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(54) **ORTHOPAEDIC IMPLANT WITH SENSORS**

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See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,646,940 A 3/1972 Timm et al.  
3,745,995 A 7/1973 Kraus  
3,783,880 A 1/1974 Kraus  
3,788,647 A 1/1974 Evans et al.

3,820,534 A 6/1974 Kraus et al.  
3,842,841 A 10/1974 Brighton et al.  
3,918,440 A 11/1975 Kraus  
3,922,918 A 12/1975 Farrar, Jr. et al.  
3,964,473 A 6/1976 Wickham et al.  
3,977,391 A 8/1976 Fleischmann  
4,006,735 A 2/1977 Hitman et al.  
4,014,319 A 3/1977 Favre  
4,026,276 A 5/1977 Chubbuck  
4,026,304 A 5/1977 Levy  
4,027,661 A 6/1977 Lyon et al.  
4,062,354 A 12/1977 Taylor et al.  
4,114,606 A 9/1978 Seylar  
4,127,110 A 11/1978 Bullara

(Continued)

**FOREIGN PATENT DOCUMENTS**

CH 662 279 A5 9/1987

(Continued)

*Primary Examiner* — Thomas Barrett

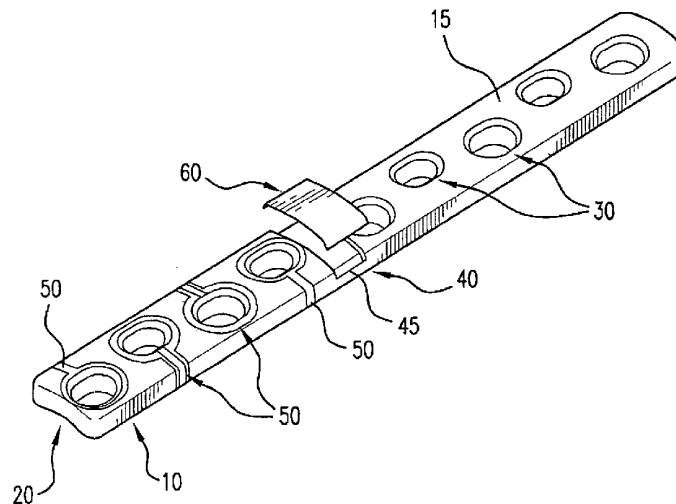
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(57) **ABSTRACT**

The present invention relates to an orthopaedic implant, such as a bone plate, for the fixation of bone where the implant also has at least one microchip and at least one sensor connected to the microchip. The sensor or sensors are configured to receive physical stimulus from a portion of the implant or the patient's tissue such as temperature, pressure, and strain. The information received from the sensor or sensors is gathered by the microchip and transmitted to a receiver, such as a personal computer, outside the patient. This information enables doctors to diagnose the useful life of the implant, the load sharing of the bone plate, and possible complications typically associated with orthopaedic implants such as infection, fracture non-union, and fatigue. The implant may also have one or more electrodes located on its surface which emit an electric current to stimulate healing of the broken or fractured bone.

**36 Claims, 10 Drawing Sheets**



U.S. PATENT DOCUMENTS							
4,141,349	A	2/1979	Ory et al.	6,113,553	A	9/2000	Chubbuck
4,153,060	A	5/1979	Korostoff et al.	6,117,089	A	9/2000	Sinha
4,186,749	A	2/1980	Fryer	6,120,467	A	9/2000	Schallhorn
4,195,367	A	4/1980	Kraus	6,120,502	A	9/2000	Michelson
4,214,322	A	7/1980	Kraus	6,143,035	A *	11/2000	McDowell ..... 623/22.11
4,216,548	A	8/1980	Kraus	6,165,135	A	12/2000	Neff
4,231,376	A	11/1980	Lyon et al.	6,176,879	B1	1/2001	Reischl et al.
4,246,908	A	1/1981	Inagaki et al.	6,248,080	B1	6/2001	Miesel et al.
4,265,252	A	5/1981	Chubbuck et al.	6,261,247	B1	7/2001	Ishikawa et al.
4,306,564	A	12/1981	Kraus	6,278,379	B1	8/2001	Allen et al.
4,313,438	A	2/1982	Greatbatch	6,289,753	B1	9/2001	Basser et al.
4,314,554	A	2/1982	Greatbatch	6,292,699	B1	9/2001	Simon et al.
4,333,469	A	6/1982	Jeffcoat et al.	6,305,229	B1	10/2001	Inoue
4,354,506	A	10/1982	Sakaguchi et al.	6,311,562	B1	11/2001	Hanada
4,391,124	A	7/1983	Drost et al.	6,322,562	B1	11/2001	Wolter
4,414,979	A	11/1983	Hirshorn et al.	6,357,303	B1	3/2002	Smith et al.
4,421,115	A	12/1983	Kraus	6,387,096	B1	5/2002	Hyde, Jr.
4,432,361	A	2/1984	Christensen et al.	6,433,629	B2	8/2002	Hamel et al.
4,506,681	A	3/1985	Mundell	6,443,891	B1	9/2002	Grevious
4,549,546	A	10/1985	Kelly et al.	6,447,448	B1	9/2002	Ishikawa et al.
4,549,547	A	10/1985	Brighton et al.	6,453,198	B1	9/2002	Torgerson et al.
4,558,701	A	12/1985	Spalten	6,481,440	B2	11/2002	Gielen et al.
4,576,158	A	3/1986	Boland	6,494,097	B1	12/2002	Shihadeh
4,602,638	A	7/1986	Adams	6,529,127	B2	3/2003	Townsend et al.
4,611,597	A	9/1986	Kraus	6,533,733	B1	3/2003	Ericson et al.
4,618,822	A	10/1986	Hansen	6,546,293	B2	4/2003	Errico et al.
4,665,920	A	5/1987	Campbell	6,554,781	B1	4/2003	Carter et al.
4,738,267	A	4/1988	Lazorthes et al.	6,572,543	B1	6/2003	Christopherson et al.
4,784,154	A	11/1988	Shirley et al.	6,575,042	B1	6/2003	Rinner
4,869,265	A	9/1989	McEwen	6,581,481	B1	6/2003	Perusek
4,993,428	A	2/1991	Arms	6,583,630	B2	6/2003	Mendes et al.
5,024,239	A	6/1991	Rosenstein	6,585,666	B2	7/2003	Suh et al.
5,030,236	A	7/1991	Dean	6,591,698	B1	7/2003	Carlsson et al.
5,037,442	A	8/1991	Wintermantel et al.	6,605,089	B1	8/2003	Michelson
5,052,375	A	10/1991	Stark et al.	6,610,096	B2	8/2003	MacDonald
5,056,518	A	10/1991	Pethica et al.	6,622,567	B1	9/2003	Hamel et al.
5,056,530	A	10/1991	Butler et al.	6,636,760	B1	10/2003	Casey et al.
5,083,573	A	1/1992	Arms	6,638,276	B2	10/2003	Sharkey et al.
5,188,109	A	2/1993	Saito	6,648,903	B1	11/2003	Pierson, III
5,197,488	A	3/1993	Kovacevic	6,656,135	B2	12/2003	Zogbi et al.
5,290,281	A	3/1994	Tschakaloff	6,689,087	B2	2/2004	Pal et al.
5,304,210	A	4/1994	Crook	6,706,005	B2	3/2004	Roy et al.
5,314,458	A	5/1994	Najafi et al.	6,802,811	B1	10/2004	Slepian
5,326,363	A	7/1994	Aikins	6,932,308	B2	8/2005	Talish et al.
5,330,477	A	7/1994	Crook	6,974,417	B2	12/2005	Lockwood et al.
5,360,016	A	11/1994	Kovacevic	6,976,982	B2	12/2005	Santini et al.
5,368,546	A *	11/1994	Stark et al. .... 601/34	7,007,699	B2	3/2006	Martinelli et al.
5,406,853	A	4/1995	Lintilhac et al.	7,060,075	B2	6/2006	Govari et al.
5,425,775	A	6/1995	Kovacevic et al.	7,237,556	B2 *	7/2007	Smothers et al. .... 128/898
5,433,203	A	7/1995	Kimura et al.	2001/0000195	A1	4/2001	Smith et al.
5,441,527	A	8/1995	Erickson et al.	2001/0000803	A1	5/2001	Gielen et al.
5,456,724	A	10/1995	Yen et al.	2001/0047246	A1	11/2001	Fullen et al.
5,470,354	A *	11/1995	Hershberger et al. .... 128/898	2002/0024450	A1	2/2002	Townsend et al.
5,497,147	A	3/1996	Arms et al.	2002/0049394	A1	4/2002	Roy et al.
5,524,624	A	6/1996	Tepper et al.	2002/0050174	A1	5/2002	Valdevit et al.
5,565,005	A	10/1996	Erickson et al.	2002/0110715	A1	8/2002	Schulman et al.
5,626,579	A	5/1997	Muschler et al.	2002/0111660	A1	8/2002	Errico et al.
5,678,448	A	10/1997	Fullen et al.	2002/0115944	A1	8/2002	Mendes et al.
5,695,496	A	12/1997	Orsak et al.	2002/0143268	A1	10/2002	Meredith et al.
5,738,521	A	4/1998	Dugot	2002/0147416	A1	10/2002	Zogbi et al.
5,752,976	A	5/1998	Duffin et al.	2002/0151770	A1	10/2002	Noll, III et al.
5,766,231	A	6/1998	Erickson et al.	2002/0198604	A1	12/2002	Schulman et al.
5,777,467	A	7/1998	Arms et al.	2003/0029247	A1	2/2003	Biedermann et al.
5,791,350	A	8/1998	Morton	2003/0032997	A1	2/2003	Pianca et al.
5,792,076	A	8/1998	Orsak et al.	2003/0040806	A1	2/2003	MacDonald
5,827,209	A *	10/1998	Gross ..... 602/19	2003/0055476	A1	3/2003	Vinup et al.
5,873,840	A	2/1999	Neff	2003/0066365	A1	4/2003	Biermann et al.
5,887,351	A	3/1999	Arms et al.	2003/0069623	A1	4/2003	Stypulkowski
5,978,972	A	11/1999	Stewart et al.	2003/0069644	A1	4/2003	Kovacevic et al.
6,022,349	A	2/2000	McLeod et al.	2003/0078633	A1	4/2003	Firlirk et al.
6,025,725	A	2/2000	Gershenfeld et al.	2003/0083746	A1	5/2003	Kuslich
6,034,295	A	3/2000	Rehberg et al.	2003/0088301	A1	5/2003	King
6,034,296	A	3/2000	Elvin et al.	2003/0105461	A1	6/2003	Putnam
6,059,784	A *	5/2000	Perusek ..... 606/54	2003/0120323	A1	6/2003	Meadows et al.
6,083,174	A	7/2000	Brehmeier-Flick et al.	2003/0135253	A1	7/2003	Kokones et al.
6,092,530	A	7/2000	Weissman et al.	2003/0139690	A1	7/2003	Aebli et al.
6,111,520	A	8/2000	Allen et al.	2003/0139782	A1	7/2003	Duncan et al.
6,112,122	A	8/2000	Schwardt et al.	2003/0153918	A1	8/2003	Putnam et al.
				2003/0153959	A1	8/2003	Thacker et al.

