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(54) **WIRELESS COMMUNICATION DEVICE FOR ELECTRIC METER AND METHOD OF MANUFACTURE THEREOF**

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(52) **U.S. Cl.** **343/719; 340/870.02; 340/870.03**
(58) **Field of Search** **343/700 MS, 719; 340/870.02, 870.03; 324/113**

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(56) **References Cited**

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U.S. PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 81 days.

4,795,974 A * 1/1989 Landman et al. 324/142
4,884,021 A 11/1989 Hammond et al.
5,122,735 A 6/1992 Porter et al.
6,462,713 B2 * 10/2002 Porter et al. 343/719

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This patent is subject to a terminal disclaimer.

Primary Examiner—Tho Phan

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(57) **ABSTRACT**

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For use with an electric meter chassis having a dielectric housing protruding therefrom, a wireless communication device that permits information to be communicated to and from the electric meter and a method of manufacturing the same. In one embodiment, the device is comprised of: (1) a communication circuit within the chassis coupled to electric meter circuitry, and (2) an antenna element within the dielectric housing, the antenna element coupled to the communication circuit.

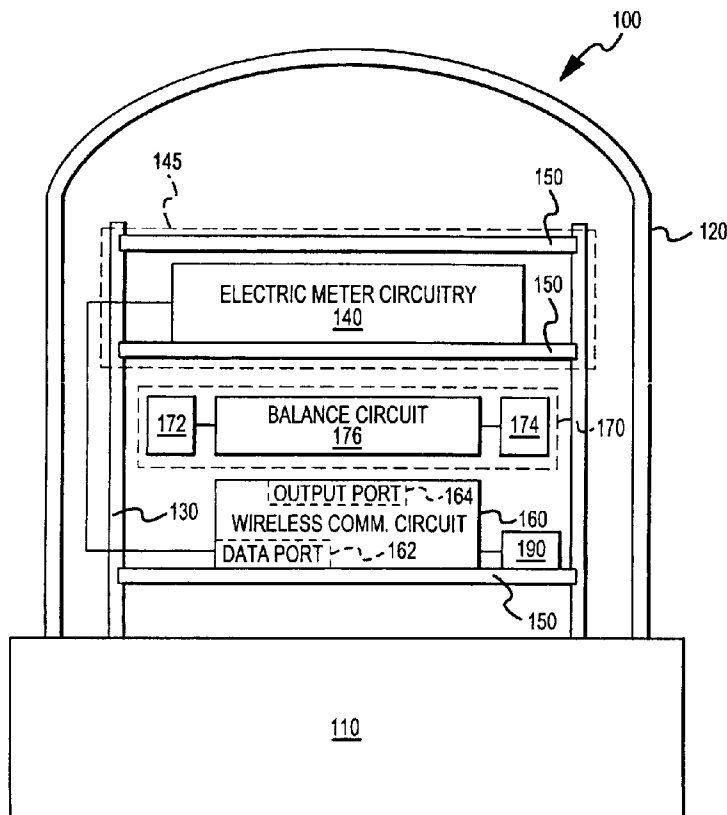
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Related U.S. Application Data

(63) Continuation-in-part of application No. 09/769,838, filed on Jan. 25, 2001, now Pat. No. 6,462,713, which is a continuation of application No. 09/040,113, filed on Mar. 17, 1998, now Pat. No. 6,181,294.

