

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
10 May 2002 (10.05.2002)

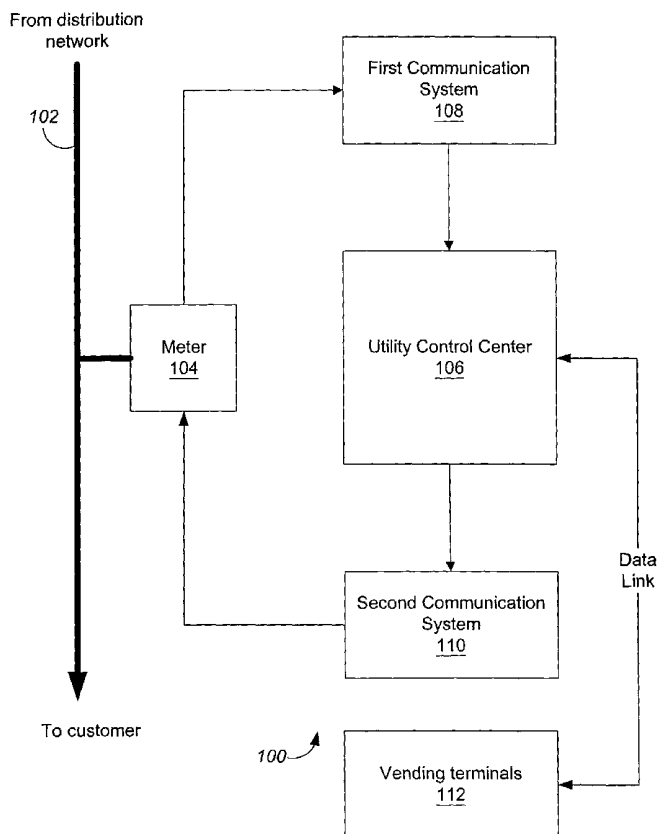
PCT

(10) International Publication Number
WO 02/37227 A2

- (51) International Patent Classification⁷: **G06F** (71) Applicant (for all designated States except US): **BCN DATA SYSTEMS** [US/US]; Two Transamerica Center, 505 Sansome Street, 7th Floor, San Francisco, CA 94111-3106 (US).
- (21) International Application Number: PCT/US01/46577
- (22) International Filing Date: 6 November 2001 (06.11.2001) (72) Inventor; and (75) Inventor/Applicant (for US only): **JONES, Alan** [GB/GB]; 95 Lincoln Avenue, Clayton, Newcastle Staffs ST538A (GB).
- (25) Filing Language: English
- (26) Publication Language: English (74) Agent: **PHAM, Tim**; Fish & Richardson P.C., 500 Arguello Street, Suite 500, Redwood City, CA 94063 (US).
- (30) Priority Data: 60/246,408 6 November 2000 (06.11.2000) US (81) Designated States (national): AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US 60/246,408 (CON)
Filed on Not furnished

[Continued on next page]

(54) Title: ASYMMETRICAL COMMUNICATION IN PREPAYMENT METERING



(57) Abstract: Methods and apparatus implementing techniques for asymmetrical communication in prepayment metering. In general, in one aspect, the techniques provide a utility system that includes a distribution network for distributing a resource to a customer. The system includes a meter for metering the resource and for connecting and disconnecting a supply of the resource distributed to the customer. The meter includes a control system for maintaining an account of the customer and for controlling distribution of the resource based on the account information. The meter includes a first communication system for sending, over a first medium, information from the prepayment meter to the control system. The meter includes a second communication system for sending, over a second medium, information from the control system to the prepayment meter, wherein the information includes signals for disconnecting or connecting the supply of the resource distributed to the consumer.



WO 02/37227 A2



(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

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.

ASYMMETRICAL COMMUNICATION IN PREPAYMENT METERING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of U.S. Provisional Application No. 60/246,408,
5 filed November 6, 2000, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention relates to utility metering.

A significant issue for many utility companies ("utilities") is in providing a method for customers who either are having financial difficulty or have incurred debt to
10 pay for the use of the commodity or resource. A method often employed is that of prepaying for the resource. Prepaying, particularly in the United Kingdom ("UK"), has become the preferred method of utilities for managing customer debt and of consumers for budgeting finances. Prepaying methods is will be referred to as prepayment metering. Utilities usually implement prepayment metering by adding prepayment meters to their
15 utility systems.

Prepayment metering in its simplest form refers to paying for utilities, such as but not limited to electricity, gas, and water, before the resource is consumed. In such systems, a consumer purchases credit and then uses the resource until the credit expires. The concept of prepayment metering was introduced in the form of coin gas meters in the
20 UK. Major development took place in the 1980s when electronic or numeric transfer of the credit was introduced and used to transfer other information.

As shown in FIG. 9, a conventional electronic prepayment metering system operates on three levels. At the first level are the prepayment meters ("PPMs" or "PPM") that are installed at the homes of consumers. At the next level are the vending stations
25 that are usually situated at the utility company's offices or at an appointed agent's place of business. The communication between the vending stations and the PPMs is usually in the form of a token, which is used to top up the credit in a prepayment meter. Tokens also transfer or download information to the PPMs and, in some cases, upload information (depending on the token choice) back to the vending stations.

30 At the top level is a control system, which is necessary to ensure a common database for reporting and to provide total management, administration, financial, and engineering control. The control system communicates with the various vending stations

by the plain old telephone network ("PSTN") or, alternatively, by other data links. Information related to utility service, such as but not limited to information on consumers and tariff changes, is communicated to the vending stations and detailed customer sales are communicated back up to the control system.

5 In the UK, out of a total of 24 million domestic customers there are approximately 3.7 million domestic electricity customers using a PPM. The current generation of PPMs was installed in the late 1980's and early 1990's as a response to the large number of customer being disconnected for non-payment. Currently, only a minority of PPM customers are paying off debt; but customers continue to use the PPM for convenience,
10 habit, or because they need help in budgeting.

Prepayment metering is now an established technology with a significant role to play in helping both the consumer and utility. The prime benefits to the utility include:

- simplified and lower cost business processes
- increased customer control over consumption
- 15 · no credit line and elimination of bad debts
- improved cash flow
- no need for account posting or additional billing systems
- elimination of disconnection and reconnection fees
- no need to access consumer's property
- 20 · elimination of inaccurate meter readings

Usually, customers welcome this technology provided it has been introduced in a customer-oriented manner. The customer enjoys:

- improved budget management
- no cost for disconnection/reconnection
- 25 · no waiting for reconnection
- no deposits
- the ability to pay back debts

Unfortunately, prepayment metering is costly. As discussed, in conventional utility systems, prepayment requires the installation of a conventional PPM, which is
30 usually complex and expensive; and continuation of supply requires regular credit transfer by a payment 'token' that is passed between the PPM and a payment center. Often, these tokens are electronic and are extended to transfer other information, such as meter readings and control information for the remote meter.