2003/0174066	A1	9/2003	Goetz et al.	DE	101 37 011	A1	2/2003
2003/0199948	A1	10/2003	Kokones et al.	EP	0 553 517	A1	8/1992
2003/0204161	A1	10/2003	Ferek-Petric	EP	0 561 068	A1	12/1992
2003/0204221	A1	10/2003	Rodriguez et al.	EP	0 611 583	A1	1/1994
2003/0204222	A1	10/2003	Leinders et al.	EP	0 611 583	B1	1/1994
2003/0204223	A1	10/2003	Leinders et al.	EP	0 956 811		11/1999
2003/0204224	A1	10/2003	Torgerson et al.	EP	1 351 428	A1	10/2003
2003/0212445	A1	11/2003	Weinberg	EP	1 671 577	A1	6/2006
2003/0216666	A1	11/2003	Ericson et al.	EP	1 854 503	A1	11/2007
2003/0236558	A1	12/2003	Whitehurst et al.	FR	28 75 972	A1	3/2006
2004/0011137	A1	1/2004	Hnat et al.	GB	2 223 406	A1	4/1990
2004/0015202	A1	1/2004	Chandler, III et al.	JP	5-277195		10/1993
2004/0015204	A1	1/2004	Whitehurst et al.	JP	9 098 978	A2	4/1997
2004/0015205	A1	1/2004	Whitehurst et al.	JP	2000-237219	A	9/2000
2004/0016298	A1	1/2004	Scott	WO	WO 90/06720		6/1990
2004/0019369	A1	1/2004	Duncan et al.	WO	WO 95/32673		12/1995
2004/0019382	A1	1/2004	Amirouche et al.	WO	01 / 78226		10/2001
2004/0019384	A1	1/2004	Kirking et al.	WO	2005 / 050 090	A2	1/2005
2004/0073221	A1	4/2004	Biscup	WO	2005 / 049 105	A2	6/2005