20 Claims, 2 Drawing Sheets



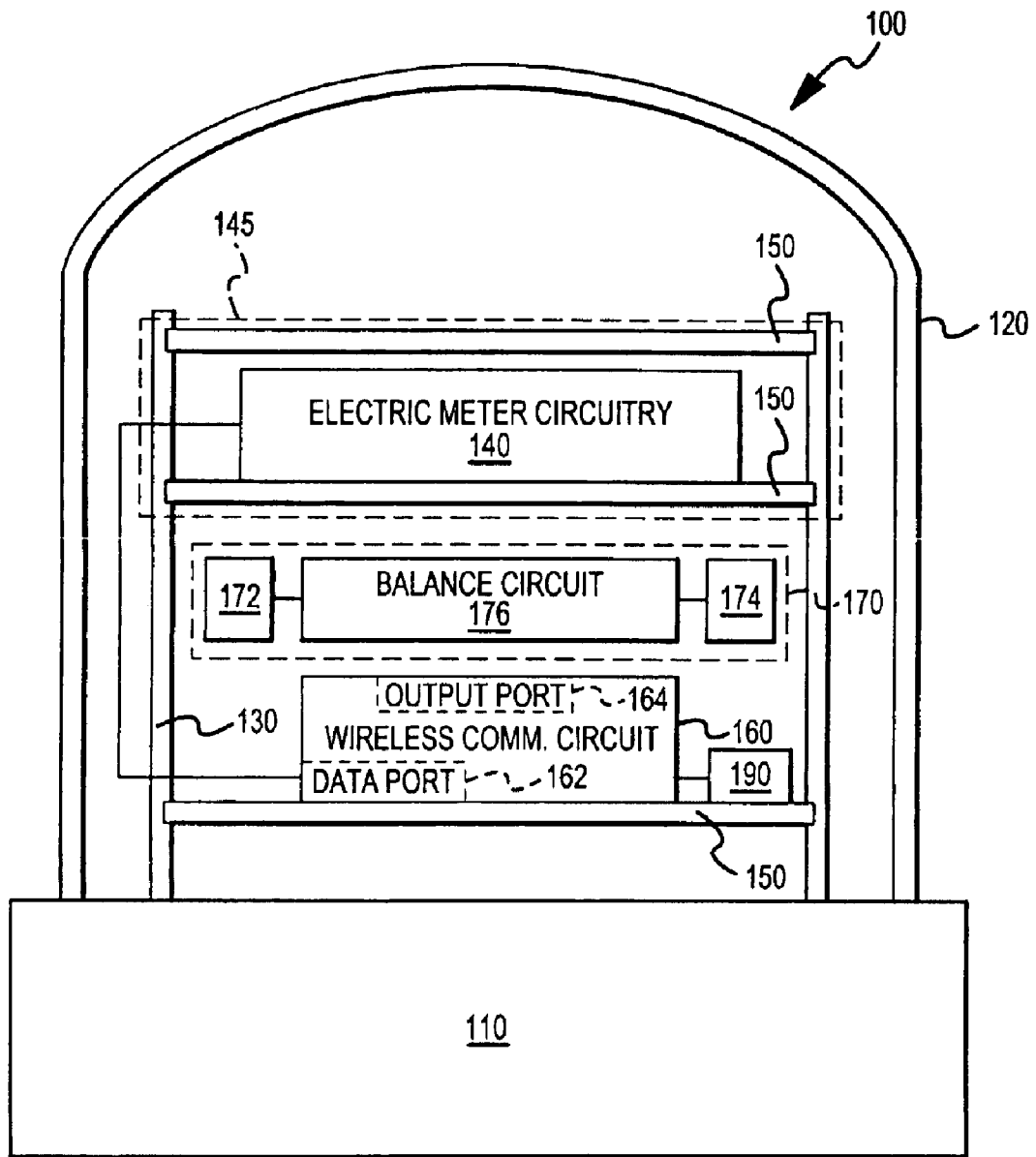


FIG.1

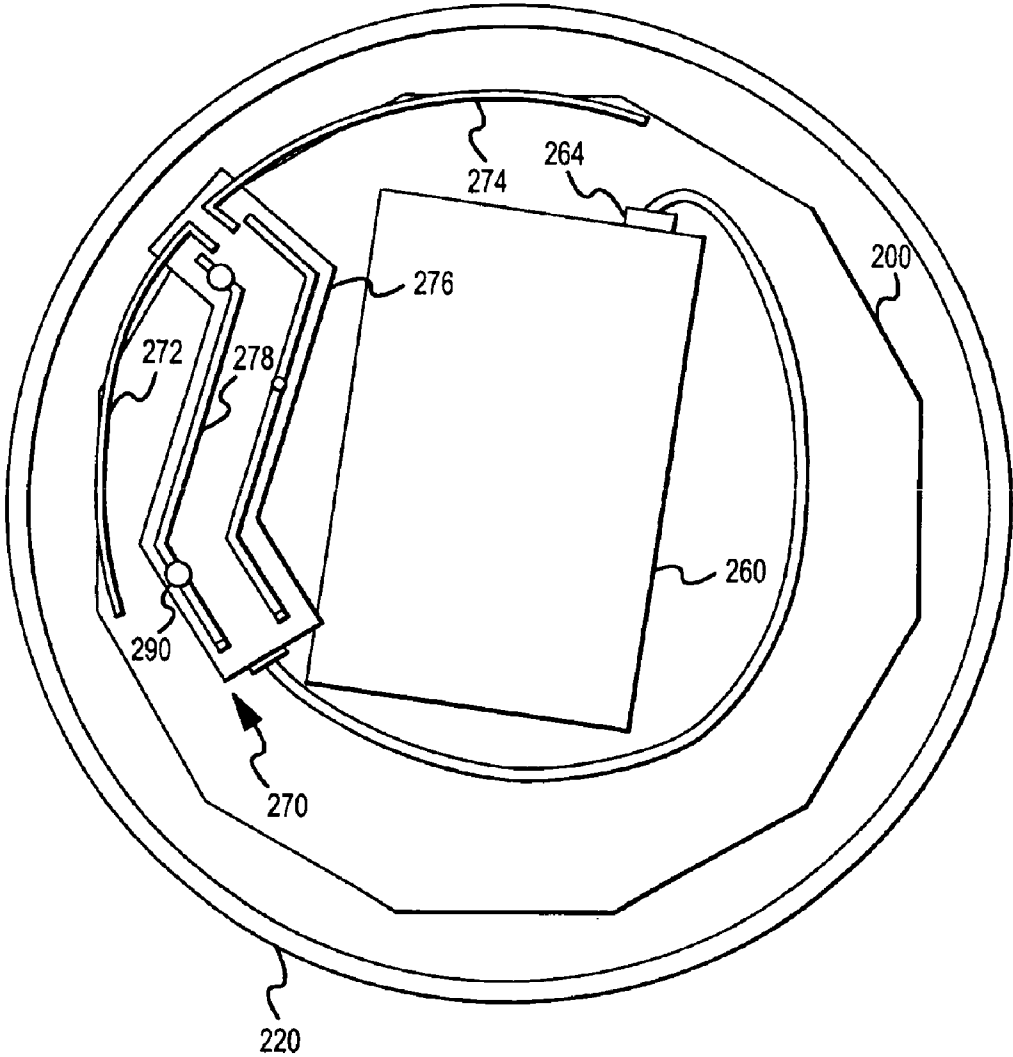


FIG. 2

**WIRELESS COMMUNICATION DEVICE
FOR ELECTRIC METER AND METHOD OF
MANUFACTURE THEREOF**

**CROSS-REFERENCE TO RELATED
APPLICATION**

This application is a continuation-in-part of U.S. patent application Ser. No. 09/769,838 filed on Jan. 25, 2001, now U.S. Pat. No. 6,462,713 entitled "Antenna For Electric Meter And Method of Manufacture Thereof" to Lawrence R. Porter, et al., incorporated herein by reference, which was a continuation of U.S. patent application Ser. No. 09/040,113, filed on Mar. 17, 1998, and issued as U.S. Pat. No. 6,181,294 B1.

TECHNICAL FIELD OF THE INVENTION

The present invention is directed, in general, to electric meters and, more specifically, to an antenna for an electric meter to enable the meter to communicate over a public wireless data network, a method of manufacturing the antenna and an electric meter employing the antenna.

BACKGROUND OF THE INVENTION

Until recently, a single utility provided electric service to all consumers in a given area. Establishment of electric service, maintenance, meter reading and billing were centralized in the single utility. Customers had no freedom to choose their electricity provider. Now, the kind of deregulation that changed the face of the telecommunications industry is sweeping through the electric power industry. One by one, states are allowing electric power resellers to buy electricity in quantity and to resell the electricity directly to consumers.

At the same time, electricity providers are becoming more sophisticated about billing practices. Gone are the days when consumers were billed flat rates. Numbered are the days that consumers are simply billed on the basis of kilowatt-hours consumed. Now, electricity providers are interested in gathering qualitative and additional quantitative data regarding electrical service delivered to consumers in an effort to correlate charges and costs of the service provided.

In response, consumers (particularly commercial consumers) are becoming more sophisticated regarding their use of electricity. Realizing that management of electrical usage may result in monetary savings, consumers are also demanding greater amounts of qualitative and quantitative data.