The cost of serving prepayment customers is exacerbated by the nature of their geographic dispersal. Complexity is increased considerably with the need to have a two-way communication method to download credit and other data. Therefore, the cost of installing a two-way communication system solely for prepayment meters becomes
5 disproportionate to the savings.

South Africa has developed a prepayment technology, based on a keypad meter, that costs less than those implemented elsewhere. However, this prepayment technology is rudimentary and, thus, lacks some of the features described and cannot support certain emerging needs.

10 SUMMARY OF THE INVENTION

The present invention provides methods and apparatus, including computer-program products, for providing a utility prepayment system that includes one method of sending information to prepayment meters and further includes another method of receiving information from prepayment meters.

15 In general, in one aspect, a utility system includes a distribution network for distributing a resource to a customer. The system includes a meter for metering the resource and for connecting and disconnecting a supply of the resource distributed to the customer. The meter includes a control system for maintaining an account of the customer and for controlling distribution of the resource based on the account
20 information. The meter includes a first communication system for sending, over a first medium, information from the prepayment meter to the control system. The meter includes a second communication system for sending, over a second medium, information from the control system to the prepayment meter, wherein the information includes signals for disconnecting or connecting the supply of the resource distributed to the
25 consumer.

In general, in another aspect, a prepayment meter includes a measuring unit for metering consumption of a resource by a customer. The meter includes a keypad for receiving a prepayment token that represents an amount of resource available to the customer for consumption. The meter includes a processor electrically connected for
30 receiving input from the measuring unit and from the keypad. The processor is configured to determine, from the token, an amount of resource available to the customer, calculate an amount of resource consumed by the customer based on input from the

measuring unit, and decrement the amount of resource available to the customer by the amount of resource consumed by the customer. The meter includes a radio transmitter electrically connected for transmitting from the processor information specifying the amount of resource consumed by the customer.

5 The invention can be implemented to realize one or more of the following advantages. A system in accordance with the invention enables the use of asymmetrical communication channels to communicate with prepayment meters. The communication channels can be selected to best suit the type of data being transmitted. The ability to maximize the rate of transmission of data increases the efficiency of the system and
10 provides other operational, strategic, and external benefits. The system provides two-way communication over multiple mediums thus allowing meters to operate as a part of a remote meter reading system and, furthermore, to have full functionality without requiring direct two-way communication via that communication network. Usually, a significant cost of a utility system is attributable to the cost of its prepayment meters. A
15 system in accordance with the invention reduces cost by using one method to send information to its prepayment meters and another method to receive information to its prepayment meters. The system thus can use simplified prepayment meters that uses a simple transmitter. The simple transmitter can communicate on a regular basis to a local collector. The system can use a fixed radio network that enables prepayment meters to be
20 read remotely at a cost level not attainable by other communication solutions. Low cost telemetry is a key enabler for providing additional services and capabilities to utilities that would normally require more complex prepayment meters. Regular raw data from the prepayment meters can be processed and used by other systems for enhanced customer service, billing, load control, other network management systems, and prepayment. The
25 system can combine the communications technology of network meter reading ("NMR") with low cost prepayment meters. The system includes prepayment meters as a part of a remote meter reading system. NMR has solves all of the problems of both communicating with prepayment meters and administering a support system. Combining NMR technology with conventional prepayment meters further enhances the benefits to
30 both utility companies and consumers.

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 system in accordance with the invention.

FIG. 2 shows one implementation of the system.

5 FIG. 3 shows a fixed radio network.

FIG. 4 shows a power distribution network of a second implementation of the system.

FIG. 5 shows an asymmetrical two-way communication scheme of the second implementation of the system.

10 FIG. 6a-c illustrates power-line communication.

FIG. 7 shows a keypad meter.

FIG. 8 shows a third implementation of the system.

FIG. 9 shows a conventional prepayment system.

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

DETAILED DESCRIPTION

As shown in FIG. 1, a utility system 100 in accordance with the invention includes
20 distribution lines such as distribution line 102, utility meters such as meter 104, and a utility control center such as utility control center 106. The system 100 further includes a first communication system 108 and a second communication system 110. Optionally, the system includes vending terminals 112.

25 The distribution line 102 carries the resource being distributed. The resource can be but is not limited to electricity, gas, or water.

The utility meter 104 usually includes a sensing circuit (not shown) and a processor (not shown) to calculate information related to utility consumption. The information calculated includes but is not limited to the amount and rate of resource consumption. The utility meter 104 also includes a transmitter (not shown) for
30 transmitting information to the control center. The transmitter is part of the first communication system 108. The utility meter 104 further includes a receiver (not shown) for receiving information from the control center 106. The receiver is part of the second communication system 110. Optionally, the receiver can be a simple user interface

device for a user to enter data into the processor of the utility meter 104. Such devices include but are not limited to a simple alpha-numeric keypad, an optical port, or an LCD display having a graphical user interface.

The utility control center 106 includes memory (not shown) for storing
5 information related to utility service. The utility control center 106 also includes applications (not shown) such as a database, a corresponding database management system for maintaining and calculating information related to utility service, as well as a prepayment programs that can interact with the database system or, alternatively, directly with the database. The utility control center 106 further includes a processing device
10 such as a computer or a server (neither shown) for processing information related to utility service. Information related to utility service includes but is not limited to customer profile information and customer account information.

The first and second communication system 108 and 110 can be any two communication systems that use different mediums. For example, the first
15 communication system can be a wireless communication system that sends signals over the atmosphere and the second communication system can be one that sends signals over the distribution line 102.

In operation, a customer prepays either at the utility control center 106 or remotely by calling the utility control center 106 and providing an operator there with a credit card
20 number. Alternatively, the customer can remotely interface with a server or computer of the utility control center 106 through a network such as the Internet. In this case, the user can prepay and access account information without having to rely on a human operator. Once the customer prepays, the server or computer of the utility control center 106 processes the prepayment and stores the prepayment information in memory. As the
25 customer uses the utility resource, the meter 104 tracks the amount of resource consumed and sends this information to the utility control center 106 using the first communication system 108. The utility control center 106 uses the information sent from the meter 104 to maintain the customer's account balance. When the customer has nearly consumed the amount of resources that was prepaid for, i.e., when the customer's account balance is
30 close to zero, the utility control center 106 optionally sends a signal to the meter 104 through the second communication system 110 that causes the meter to indicate that the customer's account balance is near zero. Such indication can be a simple flashing LED or any warning that can notify the customer. Prompted by the meter 104, the customer

makes another prepayment. Alternatively, the utility control center 106 can automatically telephone the customer and report that a prepayment is required. When the customer's account balance is zero and the customer has not made another prepayment, the utility control center 106 sends a signal to the meter stopping the distribution of resources to the customer. Alternatively, the utility control center 106 can send a signal to a switch or valve (not shown) that stops the distribution of resources to the customer.