FOREIGN PATENT DOCUMENTS

DE	3 245 453	A1	9/1984
DE	3414992	A1	10/1985
DE	3 442 549	A1	5/1986
DE	44 42 930	A1	6/1996

WO	2005 / 074 821	A	8/2005
WO	2005 / 12 0203	A3	12/2005
WO	2006 / 045 607	A	5/2006
WO	2006 / 098 759	A1	9/2006

\* cited by examiner





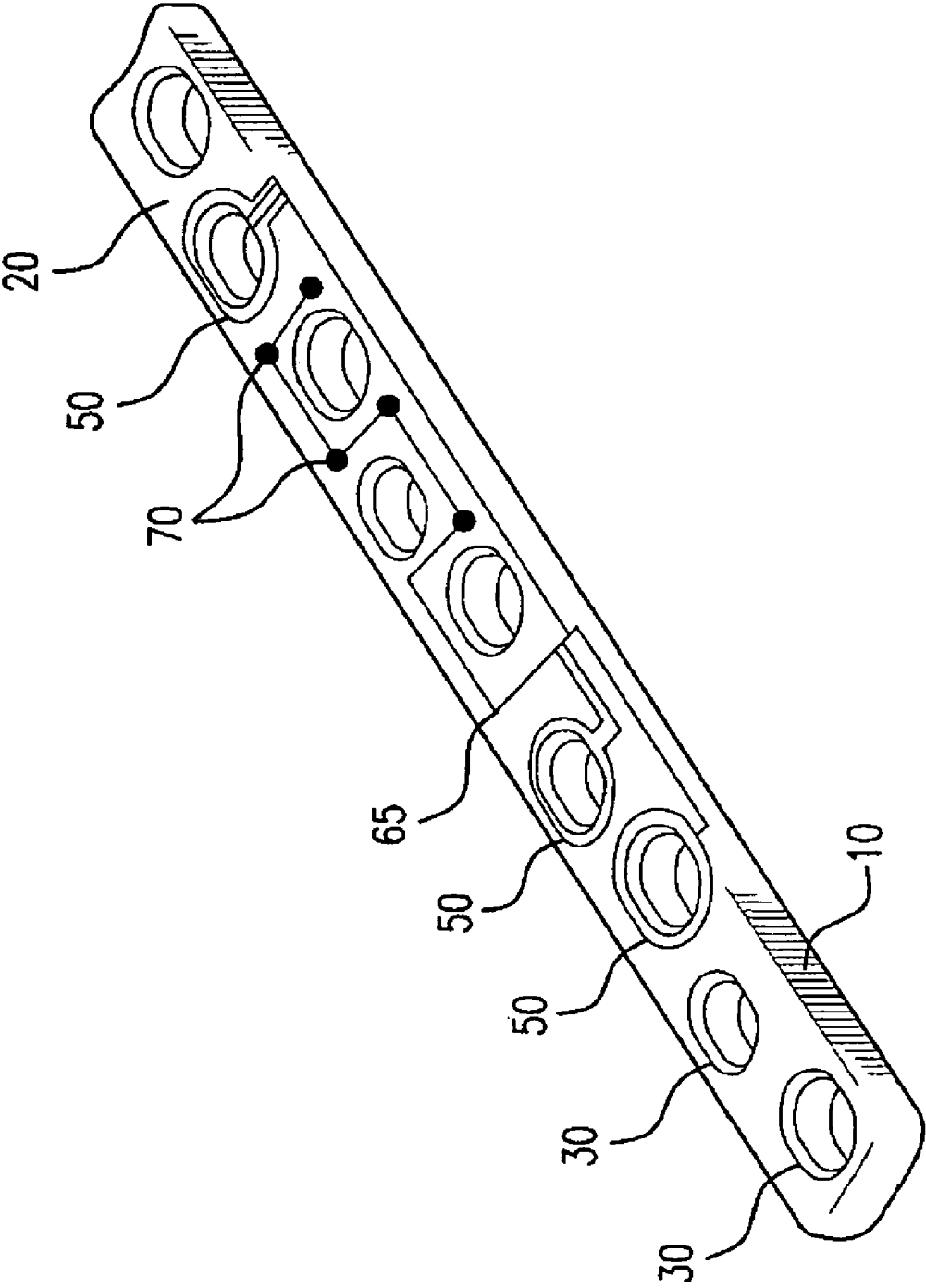


FIG. 3

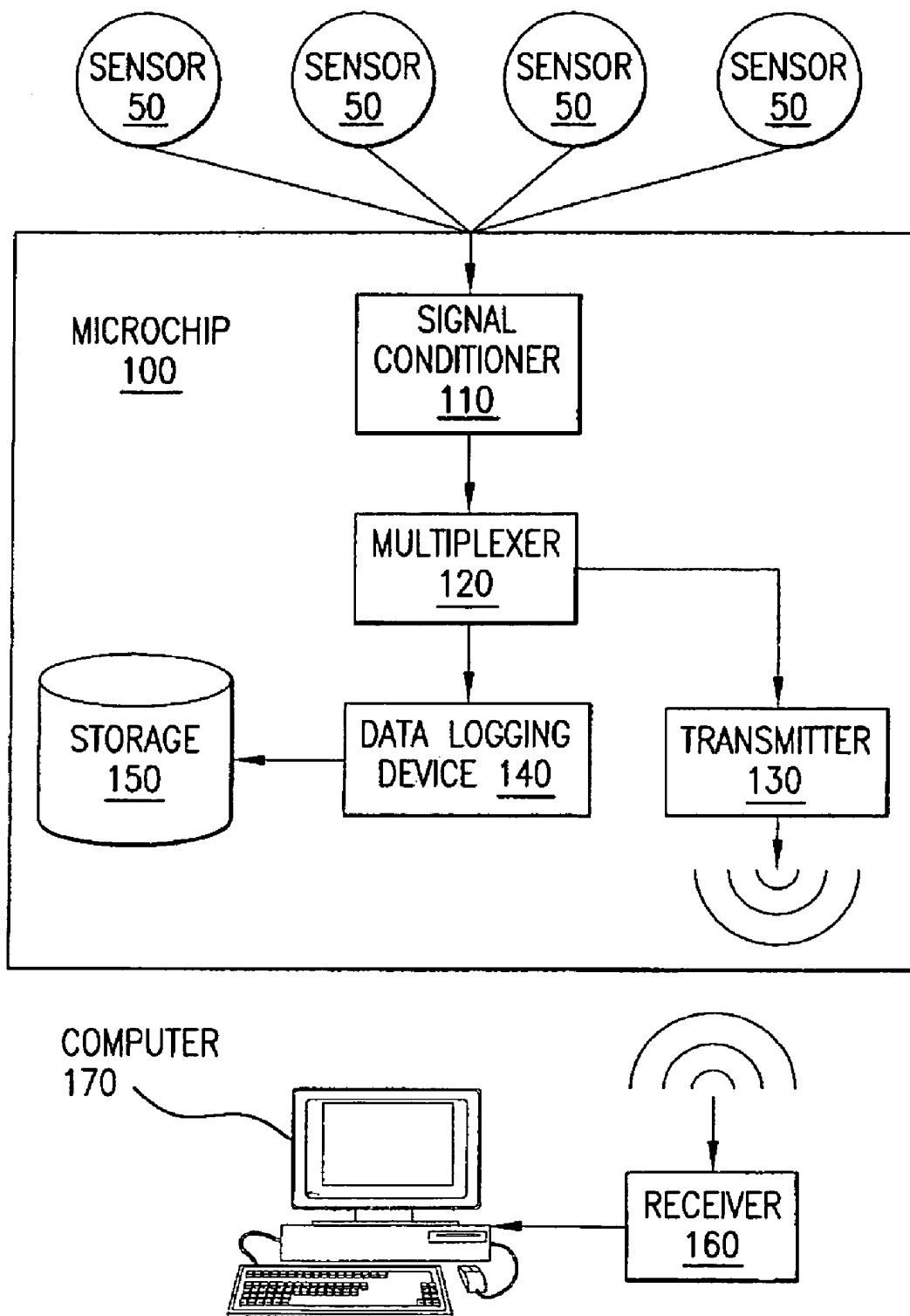


FIG. 4



FIG. 5

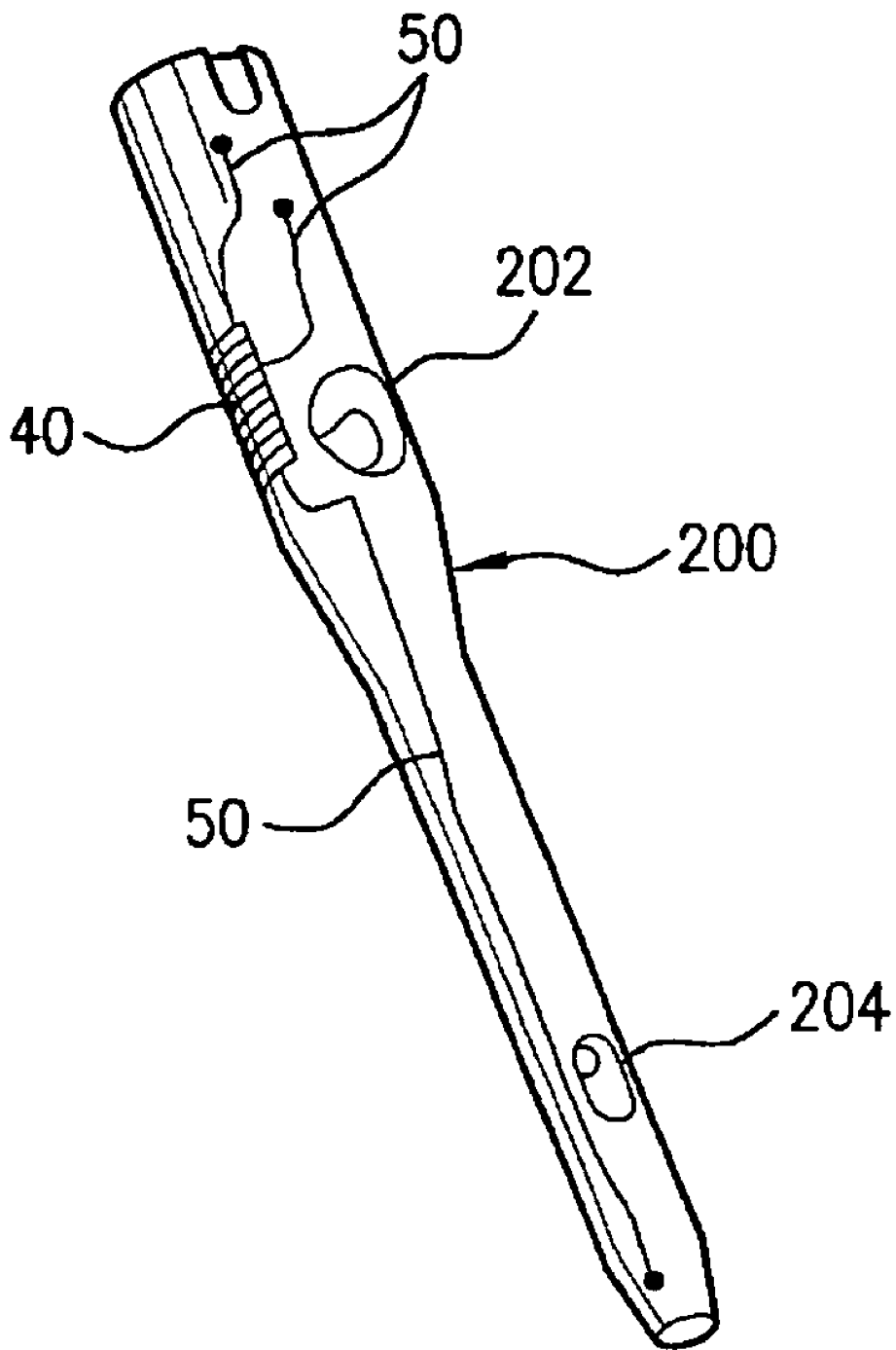


FIG. 6

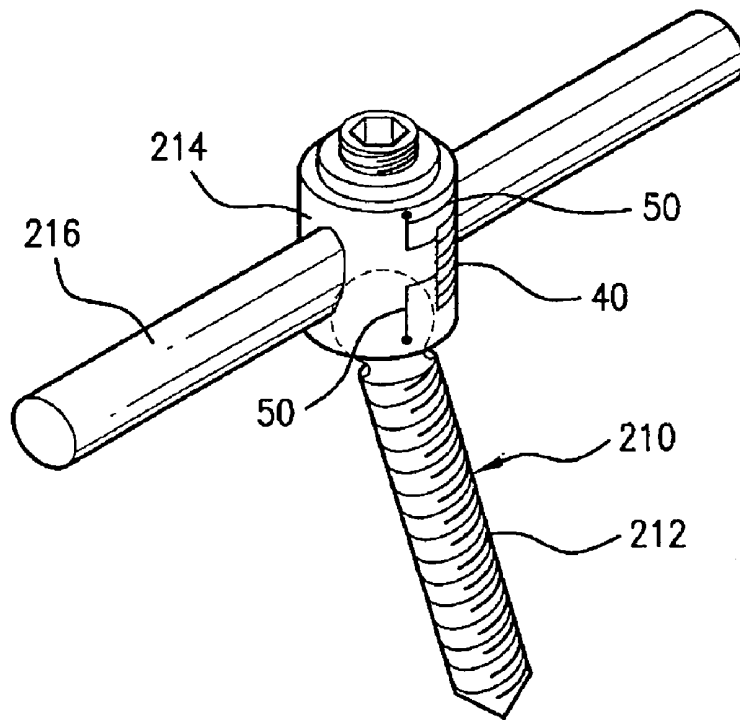


FIG. 7

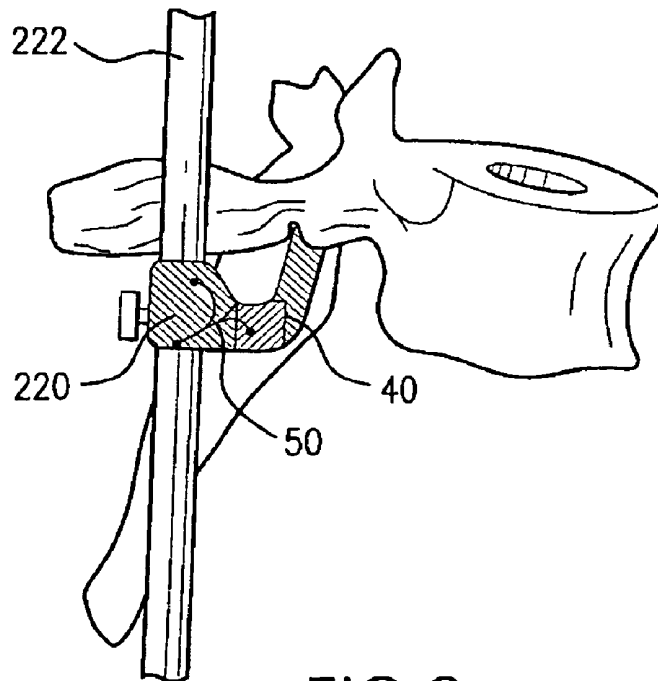


FIG. 8

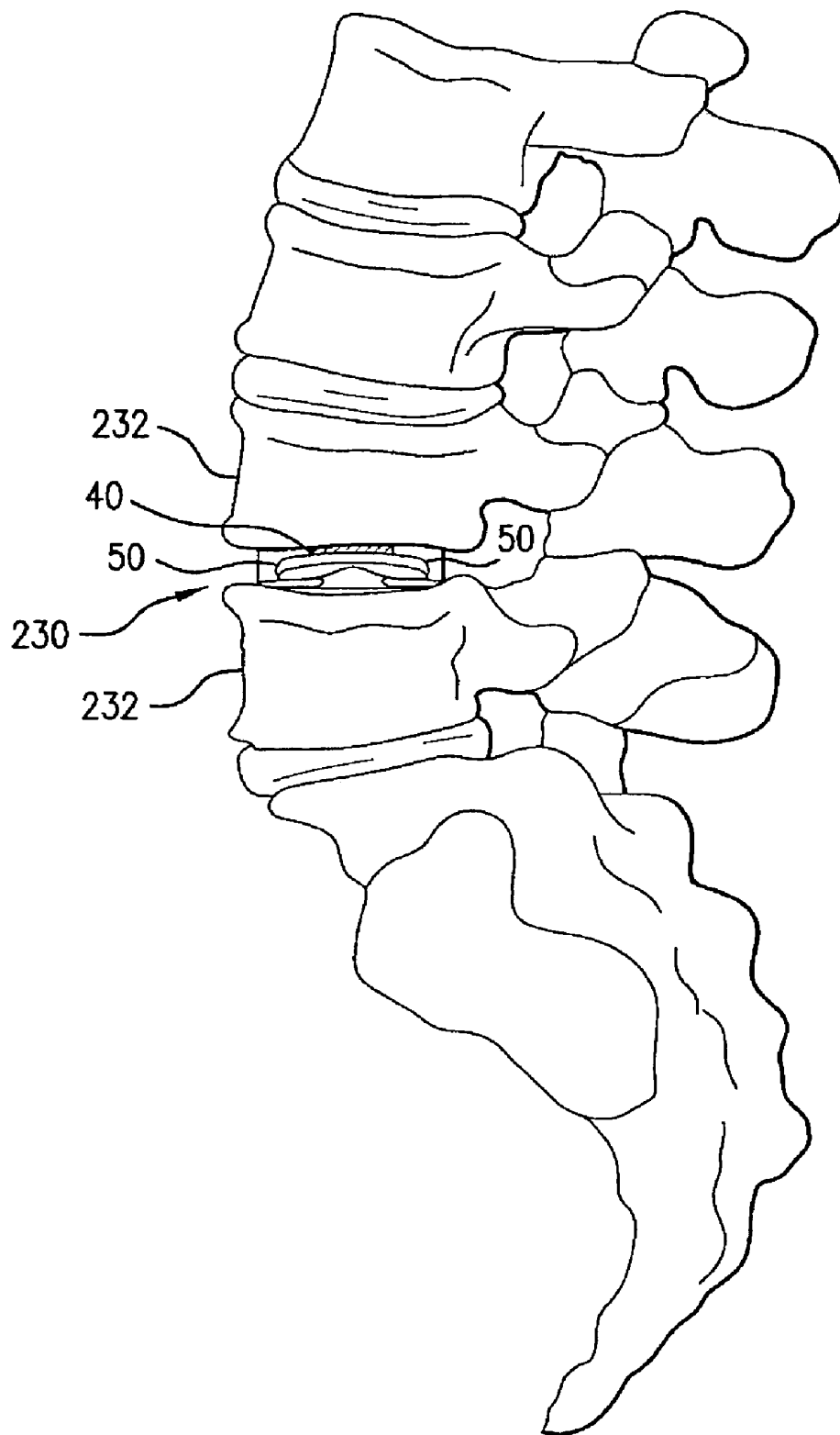


FIG. 9

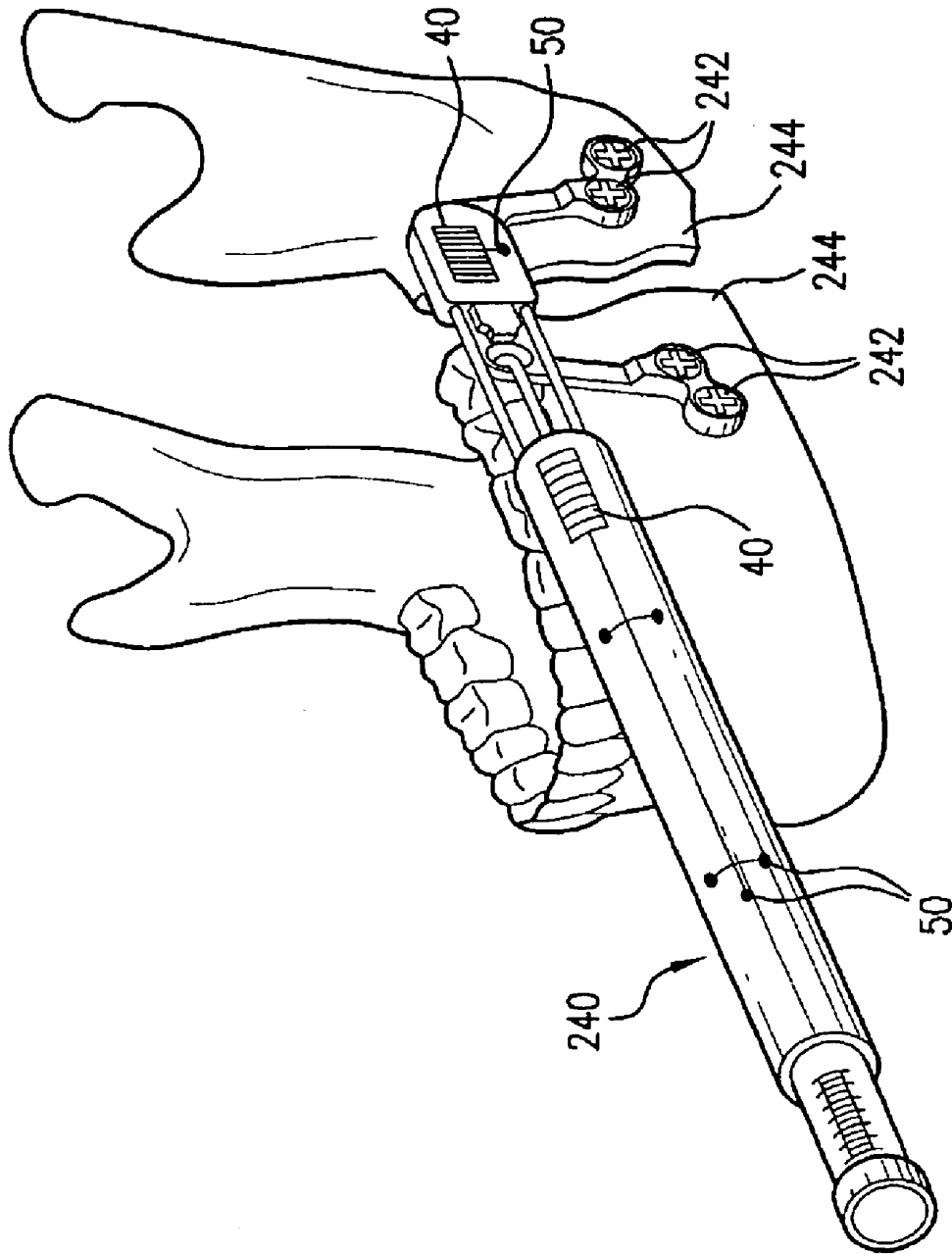


FIG. 10

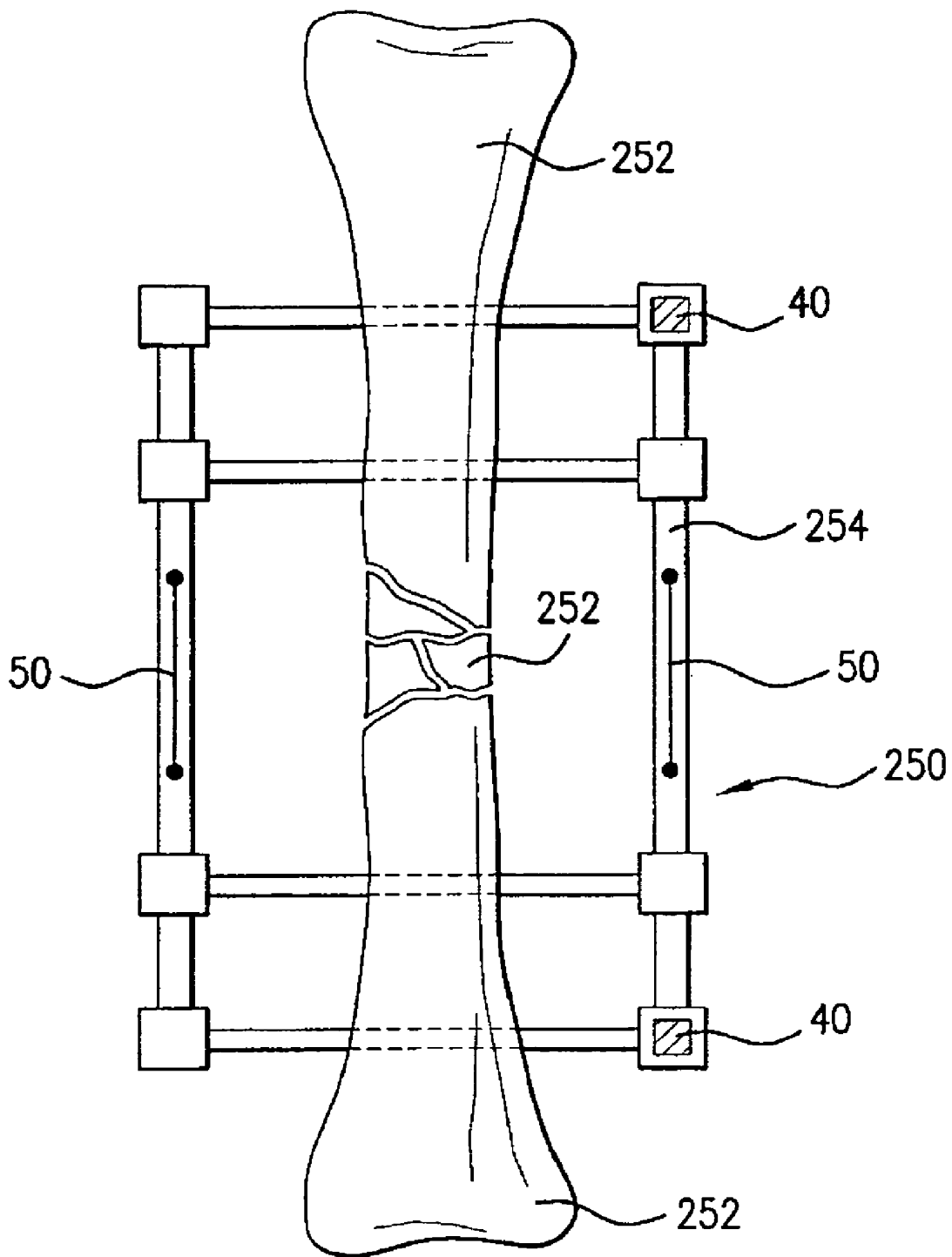


FIG. 11

**ORTHOPAEDIC IMPLANT WITH SENSORS**

## RELATED APPLICATION DATA

The present application claims priority to U.S. Provisional Patent Application Ser. No. 60/578,107, filed Jun. 7, 2004.

## FIELD OF THE INVENTION

The present invention relates to orthopaedic implants, such as bone plates, for use in repairing fractured bones or for addressing other orthopedic conditions. More particularly, the present invention relates to an orthopaedic implant having sensors and/or a microchip for measuring and transmitting data concerning the implant and/or the surrounding tissue to doctors and/or patients.

## BACKGROUND OF THE INVENTION

Bone plates have been used for many years in the field of orthopedics for the repair of broken bones and are well known in the art. One example of such a bone plate is shown and described in U.S. Pat. No. 6,623,486 to Weaver, et al. which is hereby incorporated by reference. Such bone plates function well in most instances, and fracture healing occurs more predictably than if no plate were used. In some instances, however, improper installation, implant failure, infection or other conditions such as patient non-compliance with prescribed post-operative treatment may contribute to compromised healing of the fracture, as well as increased risk to the health of the patient. Health care professionals currently use non-invasive methods such as x-rays to examine fracture healing progress and assess condition of implanted bone plates. However, x-rays may be inadequate for accurate diagnoses. They are costly, and repeated x-rays may be detrimental to the patient's and health care workers' health. In some cases, non-unions of fractures may go clinically undetected until implant failure. Moreover, x-rays may not be used to adequately diagnose soft tissue conditions or stress on the implant. In some instances, invasive procedures are required to diagnose implant failure or infections early enough that appropriate remedial measures may be implemented.

Therefore there is a need for an orthopaedic implant that can provide precise and accurate information to doctors and patients concerning the status of the implant, progress of fracture healing, and the surrounding tissue without the need for x-rays or invasive procedures.

## SUMMARY OF THE INVENTION

The present invention comprises an orthopaedic implant, e.g., a bone plate, intramedullary nail, etc., for fixation of bone having one or more microchips (ie., integrated circuits) and various sensors for the gathering of information relating to the implant and its environment.

An implant is provided comprising a body portion configured to contact patient tissue, one or more microchips, and a plurality of sensors arranged on the implant body and connected to said microchip wherein at least one sensor is configured to receive physical stimulus from a portion of the implant or the patient's tissue. The microchip may further comprise a data logger and a power source, such as a battery.

The implant may be a bone plate, bone screw, intramedullary nail, spinal fixation element (pedicle screw, pedicle hook, fixation plate, fixation rod, etc.), intervertebral implant (artificial spinal disc or fusion spacer), distractor, external fixation system or other orthopaedic implant. The implant may have a