The electric meter industry has responded with digital electric meters that measure such characteristics as volt-hours, volt-squared-hours, watt-hours, kilowatt-hours, Qhours, VAR-hours and VA-hours over time, giving both the electricity provider and the consumer a greater quantity of, and more timely, data regarding electricity use. Examples of digital meters may be found in U.S. Pat. No. 4,884,021, issued Nov. 28, 1989, to Hammond, et al., entitled "Digital Power Metering" and U.S. Pat. No. 5,122,735, issued Jun. 16, 1992, to Porter, et al., also entitled "Digital Power Metering," commonly assigned with the present invention and incorporated herein by reference. Digital meters can measure these characteristics instantaneously or over a period of time, allowing electricity providers to track peak electricity usage and to better plan generator capacity. Electricity providers may then allow consumers to reduce costs by avoiding peak usage periods. Overall, digital meters have

brought about more accurate measurement and billing and, in some cases, have resulted in more cost-effective use on the consumer's part.

Like traditional mechanical meters, many digital meters must be read by direct visual observation. In large urban areas with millions of customers, this represents a considerable labor cost, even when spread out over an entire month. Additionally, meters have proven difficult to read from distances over 12 feet. Intervening fences, brush, trees, yard tools and pets may make close access difficult or even impossible. Sun glint and bad weather may add to the problem, particularly in remote areas with poor roads or during winter storms that may cover the meters with snow or ice. Ever-present is the risk that a meter reading may be erroneous. Deregulation of electric power may exacerbate this problem by creating geographically distributed electricity providers, thereby dramatically increasing the cost of reading meters and potentially threatening the economics of deregulation.

The electric meter industry has responded by adding wire-based communication circuitry to newer models of electric meters. Such circuitry typically employs a telephone line to communicate with a central location. While adequately addressing the cost issue of meter reading, the use of telephone lines introduces other problems.

If an electric meter is given a dedicated telephone line, the cost of the dedicated line must be considered when calculating the cost of reading the meter. On the other hand, if the electric meter shares a telephone line with another user (e.g., a residential meter may employ the residence's main telephone line), the line may not be available when required by the meter. In fact, a consumer may intentionally make the line unavailable to the meter, thereby preventing the meter from reporting its data.

Alternatively, the meter may be provided with an external antenna to allow wireless communication over a range of a few hundred feet. A roving truck carrying a transceiver may then establish communication with the meter as it passes nearby, thus reading the meter. Unfortunately, the truck must be physically deployed to locations proximate the meters. Truck-based wireless reading, therefore, provides only a marginal advantage over direct visual observation. Further, the meter's external antenna may be subject to tampering and to severe weather.

Accordingly, what is needed in the art is a more effective way to receive frequent, timely and accurate electrical consumption data from, and provide remote commands to, geographically-distributed electric meters.

SUMMARY OF THE INVENTION

To address the above-discussed deficiencies of the prior art, the present invention provides a wireless communication device for use with an electric meter chassis having a dielectric housing protruding therefrom, that permits information to be communicated to and from the electric meter and a method of manufacturing the same. In one embodiment, the device is comprised of: (1) a communication circuit within the chassis coupled to electric meter circuitry, and (2) an antenna element within the dielectric housing, the antenna element coupled to the communication circuit.

The present invention therefore introduces the broad concept of outfitting an electric meter with communications device that permits the meter to be in wireless communication with a remote location. Those of ordinary skill in the pertinent art will understand that such communication can

be bidirectional, allowing the meter to report data to a central location or to accept remotely-generated operational commands. Some of the advantages of the invention are that meter information can be instantly communicated thereby permitting energy usage to be continuously monitored, without the requirement of a meter reader physically going to a meter location in order to secure the information.

In one embodiment of the invention, the communication circuit communicates over cellular frequencies. In another embodiment, the communication circuit communicates information selected from the group consisting of: (1) power quality information, (2) power outage information, (3) site analysis information, (4) diagnostic information, (5) energy usage, (6) power demand, (7) power factor, (8) time of use, and (9) interval recordings of energy usage.

In a particularly useful embodiment of the invention, the communication circuit receives information selected from the group consisting of: (1) meter information queries, (2) meter commands, (3) diagnostic queries, and (4) maintenance commands. In one embodiment, the communication circuit has a carrier frequency of between 700 and 950 megahertz. In yet another embodiment, the communication circuit has a carrier frequency of between 1.8 megahertz and 2.0 gigahertz. In still yet another embodiment, the communication circuit is digital.