Alternatively, the meter 104 can track the account balance. In this case, the meter does not rely on the utility control center 106 to control a cut-off switch or valve.

The optional vending terminals 112 connect with a server or computer of the utility control center 106 through the PSTN. Alternatively, the vending terminals 112 can connect through any link or network, including but not limited to E1 lines and the Internet. The vending terminals 112 are in essence extensions of the utility control center 106 and allow customers to prepay remotely.

FIG. 2 shows an electricity distribution system 200, which is one implementation of utility system 100. In this implementation, the system 200 includes an asymmetrical two-way communication system between its endpoints such as the prepayment meters and its utility control center.

In conventional two-way communication system, a common medium is used to both transmit and receive. Usually, two-way communications can mean more expensive endpoints (such as meters) and, worse still, drive a need to significantly increase the network density and complexity to compensate for the random distribution of prepayment customers. In some cases the low density of prepayment customers may make it economically unfeasible to deploy a full two-way network for this purpose.

In contrast, the electricity distribution system uses radio as the communication medium from the meter to a utility control center and power line communication back to the meter from the utility control center. Alternatively, the electricity distribution system can use power line communication as the medium from the meter to a utility control center and radio back to the meter from the utility control center.

As shown, the system 200 includes a pre-payment application 202, a distribution network 204, a remote prepayment meter 206 having a radio transmitter and a receiver (neither shown), a MicroCell Controller ("MCC") radio receiver 208, a low power transmitter 210, and a control switch 212 (or valve when the utility resource is a fluid such as water or gas).

In operation, the application 202 (which can be located at a utility control center) receives regular consumption updates from the remote prepayment meter 206. Together, the physical prepayment meter 206 and the calculation logic of the application 202 create a virtual prepayment meter that has can calculate any function related to utility
5 distribution, including but not limited to the customer's remaining credit with respect to energy consumed. Only consumption data is required from the prepayment meter 206. The prepayment meter 206 sends this data through its radio transmitter (not shown). The MCC radio receiver 208 receives the data and, in turn, sends the data to the application 202 through the wide area network ("WAN") 214. This communication method is further
10 described below in reference to FIG. 3. Other data such as tariff and time of use calculations is determined by the application 202.

When credit expires or is extended, the application 202 sends a signal to shut or open the control switch 212 (or valve for resources that are fluids) that either connects or disconnects the electricity supply to the consumer. The control switch 212 (or valve) is
15 internal to the prepayment meter 206. Alternatively, the control switch or valve can be positioned at any location where it can selectively control distribution the customer. The signal path of the signal includes the WAN 214, the low power transmitter 210, the distribution network 204, and the receiver in the prepayment meter 206. This communication method is similar to that described in reference to FIGs. 5 and 6.

20 As discussed, the system 200 uses radio as the communication medium. Specifically, the system includes a fixed-network automatic meter reading system ("NMR") that uses radio communication to remotely monitor prepayment meters distributed over a wide geographic area.

Using the NMR, the system 200 collects energy usage and other information and
25 delivers it to utility companies and customers on a real-time basis. Utility companies can then use the information to reduce operating costs, improve customer service, increase revenues, and differentiate themselves from other service providers in competitive environments. The NMR can also be used, where radio frequency rules allow, for other commercial wireless data applications such as home security and remote status
30 monitoring of vending machines and office equipment.

As shown in FIG. 3, the NMR includes a hierarchy of three tightly integrated networks: A microcellular local area network (LAN), a wide area network (WAN), and a system controller network.

The NMR is made up of hundreds or thousands of LAN micro-cells, each operating independently to provide reliable data collection. Utility meters and other endpoint devices equipped with radio communications modules transmit data on a regular basis to a MCC located at the center of each micro-cell. As discussed, the communication modules can be a simple radio transmitter which reduces the cost of the meters. The MCC stores and processes the data received, and sends it up via the WAN to the System Controller on a scheduled or event-driven basis. The WAN provides data communications between the System Controller and MCCs, distribution automation devices, and other WAN clients. The System Controller Network manages overall network communications and processes and stores the data received from devices on the network. The System Controller needs to have the ability to manage a network potentially containing millions of devices transmitting information every few minutes.

FIGs. 4-6 show an electricity distribution system 400, which is another implementation of system 100. In this case, the system 400 includes an electrical power distribution network 401, as shown in FIG. 4. The power distribution network 401 includes a very high voltage (VHV) network 402, a high voltage (HV) network 404, a medium voltage (MV) network 406, and a low voltage (LV) network 408. In order to reduce resistive losses associated with the long-distance transmission of electrical power, the power station 410 supplies electrical power to the network 400 at a significantly higher voltage than that required by the end user. The voltage from the power station 410 is reduced at a number of stages; the final stage is at a secondary substation 422, which is configured to reduce the voltage from typically about 11 kV to 415 volts. This voltage can be distributed from a feeder node of the substation 422 to a plurality of low voltage customers 424 in the LV network 408. Power lines interconnect the components of the power distribution network 400.

Referring to FIG. 5, the system 400 further includes a system controller 502 communicating with one or more remote stations 504 through wired or wireless communication channels 506. The system controller 502 can be a computer used by an electrical utility company for preparing customer billing statements and monitoring the operation of the system 400, for example. The system controller 502 includes a database of control signals that can be transmitted to the remote stations 504 as desired. The functions of the system controller 202 depend upon the intended application for the system 400. For example, an electrical utility company could use the system controller

502 to send control signals to determine the power consumed each hour over the last twenty-four hours, the total amount of power consumed between 6 p.m. and 8 p.m. over the last month, and the time of peak power consumption in the previous day for each house in a residential neighborhood. Alternatively, the system controller 502 can send a control signal after a resumption of power following a power outage in the system 400 to query the number and location of the houses in a residential neighborhood without power.

Each remote station 504 is connected to the feeder node 508 of the substation 422. The remote station 504 includes a signal injector 510 (e.g., an injection transformer) that is constructed to send a power line signal from the feeder node 508 to the meters 512 at the meter nodes 514 over the power lines 516 of the power distribution network 401. The signal injector 510 is implemented as a power line carrier (PLC) transmitter, which uses the existing power lines 516 as a communication channel. Due to the power lines 516 having a low data rate and being a low frequency carrier, the use of power lines 516 can be a highly efficient means for transmitting the control signal sent by the system controller 502 to a large number of meters 512 in the system 400. The signal injector 510 may be attached permanently to the power distribution network 401; alternatively, the signal injector 510 may be attached on an ad hoc basis.