coating, which may include a polymer or a porous metal, and may act as a carrier or substrate for a pharmaceutically active agent or other therapeutic substance. The implant may also include a compartment for storing a therapeutic agent, such as an antibiotic, a growth factor, a chemotherapeutic agent, etc. The therapeutic agent may be released in response to a signal received by the microchip.

One or more sensors on the implant may be configured and adapted to receive a strain from at least a portion of the implant. The sensors may be configured and adapted to receive a pressure applied to at least a portion of the implant, and/or to receive a temperature of at least a portion of the implant. The sensors may also be configured to capture digital images (video and/or photographs) of the surrounding patient tissue. The sensors may also be configured and adapted to emit an electric current for stimulating bone growth.

The patient tissue may comprise first and second bone portions of a fracture, the implant may further comprise an element configured to apply a micro-motion to the first and second bone ends to facilitate fusion of the fractured portions.

The implant may further comprise a counter for counting a number of loading cycles applied to the implant.

In another embodiment, an implant for the fixation of bone comprises a plurality of holes for accepting fasteners, an onboard microchip comprising a data logger, signal conditioner, multiplexer, and transmitter, and a plurality of sensors connected to the microchip and arranged at various points on said implant, wherein said sensors are configured to receive at least one physical stimulus at a portion of the implant.

One of said sensors may be selected from at least one of the group consisting of a pressure transducer, a thermocouple, a strain gauge and a cycle counter.

In another embodiment, the present invention relates to a method of mending a broken bone, comprising providing a bone fixation implant with a microchip, arranging a plurality of sensors on said implant, connecting said plurality of sensors to said microchip, affixing the implant to first and second portions of the broken bone using a plurality of fasteners, providing data from said sensors to said microchip, and transmitting said data from said microchip to an external receiving device.

In another embodiment, a monitoring system is provided comprising an implant having at least one sensor and configured for at least partial insertion into a patient, a microchip associated with the implant and the sensor, the microchip configured to receive at least a first signal from the sensor, a transmitter associated with the microchip for transmitting a second signal, representative of the first signal, a receiver located outside of the patient, the receiver configured receive the transmitted second signal, and a display device associated with the receiver, the display device configured to provide an audible or visual representation of the second signal to a user. The display device may be further configured to continuously record the transmitted second signal.

The implant may be coated. Such a coating may include a polymer or porous metal, such as magnesium, that can be a carrier or substrate for a pharmaceutically active agent or synthetic agent.

## BRIEF DESCRIPTION OF THE DRAWINGS

To facilitate an understanding of and for the purpose of illustrating the present invention, exemplary and preferred features and embodiments are disclosed in the accompanying drawings, it being understood, however, that the invention is not limited to the precise arrangements and instrumentalities

shown, and wherein similar reference characters denote similar elements throughout the several views, and wherein:

FIG. 1 is a perspective view of a first embodiment of a bone plate according to the present invention;

