A single system collects commodity transfer data from commodity meters (70) at remote sites and controls commodity transfer at the remote sites. Controller circuit (82) converts commodity transfer signals into digital metering data which is stored pending interrogation. Polling device (52) initiates dialed access to each remote site to retrieve the metering data. Telephone interface control circuit (80) effects two-way communication between polling device (52) and controller circuit (82) in response to a sequence of gateway conditions indicating that dialed access has been secured by polling device (52). The gateway conditions comprise a ringing signal closely succeeded by an off-hook condition and within a predetermined time thereafter an identifying access tone from polling device (52). Gatekeeper mechanisms (76) in commodity supply lines (68, 78) are controllable by the controller circuit (82), and therethrough by the polling device (52), to initiate or terminate commodity transfers.
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METHOD AND APPARATUS
FOR
REMOTE COMMODITY TRANSFER CONTROL AND MONITORING

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to the remote control and monitoring of the transfer of commodities, such as those measureable commodities provided to consumers by utility services. More particularly, the present invention pertains to novel methods, systems, and apparatus that permit the centralized retrieval of commodity consumption data and the centralized termination or initiation of commodity supply. The invention has specific application to remote control and monitoring systems utilizing existing telephone networks to effect communication between consumer locations and the centralized location from which the data retrieval and transfer control functions of the system are exercised.

2. Background Art
The growth of industrialized society has been accompanied by the expansion of utility systems for the distribution of commodities to consumers. Examples include utility systems permitting water and energy, such as electricity and natural gas, to be safely and efficiently supplied to the public. Utility networks deliver such commodities from central sources to a myriad of individual consumer locations through elaborate networks of piping or cables which, while largely out of view, permeate the physical space in which society exists. In this distribu-
tion aspect of utility operation, these networks have been admirably successful.

In contrast to their effectiveness in delivering commodities, utility systems have not achieved effective centralization in two essential functional areas. These areas involve regulating commodity transfers by initiating and terminating commodity flow at individual consumer locations and retrieving commodity consumption data from those locations.

In order to initiate or terminate the supply of a utility commodity, such as electricity, gas, or water, at a given consumer residence or business, the corresponding utility company is required to dispatch personnel to each individual site involved. Additionally, to obtain reliable metering data about the consumption of such commodities, utility employees must visit each consumer location on a periodic basis. This is a labor-intensive way in which to accomplish either objective. It also has other undesirable ramifications.

Utility company personnel who to travel about a utility distribution system for these purposes require the use of company vehicles, with the liability exposure attendant thereto. These employees also confront awkward and sometimes perilous situations, in that they are required to enter onto the private property of others to perform their tasks. On such properties often lurk dangerous or intimidating animals and a host of potential slip-and-fall circumstances. Consumer residences and businesses are also highly individualized. Thus, it is frequently necessary for utility personnel to waste time and to brave unpleasant circumstances to locate the meters, switches, or valves to which their attentions are to be directed. In addition the quality of metering data
economically obtainable even using such labor-intensive methods has frustrated desirable social objectives.

The high capital cost of providing adequate equipment to satisfy peak utility demand periods and the under-utilization of that equipment at nonpeak periods has motivated utilities to try to shift consumer consumption away from peak demand periods. As in the case of telephone usage, it has been thought that this could be effected by employing differential commodity consumption rate schedules that offers lower rates at off-peak hours. In this manner economic incentives would operate to induce voluntary changes in consumption patterns. Nevertheless, at present an economical technology has not been developed by which to implement this policy in relation to the utility systems here at issue.

Utilities collect information only about the total quantity of the commodity that has been transferred between periodic on-site meter readings. The few commodity meters that are capable of discriminating between a unit of commodity transferred during a peak demand period and a unit of commodity transferred at other times are too costly to utilize on a mass basis. Accordingly, efforts to shift utility commodity consumption away from peak demand periods has been largely without success.

Commodity systems exist which, while not delivering goods to individual consumers, do transfer commodities among a plurality of sites. The network of piping and valves required to operate a gas or oil field is an example. Such commodity transfer systems are, nevertheless, also afflicted by an inability to centralize the processes of control and monitoring. The actual control of flow channels and the securing of information about quantities of commodities transferred within a gas or oil field network requires in most instances on-site visits
by company employees. Valves and meters in such environments are as widely separated as are the various consumer locations scattered throughout an urban utility system. Energy fields and the piping network associated therewith are additionally difficult to service, as they are often located some distance from settled areas or from the administrative and engineering headquarters of the energy company involved. Similar impediments to centralized monitoring and control exist in the cases of slurry systems and agricultural irrigation waterways or piping.

The above-described shortcomings of commodity transfer systems can be traced to the absence in such systems of technology by which to obtain feedback on micro-functioning. Hand in hand can be found poor system responsiveness and an inability to control that micro-functioning in any centralized manner. These deficiencies arise in major part due to a lack of effective communication within the components of commodity distribution systems.

In an effort to compensate for this lack, communications systems, such as telephone networks, have been looked to with some promise. These networks are relatively pervasive, extending in many instances to remote areas where even distribution systems for commodities such as water and gas are prohibitively expensive to install. The lines of a telephone network have for some time already been successfully employed in data transfer systems. The existing hard-wiring and microwave communication capacity in telephone networks is highly advantageous when compared with monitoring and control systems using radio. No spectrum allocation or radio interference issues arise in the use of telephone lines for communication purposes.
To understand some of the prior attempts to use telephone lines to collect commodity transfer data or to effect the remote control of commodity transfer systems, it will be necessary to first understand the manner in which existing telephone networks function. Of pivotal importance is the operation of the switching center of a telephone network in undertaking to couple the telephone lines of a calling party to those of a party being called.

The telephone of each conventional paid subscriber in a telephone network is connected to the switching center of the network by a pair of telephone lines. For largely historical reasons one is called the tip line and the other the ring line. In the context of systems using the lines of a telephone network for the purpose of collecting commodity transfer data or for effecting the remote control of commodity transfer systems, the telephone lines of such conventional paid subscribers are often referred to as being nondedicated in that they are subject to general uses rather than being dedicated to serving a control or metering function exclusively. The tip and ring lines of each subscriber terminate in the switching center at a unique pair of corresponding terminals on a distribution mainframe. The terminals of all the subscribers serviced by a given switching center are selectively accessible to the switching equipment located there.

At the subscriber end of each pair of telephone lines the trip and ring lines are normally electrically separated, or open. When a subscriber lifts the telephone headset from its cradle, the tip and ring lines connecting that subscriber to the switching center become shunted, or electrically coupled. An off-hook condition is said to result. This occurs regardless of whether the headset has been lifted in order to make a call or in order to answer one. The shunted tip and ring lines generate an off-hook
condition signal which is detectable at the switching center.

An off-hook condition signal can be generated at a subscriber location in ways other than just by lifting the headset of the telephone at that location. Electrically connecting the tip and ring lines anywhere between a subscriber telephone and the switching center will shunt those lines, creating an off-hook condition signal which is indistinguishable at the switching center from that generated when a headset is lifted. Technically speaking, an off-hook condition created without lifting a headset is only an apparent one. Nevertheless, for simplicity of discussion, the expression "off-hook condition" as used herein and in the appended claims will include both the condition resulting when a telephone headset is removed from its cradle and an apparent off-hook condition caused by shunting the telephone lines intermediate a subscriber telephone and a switching center. In both instances an off-hook condition signal is generated.

When an off-hook condition signal is received at the switching center from a would-be caller, the switching center is placed on notice that an attempt is about to be made to secure dialed access to another telephone in the network. The caller dials the desired telephone number, thereby communicating to the switching center the identity of that other telephone.

In responding to a request of a caller to be connected to another telephone, the switching center proceeds first to locate and access the distribution mainframe terminals of the tip and ring lines that lead to the telephone at the location to be called. These terminals are not immediately coupled to the telephone lines to the party placing the call. Instead, the switching center transmits on the lines to the telephone to be called periodic voltage pulses or
ringing signals that are capable of causing that telephone to ring. The lines of the caller and the party being called remain disconnected, and the caller actually need not hear anything in the headset during this period.

The lines to the telephone of the caller are, however, supplied by the switching center with a periodic tone that has incorrectly come to be assumed to correspond in a direct temporal sense to ringing occurring at the phone to which the call has been placed. The periodic tones are in reality just "wait-and-see" messages supplied by the telephone network to assure the caller that another portion of the switching center is in the process of trying to get the party at the other location to answer the telephone there. During ringing the caller receives "wait-and-see" messages that are totally independent of the voltage pulses that cause the telephone to ring at the location being called.

The two separate parts of the switching center that are performing these independent tasks get coupled together only if the switching center receives an off-hook condition signal from the lines to the telephone being called. Under normal conditions this means that the telephone of the party being called has just been answered in response to ringing. Then the terminals of the telephone lines of the caller and the terminals of the telephone lines to the dialed party are electrically coupled to each other in the switching center. It is only at this point that any message from the caller can reach the telephone lines to the party being called.

Thus, for direct dialed access to be effected between a caller and another telephone, an off-hook condition must first have been created on the lines at that other telephone. The resulting off-hook condition signal is the only cue that will induce the switching center to
interconnect the two parties. This fact of telephone network operation has presented insurmountable problems for remote commodity monitoring and control systems that attempt to utilize existing telephone networks.