Referring to FIGS. 6a, 6b, and 6c, the signal injector 510 is configured to send the power line signal containing the control signal over the power lines by modulating supply voltage waveform 602 (e.g., of the form $E_{pk} \sin(\omega t)$) near the zero crossover point 604. In particular, the signal injector 510 distorts the supply voltage waveform 604 in the region of zero crossover. In this way, a relatively high power line signal amplitude may be used without significant disturbance to the RMS (root mean square) value of the supply voltage. The disturbance of the supply voltage waveform 604 is created using a thyristor 606 connected between each phase and neutral of the transformer of the substation 422. The thyristor 606 is switched at a point 610 on the supply voltage waveform 602 that is displaced by a switching angle θ (e.g., about 25°) before a zero crossing.

As shown in Fig. 6b, the resulting current produces a depression 612 of the supply voltage waveform 602 at the point of common crossing (PCC), the value of which depends upon the relative impedances R_s , L_s , R_t and L_t . The thyristor current is limited by DC (direct current) transients to about 10% of the peak prospective fault current, and turns off upon returning to zero as a result of the unidirectional characteristic of the

thyristor 606. The line to neutral voltage at the transmitter terminals collapses to near zero for the duration of the current flow. The resulting supply voltage waveform 614 is described in percentage terms, where signal strength (S) is expressed as the percentage change of instantaneous voltage (δv) with respect to the normal sinusoidal waveform (v):

$$S = \frac{\delta v}{v} \times 100 \%$$

Signals are received between line and neutral at any low voltage point supplied from the same substation transformer. The power line signals are detected by integrating the supply voltage waveform 614 during a small fixed period before each positive-going zero crossing. The amplitude of each integral is compared with that of the previous supply cycle in order to determine whether the difference exceeds a pre-set value (the receiver setting), in which case a power line signal is assumed to have been detected. The meters 514 construct the power line signal message (i.e. the control signal) from a number of individual cycles, altered in a coded pattern, which is produced by a code generator 616 (FIG. 6c).

Returning to FIG. 5, each meter has a receiver 516, which is configured to receive and decode the power line signal sent by the signal injector 510. Once decoded, the meter 512 performs a status inquiry or measuring operation as required, and transmits a response signal containing the meter status (e.g., "in service" or "out of service") or the meter measurement (e.g., current power consumption, cumulative power consumption over a time period, or otherwise) from a transmitter 518 to the remote station 504 through a wireless communication channel 520. The response signal can be in the form of any sort of wireless signal (e.g., radio frequency, microwave, and infrared signals).

The remote station 504 receives response signals from one or more meters 512. Although only four meters 512 are shown, the remote station 504 may receive response signals from fifty to one thousand meters, more preferably two hundred to five hundred meters. Each remote station 504 and its associated meters 512 form a "cell". Each meter 512 has to have enough processing power to decode the power line signal received, perform the required status inquiry or measuring operations and transmit the response signal to the remote station 504.

Although only one remote station 504 is shown, there may be hundreds or thousands of remote stations 504, depending upon the number of meters 512 in the system 400. The remote stations 504 communicate with the system controller 502

through wired or wireless communication channels 506. In an implementation where the remote stations 504 communicate with the system controller 502 only through wireless communication channels, some or all of the remote stations 504 are positioned at elevated locations (e.g., placed on a telephone pole) to facilitate the two-way communication with the system controller 502, as well as, facilitate the reception of wireless response signals from the meters 512.

System 400 operates similarly to system 200. A customer prepays for electricity. The system controller 502 maintains the customer's account balance. The meters 512 transmit by radio meter measurements to the system controller 502. The system controller 502 calculates the customer's power consumption and decrements the customer's account. When the customer's account balance is zero, the system controller 502 causes the signal injector 510 to send a power line signal to the meter 512, causing the meter to cut-off power to the customer.

FIGs. 7 and 8 show power distribution system 700, which is another implementation of the system 100. Sometimes, it is not possible to deployment of a two-way network specifically for prepayment users. In these cases, radio is used to communicate to an application as described above and a simple physical token is used as a means to communicate payment back to the meter.

The low-cost prepayment meters include keypad technology. These simple meters when combined with network radio technology provide asymmetrical two-way communication without requiring an expensive two-way network. FIG. 7 shows a keypad meter, which works as follows: Instead of using a token, the customer is given a multi digit code number, which the customer enters using a keypad on the meter. Conventionally, this code credits the meter with the appropriate number of units of the commodity, which in the case of electricity would be a kWh figure. A realistic limit to the code is twenty digits, this limits the input to a single parameter. The input of a single parameter confines the meter to a single tariff rate, unless an internal clock is included. An internal clock increases cost and requires a site visit to change tariff rates.

The limitations of a keypad meter and need for a clock is resolved when the meter includes a radio that regularly transmits consumption data. The data can then be used to remotely calculate tariffs. In this case, the code number is used to represent units of time instead of units of the commodity. This approach uses the regular 'tick' of data and processing in a MCC to implement a virtual meter capable of implementing the

functionality normally found in an a complex token based prepayment meter. The MCC implements multi-tariffs and debt and fixed charge collection. Credit entered using the keypad removes the need to have an expensive two-way communication and yet provides remote disconnection.

5 FIG. 8 illustrates the operation of system 700. No physical token is required at the point of purchase. A printed receipt with the code number can contain all the details of the consumers account, i.e., debt and credit status. Alternatively, the number and data could be issued via IVR and payment made by transferring money from a credit card.

10 The code number would make electricity/gas supply available for a pre-set period of time. This is a fundamental difference to how conventional prepayment meters operate. At the end of that time period, represented by the code number, the meter would disconnect the supply of resource.

 The credit is decremented remotely from the payment made. The decrement will vary according to the rate of consumption communicated via the radio transmitter,
15 amount of debt recovery and current time varying tariff rate. In actual fact, this does not need to be real time and can be reconciled when a new transaction takes place. Using this approach tariffs and debt collection can be implemented.

 At the next purchase event, the consumer can buy more time; the cost or time the customer is given will depend on whether the customer has remaining credit or debit.
20 This is a function of past consumption, rate of debt collection, and tariff scheme. As described, a closed loop is implemented where the available time or cost is modified to ensure the net credit/debt balance is approximately zeroed.

 An advantage to the consumer is that the display of the meter only needs to indicate the remaining time. This ensures the consumer has exact knowledge of when a
25 purchase is necessary regardless of consumption, which is an improved method of budgeting. In addition to the normal benefits of the consumers being in control of their electricity budgets and being able to decide for themselves how often they wish to purchase electricity and to what value system 700 provides these additional advantages:

- IVR can be used to reduce infrastructure cost
- 30 · consumers will have convenience of purchasing via the vending units or via telephone.
- consumers can be provided with a more comprehensive statement at the time of credit purchase or via IVR.

- the prepayment consumer will be able to enjoy the full service as offered to credit customers.
- this approach resolves the need for a two way network but offers full flexibility to a utility
- 5 · cost of the meter should be lower if based on keypad technology
- the same approach can be used for gas meters
- the consumer has exact knowledge of when a purchase is necessary regardless of consumption

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, the commodity described is not limited to electrical power, water, and gas, but can be any utility commodity.