FIG. 2 is a side view of a second embodiment of a bone plate according to the present invention attached to a bone;

FIG. 3 is a perspective view of the underside of an embodiment of a bone plate according to the present invention;

FIG. 4 is a block diagram of an embodiment of the various microchip components;

FIG. 5 is a cross-section of a bone plate according to the present invention as attached to a bone;

FIG. 6 is perspective view of an intramedullary nail according to a preferred embodiment of the present invention;

FIG. 7 is a perspective view of a pedicle screw according to another preferred embodiment of the present invention;

FIG. 8 is a perspective view of a pedicle hook according to yet another preferred embodiment of the present invention;

FIG. 9 is a side view of an intervertebral implant according to still another preferred embodiment of the present invention;

FIG. 10 is a perspective view of a maxillofacial distractor according to a preferred embodiment of the present invention; and

FIG. 11 is a side view of an external bone fixation system according to a preferred embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference is now made to FIGS. 1-2, which show a bone plate 10 according to a first preferred embodiment of the present invention. The bone plate 10 shown in FIG. 1 comprises upper surface 15 and lower surface 20, with the lower surface 20 configured to contact the bone. The plate may further have a number of holes 30 configured and adapted to receive fasteners, such as, for example, screws, that will affix the bone plate to the bone. One or more microchips 40 may be located on the plate top surface 15, bottom surface 20, the side wall of the bone plate, or as with the illustrated embodiment, may be placed within a compartment 45 in the bone plate for recording information gathered by numerous sensors 50 which may be located at various locations anywhere on the top, bottom or sides of the plate, or may surround or be located within the plate holes. The sensors may be located on the surface of the plate, or they may be embedded therein. A small cover 60 may be provided to conceal and protect microchip 40 within the bone plate. The cover 60 may seal the microchip from exposure to the environment within which the bone plate is placed. Alternatively, microchip 40 may not be covered and may be openly exposed. While reference is made to a plate having the configuration illustrated in FIG. 1, it will be noted that one or more microchips 40 and sensors 50 may be used in conjunction with any appropriate fixation device known in the art, e.g., intramedullary nails, screws for external or internal fixation, spinal fixation elements (pedicle screws, hooks, fixation rods, etc.), intervertebral implants (artificial spinal disks and spacers), distractors for lengthening bones and correcting deformities, etc. Furthermore, it should be emphasized that multiple microchips 40 and/or multiple sensors 50 may be provided for a single fixation device to monitor different segments of the fixation device or to monitor different types of sensors (e.g. strain, pressure, temperature, cycle count) provided with the plate. Moreover, microchips 40 located in one implant 10 can send and receive data to and from other implants. For example, a bone plate 10 located at one fracture site can send data to another plate 10

located at a different fracture site in the same or a different bone. Similarly, pedicle screws at one location can receive data from other pedicle screws, hooks or fixation rods. The implants of the present invention may also be used at an impending pathological fracture site, where information concerning increasing strain on the implant would indicate that the affected bone is weakening. Similarly, such implants could also be employed at locations where osteotomies or resections have been performed to monitor bone strength.