It is possible for one that is not a conventional paid subscriber to obtain access to the telephone lines at a remote site without the creation of an off-hook condition there. This, however, requires special access to the machinery inside the switching center or direct physical access to outgoing telephone lines at their terminals on the distribution mainframe. Such forms of special access require a party either to locate the dialing equipment it will use inside the switching center itself or to obtain access thereto over telephone lines other than those of a conventional paid subscriber. Both involve substantial cost. Special forms of access have been used in prior efforts to develop systems for utility commodity transfer control and monitoring, but it is undesirable to require that a business enter into a costly relationship of special access with the telephone network in order to compete in the market as a remote utility monitoring and control entity.

All systems that attempt over the lines of a telephone network to collect metering data or to control commodity transfers at remote sites require that some type of interface equipment be initially installed at the remote site and interconnected with the telephone and the utilities there. The interface equipment and the consumer telephone itself are part of the so-called consumer-provided equipment (CPE) that is considered to be beyond the province of the telephone utility company, being the ownership and maintenance responsibility of the consumer alone. Such equipment is coupled to the lines on the consumer side of foreign voltage protectors. These shield
the telephone network from damage due to stray voltages, such as lightning and malfunctioning consumer-provided equipment, and constitute the outer boundaries of the telephone network that is owned and maintained by the telephone utility.

Some remote monitoring and control systems have installed interface equipment directly in the telephone lines at each remote site, so that signals from the switching center are in effect forwarded by the interface equipment to the telephone at the remote site. The interface equipment then monitors all incoming signals, including ringing voltage pulses, for the presence of identifying signals from a polling device. This monitoring occurs in advance of the answering of the telephone at the remote site and thus requires the receipt of identifying signals prior to the interconnection of the lines of the caller and of the party being called. Accordingly, interface equipment of this type can only be utilized with a polling device that enjoys some form of special access to the switching center of the telephone network. Special forms of access afford the only way that messages could be sent to a remote site on the lines of a telephone network without the answering of the telephone there.

Such arrangements are undesirable, not only for requiring special access to the switching center on behalf of the polling device, but because the interposition of equipment directly in the lines between the switching center and a subscriber telephone requires messages to pass through additional equipment before the subscriber telephone is reached. This reduces the reliability of the telephone system and renders inconclusive many attempts to determine the source of malfunctions therein.

Interface equipment has been developed for remote monitoring and control systems that permits a centrally
located polling device to be connected to a telephone switching center as a customary paid subscriber. One way in which this has been accomplished has been to include in the interface equipment an automatic dialer. The automatic dialer is programmed to seize the telephone lines at the consumer location on a periodic basis and to then initiate conventional dialed access from the remote site through the telephone network switching center to the central location of the metering and switching system. Such arrangements also have profound drawbacks.

First, the time at which an automatic dialer can attempt to obtain dialed access to the central location is seriously circumscribed by the need to insure that a plurality of such automatic dialers located at various sites throughout a utility system do not dial the central location simultaneously and overload the capacity of the equipment there to receive calls. Accordingly, the time at which calls are to be made by each automatic dialer must be coordinated with the times programmed in automatic dialers at other locations throughout such remote monitoring and control systems. This requires much more than the routine installation at consumer locations of a large plurality of standard interface equipment units. System-wide planning and individualized programming at each consumer location is implicated, so that the placement of each interface unit constitutes a custom installation and programming effort.

Secondly, the presence of an automatic dialer on a telephone line makes it virtually impossible for a subscriber to dispute the accuracy of billing statements from the telephone utility. Automatic dialers may be susceptible to malfunctioning. This can result in unwanted outgoing calls being placed from the dialer through the telephone network. These are, nevertheless, rightfully billable to the subscriber. A subscriber with an automatic
dialer can never be absolutely certain of what calls have been made from the telephone of that subscriber. Thus, most telephone companies refuse to give credence to objections about billing accuracy, if an automatic dialer is located on the telephone lines involved.

Other forms of remote metering and switching systems that attempt to place the polling equipment of the system in the position of a paid subscriber of the telephone network do so by using interface equipment at each consumer site which seizes the telephone lines thereat during a preprogrammed time each month or week. Such interface equipment then waits for a fixed interval for ringing signals. During that fixed interval, the polling device at the central location is supposed to operate as a conventional paid subscriber and attempt to secure dialed access to the consumer site through the telephone network switching center.

When a ringing signal is received by such interface equipment during the time the telephone lines have been seized, that equipment itself shunts the telephone lines creating an apparent off-hook condition for the benefit of the telephone switching center. Although no telephone at the given location is actually in an off-hook condition, an off-hook condition signal is thus created which triggers the switching center to effect actual interconnection between the consumer location and the central polling equipment of the metering and switching system.

This arrangement is complicated in that its success is dependent on adept choreography: on the initial, simultaneous action by equipment at two widely separated locations that are not yet in communication with each other. It is increasingly difficult as the number of consumer locations to be monitored becomes substantial. Furthermore, the ability to control commodity transfers at
each consumer location is rigidly limited to the times at which the interface equipment there has been programmed to seize the telephone lines and wait for ringing signals. The polling device cannot obtain access to the interface equipment at any other time.

The activity of the interface equipment in seizing telephone lines interferes with the normal use of a subscriber telephone. While the impact of this interference can be reduced by minimizing the window of the fixed interval during which the interface equipment has usurped a consumer's telephone lines, the shorter that fixed interval, the more difficult is the coordination of mechanical operations at the central location and the consumer site. As a result, such systems are disadvantageously limited in a practical sense to use during off-peak hours, usually in the middle of the night, when subscriber telephone activity is the least likely.

Each interface unit must of necessity include an appropriate coupling between any utility meter being monitored and the electronics of the interface equipment. Methods are known for retrofitting utility meters with structures which will permit a device remote from that meter to ascertain the reading thereon. Such interface equipment, however, involves complex installation procedures which in effect encode the meter involved, converting the visually appreciable reading on the face of that meter to a corresponding electrically detectable reading that may be communicated to a polling device. The complexity of these types of encoded meters impacts unfavorably on the cost of installing remote monitoring and control systems.
SUMMARY OF THE INVENTION

One object of the present invention is an improved utility network monitoring system that utilizes the lines of a telephone network to collect at a central location data concerning the transfer of a commodity at one or more sites remote therefrom.

Another object of the present invention is an improved utility network control system with which commodity transfers at a plurality of remote sites can be controlled individually and at will from a distinct central location.

It is an objective of the present invention that both the monitoring and control functions of the two systems described above be combined in a single unified commodity transfer and control system.

It is an important object of the present invention to provide systems as described above in which both the central location and each remote site are connected to the switching center of the telephone network involved as conventional paid subscribers on nondedicated lines.

Another object of the present invention is to permit the remote control and monitoring of the transfer of commodities at one or more remote sites without initiating telephone calls from those remote sites.

A further object of the present invention is a system as described above which minimizes interference with the use of telephones located at remote sites.

Yet another object of the present invention is a remote metering and control system as described above which is not limited as to time of day at which it may be operated effectively.

The present invention has the additional object of providing a remote control and monitoring system that does not interpose equipment in the telephone lines between a
telephone network switching center and the sites at which commodity transfers are being effected.

Additionally, it is an object of the present invention to provide a system for collecting commodity consumption data over the telephone lines of a telephone network without requiring the cost and complication encoded meters.

Yet another object of the present invention is a remote metering system as described above which reliably and inexpensively can contribute to the use of differential commodity consumption billing rate schedules by collecting metering data about the time of day at which the transfer of each unit of commodity occurred.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will become apparent from the description, or may be learned by the practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims.

To achieve the foregoing objects, and in accordance with the invention as embodied and broadly described herein, a remote metering and switching system is provided for exercising control and monitoring functions over a commodity distribution system from a central location using the lines of a telephone network. In outline the system comprises a polling means at a central location connected to the switching center of the telephone network and a metering and switching module at a remote site to which the telephone network extends and at which commodity transfers are to be monitored or controlled. To enable the monitoring function, the commodity transfer system includes at the remote site a meter of the commodity being transferred. Correspondingly, if any remote switching
function is to be carried out, a gatekeeper mechanism is required there that is at least capable of initiating and terminating the transfer of the commodity.

In one embodiment of the present invention a metering and switching module is provided as interface equipment at each remote site. The module comprises a meter interface means coupled to the meter at the remote site for continuously generating from the meter commodity unit transfer signals at a rate corresponding to the simultaneous rate of transfer of the metered commodity. The module further comprises a controller means for receiving the commodity unit transfer signals and for creating from them metering data which is stored in the controller means pending its interrogation over the lines of the telephone network by the polling means. Also included in the metering and switching module is a telephone interface control means that is coupled to the telephone lines at the remote site and connected to the controller means.

The telephone interface control means monitors the telephone lines at the remote site and effects two-way communication between the polling device and the controller means over the lines of the telephone network by coupling the controller means to the telephone lines at the remote site. This occurs in response to detecting a sequence of gateway conditions on the telephone lines at the remote site that indicate that direct access has been secured between the polling device and those telephone lines. Where remote control of commodity transfers is to be effected, the module further comprises a switching means for selectively operating the gatekeeper mechanism to regulate the transfer of the commodity.

To secure two-way communication with the controller means of the metering and switching module, the polling
means of the system initially attempts to secure dialed access through the switching center of the telephone network to the telephone lines at the remote site. Thereupon the switching center commences in routine fashion to send ringing signals to the remote site.

In the method of the present invention an off-hook condition signal will then inevitably be generated at the remote site. The telephone at the remote site may simply be answered in response to ringing signals. In the alternative, once a predetermined large number of successive ringing signals are detected on the telephone lines at the remote site, the controller means operates a telephone drop switch to shunt the telephone lines at the remote site. Either chain of events will result in an off-hook condition signal which cause the switching center to connect the polling means to the telephone lines at the remote site.