The foregoing has outlined, rather broadly, preferred and alternative features of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they can readily use the disclosed conception and specific embodiment as a basis for designing or modifying other structures for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a simplified block diagram of an electric meter chassis with a wireless communication device constructed according to the principles of the present invention; and

FIG. 2 illustrates a top view of a circuit board containing a communication circuit and an antenna element within a dielectric housing constructed according to the principles of the present invention.

DETAILED DESCRIPTION

Referring initially to FIG. 1, illustrated is a simplified, combination electrical/mechanical, block diagram of an electric meter **100** constructed according to the principles of the present invention. The meter **100** includes an electric meter chassis **110**, having a dielectric housing **120** protruding therefrom. In the illustrated embodiment, the dielectric housing **120** is a dome of cylindrical cross-section and intended to represent a conventional electric meter housing. Of course, the use of other geometries for the dielectric housing **120** is well within the scope of the present invention.

The meter **100** further includes a circuit board rack **130**, located within the dielectric housing **120**, that contains a

plurality of circuit boards **150**. The meter **100** further includes electric meter circuitry **140**, located on one or more of the circuit boards **150**. The electric meter circuitry **140** may include, for example, a microprocessor, memory, display and current or voltage sensors. The patents cited above contain greater detail concerning possible configurations for the electric meter circuitry **140**.

The meter **100** further includes an electromagnetic shield **145** (illustrated in broken line), located about a portion of the electric meter circuitry **140**. The meter **100** further includes a wireless communication circuit **160**, coupled to the electric meter circuitry **140** via a data port **162**. In a preferred embodiment, the electric meter circuitry **140** is coupled to the wireless communication circuit **160** via a flexible strip connector. Of course, the use of other coupling devices is well within the broad scope of the present invention.

The meter **100** further includes an antenna **170** that allows the electric meter circuitry **140** to communicate wirelessly through the dielectric housing **120**. The meter **100** still further includes a capacitively backed up power supply **190** that powers the electric meter circuitry **140** and the wireless communication circuit **160**. The meter **100** may thus communicate power outage information to the electricity provider during a loss of power.

The electromagnetic shield **145** is designed to attenuate interference from the electric meter circuitry **140** that may disrupt an operation of the wireless communication circuit **160**. The electromagnetic shield **145** is also designed to protect the electric meter circuitry **140** from interference generated by the wireless communication circuit **160**. Those skilled in the art will understand, however, that the electromagnetic shield **145** is not necessary to the present invention.

The antenna **170** includes antenna elements **172**, **174**, located within the dielectric housing **120**. In the illustrated embodiment, the antenna elements **172**, **174** are located between the circuit boards **150** and proximate the electric meter circuitry **140**. Of course, the antenna elements **172**, **174** may also be located elsewhere within the dielectric housing **120**. The antenna elements **172**, **174** are adapted to transmit and receive electromagnetic radiation. The antenna **170** further includes a balance circuit **176**, coupled to the antenna elements **172**, **174**, that causes the antenna elements **172**, **174** to cooperate to act as a dipole. Again, the present invention is not limited to a dipole.

The balance circuit **176** is couplable to an unbalanced output port **164** of the wireless communication circuit **160** to balance an impedance of the output port **164** and thereby to balance the dipole. The balance circuit **176** may also compensate for unfavorable electromagnetic conditions caused by, for example, sources of constructive and destructive interference within the meter **100**. In one embodiment of the present invention, the balance circuit **176** is a microstrip. Of course, the use of other devices for the balance circuit **176** is well within the broad scope of the present invention.

In the illustrated embodiment, the electric meter circuitry **140** includes current and voltage sensors that scale input voltage and current, thereby allowing metering data (e.g., voltage, current, power, energy usage, power demand, power factor, time of use, interval recordings of energy usage, power quality information, power outage information, site analysis information, diagnostic information, and meter billing information) to be gathered. The data gathered may be instantaneous or may be gathered over a period of time. Those skilled in the art will realize that the present invention is not limited to the types of data

mentioned herein, but may also be used to measure and gather other types of data related to the electric power provided and consumed.

The wireless communications circuit **160** and the antenna **170** allow the meter **100** to communicate via wireless communication networks, such as conventional Ardis® or RAM Mobile Systems® Wireless Data networks. The meter **100** may thus report data to the electricity provider. In a preferred embodiment, the communication is bidirectional, allowing the meter **100** to report data or to accept remotely-generated operational commands. In one embodiment the communications circuit **160** is digital. The communications circuit **160** can also be used to receive information, to include, without being limited to, information consisting of meter information queries, meter commands, diagnostic queries, and maintenance commands. In a particularly useful embodiment, the communications circuit **160** communicates over cellular frequencies.