CLAIMS

What is claimed is:

1. A utility system, comprising:

a distribution network for distributing a resource to a customer;

5 a meter for metering the resource and for connecting and disconnecting a supply of the resource distributed to the customer;

a control system for maintaining an account of the customer and for controlling distribution of the resource based on the account information;

10 a first communication system for sending, over a first medium, information from the prepayment meter to the control system; and

a second communication system for sending, over a second medium, information from the control system to the prepayment meter, wherein the information includes signals for disconnecting or connecting the supply of the resource distributed to the consumer.

15 2. The utility system of claim 1, wherein:

the information the meter sends to the control system includes resource consumption information; and

20 the control system includes a prepayment unit for receiving prepayments from the customer and crediting the customer's account to reflect the prepayment, the control system being configured to maintain the customer account based on prepayments from the customer and the resource consumption information, the control system further being configured to send a signal to the meter for disconnecting the supply of resource to the customer based on the customer's account.

3. The utility system of claim 2, wherein:

25 the utility resource is electrical power;

the first communication system is a fixed-network radio system; and

the second communication system is an power-line communication system.

4. The utility system of claim 1, wherein the control system is configured to:

30 calculate, based on information received from the meter, an amount of resource the customer has consumed;

calculate, based on the calculated amount of resource the customer has consumed,
an amount to debit the customer's account; and

debit from the customer account the amount of debit calculated.

5. The utility system of claim 4, wherein calculating an amount to debit includes:

5 calculating tariffs on the resource.

6. The utility system of claim 1, wherein:

the first communication system includes a radio transmitter connected to the meter
for sending information from the meter to the control system;

the meter is a keypad-based token meter that includes a processor, the meter being
10 configured to send resource consumption information to the control system through the
radio transmitter;

the control system is further configured to receive a prepayment from the
customer and generate an electronic token representing an amount of resource, the
electronic token being transferable to the customer; and

15 the second communication system includes the keypad through which the
customer can enter the electronic token into the processor in the meter.

7. The utility system of claim 6, wherein:

the meter includes a clock and the electronic token specifies a period of time; and

the meter is configured to supply the resource to the customer until the period of
20 time specified by the token has expired.

8. The utility system of claim 6, wherein:

the electronic token specifies a quantity of resources.

9. The utility system of claim 8, wherein:

the processor of the meter is configured to calculate the supply of resource
25 consumed by the customer, decrement the amount of resource specified by the electronic
token, and cause the meter to automatically disconnect the supply of resource when the
consumer has consumed all of the amount of resource specified by the electronic token.

10. The utility system of claim 6, wherein:

the amount of resource represented by the electronic token is based on the prepayment and the customer's account.

11. The utility system of claim 10, wherein:

5 the meter is a single-rate meter; and

the controller is further configured to support multiple billing rates, debt recovery, varying tariff schemes, and other fixed charge collection in generating the electronic token.

12. The utility system of claim 11, wherein:

10 the control system maintains the customer's account at a specific balance when calculating an amount of resource represented by the electronic token.

13. The utility system of claim 12, wherein:

the control system anticipates consumption by calculating the customer's past resource consumption and current prepayment amount.

15 14. A prepayment meter, comprising:

a measuring unit for metering consumption of a resource by a customer;

a keypad for receiving a prepayment token that represents an amount of resource available to the customer for consumption;

20 a processor electrically connected for receiving input from the measuring unit and from the keypad, wherein the processor is configured to determine, from the token, an amount of resource available to the customer, calculate an amount of resource consumed by the customer based on input from the measuring unit, and decrement the amount of resource available to the customer by the amount of resource consumed by the customer; and

25 a radio transmitter electrically connected for transmitting from the processor information specifying the amount of resource consumed by the customer.