The polling means is then in direct communication with the lines at the remote site, and it transmits thereto an identifying access tone. The access tone is detected by the telephone interface control means, which then couples the controller means to the telephone lines at the remote site. This coupling is made through an isolation transformer and a modem, and during the time such coupling is in effect, the telephone at the remote site is dropped from the telephone lines thereat, so that the two-way communication of data between the polling device and the controller means is not impeded by signals representing audio messages received through the telephone headset. Following communication between the central location and the remote site, the controller means is decoupled from the telephone lines at the remote site and the telephone there is reconnected to permit routine use.
Thus, the sequence of gateway conditions on the telephone lines at the remote site which cause the telephone interface control means to effect two-way communication between the polling means and the controller means comprise a ringing signal closely succeeded by the onset of an off-hook condition and thereafter within a predetermined period of time by the access tone. In order to detect the elements of the gateway sequence, the telephone interface control means comprises a ring detector circuit, an off-hook detector circuit, and an access tone detecting circuit, all coupled to the telephone lines at the remote site and to the controller means. The ring detector circuit notifies the controller means of individual ringing signals on the telephone lines at the remote site; the off-hook detector circuit notifies the controller means of off-hook conditions; and the access tone detector circuit notifies the controller means of the presence of the identifying access tone from the polling means. It is the controller itself that verifies that these gateway conditions have been received in the correct sequence and temporal proximity one to another.

In one embodiment of the present invention the meter interface means of the metering and switching module comprises an optical coupling between the meter and the controller means. One form of such an meter interface means comprises an optical signal source, an optical signal detector for generating commodity unit transfer signals in response to optical signals, an optical wave guide for transmitting optical signals from the optical signal source to the optical signal detector, and an optical signal interrupt means for temporarily interrupting the transmission of optical signals by the optical signal wave guide when the meter indicates that the transfer of a preselected unit of the metered commodity has occurred at
the remote site. The optical signal interrupt means comprises an opaque member movable by operation of the meter to temporarily block the transfer of optical signals by occluding on the optical wave guide.

Where the commodity meter has a rotating metering element which indicates the simultaneous transfer of the commodity, the occlusion means preferably comprises a shaft attached to the metering element. The longitudinal axis of the shaft is aligned with the axis of rotation of the metering element. Formed in the shaft is a metering aperture periodically alignable by rotation of the metering element with the optical waveguide. Alignment of the aperture with the optical waveguide permits optical signals to reach the optical signal detector.

Preferably, the optical signal source produces an optically encoded bit stream, and optical signals received by the optical signal detector are verified as comprising a component of that optically encoded bit stream. This insures the accuracy of all commodity unit transfer signals generated.

The metering data created by the controller means comprises a count of the number of commodity unit transfer signals received by the controller means. Optionally, however, the count of commodity unit transfer signals received by the controller means is subdivided into a count of such commodity unit transfer signals received during each of a plurality of successive time intervals of individually predetermined duration. By permitting the time intervals to correspond to periods in which different billing rates are imposed on consumption of the commodity transferred, time-based differential commodity transfer billing rates may be instituted in the commodity transfer system involved.
The controller means comprises a microprocessor coupled to the data collection means and to the telephone interface control means, a read-only-memory accessible to the microprocessor, and a random-access-memory coupled to the meter interface means and accessible to the microprocessor. The random-access-memory stores the metering data pending interrogation. Where remote switching is to be undertaken, the controller means further comprises a switching circuit for controlling the gatekeeper mechanism in response to signals communicated by the polling means to the controller means. Optionally, the controller means may further include a security means for periodically investigating the integrity of the meter housing and reporting any breach of that integrity to the controller means for communication to the polling means during two-way communication therewith.

In another aspect of the present invention, the off-hook detection means of the telephone interface control means comprises an output driver circuit for generating at an output portion thereof an off-hook register signal by which to inform the controller means of voltage changes on the telephone lines at the remote site that correspond to an off-hook condition. Preferably, the output portion of the output driver circuit is optically isolated from the telephone lines at the remote site. The off-hook detection means also comprises a ring rejection circuit connected between the output driver circuit and the telephone lines at the remote site for preventing ringing signals thereon from activating the output driver circuit. Additionally, a threshold detection circuit may be connected between the output driver circuit and the telephone lines at the remote site for rendering the output driver circuit insensitive to line voltage variations between different telephone networks.
In yet another aspect of the present invention, a remote metering and switching system as described is further provided at each remote site with a regulated power source connected to the electric utility power thereat. The power source includes a rechargeable battery to sustain operation in case of a temporary failure of electric power to the remote site.

The present invention also includes a method for remote metering and switching, wherein a polling device at a central location attempts through the switching center of a telephone network to obtain dialed access to the telephone lines at a remote site. Upon obtaining such access, the polling means transmits to the remote site an identifying access tone, whereupon a remote site metering and switching module as described briefly above effects two-way communication between the polling means and a memory means or a switching circuit at the remote site. The telephone at the remote site is dropped from the lines thereat during such two-way communication.

In order to effect the required two-way communication between the polling device and the telephone lines at the remote site, the remote monitoring and switching system of the present invention distinguishes between calls originating at the polling device and other incoming calls received at the remote site. The method by which this is accomplished comprises the steps of attempting to secure dialed access from the central location to the telephone lines at the remote site, detecting ringing signals on the telephone lines at the remote site, counting the number of successive ringing signals, and effecting dialed access to the remote site in the absence of the answering of any telephone there. This is accomplished by shunting the telephone lines at the remote site when the number of
successive ringing signals detected equals a predetermined large number.

The method further comprises the step of registering off-hook conditions on the lines at the remote site, thereby to detect when the telephone at the remote site has either been answered or when the telephone lines have been shunted in the manner already described due to a lack of such an answer. An identifying access tone is transmitted from the central location immediately upon securing dialed access with the telephone lines at the remote site. These lines at the remote site are monitored for the access tone which constitutes the final event in the sequence of gateway conditions already described above.

Thus, the method, system, and apparatus associated with the present invention permits remote commodity transfer control and monitoring over the lines of existing telephone networks. This may be accomplished from a central location at any time of day or night and without special access to the switching center of the telephone network. No outgoing calls need be initiated from the locations at which commodity transfers are occurring. Meters being monitored by the inventive method require retrofitting in a simple manner only, and the metering data generated and retrieved at the central location is capable of including time-of-consumption parameters.
BRIEF DESCRIPTION OF THE DRAWINGS

In order that the manner in which the above-recited and other advantages and objects of the invention are obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope, the invention will be described with additional specificity and detail through use of the accompanying drawings in which:

Fig. 1 is a perspective view of a metering and switching module incorporating teachings of the present invention interconnected by way of example with the utility services delivered to a typical consumer residence or business;

Fig. 2 is a schematic overview of the primary functional subcomponents of a remote metering and switching system incorporating teachings of the present invention;

Fig. 3 is a flow chart illustrating the decisional pathway followed by the controller circuit of Fig. 2 in utilizing a sequence of gateway conditions on the telephone lines to a remote site to cause coupling of the metering and switching module of Fig. 2 to those telephone lines;

Fig. 4 is a detailed schematic drawing illustrating the primary functional subcomponents of the telephone interface control means and of the controller circuit shown in Fig. 2;

Fig. 5 is a schematic diagram illustrating the primary functional subcomponents a preferred embodiment of a data collection means such as that shown in Fig. 2;

Fig. 6A is a perspective view of the housing of a utility meter provided according to the teachings of the
present invention with a security means for verifying the integrity thereof;

Fig. 6B is a detailed disassembled view of selected components of the housing of the meter shown in Fig. 6A;

Fig. 6C is a detailed fragmentary view of the meter housing elements shown in Fig. 6B in an assembled state with the security means shown in Fig. 6A coupled thereto;

Fig. 6D is a schematic electrical circuit diagram of the components of the security means shown in Fig. 6C interconnected to the security circuit shown in of Fig. 5;

Fig. 7 is a perspective view of one embodiment of an occlusion means for use in an optical meter interface means according to the present invention;

Fig. 8 is a cross-sectional plan view of the occlusion means shown in Fig. 7 and taken along section lines 8-8 thereof;

Fig. 9 is a cross-sectional plan view of an alternate embodiment of an occlusion means according to the teachings of the present invention corresponding to the cross-sectional plan view shown in Fig. 8;

Fig. 10 is a perspective view of a third embodiment of an occlusion means for use in an optical meter interface means according to the teachings of the present invention;

Fig. 11 is a perspective view of a fourth embodiment of an occlusion means for use in an optical meter interface means according to the teachings of the present invention;

Fig. 12 is an electrical schematic diagram of selected components of one embodiment the telephone interface control circuit shown in Fig. 4;

Fig. 13 is an electrical schematic diagram of the components of one embodiment the off-hook detection circuit shown in Figs. 4 and 7;
Fig. 14 is an electrical schematic diagram of the components of one embodiment the controller circuit shown in Fig. 4; Fig. 15 is an electrical schematic diagram of the components of one embodiment the light signal emitter circuit shown in Fig. 5; Fig. 16 is an electrical schematic diagram of the components of one embodiment the light signal receiver circuit shown in Fig. 5; and Fig. 17 is an electrical schematic diagram of the components of one embodiment the regulated power supply shown in Fig. 2.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The method and apparatus of the present invention have widespread utility in environments ranging from the residential and business locations to which meterable utility commodities such as electricity, gas, and water, are delivered to industrial settings, such as oil fields, irrigation systems, and factories. Nevertheless, as an illustration of the environment in which some components of the inventive system can be expected to function, Fig. 1 depicts the exterior of a consumer residence or business 10 to which various meterable commodities are delivered by utility systems. In the discussion which follows, like components will be identified to the extent possible by identical reference numbers.

