device **78**.

51. The device of claim 50 further comprising a control device **104** connected to microprocessor **102** and wherein the sensed parameter information controls or activates the control device **104**.

52. The device of claim 51 wherein the control device is chosen from the group consisting of a pump, a valve in a CSF drainage system, a drug delivery system or an electrical stimulation device.

53. A device for measuring and communicating parameters of a brain, tissue or other organs of a body comprising:

an implantable first sensor **16** capable of measuring and communicating parameters of a brain, tissue or other organs;

an activation system **15** connected to and responding to sensor **16**, the activation system **15** including a user communication system **28** that communicates information from or about sensor **16** or may communicate alarms or other information based on the values that sensor **16** detects;

a probe **12** having a proximal end and a distal end, wherein the probe **12** includes sensor **16**, probe electronics **18** and a probe coil **20**, wherein the probe electronics **18** includes sensor electronics **58** and a transmitter **60** wherein the sensor electronics **58** is connected to sensor **16** and provides power to sensor **16**, directs sensor **16** to take measurements and processes the sensed measurement signal from sensor **16**, wherein the probe **12** includes a probe head **36** located at the proximal end **30**, the probe head **36** having an outer edge **40**, wherein the sensor **16** is located at the distal end of the probe **12**.

54. A device for measuring and communicating parameters of a brain, tissue or other organs of a body comprising:

an implantable first sensor **16** capable of measuring and communicating parameters of a brain, tissue or other organs;

an activation system **15** connected to and responding to sensor **16**, the activation system **15** including a user communication system **28** that communicates information from or about sensor **16** or may communicate alarms or other information based on the values that sensor **16** detects;

a probe **12** having a proximal end and a distal end, wherein the probe **12** includes sensor **16**, probe electronics **18** and a probe coil **20**, wherein the probe electronics **18** includes sensor electronics **58** and a transmitter **60** wherein the sensor electronics **58** is connected to sensor **16** and provides power to sensor **16**, directs sensor **16** to take measurements and processes the sensed measurement signal from sensor **16**, wherein the probe **12** includes a probe head **36** located at the proximal end **30**, the probe head **36** having an outer edge **40**, wherein the sensor **16** is located at the distal end of the probe **12**, wherein the probe head **36** is roughly discoid in shape and includes an embedded probe coil **20** and wherein the probe coil **20** is an inductive coil, wherein the probe coil **20** is wound around axis **34** in the plane of probe head **36**; and,

a storage device **78** located in probe head **36**.

55. A device for measuring and communicating parameters of a brain, tissue or other organs of a body comprising:

an implantable first sensor **16** capable of measuring and communicating parameters of a brain, tissue or other organs;

an activation system **15** connected to and responding to sensor **16**, the activation system **15** including a user communication system **28** that communicates information from or about sensor **16** or may communicate alarms or other information based on the values that sensor **16** detects;

a probe **12** having a proximal end and a distal end, wherein the probe **12** includes sensor **16**, probe electronics **18** and a probe coil **20**, wherein the probe electronics **18** includes sensor electronics **58** and a transmitter **60** wherein the sensor electronics **58** is connected to sensor **16** and provides power to sensor **16**, directs sensor **16** to take measurements and processes the sensed measurement signal from sensor **16**, wherein the probe **12** includes a probe head **36** located at the proximal end **30**, the probe head **36** having an outer edge **40**, wherein the probe head **36** is roughly discoid in shape and includes an embedded probe coil **20** and wherein the probe coil **20** is an inductive coil, wherein the probe coil **20** is wound around axis **34** in the plane of probe head **36**;

a storage device **78** located in probe head **36**; and.

a body **48** having a proximal and a distal end, the proximal end of the body **48** connected to the probe **12**, wherein the sensor **16** is located at the distal end of the body **48**.

56. The device of claim 55 wherein the body **48** is rigid.

57. The device of claim 55 wherein the body **48** is flexible.

58. A method for measuring and communicating a parameter of a brain, tissue or other organs of a body comprising the steps of:

providing a device for measuring and communicating parameters of a brain, tissue or other organs of a body comprising:

an implantable first sensor **16** capable of measuring and communicating parameters of a brain, tissue or other organs; and

an activation system **15** connected to and responding to sensor **16**, the activation system **15** having an external device capable of transmitting power to the sensor and receiving parameter information from the sensor;

cutting through the skin;

placing the sensor **16** at a desired location within the body;

closing the skin is closed so that the sensor **16** is entirely contained within the patient's skin;

bringing the external device **14** near the sensor **16** so that power is transferred from the external device **14** to the sensor **16**;

uplinking information from the sensor **16** to the external device **14**.

* * * * *

patsnap

专利名称(译)	带传感器的植入式医疗设备		
公开(公告)号	US20020151770A1	公开(公告)日	2002-10-17
申请号	US10/041431	申请日	2002-01-04
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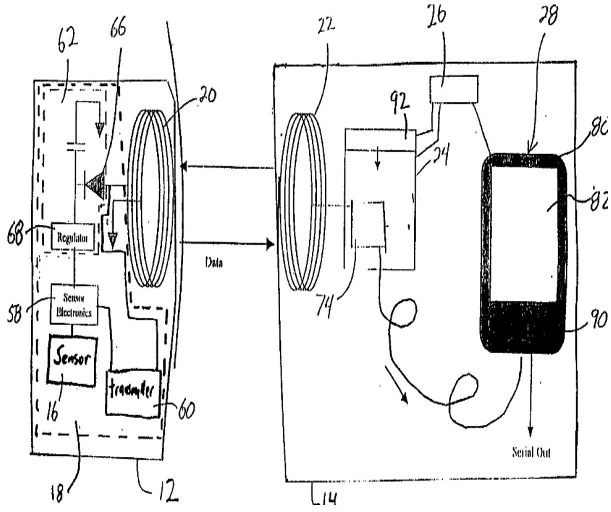
摘要(译)

公开了一种用于测量和传递脑，组织或其他器官的参数的装置和方法。本发明包括用于感测感兴趣的参数然后将感测的参数传送到激活系统的传感器。激活系统可以使参数显示，处理或引起动作。激活系统可以完全或部分植入或完全在患者体外。



62
66
20
22
26
28
92
24
86
82
68
Regulator
Data
74
58
Sensor Electronics
90
Sensor
transmitter
16
60
Serial Out
18
12
14