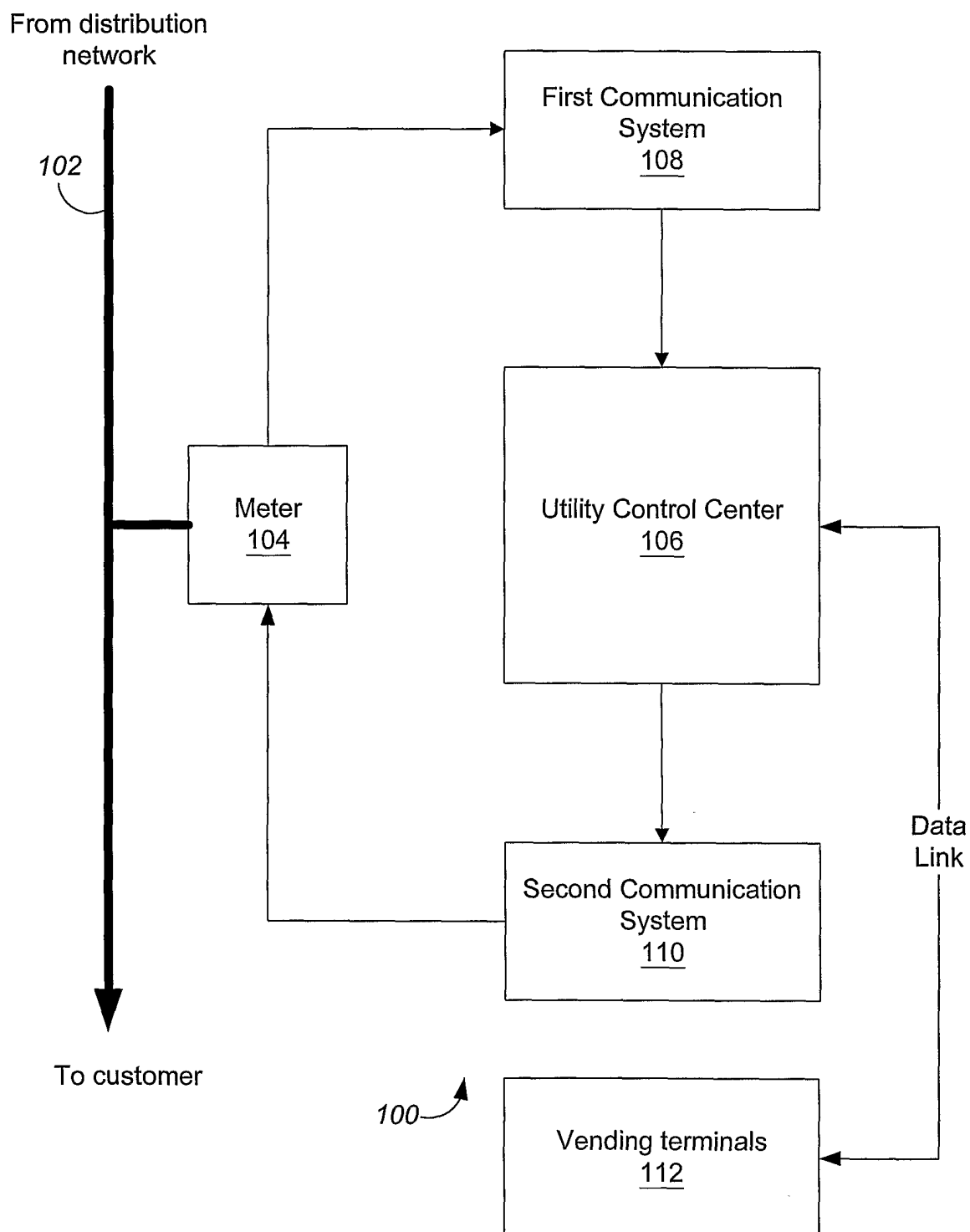


FIG. 1

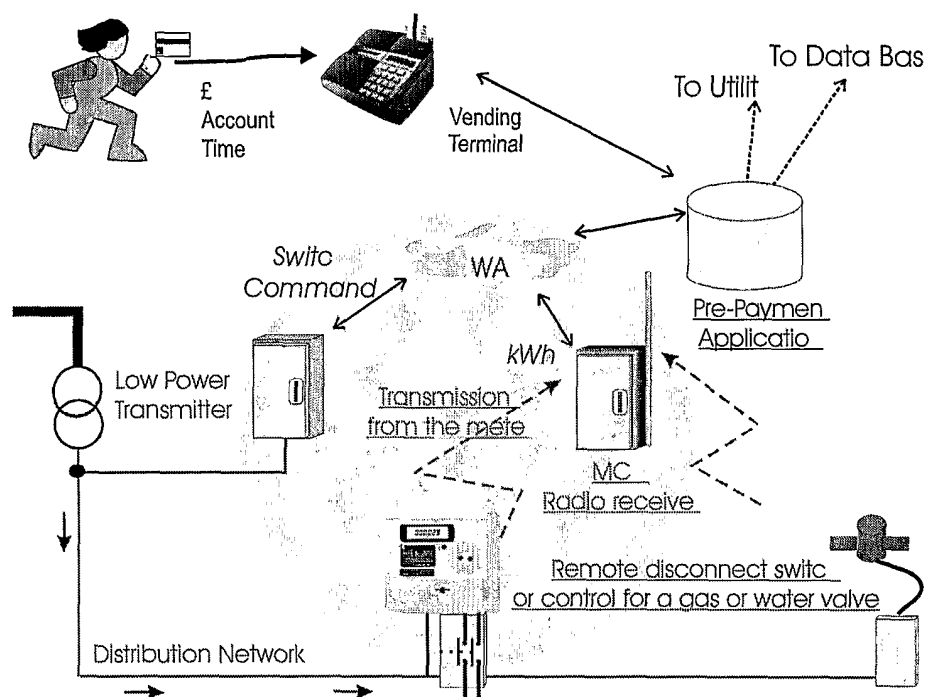


FIG. 2

