AUXILIARY METERING APPARATUS AND METHODS

Methods and apparatus implementing a technique for measuring electricity consumption. In general, in one aspect, the technique provides an electricity meter that includes a sensor unit for measuring current and voltage of a distribution wire of an electricity distribution system. The meter also includes a processor electrically connected to receive input from the sensor unit, the processor calculating power consumed and generating messages that report the calculated power consumed. The meter also includes a radio transmitter electrically connected to receive and transmit the messages generated from the processor. The meter also includes a housing for the sensor unit, the processor, and the radio transmitter.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
AUXILIARY METERING APPARATUS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of U.S. Provisional Application No. 60/246,409, filed November 6, 2000, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention relates to electricity metering devices.

Some electrical distribution systems, such as the one used in the United Kingdom, include a large population of single-phase electricity meters, such as Legacy meters. These incumbent meters are rudimentary; over 90% of them are of the simple electromechanical variety and have no communication capability. Furthermore, there is great diversity of construction among incumbent meters, including the Legacy meters, because they are made by many different manufacturers and they utilize various different technologies.

The incumbent meters have a typical service life of between 15-25 years with an average remaining lifetime of the population being about 10 years. Within the decade, it will thus be necessary to replace or upgrade the rudimentary and diverse population of meters to continue service to utility customers.

Their wide variety and type make it difficult to find a feasible and economical solution to upgrade these incumbent meters. Attempts have been made to optically sense the rotation of the disc within the meter but none of these techniques reached commercial reality. Consequently, utility customers are concerned about having to pay for the cost, such as write-off costs, of upgrading incumbent meters. In addition to the cost issue, regulatory changes present the possibility that incumbent meters will have to be transferred from their current owners to a third party.

These issues, including those associated with continuous structural and ownership changes in the electricity supply industry, make Legacy meters a potential barrier to customers moving forward with automated meter reading.

SUMMARY OF THE INVENTION

The present invention provides methods and apparatus, including computer-program products, for providing an integrated electricity meter and a radio
communication device that can be retrofitted to all existing single-phase Legacy meter and work in series with an incumbent meter.

In general, in one aspect, a device in accordance with the invention includes an integral electronic meter and internal radio. The device optionally includes a permanent display. Power for the device is accessed from a through connection between a legacy meter and a consumer distribution board.

In general, in another aspect, an electricity meter in accordance with the invention includes a sensor unit for measuring current and voltage of a distribution wire of an electricity distribution system. The meter includes a processor electrically connected to receive input from the sensor unit, the processor calculating power consumed and generating messages that report the calculated power consumed. The meter includes a radio transmitter electrically connected to receive and transmit the messages generated from the processor. The meter includes a housing for the sensor unit, the processor, and the radio transmitter.

In general, in another aspect, a system in accordance with the invention for retrofitting an incumbent electricity meter in an electrical distribution system includes a housing that is mechanically attachable to the incumbent electricity meter and a sensor unit situated inside the housing. The sensor unit measures current and voltage of a distribution wire of the electricity distribution system. The sensor unit includes connectors that are interposable between the incumbent electricity meter and the distribution wire, wherein the connectors electrically attaches the system to the electricity distribution system, and wherein the connectors mechanically attaches the electricity meter to the incumbent electricity meter. The system further includes a processor situated in side the housing. The processor electrically connected to receive input from the sensor unit. The processor calculates power consumed and generates messages that report the calculated power consumed. The system also includes a radio transmitter situated inside the housing. The radio transmitter is electrically connected to receive and transmit the messages generated from the processor, wherein the system replaces the incumbent electricity meter which remains in place as a backup to the system.

The invention can be implemented to realize one or more of the following advantages. A device in accordance with the invention directly monitors the power flow through an existing meter and can be used as the measuring element, replacing the existing meter for functions such as billing. The device maximizes the range of exiting
meters and installations that will allow the operation of a remote meter reading service. At the same time, the device minimizes cost and reduces installation complexity. The device can retrofit all existing single-phase legacy meter and work in series with an incumbent meter. Thus, to upgrade existing meters, only one type of device need be manufactured, advantageously providing uniformity and saving manufacturing costs. The device is estimated to cost less than a discrete meter and module. The device allows an existing meter to remain in place. The existing meter can be reinstated if necessary, providing a backup to the device. In one implementation, the device does not need a display, requires fewer terminals than does a conventional meter, and includes a simpler case than does a conventional meter. The device advantageously costs less and is smaller in size than a conventional meter and module. When applied to British Standard meters, in which the terminals arrangement is live in, neutral, neutral, and live out, the invention provides a compact and secure interface between an existing meter and the device. In this case, the mechanical arrangement provides a compact and secure interface between the meter and auxiliary-metering device. The device uses only the two outgoing terminals as a mechanical fixing and single point fixing. (Normally retrofits to meters are included internally or replace the lower terminal cover.)