Shown on the exterior of consumer residence or business 10 is a conventional electric meter 12 which is connected to the overhead wires 14 of an electric utility system. Wires from electric utility meter 12 not shown in Fig. 1 enter consumer residence or business 10 to provide electricity therein. Consumer residence or business 10 also receives natural gas service. As shown in Fig. 1, slightly above the level of ground 16 exterior thereto, consumer residence or business 10 is provided with a conventional gas meter 18 connected to an underground distribution system by gas system piping 20 and to consumer residence or business 10 by a gas supply pipe 22. Water for consumer residence or business 10 is supplied through underground water piping 24. Exterior to consumer residence or business 10, located in an enclosure 28 below the surface of ground 16, is a water meter 26 interposed in piping 24. A removable plate 30 covers an opening to enclosure 28 through which water meter 26 may be observed.
Typically, within a decade of the construction of consumer residence or business 10 electric meter 12, gas meter 18, and plate 30 over water meter 26 will, in all probability, have become obscured by an overgrowth of uncooperative and possibly thorny plantings, much to the discomfort of itinerate utility company personnel.

In the method and apparatus of the present invention, the monitoring and control of the electricity, natural gas, and water delivered to consumer residence or business 10 is exercisable from a central location. Toward this end, however, it is necessary that the lines of a local telephone network extend to the remote site at which such commodities are being transferred to a consumer. Thus, as shown in Fig. 1, underground telephone lines 32 terminate at consumer residence or business 10 in a junction box 34. The telephone system interconnection with consumer residence or business 10 can, in the alternative, involve overhead lines or direct microwave channels. It is over the lines of the local telephone network terminating at junction box 34 that the monitoring and control functions of the inventive method and apparatus are exercised.

Each remote site at which this is to occur is provided with a metering and switching module 40 which interfaces between the telephone network extending to the remote site and one or all of the utility systems thereat. As shown by way of example, metering and switching module 40 is connected to junction box 34 of the telephone network by a telephone network interface cable 42 and to each of the utility meters illustrated in Fig. 1 by utility system interface cables 44. In the description to follow, the structure and functioning of metering and switching module 40 will be explored in some detail. Also described will be the interaction over the lines of the telephone network of metering and switching module 40 with a polling
device at a central location, whereby to achieve the objects of the inventive method and apparatus.

Nevertheless, it should be understood that the inventive method and apparatus finds utility not merely at remote sites such as consumer residences or businesses, but at any site on a commodity transfer or distribution system to which the lines of a telephone network extend and at which either or both the remote monitoring or the remote control of commodity transfers is desired. The inventive method and apparatus need not be utilized in relation to all of the utility services provided to any given remote site. That method and apparatus are adaptable for monitoring and controlling commodity transfers in types of utility systems other than those illustrated in Fig. 1.

Neither is it necessary that the remote site at which the control and monitoring functions are to be exercised include an edifice, such as consumer residence or business 10. In many instances meters to be monitored or switches to be operated will constitute the only structures in addition to metering and switching module 40 that are apparent at a remote site.

Figure 2 affords an overview of the functional subcomponents of a remote commodity transfer control and monitoring system 50 incorporating teachings of the present invention. Control and monitoring system 50 includes a metering and switching module 40 located at a remote site, such as consumer residence or business 10, and a polling device 52 situated at a central location distinct therefrom. Polling device 52 and metering and switching module 40 employ the lines of a telephone network in order to communicate with each other.

As shown schematically in Fig. 2, that telephone network includes a telephone network switching center 54 to which polling device 52 is connected, by telephone
lines 56. While it is possible by foregoing some of the advantages of the inventive control and monitoring system to place polling device 52 at or in switching center 54, it is preferable that polling device 52 be located outside of switching center 54 and that it be connected thereto by telephone lines 56 which are nondedicated. Through telephone lines 56 polling device 52 can secure dialed access to selected individual subscribers of the telephone network illustrated. Polling device 52 can thus be located anywhere to which extend the telephone lines of the telephone network serviced by switch center 54. Furthermore, the operation of control and monitoring system 50 then need not be burdened by the substantial cost of purchasing special access to switching center 54.

The nature of polling device 52 may vary according to the nature of control and monitoring system 50. Nevertheless, polling device 52 should include a programmable machine and an automatic dialer capable of obtaining dialed access on an individual basis to telephones to which the network serviced by switching center 54 extends. For illustrative purposes, one such telephone 58 is located at consumer business or residence 10. The dialed number for telephone 58 is stored in a memory device component of the programmable machine in polling device 52.

To enable optimum data transfer to and from polling device 52 over the lines of the telephone network, polling device 52 will preferably include a modem which will convert the digital signals utilized in the programmable machine of polling device 52 into analog signals transmittable through the telephone network of switching center 54. This is at the present time most commonly effected by modulating the internal digital signals of polling device 52 on a suitable frequency and transmitting
the resulting composite signal over the telephone lines to another location where the signal is demodulated to recover its digital constituents.

For use in the system of the present invention, polling device 52 must also be capable of transmitting an identifying tone over the lines of the telephone network immediately upon securing dialed access to the telephone lines at any desired remote site. Thereafter polling device 52 must be capable of participating in two-way communication with metering and switching module 40 over the lines of the telephone network, and preferably in a verified manner. Typically, polling device 52 will thus include substantial electronic memory, as well as hardware that embodies or is operated by software suitable for that purpose.

The telephone network serviced by switching center 54 must extend to each consumer residence or business that is to be involved in control and monitoring system 50. Toward this end, as shown in Fig. 2, telephone 58 is connected through a foreign voltage protector 60 by nondedicated telephone lines 62 to switching center 54. From the side of foreign voltage protector 60 remote from switching center 54 nondedicated telephone lines 62 extend in the form of tip line 64 and ring line 66 through metering and switching module 40 to telephone 58. The consumer-provided telephone-related equipment shown in Fig. 2 includes both tip and ring lines 64, 66, respectively, as well as metering and switching module 40 and telephone 58.

It may be helpful in addition to remember that Fig. 2 does not depict all of the subscribers of the telephone network serviced by switching center 54. While only telephone 58 and polling device 52 of that telephone network are illustrated, any of the other subscribers of
that network could attempt to obtain dialed access through switching center 54 to telephone 58.

In Fig. 2, consumer residence or business 10 is supplied with meterable commodities from the commodity distribution networks of four different utilities identified individually as utilities A, B, C, and D. These utilities may include the electricity, gas, and water utilities shown in Fig. 1, as well as any other commodity transferred by a utility system utilized now or in the future. Commodities from each of utilities A, B, C, and D are illustrated as arriving at and entering consumer residence or business 10 by correspondingly lettered arrows. Each commodity is received at consumer residence or business 10 from its corresponding commodity distribution system through a conduit 68 that terminates in a correspondingly lettered meter 70. While in Fig. 2, conduits 68 take on the appearance of piping, this results only out of a desire to represent schematically the utilities involved. Each conduit 68 could correspond to pipes, wiring, and optical or microwave waveguides. Thus, conduits 38 could represent gas system piping 20, underground water pipes 24, and overhead electrical wires 14, all shown in Fig. 1, as well as any commodity distribution means prevalent in the future.

The commodities delivered to consumer residence or business 10 by utilities A, B, C, and D leave each respective meter 70 and enter consumer residence or business 10 through supply conduits 72. Like conduits 68, supply conduits 72 may constitute any type of utility commodity transfer channel, such as pipes and wires, or even microwave channels or optical waveguides. Meters 70, which are essential to the monitoring function of control and monitoring system 50, are coupled with metering and switching module 40 through data collection leads 74, 75
which would typically be found within utility system interface cables 44 shown in Figure 1. Data collection leads 74, 75 may be electrical conductors, or as in the preferred embodiment, to be described subsequently, optical fibers. Pneumatic, hydraulic, magnetic, or mechanical coupling may also prove workable.

To enable control and monitoring system 50 to initiate and terminate or to otherwise regulate the transfer of commodities in utilities A, B, C, and D, gatekeeper mechanisms 76 are interposed in conduits 68 on the utility system side of each meter 70. Gatekeeper mechanisms 76, as depicted in Fig. 2, are on/off devices such as valves or gates capable of regulating the transfer of the commodity of each respective utility system to consumer residence or business 10. Each gatekeeper mechanism 76 is thus capable at a minimum of terminating and of initiating the transfer of meterable commodities in the utility system with which it is employed. Optionally, however, in more sophisticated control systems gatekeeper mechanism 76 may also be operable in degrees in order to control through a continuous range of transfer rates the rapidity with which each commodity is delivered to consumer residence or business 10.

Gatekeeper mechanisms 76 are coupled by utility switching lines 78 to metering and switching module 40. Utility switching lines 78 would typically be found within utility system interface cables 44 shown in Fig. 1. While in the preferred embodiment, utility switching lines 78 are electrical conductors, it is equally conceivable that within the context of the present invention, utility switching lines, such as utility switching lines 78, could comprise other structures through which the control of gatekeeper mechanisms 76 could be effected. Such other forms might include for example optical or microwave
waveguides, pneumatic and hydraulic lines, or mechanical actuator cables.

Having illustrated one of several environments in which control and monitoring system 50 could be operated, the functional subcomponents of metering and switching module 40 will now be described in additional detail.