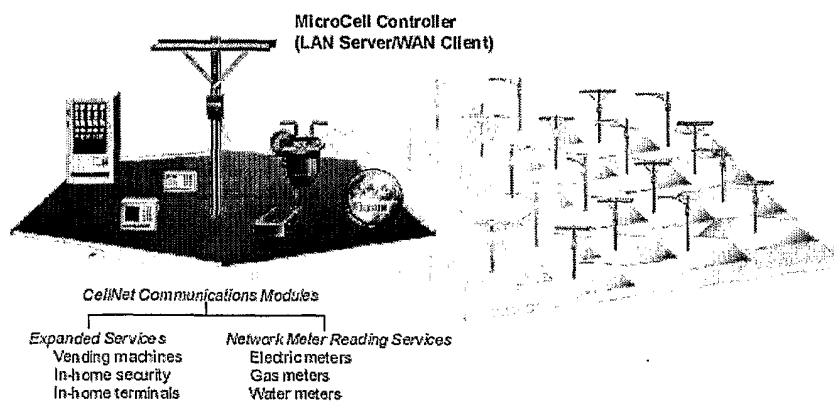
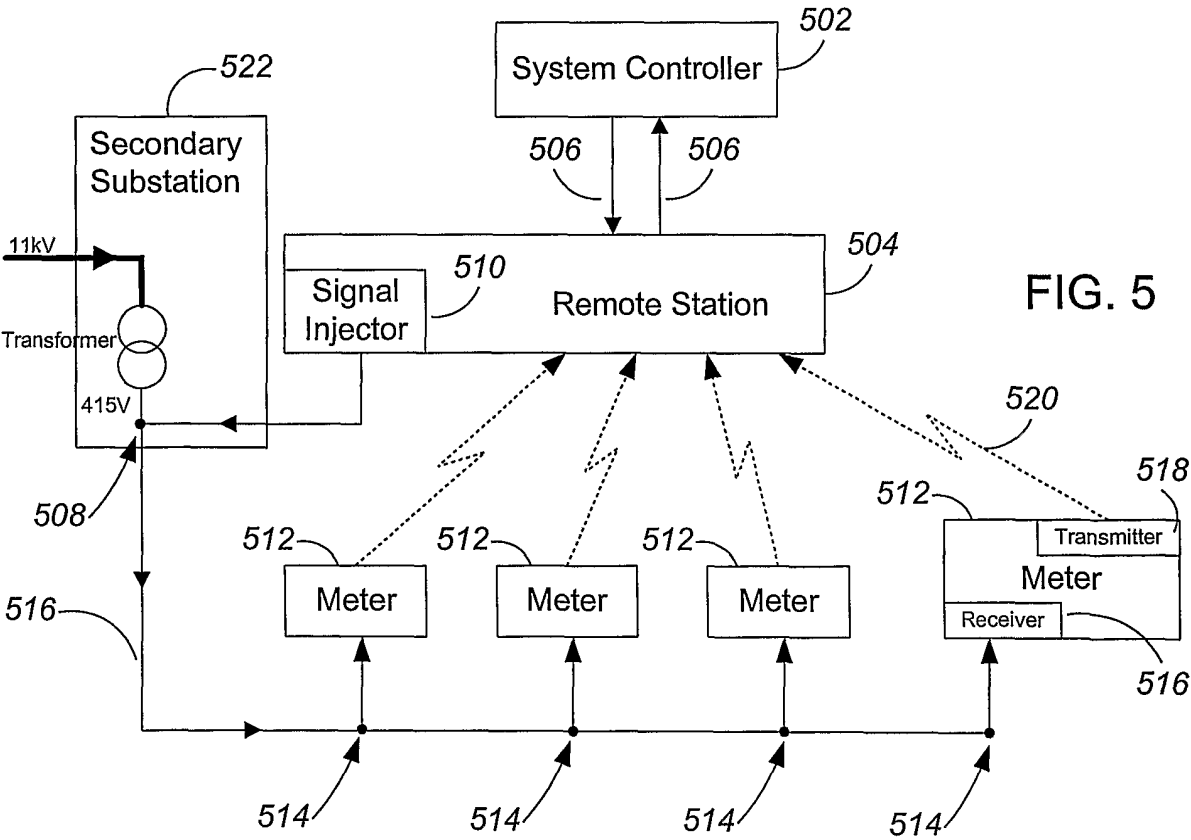
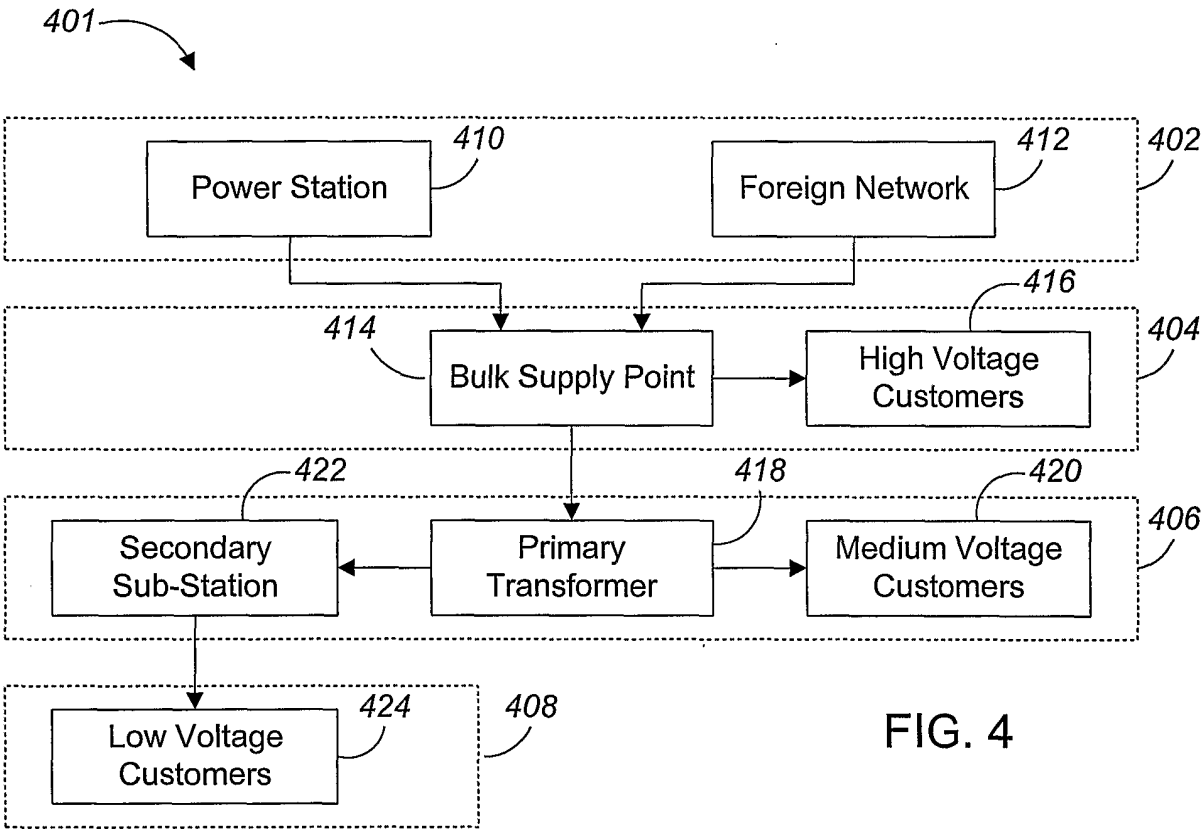