Turning now to FIG. 2, illustrated is a top view of a circuit board **200** containing a wireless communication circuit **260** and an antenna **270** constructed according to the principles of the present invention. In the illustrated embodiment, the wireless communication circuit **260** is a Motorola 505sd transmit/receive modem. Of course, the use of other commercially-available or custom wireless communication circuits is well within the broad scope of the present invention. In one embodiment of the present invention, the wireless communication circuit **260** operates with a carrier frequency of between 700 and 950 megahertz. In a preferred embodiment, the wireless communication circuit **260** transmits at a frequency of about 806 to 825 megahertz and receives at a frequency of about 851 and 870 megahertz. Those skilled in the art will realize that the illustrated frequencies are compatible with conventional Ardis® or RAM Mobile Systems® Wireless Data networks. In another embodiment, the wireless communication circuit **260** operates using a carrier frequency of between 1.8 megahertz and 2.0 gigahertz. Of course, the principles of the present invention are equally applicable to other carrier frequencies and other wireless networks.

The antenna **270** contains antenna elements **272**, **274**, and a balance circuit **276**. In one embodiment of the present invention, the antenna elements **272**, **274** are arcuate, have a flattened lateral cross-section, and generally conform to a portion of an internal surface of a dielectric housing **220**. In the illustrated embodiment, the antenna elements **272**, **274** are composed of 0.028" thick copper, approximately 3.1" long and 0.25" wide, with a radius of curvature of about 2.625". Of course, other conductor shapes and radii of curvature are well within the broad scope of the present invention.

In the illustrated embodiment, the balance circuit **276** is a microstrip circuit board having conductive traces (one of which is labeled **278**) located therein. The balance circuit **276** is coupled to and mechanically supports the antenna elements **272**, **274**. The antenna elements **272**, **274** may thus cooperate to act as a dipole. The wireless communication circuit **260** has an unbalanced output port **264**, coupled to the balance circuit **276**. In the illustrated embodiment, the conductive traces **278** vary in width and therefore in impedance to balance an output impedance of the unbalanced output port **264**. Of course, the broad scope of the present invention is not limited to this technique.

The circuit board **200** contains a plurality of mounts (one of which is designated **290**) that position the balance circuit **276** above the circuit board **200**. The antenna elements **272**,

274 may thus be prevented from contacting and shorting to the circuit board **200**.

Additionally, the mounts **290** allow the balance circuit **276** to be inverted, thereby reorienting the dipole formed by the antenna elements **272**, **274**, with respect to the circuit board **200**. Reorientation of the dipole may improve transmission or reception of the wireless communication circuit **260**, depending upon the location in which the meter **100** is mounted. In one embodiment of the present invention, the meter **100** may be mounted to a wall of a building. The antenna elements **272**, **274** may thus cooperate to form a vertically-polarized, essentially omnidirectional dipole antenna. In a preferred embodiment, the dipole transmits and receives data over a distance of 10 to 40 miles, depending on environmental conditions, such as weather, line of site obstructions and a height of transmitting and receiving antennas. The meter **100** may thus communicate over the well-known ARDIS® or RAM Mobile Systems® Wireless Data networks.

Positioning the antenna **270** within the dielectric housing **220** may provide a number of advantages. The dielectric housing **220** may protect the antenna **270** from physical damage due to weather or contact with foreign objects. Additionally, strict criminal meter tampering laws may discourage vandals from damaging the antenna **270**. Further, since separate installation of the antenna **270** is not necessary, the meter **100** may be installed using conventional techniques.

From the above, it is apparent that the present invention provides, for use with an electric meter chassis having a dielectric housing (of any geometry) protruding therefrom, an antenna for allowing electric meter circuitry within the chassis to communicate wirelessly through the dielectric housing and a method of manufacturing the same. In one embodiment, the antenna includes: (1) antenna elements, located within and generally conforming to a portion of an internal surface of the dielectric housing and adapted to transmit and receive electromagnetic radiation and (2) a balance circuit, coupled to the antenna elements to cause the antenna elements to act as an antenna and coupleable to an unbalanced output port of a wireless communication circuit, that balances an impedance of the unbalanced output port thereby to balance the antenna.