According to one aspect of the present invention, a remote commodity transfer control and monitoring system, such as control and monitoring system 50, is provided in one embodiment of the invention with a telephone interface control means 80 for effecting two-way communication between a polling means, such as polling device 52, and metering and switching module 40 over the lines of the telephone network serviced by switching center 54. This two-way communication is effected when telephone interface control means 80 detects a sequence of gateway conditions on lines 64, 66 which indicate that access has been secured thereto by polling device 52. Tip and ring lines 64, 68, respectively, pass through telephone interface control means 80 on their way from foreign voltage protector 60 to telephone 58.

In an additional aspect of the present invention, control and monitoring system 50 further comprises a meter interface means coupled to the meters at the remote site for continuously generating therefrom commodity unit transfer signals at a rate corresponding to the simultaneous rate of transfer there of the metered commodity at issue. As illustrated, by way of example and not limitation, there is provided in Fig. 2 a data collection circuit 81, also described in additional detail subsequently, which is coupled to each meter 70 by data collection leads 74, 75.

According to another aspect of the present invention, a remote commodity transfer control and monitoring system,
such as control and monitoring system '50, further comprises a controller means for receiving commodity unit transfer signals and for creating therefrom metering data. The metering data is stored by the controller means pending interrogation or control by polling device 52. As shown by way of example and not limitation, controller circuit 82 is coupled with telephone interface control means 80 by a first signal bus 84, as well as by telephone switching lines 88, 89. It is over telephone switching lines 88, 89 that controller circuit 82 is able to initiate or terminate telephone service to telephone 58 by causing the operation of elements of telephone interface control means 80 that are to be discussed in further detail subsequently. Data collection circuit 81 is coupled to controller circuit 82 by a second signal bus 92.

Metering and switching module 40 further comprises a regulated power source 94 connected by conventional electrical wiring 96 to the electric utility power at consumer residence or business 10. Through connectors 98, regulated power source 94 supplies direct current power to the other subcomponents of metering and switching module 40.

In summary, data collection circuit 81, linked to meters 70 by data collection leads 74, 75 generates commodity unit transfer signals. These are sent over second signal bus 92 to controller circuit 82, where they are converted into metering data pertaining to the transfer of the commodity delivered by each of utilities A, B, C, and D, respectively. The metering data is then stored in controller circuit 82 pending its interrogation by polling device 52.

In order for interrogation to occur, it is necessary for telephone interface control circuit 80 to detect on lines 64, 66 a sequence of gateway conditions indicating
that polling device 52 has secured access to lines 64, 66 through the telephone network associated with switching center 54. The interconnection between polling device 52 and the telephone lines at consumer residence or business 10 is secured, neither by initiating outgoing calls from consumer residence or business 10, nor by seizing the lines thereto in advance of any anticipated in-coming telephone call from polling device 52.

One important aspect of the present invention involves a method for distinguishing among the incoming telephone calls that will be made by other telephone network subscribers to consumer residence or business 10. In particular, in the method of the present invention calls on lines 64, 66 that originate at polling device 52 are distinguishable from other calls that are directed through switching center 54 to telephone 58. Naturally, such a method begins by polling device 52 attempting to secure dialed access through switching center 54 to the lines 64, 66. As a result, switching center 54 will commence sending over nondedicated telephone lines 62 voltage pulses capable of causing telephone 58 to ring.

All such ringing signals received on lines 64, 66 are detected by telephone interface control circuit 80, which communicates to controller circuit 82 over first signal bus 84 the fact of the passage of each ringing signal. Telephone interface control circuit 80 also monitors lines 64, 66 for the presence of off-hook condition signals. The manner in which off-hook condition signals may be generated is immaterial to telephone interface control circuit 82. Off-hook condition signals on lines 64, 66 may be caused by the lifting of the headset of telephone 58, either in response to ringing signals or in order to place an outgoing call. In addition, off-hook condition signals on lines 64, 66 can be a result of the
shunting of nondedicated telephone lines 62 or of tip line 64 and ring line 66 themselves.

As will be made clear subsequently, the shunting of lines 64, 66 can be effected by telephone interface control circuit 80 when so directed by controller circuit 82 over either of telephone switching lines 88, 89. Nevertheless, this event occurs only under carefully circumscribed conditions which will be explained in a discussion of the method of the present invention for distinguishing calls originating at polling device 52 from other incoming telephone calls to consumer or business residence 10.

Briefly, Fig. 3 is a flowchart illustrating the decisional pathways available to controller circuit 82 once telephone interface control circuit 80 has detected a first ringing signal in any sequence of successive ringing signals sent to telephone 58 by switching center 54. The receipt of a first ringing signal is shown as the starting point for the steps illustrated in Fig. 3 as the condition described in oval 110. Thereupon controller circuit 82 commences to analyze information provided by telephone interface control circuit 80 regarding the nature of the signals being transmitted over lines 64, 66. Controller circuit 82 includes a timing means by which to ascertain the temporal relationship among events on lines 64, 66. In this manner, the controller circuit 82 can detect the unique, prerequisite sequence of gateway conditions that in control and monitoring system 50 indicate that polling device 52 is in contact with lines 64, 66.

A first ringing signal on lines 64, 66 causes a ringing signal counter in controller circuit 82 to be set to n=1, as shown in instruction box 112. Controller circuit 82 then compares the value of n to a predetermined large number X, which corresponds to some number larger than the number of ringing signals that would be generated
in the typical, unsuccessful effort of a caller to obtain
dialed access to telephone 58.

The predetermined large number X is thus greater than
the number of ringing signals that would normally be
expected before a reasonable caller would conclude that
nobody will answer telephone 58, whereupon to terminate
efforts to secure dialed access thereto. One assumption
underlying the decisional pathways shown in Fig. 3 is thus
the assumption that any caller that persists in permitting
switching center 54 to send successive ringing signals to
telephone 58 in excess of predetermined large number X,
will with a high degree of probability, only be polling
device 52. The length of time that polling device 52 is
programmed to persist in ringing each given number is of
course subject to limits, but that limitation is never less
than the amount of time that would be necessary to generate
X ringing signals.

As indicated in decisioned diamond 114, if the number
in the ringing signal counter is not greater than or
equal to X, then decisional pathway 116 is followed.
Controller circuit 82 then waits a predetermined period of
time, $\Delta T_1$ for additional information from telephone
interface control circuit 80 about subsequent signals
passing on lines 64, 66. This step is indicated in the
flowchart of Fig. 3 by instruction box 118.

Typically, $\Delta T_1$ should be set to correspond to a period
of time slightly longer than the time between consecutive
successive ringing signals in the telephone network
involved. During the period of time $\Delta T_1$ following the
receipt of each ringing signal on lines 64, 66, controller
circuit 82 looks initially for an indication from telephone
interface control circuit 80 that an off-hook condition
signal has begun on lines 64, 66. If an off-hook condition
signal commences within a time $\Delta T_1$ following a ring signal,
then it is another underlying assumption of the decisional pathways shown in Fig. 3 that telephone 58 has been answered in response to ringing signals. This is taken to signify that a person at telephone 58 is now listening on lines 64, 66. The off-hook condition signal will have also stimulated switching center 54 to connect the calling party to lines 64, 66. Thus yet another assumption underlying the decisional pathways of Fig. 3 is that an off-hook condition signal following within a time $\Delta T_2$ of a ringing signal will mean that a caller is also listening on lines 64, 66. In other words, an off-hook condition signal in such circumstances is assumed to reflect that a caller and someone at telephone 58 have been placed in communication with each other.

As indicated by decisional diamond 120, if an off-hook condition signal is detected, decisional pathway 122 is followed to instruction box 124. Controller circuit 82 then determines whether or not the caller that has just been connected by switching center 54 to the telephone lines to consumer business or residence 10 is polling device 52, or just some other caller unimportant to the monitoring and control functions in which metering and switching module 40 is to participate. This is accomplished in cooperation with polling device 52 itself, if it is polling device 52 that is on lines 64, 66.

Polling device 52 is programmed to transmit an identifying access tone immediately upon securing dialed access through switching center 54 to the telephone lines at a remote site, such as consumer residence or business 10. That access tone may comprise a single-frequency signal that is recognizable by telephone interface control circuit 80 or an encoded and possibly modulated identifying bit stream, which telephone interface control circuit 80 is programmed to recognize. The use of
an encoded bit stream enhances the protection against a single-frequency signal that accidentally appears on lines 64, 66 from being misconstrued as an indication that polling device 52 is connected to those telephone lines.

To distinguish between calls from polling device 52 and calls from all other locations in the telephone network, controller circuit 82 waits a period of time $\Delta T_2$ for a report from telephone interface control circuit 80 of further events on lines 64, 66. This is shown in instruction box 124. The time $\Delta T_2$ corresponds to a period of time in excess of the period of time following the connection of polling device 52 to the lines at a remote site within which polling device 52 is programmed to transmit the identifying access tone.

If no identifying access tone is detected on lines 64, 66 within the period of time $\Delta T_2$, then it is yet a further underlying assumption of the decisional pathways of Fig. 3 that the caller that has just effected dialed access to telephone 58 is not polling device 52.

Under such circumstances, no reason exists for controller circuit 82 to be coupled to lines 64, 66, and decisional diamond 126 directs that decisional pathway 128 be followed. Controller circuit 82 then exits the decisional pathways shown in Fig. 3 to await the beginning of another sequence of successive ringing signals on lines 64, 66.