FIG. 3



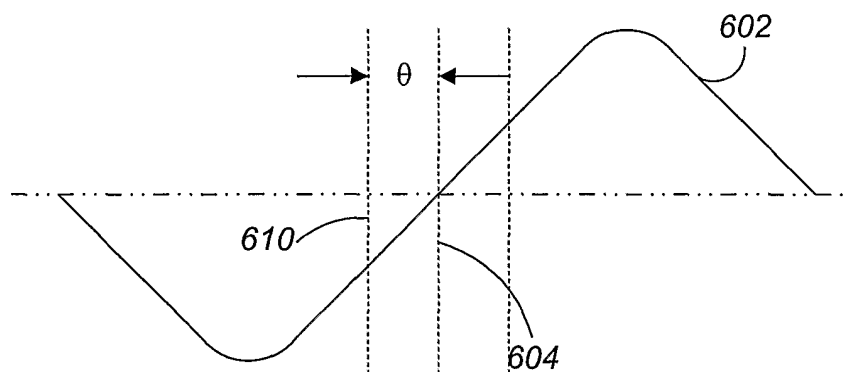


FIG. 6a

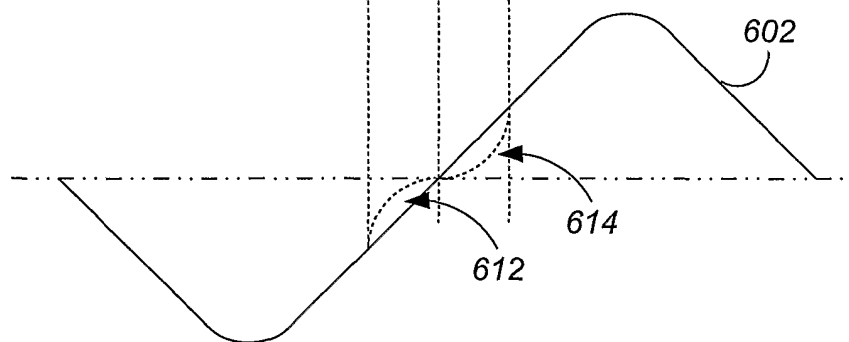


FIG. 6b

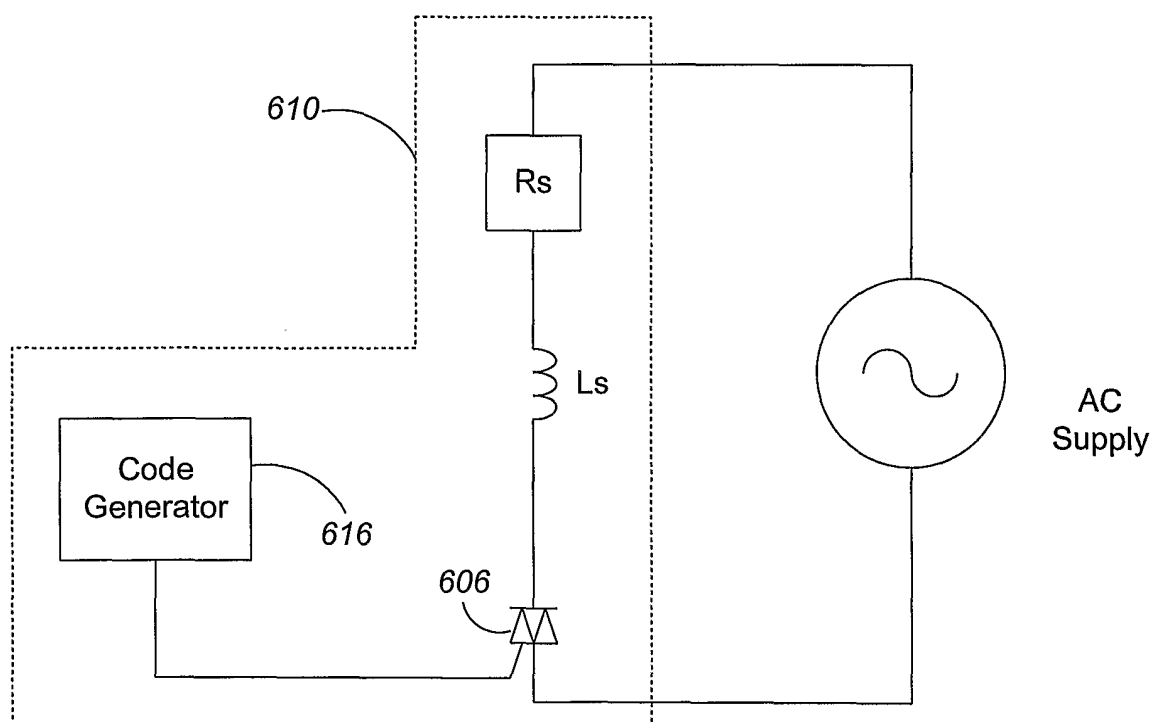


FIG. 6c

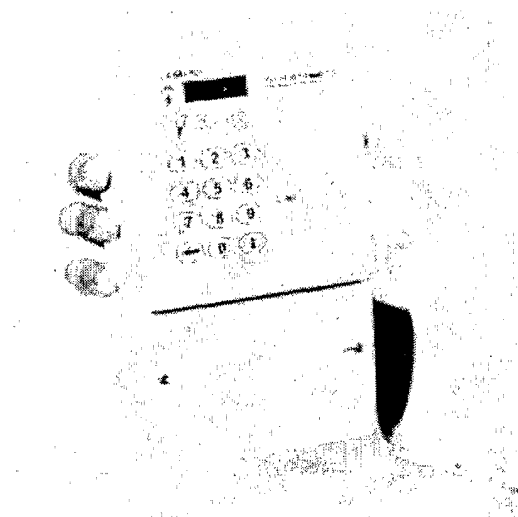


FIG. 7

Keypad Prepayment System

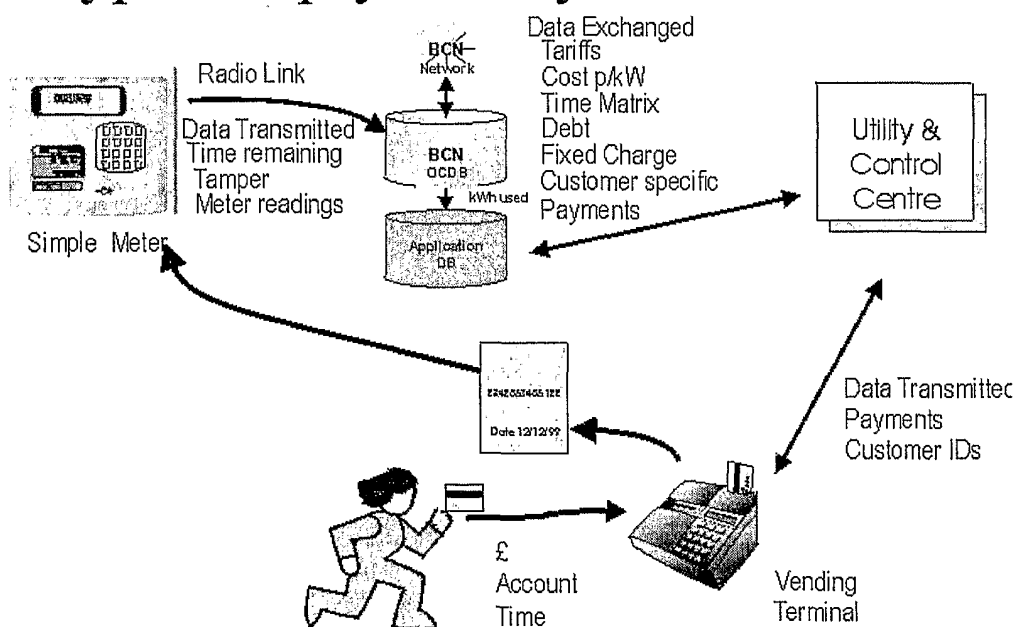


FIG. 8

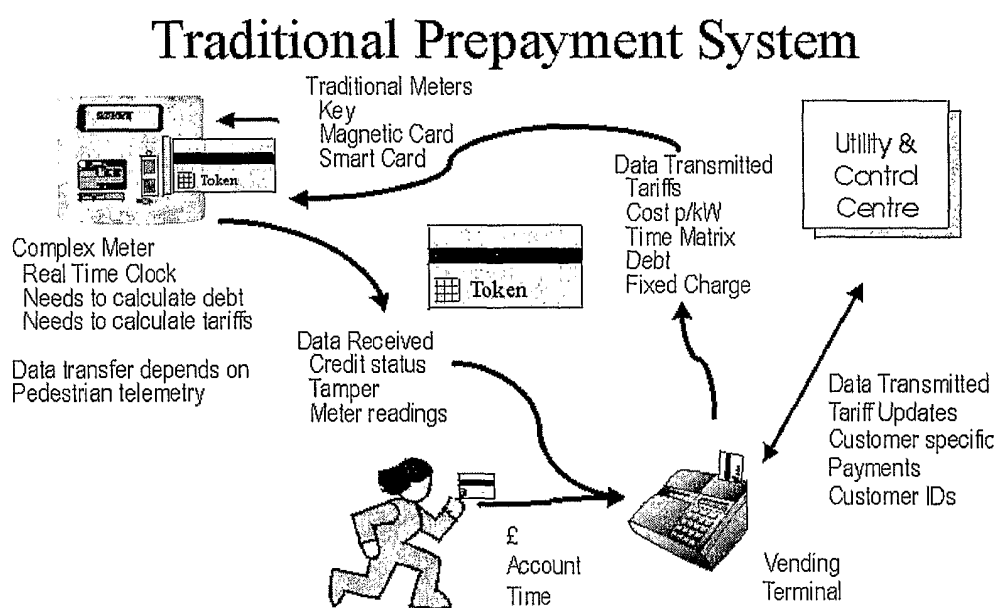


FIG. 9
PRIOR ART