Turning now to FIG. 3, illustrated is a planar view of a wireless metering communications device **300** that permits information to be communicated between an electric meter **310** and a communications circuit **320** (not shown) housed within a communications chassis **330**. Coupled to the communications circuit **320** is a data port **340**. The illustrated communications device **300** shows a communications cable **350** coupling the data port **340** on the communications circuit **320** with the electric meter **310**. When thus coupled, communication between the meter **310** and the communications circuit **320** is possible. The meter **310** is able to transmit data, such as power usage, through the cable **350** to the communications circuit **320**. The communications device **300** can then wirelessly transmit such data to a remote location, such as a data network of a power utility. In turn, a power utility can use the communications device **300** to transmit data to the meter **310**. In one embodiment of the invention, the data port **340** provides a serial interface connection while in another a parallel interface connection is provided. Those of ordinary skill in the pertinent art will understand that any type of connection between the meter **310** and the communications circuit **320**, including a wireless connection, is within the intended scope of the present invention.

Although the present invention has been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.

What is claimed is:

1. For use with an electric meter chassis having a dielectric housing protruding therefrom, a wireless communication device, comprising:

a communication circuit within said chassis coupled to electric meter circuitry;

an antenna element within said dielectric housing, said antenna element coupled to said communication circuit.

2. The device as recited in claim 1 wherein said communication circuit communicates over cellular frequencies.

3. The device as recited in claim 1 wherein said communication circuit communicates information selected from the group consisting of:

- power quality information,
- power outage information,
- site analysis information,
- diagnostic information,
- energy usage,
- power demand,
- power factor,
- time of use, and
- interval recordings of energy usage.

4. The device as recited in claim 1 wherein said communication circuit receives information selected from the group consisting of:

- meter information queries,
- meter commands,
- diagnostic queries, and
- maintenance commands.

5. The device as recited in claim 1 wherein said communication circuit has a carrier frequency of between 700 and 950 megahertz.

6. The device as recited in claim 1 wherein said communication circuit has a carrier frequency of between 1.8 megahertz and 2.0 gigahertz.

7. The device as recited in claim 1 wherein said communication circuit is digital.

8. A method of manufacturing a device for communicating meter information to and from an electric meter chassis having a dielectric housing protruding therefrom, comprising:

locating a wireless communication circuit within said chassis, and coupling said wireless communication circuit to electric meter circuitry;

locating an antenna element within said dielectric housing, said antenna element coupled to said wireless communication circuit.

9. The method as recited in claim 8 wherein said communication circuit communicates over cellular frequencies.

10. The method as recited in claim 8 wherein said communication circuit communicates information selected from the group consisting of:

- power quality information,
- power outage information,
- site analysis information,
- diagnostic information,
- energy usage,
- power demand,
- power factor,
- time of use, and
- interval recordings of energy usage.

11. The method as recited in claim 8 wherein said communication circuit has a carrier frequency of between 700 and 950 megahertz.

12. The method as recited in claim 8 wherein said communication circuit has a carrier frequency of between 1.8 megahertz and 2.0 gigahertz.

13. The method as recited in claim 8 wherein said communication circuit is digital.

14. The electric meter as recited in claim 13 wherein said communication circuit has a carrier frequency of between 1.8 megahertz and 2.0 gigahertz.

15. The electric meter as recited in claim 13 wherein said communication circuit is digital.

16. An electric meter chassis having a dielectric housing protruding therefrom, comprising:

- a wireless communication circuit within said chassis for communicating meter information, said wireless communication circuit coupled to electric meter circuitry;
- an antenna element coupled to said wireless communication circuit and located within said dielectric housing.

17. The electric meter as recited in claim 14 wherein said communication circuit communicates over cellular frequencies.

18. The electric meter as recited in claim 14 wherein said communication circuit communicates information selected from the group consisting of:

- power quality information,
- power outage information,
- site analysis information,
- diagnostic information,
- energy usage,
- power demand,
- power factor,
- time of use, and
- interval recordings of energy usage.

19. The electric meter as recited in claim 14 wherein said communication circuit receives information selected from the group consisting of:

- meter information queries,
- meter commands,
- diagnostic queries, and
- maintenance commands.

20. The electric meter as recited in claim 14 wherein said communication circuit has a carrier frequency of between 700 and 950 megahertz.