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features and advantages of the invention will become apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a device in accordance with the invention.

FIG. 2 shows one implementation of a device in accordance with the invention.

FIG. 3 illustrates how the device mechanically attaches to an incumbent electricity meter.

FIG. 4 illustrates how the device electrically attaches to an incumbent electricity meter.

Like reference numbers and designations in the various drawings indicate like elements.
DETAILED DESCRIPTION

As shown in FIG. 1, a device 100 in accordance with the invention includes a measuring circuit 102, a sensor unit 102A, a processor and memory unit 104, a power supply 106, and a radio transmitter 108. Optionally, the device 100 includes a communication device 110 and a display (not shown).

The measuring circuit 102 is connected to a current and voltage sensor unit 102A. The measuring circuit 102 includes a shunt resistor (not shown) and a voltage divider (not shown). Alternatively, the measuring circuit 102 and sensor unit 102A can include any circuit or element that measures current, including but not limited to a current transformer, such as a toroid transformer, and a Hall sensor-based element. Alternatively, the measuring circuit 102 and sensor unit 102A can include any circuit or element that measures voltage, including but not limited to a potential transformer.

The processor and memory unit 104 includes a microprocessor (not shown) that receives input from the measuring unit 102 and, based on these inputs, calculates power consumed. Optionally, the processor and memory unit calculates other functions related to electricity distribution, including but not limited to administration-data, power-quality, calibration, and diagnosis functions. The processor and memory unit 104 optionally includes memory, such as and not limited to EEPROM, that can store software for calculating the various functions mentioned. Alternatively, when flexibility of function is not needed, the processor and memory can include a fixed-function IC chip, such as and not limited to a DSP, that calculates power consumed based on input from the measuring circuit 102 and the sensor unit 102A. In this case, the microprocessor and memory is not needed.

The power supply 106 derives power from the power distribution system in which the device 100 is installed. Specifically, the power supply takes power from a terminal of an incumbent meter and conditions the power for use by the device 100. The power supply 106 is a potential transformer power supply. Alternatively, the power can be of any type, including but not limited to a capacitor-based power supply. The power supply provides power to the components of device 100.

The radio transmitter 108 includes an RF transmitter and an antenna. Alternatively, the radio transmitter can include any transmitters and antennas for VHF and UHF transmissions. The radio transmitter receives input 108 from the processor and
memory unit 104. The transmitter 108 is a low power transmitter of less than 200 mW. The transmitter periodically sends data at every five minutes. Transmissions last for a few tenths of a milliseconds. Alternatively, the transmitter can be of any power and can transmit intermittently or on a variable cycle.

The optional communication device 110 communicates with the memory and processor unit 104. The communication device 110 is an optical communication device that provides a secure interface with the device 100 and, consequently, a way to read information from the device 100 without removing security seals and opening a housing of the device 100. The communication device 110 also provides an interface for field diagnostics such as but not limited to a link assessment test ("LAT"). The communication device 110 includes an infra-red communication port and a red-pulse light-emitting diode ("LED") that flashes as energy is consumed. Alternatively, the communication device 110 can include any optical emitter and any receiver, such as a phototransistor or diode. Furthermore, the port can be other than IR, including wire or inductive. However, IR reduces costs and is most convenient.

The optional display (not shown) is an independent component of the device 100 and can be attached or removed by a consumer. The processor and memory unit 104 sends data on a regular basis with the display by a simple optical port. Alternatively, the processor and memory unit 104 scan send data to the display device intermittently or on a variable cycle. The display device is battery powered to facilitate attachment to and removal from the device 100. Additionally, the life of the device 100 is not limited by the display device as is the case with conventional meters.

Optionally, the device 100 can include a switch interposed such that a consumer's electricity supply can be disconnected. A simple power line communication receiver, included in the device, controls the switch.