If the identifying access tone is detected on the lines 64, 66, however, it is understood that polling device 52 is the caller that has just been connected thereto. From decisional diamond 126 decisional pathway 130 is followed to instruction box 132. As indicated therein, controller circuit 82 directs telephone interface control circuit 80 to effect the coupling of controller circuit 82 to lines 64, 66. Once this has occurred, two-way communication can take place between
polling device 52 and controller circuit 82 over the lines of the telephone network involved.

In most instances, the party that answered telephone 58 to create the off-hook condition signal which resulted in the following of decisional pathway 122 from instructional diamond 120 will still be connected to tip and ring lines 64, 66. If this situation continues, signals from the mouthpiece of telephone 58 will interfere with the communication between polling device 52 and controller circuit 82. Thus, provisions are made in the method and apparatus of the present invention to drop telephone 58 from lines 64, 68 during such critical times. The inquiry contained in decisional diamond 134 then directs that decisional pathway 136 be followed to instructional box 138, and controller circuit 82 uses one of telephone switching lines 88, 89 to have telephone interface control circuit 80 drop telephone 58 from lines 64, 66. It may be desirable at this point to provide to the answering party at telephone 58 a recorded message indicating that telephone system-based commodity metering data retrieval or switching is independently in progress, and that the headset of telephone 58 may be replaced in its cradle.

The need for decisional diamond 134 arises because decisional pathways of Fig. 3 other than those discussed thus far can bring the operation of controller circuit 82 to instructional box 132, whereupon telephone interface control circuit 80 effects the coupling of controller circuit 82 to lines 64, 66. These other decisional pathways will be discussed in due course. They result in the coupling of controller circuit 82 to lines 64, 66 without the answering of telephone 58. Under such circumstances, no party at telephone 58 is on lines 64, 66. Nevertheless, there then exists the possibility that
someone at or newly entering consumer residence or business 10 will attempt to place an outgoing call during the progress of two-way communications between polling device 52 and controller circuit 82. As a precaution, decisional diamond 134 directs the following of decisional pathway 136, so that telephone 58 is dropped from lines 64, 66 by telephone interface control circuit 80 in advance of any such undesirable event.

With polling device 52 accessing lines 64, 66, controller circuit 82 coupled thereto, and telephone 58 dropped therefrom, two-way communication between controller circuit 82 and polling device 52 can be carried out for data retrieval or switching purposes. When such two-way communication has terminated, controller circuit 82 on its own, or upon the direction of polling device 52, operates telephone interface control circuit 80 by way of one of telephone switching lines 88, 89 to restore telephone 58 to the telephone lines at consumer residence or business 10. Controller circuit 82 then causes telephone interface control circuit 80 to decouple controller circuit 82 from lines 64, 66, and the system within metering and switching module 40 resumes waiting for a first ringing signal in a new succession.

Telephone 58 may not, however, be answered in response to each of the ringing signals sent there on behalf of either polling device 52 or other callers. Under such circumstances, no off-hook condition signal will be created on lines 64, 66, and decisional diamond 120 will direct the operation of controller circuit 82 along decisional pathway 140 to decisional diamond 142. Controller circuit 182 then determines whether an additional ringing signal has been received within the time $\Delta T_1$. If not, it is presumed that switching center 54 is no longer transmitting ringing signals because the caller attempting
to reach telephone 58 has given up. Accordingly, decisional pathway 144 is followed to exit the decisional pathways of Fig. 3, and control circuit 82 awaits the receipt of the first in a new succession of ringing signals.

On the other hand, if an additional ringing signal is received within the time $\Delta T_1$, then decisional diamond 142 directs that decisional pathway 146 be followed. The number $n$ stored in the ringing signal counter is incremented by 1, as is indicated in instruction box 148. The new value of $n$ is then again compared to $X$, in decisional diamond 114.

If no one answers telephone 58, and if the party attempting to secure dialed access thereto is persistent in staying on its own line to switching center 54, then ringing signals will continue to be sent to telephone 58. The decisional loop comprising decisional diamonds 114, 120, 142 and instruction boxes 118, 148 will be followed repeatedly until such time as the counting of successive ringing signals in ringing signal counter exceeds $X$, the predetermined large number of ringing signals. Then decisional diamond 114 will direct the use of decisional pathway 148 to the group of instructions contained in instructional group 150.

The directions in instructional group 150 effect dialed access on behalf of such a persistent caller to lines 64, 66, even without the answering of telephone 58. According to the directions in instructional box 152, controller circuit 82 directs telephone interface control circuit 80 by way of telephone switching lines 88, 89 to shunt lines 64, 66. This results in an apparent off-hook condition, and an off-hook condition signal is generated on lines 64, 66. This signal is received at switching center 54, and in response switching center 54 will couple
the lines of the persistent caller to the lines at telephone 58. If the predetermined large number X has been set large enough, that persistent caller will with a high degree of probability be polling device 52 only.

Controller circuit 82 must determine whether the persistent caller connected to lines 64, 66 is polling device 152 or just a caller of no relevance to the switching or data retrieval functions of control and monitoring system 50. The decisional pathways of Fig. 3 nevertheless insure that a persistent caller other than polling device 52 does not cause the coupling of controller circuit 82 to lines 64, 66. This is accomplished, as required in instructional box 124, by waiting a period of time \( \Delta T_2 \) thereafter for the identifying access tone of polling device 52, and then proceeding along the appropriate decisional pathways described above in relation to effecting dialed access to lines 64, 66 through the answering of telephone 58.

When dialed access between polling device 52 and lines 64, 66 has been effected by shunting pursuant to instructional box 152, it is advisable to simultaneously drop telephone 58 from lines 64, 66. Doing so precludes the use of telephone 58 during the period in which it is being determined whether the persistent caller on lines 64, 66 is polling device 52, and if so, thereafter during any period of two-way communication between controller circuit 82 and polling device 52. Instruction box 154 interposed between instruction boxes 152, 154 directs this result. Instruction box 154 is, however, substantially redundant in effect with instruction box 138 and may be omitted with only minor disadvantage.

If telephone 58 has been dropped from lines 64, 66 pursuant to instruction box 154, and if an access tone is received within the time \( \Delta T_2 \), there is no need to pass to
instructional box 138. Instead, decisional diamond 134 will direct that decisional pathway 156 be pursued. Following a failure to receive an identifying access tone after instructional grouping 150, controller circuit 82 will direct that telephone 58 be reconnected to lines 64, 66. If the access tone is received, however, coupling to lines 64, 66 and communication with polling device 52 will occur. Thereafter control circuit 82 will reconnect telephone 58 to lines 64, 66 and cause the opening of the shunt therebetweent.

Thus, using the decisional pathways shown in Fig. 3, every attempt by polling device 52 to obtain dialed access to telephone 58 will be successful, regardless of whether telephone 58 is answered. In addition, the decisional pathways of Fig. 3 permit controller circuit 82 to distinguish among incoming calls to telephone 58 those calls originating at polling device 52. In this manner controller circuit 82 becomes coupled to the telephone lines at telephone 58 only when polling device 52 is attempting to obtain two-way communication with controller circuit 82. During the time that two-way communication is occurring between controller circuit 82 and polling device 52, telephone 58 will be dropped from lines 64, 66. Thereafter, the interconnection of telephone 58 with those lines will be restored.

Alternatively, it may be said that a sequence of rigidly prescribed gateway conditions indicating that access has been secured between polling device 52 and lines 64, 66 must be detected prior to coupling controller circuit 82 to lines 64, 66. This ensures the integrity, not only of control and monitoring system 50, but of telephone 58 and the utility systems by which commodities are delivered to consumer residence or business 10. The sequence of gateway conditions comprises (1) a ringing
signal on lines 64, 66, (2) the onset of an off-hook condition signal on lines 64, 66 closely succeeding a ringing signal, and then (3) the identifying access tone of polling device 52 on lines 64, 66 within a predetermined period of time of the onset of an off-hook condition signal.

If, telephone 58 is answered in response to a call initiated by polling device 52, then an off-hook condition signal will be generated within a time $\Delta T_1$ of a ringing signal on lines 64, 66, and the first two of the above-required gateway conditions will have been met. Thereafter, an identifying access tone from polling device 52 within a predetermined time period $\Delta T_2$ will result in the third of the gateway conditions being satisfied.

On the other hand, if telephone 58 is not answered, lines 64, 66 will eventually be shunted by telephone interface control circuit 80 upon its receipt of a predetermined large number of unanswered ringing signals. Shunting will simultaneously cause the creation of an off-hook condition signal, whereby the first two of the above-required gateway conditions will have become satisfied. If thereafter within a predetermined period of time $\Delta T_2$ the identifying access tone of polling device 52 is detected on lines 64, 66, then the final condition of the above-required sequence will have occurred.

The detection of the identifying access tone of polling device 52 is not considered adequate to the integrity of control and monitoring system 50 to alone serve as the trigger for coupling controller circuit 82 to lines 64, 66 or for dropping telephone 58 therefrom. Where either of these events to occur without polling device 52 having secured access to lines 64, 66, an on-site visit by employees of control and monitoring system 50 would be
required to restore functioning to telephone 58. Thus, for example, were telephone 58 to be dropped from lines 64, 66 for communication with polling device 52 when polling device 52 was not connected to lines 64, 66, then no signal from polling device 52 would be forthcoming to cause controller circuit 82 to reconnect telephone 58 to those lines. The prevent such unwanted circumstances the sequence of gateway conditions, or other complex, low-probability entry sequence is preferably employed in the method of the present invention.