In addition, the holes 30 in the bone plate 10 may be threaded to receive screws with threaded heads, as described in U.S. Pat. No. 5,709,686 to Talos, which is hereby incorporated by reference. The threaded connection between the screw and the plate may serve to lock the screw and plate together so that the screw will not back out of the plate even if the screw shank loses purchase with the surrounding bone, which can occur in patients having substandard bone structure resulting from osteoporosis or other factors. Standard compression screws having no such plate-locking feature may tend to pull out of substandard bone when subjected to the bending forces generated in the plate during post-installation loading. Further, standard compression screws are designed to engage the screw holes of the plate in a manner that forces the fractured bone ends together to aid healing. Thus, where a plate having only compression screws is installed across a fracture site, the bone portions may move slightly in the period following fixation. As a result, the measured strain in the plate during that period may not be truly representative of the true load-bearing capacity of the bone (i.e. it may be unnaturally high). Thus, a strain reading from a sensor on a plate using only compression screws may not provide the surgeon with reliable information regarding early healing of the bone (i.e. in the days or first week following implantation) from which he or she may make a diagnosis regarding whether the fracture is healing properly. Only after the fractured bone portions have settled will strain readings become sufficiently accurate that a proper diagnosis may be made. By contrast, where locking screws (i.e. those having heads that threadably engage the plate holes) are used, there is no period of settling, and thus the strain values observed in the plate will immediately upon implantation be representative of the load carried by the plate (and correspondingly the load carried by the bone). As such, the surgeon may use these early measured strain readings to develop an accurate, early assessment of the fracture healing rate and the potential for non uniting. An early diagnosis of delayed union is advantageous because it allows the surgeon to take remedial steps as soon as a possible non-union is suspected, thus prompting intervention.

FIG. 2 shows an alternate embodiment of the invention installed on a bone. FIG. 2 shows a bone plate 10 attached to a bone 80 by several screws 90. Bone plate 10 may have curved, flared, or bent sections. The microchip cover 60 protects and covers one or more microchips 40. The various sensors 50 that wrap around different parts of the bone plate can also be seen.

FIG. 3 shows the underside of an embodiment of the bone plate 10, showing holes 30 and sensors 50. On the surface of the bone plate that attaches to the bone there may also be one or more electrodes 70 for the stimulation of bone growth. There may also be a small opening 65 for the various sensor electrodes to enter the bone plate and connect with the microchip contained therein. Opening 65 may also hold a pharmaceutically active agent, such as a bolus of antibiotics, chemotherapy agents, pain medication and/or other therapeutic agents. The agent may be released by the implant in response to a signal conveyed by the treating physician or the patient, or

may be dispensed automatically by the implant when an elevated temperature or other data signaling a need for the agent is recorded by one or more of sensors 50. In one embodiment, the agent may include growth factors, such as Bone Morphogenetic Proteins (BMPs) or Vascular Endothelial Growth Factor (VEGFs). In other pathologic applications, the agent may include angiogenesis inhibitors, e.g., fibulin-5, which act to deprive tumors of nutrients and oxygen. In other reconstructive applications, the pharmaceutically active agent may include drugs with the ability to stimulate hair growth in areas of the scalp, such as Minoxidil®. Sensors 50 may comprise pressure sensors disposed along the underside of the plate, and may be used to measure compression of the plate to the underlying bone (further described in relation to FIG. 5 below).

As seen in FIG. 4, the implant may contain a microchip 100 which may include a data logger 140, signal conditioner 110, multiplexer 120, and transmitter 130. The microchip may be connected to one or more sensors 50 attached at different locations along the implant. The sensors may be used to monitor loading of the implant by measuring strain at the individual locations and count the cycles of loading and unloading. Alternatively, the sensors may be configured to measure conditions immediately surrounding the implants; such as temperature, pH, etc. Sensors 50 and/or microchip 40 may also include digital photographic capabilities, such as a CMOS chip, which can capture and transmit images or video of patient tissue in the vicinity of the implant.

FIG. 5 is a cross-section of one embodiment of a bone plate 10 according to the present invention as attached to the bone 80. This figure shows how the bone plate 10 is semi-curved but has a different curvature from the bone 80 so that the bone plate only contacts the bone along the edges, or rails, of the bone plate. This type of contact is useful in minimizing the disruption of blood flow to the bone as described in U.S. Pat. No. 6,309,393 to Tepic, which is hereby incorporated by reference. Thus, sensors 50 disposed between the edges or rails of the plate and the bone surface may detect the compression force between the bone and the plate at those sensor locations. Resulting initial force measurements may be used to provide a baseline for the engagement of the plate with the bone immediately following implantation. Subsequent measurements may then be compared to the baseline measurements to determine whether the plate remains sufficiently engaged with the bone, or whether remedial action is required (e.g. the plate or screw(s) need to be replaced). The ideal fixation case is one in which the compression force between plate and bone remains constant from the time the implant is installed to the time it is removed. Where multiple individual sensors are disposed along the plate rails, subsequent readings associated with each sensor can be used to individually identify the condition of each screw in the plate, and may also be used to assess the overall integrity of the connection between the bone and the plate.

Thus, the various sensors arranged on the implant may include thermocouples, pressure transducers, force probes, counters, strain gauges, and digital imaging devices. At least one sensor may be used to count the number of loading cycles the implant experiences, including axial, bending and torsional loads. The information gathered from these sensors may be used to diagnose conditions associated with the implant and/or the tissue surrounding the implant.

For example, it may be important to monitor strain at various locations on the implant, since such strain may be directly related to forces applied to and experienced by the implant. Monitoring the force applied to the implant, e.g., a bone plate, over time may allow the doctor to determine

whether the bone is healing at the appropriate rate. As a bone heals, the amount of load carried by the bone will increase, and a proportionally lower load will be carried by the implant, and thus a lower strain will be measured by a strain gauge mounted to the plate. If the measured plate loading does not decrease at the expected rate, the doctor may take remedial action. Similarly, early detection of an overloading condition in the plate may allow the doctor to correct or replace an over-stressed or fatigued plate or fastener. It has been observed that non-unions are clinically diagnosed six months after the fracture event. If the strain gauge does not detect transfer of loading conditions, it may indicate delayed union and could signal potential damage to the implant or the end of its useful life.

One or more sensors may also be used to monitor the number of loading cycles, e.g., axial, bending, torsional, etc., experienced by the implant. One cycle may be defined as an application of stress to the implant followed by the release of that stress. For example, if the implant is installed along the femur of a patient, one cycle could be one step in which the patient puts pressure on the implant as his or her foot hits the ground followed by a release of that stress when the patient lifts his or her foot from the ground. The life of an implant is usually determined by how many cycles it experiences until bone healing occurs or until the implant fails. A doctor can determine when an implant needs to be replaced by using a counter programmed to log the amount of cycles the implant has been through. In addition, such a counter may be useful in determining the cause of an implant failure, such as due to over-activity of the patient or clinical non-union of the fracture.

It may also be desirable to obtain temperature readings at various locations along the implant to determine whether the tissue surrounding the implant is infected following implantation. Normal healthy human tissue has a temperature in the range of from about 36 degrees Celsius to about 37.5 degrees C. It has been observed that infected tissue may evidence an increase in temperature to a range above about 38 degrees C. Thus, if such a temperature increase is detected by one or more of the temperature sensors on the implant, the doctor may choose to initiate a regimen of antibiotics, or may take other more invasive actions to eliminate the infection. In one embodiment, as discussed above, the treating physician may send a signal to the implant to release a bolus of antibiotics stored in a compartment within the implant in order to treat an infection, or, alternatively, the implant itself may be configured to automatically release antibiotics if a certain threshold temperature is reached. Abnormally high tissue temperatures in the vicinity of the implant may also signal that the patient is experiencing an adverse reaction to the material of the implant. For example, if the implant is made of or contains a material to which the patient is allergic (e.g. nickel), the patient's body may react to the implant in a manner similar to that of an infection. Thus, patient rejection of the implant may likewise be determined through temperature measurement. Digital photographic elements within sensors 50 in the implant may also be used to view images of patient tissue for signs of infection and/or implant rejection.

Since body temperatures may be influenced by factors such as exercise, temperature readings would likely take place in the doctor's office or other controlled setting, rather than being constantly monitored or monitored by the patient. The temperature sensors preferably will be located anywhere on the surface of the plate, except between the plate and the bone. Monitoring of temperatures through sensors mounted on a bone plate thus may aid the doctor in making an important early diagnosis of infection, increasing the chance that the

infection may be effectively contained. In still other embodiments, sensors 50 on implant 10 may detect chemical agents/reagents formed by and in the patient's surrounding tissues.

Reference is now made to FIG. 4 which is a block diagram of a microchip contained on the implant of the present invention. In one embodiment, the microchip 100 may contain a data logging device 140 for storing information recorded by the sensors. The microchip may also contain a signal conditioner 110 for powering the sensor and preparing the signal received by the sensor, a multiplexer 120 for combining information received from numerous sensors, and a transmitter 130 or transmitting the information received from the sensor or sensors. As information is received by one or more sensors 50, it is passed through the signal conditioner 110 to the multiplexer 120 and on to both the data logging device 140 which may store information in storage 150 provided on microchip 100 and the wireless transmitter 130 which transmits the information to a receiving device 160 which may be connected to a computer 170. Device 160 can both send data to and receive data from microchip 100. In addition, in an alternate embodiment, wireless transmitter 130 may be replaced with a hard wired connection.