In operation, the measuring circuit 102 and sensor unit 102A measure current and voltage from an electricity distribution line and relays the measurement to the processor and memory unit 104 (or alternatively to a DSP). The processor and memory unit 104 calculates power consumed, as well as any other functions related to electricity distribution, and further generates a message that includes this data. The processor and memory unit 104 sends the message to the radio transmitter 110, which in turn, transmits the message to a receiver (not shown). The processor and memory unit 104 also sends data to the optional display unit (not shown).
The processor and memory unit 104 interfaces with a user through the optical communication port 110, through which the user can obtain any information that the processor and memory unit 102 contains. The type of information includes but is not limited to that related to: (i) Programming of key calibration and configuration parameters (which needs high security such as physical lock out of the meter); (ii) field programming of configuration parameters and customization variables (which needs medium security); (iii) linking to a payment keypad or external communication device to download payment information, configuration parameters, and customization variables (which needs medium security); and (iv) consumer access to obtain meter reading (which needs only low security).

Although the device 100 takes over the functions previously performed by an incumbent electricity meter, the incumbent electricity meter remains in place in the electrical distribution system. The incumbent electricity meter can be easily reconnected to the electricity distribution system and, thus, acts as a backup to the device 100.

FIG. 2 shows a device 200, which is one implementation of device 100. Device 200 includes the described components in a housing 202. The housing 202 includes a port for a visible LED data and indication 204 generated from the device’s optical communication port 110 (not shown). As discussed, the visible LED data and indication 204 flashes as energy is consumed. The optional display is a battery-powered LCD 205.

The device 200 includes two connections 206 and 208 that mechanically attach to an incumbent legacy meter’s consumer terminals. As shown, the connections are housed inside a housing that has a sealed and lockable cover. The device 200 also includes an optional second fixing point 210, at which the device 200 can also be mechanically attached to an incumbent legacy meter. The second fixing point 210 is provided at the top of the device 200 to ensure secure fixing to a backboard.

As shown in FIG. 3, the device 200 connects to an electrical distribution system by being close-coupled to an incumbent legacy meter such as meter 302. That is, the device 200 can be mechanically attached closely and securely to the meter 302. To close-couple with a legacy meter, the device 200 uses only the consumers terminals 304 and 306 of the incumbent meter 302 for connection. Specifically, to close-couple the device 200, one only has to detach two consumer wires 305 and 307 from the consumer terminals 304 and 306 of the meter 302. The device 200 is then interposed by connecting connectors 206 and 208 to terminals 304 and 306 and the detached consumer wires
reconnected to the device 200 at terminals 308 and 310. Optionally, the device 200 mechanically attaches to the meter 302 at the second fixing point 210. This operation is simple and quick, causing minimal disruption to a consumer. Furthermore, this approach removes the problems of a close-coupled fuse and other physical devices that are used for security purposes in some applications. A close-coupled fuse is a security device that protects the in-coming wires; it is usually a plastic device that the wires are routed though to prevent unauthorized access.

FIG. 4 illustrates how the device 200 electrically attaches to a legacy meter such as meter 302. The meter 302 includes four terminals. Terminals 402 and 404 are used to connect to supply-in wires 406 and 408 (i.e., the distribution side of an incumbent meter). Terminals 304 and 306 are used to connect to supply-out wires 305 and 307 (i.e., the consumer side of the incumbent meter). The device 200 electrically connects to the meter 302 by interposing between terminals 304 and 306 and wires 305 and 307. Note that this connection provides electrical as well as mechanical coupling to the meter 302.

In operation, the existing meter is used only as a mechanical host because the accuracy of the two measuring elements could have a differential error in reading of up to 4%.

Some or all aspects of the invention can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. The described electricity related functions can be implemented in a computer program product tangibly embodied in a machine-readable storage device for execution by a programmable processor; and method steps of the invention can be performed by a programmable processor executing a program of instructions to perform functions of the invention by operating on input data and generating output. The invention can be implemented advantageously in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. Each computer program can be implemented in a high-level procedural or object-oriented programming language, or in assembly or machine language if desired; and in any case, the language can be a compiled or interpreted language. Suitable processors include, by way of example, both general and special purpose microprocessors. Generally, a processor will receive instructions and data from a read-only memory and/or a random access memory. Generally, a computer will include one or more mass storage devices for storing data files; such devices include
magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and optical disks. Storage devices suitable for tangibly embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, such as EPROM, EEPROM, and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM disks. Any of the foregoing can be supplemented by, or incorporated in, ASICs (application-specific integrated circuits).