A more detailed understanding of the structure and operation of telephone interface control circuit 80 can be derived from Fig. 4. According to one aspect of the present invention, control and monitoring system 50 is provided with a telephone interface control means coupled to lines 64, 66 and connected to controller circuit 82 for monitoring lines 64, 66 and for effecting two-way communication between a master device, such as polling device 52, and an electronic device, such as controller circuit 82, over the lines of a telephone network. This is accomplished by coupling controller circuit 82 to lines 64, 66 upon detecting on lines 64, 66 the strictly prescribed sequence of gateway conditions already described above.

By way of example and not limitation, telephone interface control circuit 40 comprises a signal transfer means 160 for selectively coupling controller circuit 82 to lines 64, 66 once the required gateway conditions have been detected. Signal transfer means 160 comprises an isolation transformer 162 having the primary windings thereof connected by two-way communication leads 164, 166 to trip line 64 and ring line 66, respectively. Isolation transformer 162 is required in order to preserve the telephone network to which lines 64, 66 belong from any adverse electrical effects of metering and switching
module 40. The secondary windings of isolation transformer 162 are in turn connected by transformer leads 168, 170 to a modem 172.

Modem 172 functions in a customary manner to permit digital signals originating in controller circuit 82 to be sent over lines 64, 66 in a modulated form to polling device 52, avoiding data degradation. Conversely, modem 172 demodulates modulated digital signals sent over the lines of the telephone network from polling device 52 to controller circuit 82. During two-way communication, messages passing between polling device 52 and controller circuit 82 are transmitted between telephone interface control circuit 40 and controller circuit 82 over a communication bus 174 which forms a component of first signal bus 84 shown in Fig. 2. When two-way communication is not occurring, modem 172 does not relay to controller circuit 82 signals on lines 64, 66 that appear on the secondary windings of isolation transformer 62. It is only upon the detection of the sequence of unique gateway conditions already described that modem 172 is activated by controller circuit 82.

Detecting the gateway conditions is the task of other components of the telephone interface control means of the present invention. As shown by way of example, telephone interface control circuit 80 includes a ring and access tone detector circuit 176 coupled to transformer leads 168, 170 by tone detection lines 178, 180, respectively. Ring and access tone detector circuit 176 performs two distinct and significant functions in the identification of the gateway conditions necessary to couple controller circuit 82 through modem 172 to lines 64, 66.

These two functions involve the detection of ringing signals and the detection on lines 64, 66 of the access tone of polling device 52. In each instance, ring and
access tone detector circuit 176 so notifies controller circuit 82 over a tone notification lead 182 that also comprises a part of first data bus 84 shown in Fig. 2. In the embodiment shown in Fig. 4 and disclosed in further detail subsequently herein, ring and access tone detector circuit 176 is comprised of a single unified circuit. Nevertheless, the two distinct functions disclosed above for that circuitry could with equal effectiveness be performed by separate individual circuits having more specialized functioning without depa" \[ \text{ruting from the teachings of the present invention.} \]

In addition, telephone interface control circuit 40 includes an off-hook detection circuit 184 coupled by off-hook detection leads 186, 188 coupled respectively to lines 64, 66 by way of two-way communication leads 162, 164, respectively. Off-hook detection circuit 184 registers off-hook conditions on lines 64, 66, however caused. Thereupon off-hook detection circuit 184 communicates the fact of the onset of an off-hook condition to controller circuit 82 over off-hook notification lead 190, which comprises yet another portion of first data bus 84 shown in Fig. 2.

Included in telephone interface control circuit 40 is a telephone drop switch 192 through which tip line 64 and ring line 66 pass to reach telephone 58. Telephone drop switch 192 is operable from controller circuit 82 over telephone switching line 88 to selectively drop telephone 58 from lines 64, 66 as required by the needs of control and monitoring system 50. For example, it is necessary during two-way communication between polling device 52 and controller circuit 82 to eliminate telephone 58 from lines 64, 66 in order to prevent contamination of that communication by signals from the mouthpiece of telephone 52 should any attempt be made to use telephone 58 during
that time. In addition, however, when a predetermined large number X of successive ringing signals are detected on lines 64, 66 by ring and access tone detector circuit 176, controller circuit 82 will cause telephone drop switch 192 to shunt lines 64, 66, as has been described in relation to Fig. 3. This is done in order to create an off-hook condition signal and thereby to cause switching center 54 to effect dialed access to lines 64, 66 on behalf of a persistent caller. In the preferred embodiment of the invention disclosed herein, this action on the part of telephone drop switch 192 simultaneously drops telephone 58 from lines 64, 66 as well. These two functions of telephone drop switch 192 may in the alternative be performed by separate circuitry.

Optionally, telephone interface control circuit 40 may include a telephone service control switch 194 through which tip line 64 and ring line 66 pass in reaching either the balance of telephone interface control circuit 80 or telephone 58. Telephone service control switch 194 can be used to terminate telephone service to telephone 58 for testing or other purposes. This is accomplished responsive to signals sent from controller circuit 82 over telephone switching line 89. After some predetermined period of time programmed into controller circuit 82, telephone service control switch 194 is operated by controller circuit 82 to restore telephone service.

A specific detailed configuration of each of the subcomponents of telephone interface control 40 will be disclosed in an example that follows. Prior thereto, however, controller circuit 82 and data collection circuit 81 of Fig. 2 will be explored at the level of detail corresponding to that found in Fig. 4 and already
discussed in relation to telephone interface control circuit 80.

According to another aspect of the present invention, control and monitoring system 50 comprises a controller circuit 82 which controls the discretionary operations of all components of metering and switching module 40. As has already been discussed, controller circuit 82 undertakes the decisional pathways shown in Fig. 3 in order to determine whether or not the sequence of gateway conditions required for activating modem 172 have been detected on lines 64, 66. In addition controller circuit 82 operates telephone drop switch 192 and telephone service control switch 194 in telephone interface control circuit 40. It is furthermore the role of controller circuit 82 to interface with utilities, such as utilities A, B, C and D, for the purpose of collecting data about commodity consumption and for controlling commodity transfers.

As shown in Fig. 4, controller circuit 182 comprises a processor circuit 200 coupled to data collection circuit 81 by second signal bus 92 and to telephone interface control circuit 40 by first signal bus 84. A read-only-memory (ROM) circuit 102 in which are stored instructions for processor circuit 200 is accessible thereto over controller bus 204. In addition, controller circuit 82 includes a random-access-memory (ROM) circuit 206, also accessible to processor circuit 200 over controller bus 204. It is the role of random-access-memory circuit 206 to store metering data and other information as needed about the utilities at consumer residence or business 10 pending interrogation by polling device 52. Finally, controller circuit 82 includes a switching circuit 208 controllable by processor circuit 200 over a switching bus 210. Switching circuit 208 is coupled by individual utility switching lines 78 to gatekeeper mechanisms 76 in supply conduits 68.
of each of the utilities for which commodity control functions are to be exercised by control and monitoring system 50. Switching circuit 208 may typically comprise one or more relays activated by the appearance of an appropriate signal on a preselected output terminal of processor circuit 200. Alternatively to being part of controller circuit 82, such relays can be located at or be a part of gatekeeper mechanism 76, entirely outside of metering and switching module 40.

According to another aspect of the present invention, a meter interface means is provided for continuously generating from meters 70 of utility systems transferring commodities to consumer residence or business 10 commodity unit transfer signals that correspond to the transfer of a preselected unit of the commodity being metered. Ideally, the commodity unit transfer signals are produced by the meter interface means of the present invention at a rate that is proportional to the rate at which units of the commodity are simultaneously being transferred. By way of example and not limitation, as shown in Fig. 5, one type of meter interface means suitable for use in the method of the present invention is an optical interface system comprising an optical signal source, such as a light signal emitter circuit 210, and an optical signal detector, such as light signal receiver 212.

Light signal emitter circuit 210 is operated by controller circuit 82 through an emitter lead 214 comprising a part of second signal bus 192. In response light signal emitter circuit 210 generates light signals of a monochromatic or optically encoded nature. These light signals are transmitted from light emitter circuit 210 to light signal receiver 212 by suitable optical wave guides that pass individually through each of utility meters A, B, C, and D in a manner that permits the movement of meters 70
caused by the transfer of a commodity to interrupt the passage of the light signals.

The optical wave guides shown in Fig. 5 each comprise a first optical fiber 216 connected at one end 218 thereof to light signal emitted circuit 210 and a second optical fiber 220 connected at one end 222 thereof to light signal receiver circuit 212. The other end 224 of each first optical fiber 216 and the other end 226 of each second optical fiber 220 terminate at one of meters 70. There mechanical movement caused by the transfer of a metered commodity is used to temporarily interrupt the transmission of optical signals from first optical fiber 216 to second optical fiber 220. In the alternative, an otherwise blocked optical wave guide may due to mechanical movement in meter 70 be enabled to temporarily transmit light signals.

In response to receiving light signals from light signal emitter circuit 210 receiver circuit 212 generates commodity unit transfer signals that signify the consumption of units of the commodity. Commodity unit transfer signals are transferred to controller circuit 82 along a receiver lead 228 that also comprises part of second signal bus 92. There each commodity unit transfer signal is converted by processor circuit 200 into metering data which is transferred on controller bus 204 for storage by random-access-memory circuit 206 pending interrogation by polling device 52. A detailed embodiment of a light signal emitter circuit 210 and of a light signal receiver circuit 212 for use with the present invention will be disclosed hereafter, along with several embodiments of suitable optical signal interrupt means employable at the meters 70 between other ends 224, 226 of first and second optical fibers 216, 220, respectively.
Nevertheless, it should be understood that other, nonoptical forms of a meter interface means would be suitable for generating from the movements in meters, such as meters 70, commodity unit transfer signals to be processed transfer by controller circuit 82. Accordingly, although data collection leads 74, 75 of Fig. 2 in the context of Fig. 5 correspond respectively to first optical fibers 216 and second optical fibers 220, respectively, data collection leads 74, 75 could in the alternative comprise electrical, pneumatic, or hydraulic interconnections means by which commodity unit transfer signals are produced in data collection circuit 81.