In one embodiment the receiving device is a wireless handheld computer, such as a Pocket PC®, Palm Pilot®, Blackberry® device or cellular telephone, that may be used to request information from the implant, store information sent by the implant, and send information to the implant. For example, the surgeon may pass the handheld device over the portion of the patient's body containing the implant, and the device may upload strain, temperature, pH, and/or pressure data from one or more sensors located on the implant. Thereafter, software associated with the microchip 100, sensors 50 and/or handheld device 160 may manipulate the uploaded data to provide a visual readout to the surgeon. Such a readout may comprise discrete force, temperature and pressure and stress cycle values taken from the individual sensors. The readout may also comprise a graph of the values obtained from the same patient over time. It may also provide an alarm feature that would signal a dangerous condition such as substantial implant overloading, substantial loss of compression between implant and bone, a high temperature condition indicative of infection, and/or an abnormally low or high cyclic loading count indicating the patient is either not participating in the proscribed recuperative therapy or is exerting him or herself more than a prescribed amount. In one embodiment, the software may display an image of the particular implant with measured force, pressure and temperature readings displayed at or near the actual location of the sensors on the implant. Further, instead of a discrete numerical readout associated with each sensor, the image may simply be color-coded to indicate satisfactory or unsatisfactory (i.e. alarm) conditions. Thus, in an exemplary embodiment, portions of the plate that are experiencing expected values of strain, pressure, pH, time, cycle count and temperature would appear in blue, whereas portions of the plate experiencing much higher than expected values would appear in red. Threshold normal and high strain, temperature, pressure and cycle values may be programmed into the microchip on the implant, or may be selected by the surgeon using the handheld device or from another computer associated with the implant. The surgeon may then use a stylus to select desired portions of the implant on the screen, and specific loading, pressure, cycle count, time, and/or temperature data would be displayed for the affected (i.e. red) area of the implant. In other embodiments, the receiving device may include external diagnostic equipment such as a CT scanner, which can send and receive data to and from the implants 10, and/or other handheld

devices 160. The method of communication between implants 10 and/or devices 160 may include infrared communication.

In one embodiment, the microchip 100 and data logging device 140 may contain implant-specific information supplied by the manufacturer such as implant type, sensor type, implant/sensor manufacturing date, location, lot, etc. Calibration data for each sensor may also be contained therein. Further, the microchip 100 and data logging device 140 may contain all of the historical readings from all of the sensors associated with the implant. The microchip 100 may also be programmed to perform manipulation of the data received from the sensors. Thus, in one embodiment the handheld device may perform minimal manipulation of data and may instead simply display data that has already been manipulated by the microchip 100 and stored by the data logging device 140. Alternatively, the handheld device may be used to perform some data manipulation.

Thereafter, the doctor may transmit the information from the handheld device to a desktop computer or web server for long term storage or for further manipulation as desired. In one embodiment, data may be transmitted anonymously to the manufacturer confidentially via the internet or other secure transmission method (to protect patient privacy). The manufacturer may then use such data to assist in designing future implants. The implants 10 and sending/receiving device 160 may also be configured for satellite communication.

In one embodiment, the microchip may be programmed to turn on and off at predetermined intervals in order to transmit information only at certain times of the day. Such an arrangement may be advantageous where the microchip is powered by a battery, and may thus act to conserve battery power. Alternately, the microchip may be configured to continuously transmit data throughout the life of the implant. This may be useful when a computer is used to continuously gather the information so that graphs may be made of different variables, such as temperature, strain, load and fatigue, and how these variables may change throughout the day, including how the patient's activities may affect the variables and whether and how such variables may affect the implant.

As earlier noted, the information stored in the data logging device 140 may be sent to a receiver 160 outside the body using a wireless (i.e., radio frequency (RF), infrared, etc.) transmitter 130. The wireless receiver may be connected to a handheld device or a personal computer 170 so that the patient and/or surgeon may view information transmitted from the bone plate or may send the information over the Internet to a recipient for analysis. In an alternative embodiment, data stored by implant 10 may be transmitted to a receiver 160 outside the body using a hard wired connection.

Alternately, the patient in whom the implant is installed may have a receiver in their home or office. The microchip may be configured to transmit a signal wirelessly to the receiver station if a certain condition occurs. For example, if the microchip senses an increase in temperature over a predetermined temperature, it may send an alarm signal to the base station, which may then issue an alarm signal audible to the user. Similar alarms based on over-strain, under-pressure, or over-cycling conditions may likewise be implemented. Alarm signals received by a wireless base station may also be sent automatically by the base station over the Internet to a doctor who may contact the patient with immediate instructions.

In one embodiment, the microchip may be powered using the principle of induction. In this embodiment, one coil of wire is attached to the microchip within the implant and one

coil of wire is embedded in a reader device located outside the patient. Excitation in the coil located outside the patient will produce an excitation in the coil within the implant. A remote energy source, such as an ultrasound device, may be used to excite the induction coils. This arrangement may operate like a transformer to power the microchip, thus obviating the need for battery power.

In an alternate embodiment, the implant may use a piezoelectric crystal which will use the loading and unloading cycle of the bone plate to generate a voltage which may be used to power the bone plate.

In yet another alternate embodiment, the microchip may use piezoelectric technology to create micro-motion within the implant. This micro-motion may be transmitted to the bone to facilitate healing of the bone. Alternatively, the micro-motion inherent in a healing bone may be used to power the microchip. Thus, a piezoelectric crystal may be used to receive the micro-motion and convert the motion to a charge that may power the device.

Referring again to FIG. 2, a specific positioning of the sensors on bone plate 10 is illustrated. In this embodiment, the sensors 50 are positioned around the screw holes to provide information to the doctor or patient concerning the location of the screws and the stress placed on the bone plate by each screw. However, one skilled in the art would recognize that sensors of such small size may be located on any part of the bone plate and thus may be used to provide information regarding physical characteristics of the bone plate sections and/or the environment associated with individual bone plate sections.

In another embodiment, the microchip may be used to send electric current through electrodes 70 located on different locations of the bone plate in order to electronically stimulate growth of the bone. Such stimulation may speed bone growth and recovery, and such phenomenon are well known in the art. One example of electrical current used to stimulate bone growth in implants and increase infection resistance of any antibacterial agents used with the bone plate is described in U.S. Pat. No. 6,663,634 to Ahrens et al., which is hereby incorporated by reference.

In a further embodiment, at least a portion of the bone plate may be coated, where the coating may include a polymer or porous metal, such as magnesium, that can act as a carrier or a substrate for a pharmaceutically active agent or synthetic agent. Such agents can include antibiotics, microbicides, growth factors (BMPs and/or VEGFs), angiogenesis inhibitors (fibulin-5) or chemotherapeutic agents. The coating may be biodegradable in the patient. A non-limiting exemplary coating is described in detail in U.S. patent application Ser. No. 09/801,752 to Schmidmaier et al., filed on Mar. 9, 2001, which is hereby incorporated by reference.

In one embodiment, the microchip may transmit information wirelessly by radio frequency (RF) as known in the art. The bone plate may also be encoded with information such as when the plate was installed and who installed it so that doctors can access this information from the plate by using radio frequency identification (RFID).

Although the present invention has been shown and described in connection with an implanted bone plate, one skilled in the art would recognize that the present invention can also be practiced with other types of orthopaedic implants, such as bone screws, intramedullary rods, spinal fixation elements and implants (e.g., pedicle screws, hooks, etc.), external fixators and distractors. One example of such a bone screw is shown and described in U.S. Pat. No. 6,306,140 to Siddiqui which is hereby incorporated by reference. Siddiqui describes a bone screw inserted into bone which is

suitable for stabilizing a fractured bone. The bone screw has threads and provides compression to stabilize different regions of bone. A microchip may be installed within the bone screw with one or more sensors located at different locations on the bone screw to monitor stress, strain, temperature and pressure. FIG. 7 shows a pedicle screw 210, having threads 212 and an upper portion 214 for connection to a fixation rod 216. Pedicle screw 210 includes one or more microchips 40 and sensors 50, which function as described above with reference to implant 10.

An embodiment of a bone pin which may be used in connection with the present invention is shown and described in U.S. Pat. No. 6,663,634 to Ahrens et al. Ahrens discloses a bone pin for insertion into bone that is coated with an antibacterial agent. The bone pin as disclosed in Ahrens may be adapted to practice the present invention by installing a microchip within the bone pin and one or more sensors located on the bone pin.

As shown in FIG. 6, the present invention may also be practiced in a similar manner in connection with an intramedullary nail 200 having one or more openings 202, 204 for receiving locking elements and/or cross members. Intramedullary nail includes one or more microchips 40 and sensors 50 for collecting and transmitting data concerning the implant and/or the surrounding patient tissue. A cross-member (not shown) used with an intramedullary nail 200, which may pass through an upper opening 202 and penetrate the femoral head when repairing femoral fractures, may also include one or more microchips 40 and sensors 50. Another example of an intramedullary nail is shown and described in U.S. Pat. No. 6,607,531 to Frigg which is hereby incorporated by reference.

As discussed above, the present invention may also be practiced in connection with spinal fixation devices such as pedicle screws 210 (FIG. 7), pedicle hooks 220 (FIG. 8), and fixation rods 216, 222 (FIGS. 7 & 8) for insertion into and/or attachment to the spinal column. In accordance with the present invention, the pedicle screw 210, pedicle hook 220 and/or fixation rod 216, 222 may contain one or more microchips 40 and one or more sensors 50 for the collection and transmission of strain, temperature, pressure and cycle data as previously described. Other pedicle screws and spinal fixation devices are shown and described in U.S. Pat. No. 6,325,802 to Frigg and U.S. Pat. No. 6,610,063 to Kumar et al., both of which are hereby incorporated by reference.