The invention has been described in terms of particular embodiments. Other embodiments are within the scope of the following claims. For example, a device in accordance with the invention can be connected to any point in an electrical distribution system, including but not limited to the supply-side of an incumbent legacy meter. The device can mechanically attach at any point to an incumbent legacy meter and not only at the points described. The device can include a transceiver that transmits as well as receives data.
CLAIMS

What is claimed is:

1. A electricity meter, comprising:
   a sensor unit for measuring current and voltage of a distribution wire of an
   electricity distribution system;
   a processor electrically connected to receive input from the sensor unit, the
   processor calculating power consumed and generating messages that report the calculated
   power consumed;
   a radio transmitter electrically connected to receive and transmit the messages
   generated from the processor; and
   a housing for the sensor unit, the processor, and the radio transmitter.

2. The meter of claim 1, wherein:
   the sensor unit includes connectors that are interposable between an incumbent
   electricity meter and the distribution wire; and
   the connectors electrically attaches the electricity meter to the electricity
   distribution system.

3. The meter of claim 2, wherein the connectors mechanically attaches the electricity
   meter to the incumbent electricity meter.

4. The meter of claim 3, wherein the incumbent electricity meter is a legacy meter.

5. The meter of claim 2, further comprising:
   a power supply that electrically connects to the connectors and derives power
   through the incumbent meter for supplying power to the electricity meter.

6. The meter of claim 1, wherein the processor generates data to be displayed, the meter
   further comprising:
   a removable display that receives the data to be displayed generated by the
   processor.
7. The meter of claim 6, wherein:
   the display is and LCD display that is battery-powered;
   the display is detachably connected to the meter; and
   the meter operates independent of whether the displayed is attached to or removed
   from the meter.

8. The meter of claim 1, further comprising:
   an optical port for interfacing with a user.

9. The meter of claim 1, further comprising:
   a remote controlled switch for controlling the distribution of electricity from the
   electricity distribution system.

10. A system for retrofitting an incumbent electricity meter in an electrical distribution
    system, the system comprising:
    a housing that is mechanically attachable to the incumbent electricity meter;
    a sensor unit situated inside the housing, the sensor unit measuring current and
    voltage of a distribution wire of the electricity distribution system, the sensor unit
    including connectors that are interposable between the incumbent electricity meter and
    the distribution wire, wherein the connectors electrically attaches the system to the
    electricity distribution system, and wherein the connectors mechanically attaches the
    electricity meter to the incumbent electricity meter;
    a processor situated in side the housing, the processor electrically connected to
    receive input from the sensor unit, the processor calculating power consumed and
    generating messages that report the calculated power consumed; and
    a radio transmitter situated inside the housing, the radio transmitter electrically
    connected to receive and transmit the messages generated from the processor, wherein the
    system replaces the incumbent electricity meter which remains in place as a backup to the
    system.

11. The system of claim 10, wherein the incumbent electricity meter is a legacy meter.

12. The system of claim 10, further comprising:
    a power supply that electrically connects to the connectors and derives power
    through the incumbent electricity meter for supplying power to the system.
13. The system of claim 10, wherein the processor generates data to be displayed, the system further comprising:
   a removable display that receives the data to be displayed generated by the processor.

14. The system of claim 13, wherein:
   the display is an LCD display that is battery-powered;
   the display is detachably connected to the meter; and
   the meter operates independent of whether the displayed is attached to or removed from the meter.

15. The system of claim 10, further comprising:
   an optical port for interfacing with a user.

16. The system of claim 10, further comprising:
   a remote controlled switch for controlling the distribution of electricity from the electricity distribution system.
FIG. 1
Second Fixing Point

Simple LCD Battery Powered Opto comms

Sealed Cover

Two Connections

Visible LED Data and Indication

FIG. 2
Module attached to the meter

Infra-red Communication

Red Pulse LED

Radio Transmission

Optical Communication port

Power Supply 230 volt AC to DC

Processor and Memory

Measuring Circuit

Radio transmitter Aerial

Radio transmitter

Module Block Diagram

FIG._3
Normal installation of the meter

Module attached to the meter

FIG. 4