The present invention may also be practiced in connection with intervertebral implants, such as artificial spinal discs or spacers used in both fusion and non-fusion procedures for replacing damaged spinal discs. FIG. 9 shows an artificial spinal disc 230 inserted between two adjacent vertebrae 232 in the spinal column. Artificial disc 230 includes one or more microchips 40 and sensors 50, which function in the manner described above to collect and transmit implant/patient information.

As shown in FIG. 10, another embodiment of the present invention may be a distractor, such as a maxillofacial distractor. Distractor 240 is secured to bone segments 244 using bone screws 242, and includes one or more microchips 40 and sensors 50. In this embodiment, distractor 240 can provide live feedback to the physician or patient during adjustment of the distractor. In addition, microchip 40 may also be used to automatically drive the adjustment of the distractor (e.g., via motor, solenoid, etc.) based on the data recorded by microchip 40 and sensors 50 on distractor 240.

Similarly, as shown in FIG. 11, the present invention may take the form of an external fixation apparatus, e.g., spatial ring, wrist fixator, or other bone fixation system. External fixator 250 is attached to bone segments 252 using rods 254.

One or more microchips **40** and sensors **50** can record and transmit data concerning the fixation system to physicians and patients. As with distractor **240** discussed above, external fixator **250** can provide live feedback to the physician or patient during adjustment of the apparatus and microchip **40** may be used to automatically drive the adjustment of the fixator based on the implant and patient data recorded.

Another embodiment of the invention would provide for a centralized web server maintained by the manufacturer of the implants. The web server would be in communication with the various doctors that install and service the implants. When a doctor uses a computer or wireless device to collect information from the implant, the doctor may then transmit this information to the centralized web server. The manufacturer may then use this information to determine the average useful life of the particular implant model, and may also compile the data to determine what the common causes of failure for the implant model. The manufacturer also may use this data to determine whether trends in implant success or failure may be used to educate surgeons on the most effective installation technique for a particular implant. This information may assist the manufacturer in designing new and improved implants, and in refining installation techniques.

While the present invention has been described with reference to the preferred embodiments, those skilled in the art will recognize that numerous variations and modifications will be made without departing from the scope of the present invention. This is especially true with regard to the specific shape and configuration of the implant and sensors. For example, sensors for measuring strain, temperature, compression and/or load cycling may be used in virtually any known orthopedic fixation application. Non-limiting examples of such applications are: plates used in maxillofacial fixation applications, footplates used with facial distraction systems, cranial flap clamps, pins used with external fixation devices, spinal fusion plates, spinal fusion rod assemblies, etc.

Accordingly, it should be clearly understood that the embodiments of the invention described above are not intended as limitations on the scope of the invention, which is defined only by the following claims.

What is claimed is:

1. An implant comprising:
  - a body portion configured to contact patient tissue, the body portion defining a first fixation element receiving hole extending therethrough configured to receive a fixation element for coupling the body portion to a bone; a microchip; and
  - a plurality of sensors mounted on the body portion, a first one of the sensors being in contact with a perimeter of the first fixation element receiving hole, the plurality of sensors being connected to said microchip, the first sensor being configured to receive physical stimulus from one of a portion of the implant and patient tissue.
2. The implant of claim 1, wherein the microchip further comprises a data logger.
3. The implant of claim 2, wherein the microchip further comprises a power source.
4. The implant of claim 3, wherein the power source comprises a battery.
5. The implant of claim 1, wherein the implant includes a spinal fixation bone plate.
6. The implant of claim 1, wherein the implant includes a coating.
7. The implant of claim 6, wherein the coating includes a polymer or a porous metal.

8. The implant of claim 7, wherein the coating includes a pharmaceutically active agent.

9. The implant of claim 1, wherein the implant is an intramedullary nail.

10. The implant of claim 1, wherein the implant is a spinal fixation element.

11. The implant of claim 10, wherein the spinal fixation element comprises at least one of a pedicle screw, a spinal fixation plate, a spinal fixation rod and a spinal fixation hook.

12. The implant of claim 1, wherein the first sensor is configured and adapted to receive a strain from at least a portion of the implant.

13. The implant of claim 1 wherein the first sensor is configured and adapted to receive a pressure applied to at least a portion of the implant.

14. The implant of claim 1 wherein the first sensor is configured and adapted to receive a temperature of at least a portion of the implant.

15. The implant of claim 1, wherein the first sensor is configured and adapted to record images.

16. The implant of claim 1, wherein first sensor is configured and adapted to emit an electric current for stimulating bone growth.

17. The implant of claim 1, the patient tissue comprising first and second bone portions of a fracture, the implant further comprising an element configured to apply a micro-motion to the first and second bone portions to facilitate fusion of the first and second fractured bone portions.

18. The implant of claim 1, wherein said implant further comprises a counter for counting a number of loading cycles applied to the implant.

19. The implant of claim 1, further comprising a compartment for storing a therapeutic agent.

20. The implant of claim 19, wherein the therapeutic agent comprises at least one of an antibiotic, a growth factor, a pain medication, a chemotherapeutic agent, and a growth inhibitor.

21. The implant of claim 19, wherein the compartment further comprises an electronically operable cover engageable via an electric signal.

22. The implant of claim 21, wherein the electric signal is one of an externally transmitted control signal and a signal automatically transmitted in response to detection of a pre-determined stimulus.

23. The implant of claim 1, wherein the implant is an intervertebral implant.

24. The implant of claim 1, wherein the implant is a distractor.

25. The implant of claim 1, wherein the implant is an external fixation apparatus.

26. The implant of claim 1, wherein the first sensor is located within the first fixation hole.

27. The implant of claim 1, further comprising a second sensor on a bone facing surface of the implant in direct engagement with a bone surface.

28. The implant of claim 1, wherein the first sensor measures a deformation of the body portion.

29. An implant for the fixation of bone, comprising:
 

- a body portion configured to contact bone;
- a plurality of holes in the body portion for accepting fasteners;
- an onboard microchip including a data logger, signal conditioner, multiplexer, and transmitter; and
- a first sensor mounted on the body portion and connected to said microchip, the first sensor being in contact with a perimeter of a first one of the plurality of holes,

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wherein the first sensor is configured to receive at least one physical stimulus from a portion of one of the implant and the bone.

30. The implant of claim 29, wherein the implant comprises a bone plate.

31. The implant of claim 29, wherein the implant comprises an intramedullary nail.

32. The implant of claim 29, wherein the implant is a spinal fixation element.

33. The implant of claim 32, wherein the spinal fixation element comprises at least one of a pedicle screw, a spinal fixation plate, a spinal fixation rod and a spinal fixation hook.

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34. The implant of claim 29, further comprising a second sensor extending around a periphery of a second one of the holes.

5 35. The implant of claim 34, wherein one of the first and second sensors is selected from at least one of the group consisting of a pressure transducer, a thermocouple, a strain gauge, a digital imaging element, and a cycle counter.

36. The implant of claim 29, wherein the first sensor measures a deformation of the body portion.

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\* \* \* \* \*

专利名称(译)	带传感器的骨科植入物		
公开(公告)号	<a href="#">US8083741</a>	公开(公告)日	2011-12-27
申请号	US11/147750	申请日	2005-06-07
[标]申请(专利权)人(译)	斯恩蒂斯有限公司		
申请(专利权)人(译)	SYNTHES USA , LLC		
当前申请(专利权)人(译)	SYNTHES USA , LLC		
[标]发明人	MORGAN CHAD HALL IV HARRY T GREEN JAMES M FLEXNER GEOFFREY GELTZ CHARLES E		
发明人	MORGAN, CHAD HALL, IV, HARRY T. GREEN, JAMES M. FLEXNER, GEOFFREY GELTZ, CHARLES E.		
IPC分类号	A61B17/58 A61B5/00 A61B5/07 A61B5/103 A61B17/00 A61B17/60 A61B17/64 A61B17/66 A61B17/70 A61B17/72 A61B17/80 A61B17/86 A61B19/00 A61F2/00 A61F2/02 A61F2/28 A61F2/30 A61F2/44 A61F2/46 A61N1/20		
CPC分类号	A61B5/076 A61B5/14539 A61B5/411 A61B5/4504 A61B5/4839 A61B17/80 A61B19/46 A61N1/205 A61B5/01 A61B17/60 A61B17/64 A61B17/663 A61B17/70 A61B17/7001 A61B17/7037 A61B17/72 A61B17/7225 A61B17/86 A61B2017/00084 A61B2017/00734 A61B2019/464 A61B2560/0219 A61F2/442 A61F2002/2821 A61F2002/3067 A61F2002/30677 A61F2002/4666 A61F2002/4672 A61F2250/0002 A61F2310/0097 A61B90/06 A61B2090/064		
审查员(译)	BARRETT , THOMAS		
优先权	60/578107 2004-06-07 US		
其他公开文献	US20060052782A1		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

摘要(译)

本发明涉及一种用于固定骨的整形外科植入物，例如骨板，其中植入物还具有至少一个微芯片和至少一个连接到微芯片的传感器。一个或多个传感器配置成从植入物的一部分或患者的组织接收物理刺激，例如温度，压力和应变。从一个或多个传感器接收的信息由微芯片收集并传输到患者体外的接收器，例如个人计算机。该信息使医生能够诊断植入物的使用寿命，骨板的负荷分配以及通常与整形外科植入物相关的可能的并发症，例如感染，骨折不愈合和疲劳。植入物还可以具有位于其表面上的一个或多个电极，其发射电流以刺激破碎或破裂的骨的愈合。