A further aspect of the invention involves the provision within data collection circuit 90 of a security means for periodically investigating the integrity of the housings of meters 70 and for reporting any breach of the integrity thereof to controller circuit 82. The fact of any such breach is then communicated to polling device 52 during the next subsequent instance of two-way communication therewith. As shown by way of example and not limitation, in Fig. 5 data collection circuit 81 includes a security circuit 230 coupled to controller circuit 82 by a security feedback lead 232, which also comprises a portion of second signal bus 92. Security circuit 230 comprises a voltage and impedance monitor connected by way of external security leads 234 to each of meters 70.

As shown in Fig. 6A, external security leads 234 house a pair of security wires 236 which interact with the retaining ring 238 of a meter housing cover 240. As housing cover 240 is transparent, a plurality of meter dials 241 readable in a conventional manner during on-site inspections by utility personnel are shown. The two ends
of security wires 236 are joined by a connector 242 to form a security loop.

Retaining ring 238 encircling housing cover 240 at the base thereof may, for example, take the form of a flexible band having ends 244, 246 shown in disassembled state in Fig. 6B. End 244 of retaining ring 238 is provided with an outwardly extending dog 248 in which is formed a security aperture 250. In assembling retaining ring 238 about housing cover 240, ends 244, 246 of retaining ring 238 are brought together with end 244 behind end 246, so that dog 248 is inserted through a correspondingly shaped slot 252 in end 246 from the rear thereof.

Such an assembled state of ends 244, 246 is shown in Fig. 6C. Dog 248 extends through aperture 250 toward the outside of retaining ring 238. One of wires 236 of external security lead 234 is passed through security aperture 250 prior to the free ends of wires 236 being joined together by connector 242 to form the security loop. In order to remove housing cover 240 from meter 70, it is thereafter necessary to cut the one of wires 236 passing through security aperture 250 and to remove that wire therefrom. Otherwise dog 248 cannot be backed out of slot 252 or ends 244, 246 of retaining ring 238 separated in order to release housing cover 240 from meter 70.

As will be appreciated by reference to Fig. 6D, connector 242 comprises a housing 254 enclosing a zener diode 256 which is series-connected between first and second connection mechanisms 258, 260, respectively. Coupling mechanisms 258, 260, which may take the form of known U-elements, mechanically engage and electrically couple with one end of each of wires 236. This is effected in a known manner through the application of mechanical force to the exterior of housing 254. Entrance passageways 262 in housing 254 conduct the ends of wires
236 into coupling mechanisms 258, 260 prior to effecting mechanical engagement therebetween. As a result of this arrangement, wires 236, coupling mechanisms 258, 260, and zener diode 256 form a zener diode circuit connected in series with the voltage and impedance monitor in security circuit 230.

Should one of wires 236 be cut in an unauthorized entry to the housing of meter 70, then the voltage across that zener diode circuit will alter, creating a situation detectable by security circuit 230. The cutting of both of wires 236 simultaneously, or even the shunting of wires 236 prior to cutting one or both thereof, will also not escape detection. Doing so results in an alteration of the impedance in the zener diode circuit discussed. This also is an event detectable by security circuit 230.

By way of security feedback lead 232 controller circuit 82 will periodically direct security circuit 230 to investigate the integrity of the housing of each meter 70. If the zener diode circuit associated with the housing of any meter 70 has been opened or shunted, then security circuit 230 will report that to controller circuit 82. The fact of the breach will then be stored in random-access-memory circuit 206 of controller circuit 82 pending the next succeeding contact by polling device 52. Notice of a breach of security can then be utilized to direct an on-site inspection of the meter involved, as well as to warn one to disregard any metering data pertaining thereto until the effect of the indicated breach has been ascertained.

Each meter 70 in Fig. 5 is provided in one aspect of the present invention with an optical signal interrupt means between other ends 224, 226 of first and second optical fibers 216, 220, respectively. Such optical signal interrupt means are each individually operably interconnected to a meter 70 for the purpose of temporarily
interrupting the transmission of optical signals from first optical fiber 216 to second optical fiber 220 when the corresponding meter 70 indicates that the transfer of a preselected unit of the metered commodity has occurred. By way of example and not limitation, a number of embodiments of optical signal interrupt means suitable for this purpose are shown and will be discussed in relation to Figs. 7-11. Most optical fibers, such as optical fibers 216, 220 are strengthened and rendered easier to manipulate by encasement in an opaque protective sleeve. For the sake of clarity, however, such outer coatings on optical fibers 216, 218 have been omitted in the figures.

Fig 7 illustrates one optical interface device for deriving commodity transfer data from meter dial 241 of a meter 70 of the commodity. Meter dial 241 includes a metering element which rotates simultaneously with and in response to the transfer of the commodity monitored by meter 70. Typically, such a rotating meter element will include a designator, such as an arm or marker, which in cooperation with a numbered meter face 270 of meter dial 241 permits an observer to determine the quantity of commodity transferred since a previous on-site reading of meter 70. It is not, however, the purpose of the meter interface means of the present invention to permit a reading of the numbers of meter face 270.

Rather, the meter interface means of the present invention utilizes the movement of such a metering element to interrupt the passage of optical signals from optical fiber 216 to optical fiber 220. Thus in Fig. 7 a metering shaft 272 has been attached to the metering element (not shown) of meter dial 241. The longitudinal axis of metering shaft 272 is aligned with the center of meter face 270, and preferably with the axes of rotation of the metering element to which metering shaft 272 is attached.
A metering mark 274 on the exposed end of metering shaft 270 attempts to replicate the designator normally associated with the metering element of meter face 241, thereby to permit optional visual reading of meter 70 during on-site inspection by utility personnel.

The cross-sectional view of the device of Fig. 7 that appears in Fig. 8 illustrates one manner in which light signals traveling on first optical fiber 216 toward second optical fiber 220 can be efficiently interrupted due to movement of metering shaft 272, whereby to generate from light signal receiving circuit 212 desired commodity unit transfer signals. Optical fibers 216, 220 enter the stationery body portion 276 of meter dial 241 and terminate at opposite sides of a metering gap 278. Other ends 274 and 276 of optical fibers 216, 220, respectively, are aligned linearly with one another across metering gap 278, defining an optical axis. In this manner, optical signals transmitted along first optical fiber 216 are capable, if not obstructed, of passing therefrom across metering gap 278 to second optical fiber 220 for transmission thereon to light signal receiver circuit 212. In metering gap 278, however, is the opaque body of metering shaft 272. In the embodiment shown in Fig. 8, the rotational axis of metering shaft 272 is aligned with the optical axis defined by other ends 224, 226 of the optical fibers terminating on either side of metering gap 278.

In order to permit optical signals from first optical fiber 216 to periodically reach second optical fiber 220, metering shaft 272 is provided with a plurality of transversely oriented metering apertures 280 which are periodically alignable by rotation of metering shaft 272 with the optical axis defined by other ends 224, 226 of the optical fibers. Whenever such an alignment occurs, light signals from first optical fiber 216 pass through the
corresponding metering aperture 280, reaching second optical fiber 220. Further rotation of metering element 270 will then remove the metering aperture 280 involved out of alignment with optical fibers 216, 218, temporarily blocking further transmission of optical signals.

Light signal receiver circuit 212 can be designed in a number of acceptable manners to recognize either the onset or the termination of each burst of received light signals as an indication that a preselected unit of commodity has been transferred. Light signal receiver circuit 212 then generates a commodity unit transfer signal which is sent to controller circuit 82, where the transfer of each preselected unit of a commodity is counted and stored by controller circuit 82.

Rotating metering shaft 272 with metering aperture 280 formed therein thus comprises an occlusion means for temporarily interrupting the passage of optical signals as the transfer of a commodity causes movement in the metering element of meter 70. In the embodiment shown in Fig. 8, metering shaft 272 is provided with five metering apertures 280, each passing through the rotational or longitudinal axis of metering shaft 272. In this manner, one complete rotation of metering shaft 272 will result in ten bursts of light signal passing through metering gap 278, much in the same way that the complete rotation of metering shaft 272 will carry mark 274 past the ten digits on meter face 270. Nevertheless, it may not be necessary that a plurality of bursts of light signal pass through the occlusion means of the present invention during each rotation of the metering element associated with a given meter.

Thus, by contrast, in Fig. 9, an alternative embodiment of the structure shown in Fig. 8 is illustrated in cross-section. There, metering shaft 272 is provided
with a single metering aperture 282 which is radially remote from the longitudinal or rotational axis of metering shaft 272. As a result, metering aperture 282 will align itself with the optical axis defined by other ends 224, 226 of optical fibers 216, 220, respectively, only once per revolution of metering shaft 272. Metering aperture 282 permits the passage of light from first optical fiber 216 to second optical fiber 220 only when oriented as shown in Fig. 9. When metering shaft 272 is rotated 180° from the position there depicted, metering aperture 282, unlike the metering apertures 280 shown in Fig. 8, does not become aligned with optical fibers 216, 218. Thus, the structure shown in Fig. 9 permits only one short light signal to pass through metering gap 278 for each full rotation of metering shaft 272.

Figs. 10 and 11 depict alternative embodiments of occlusion means suitable for use with the optical meter interface of the present invention. In both these figures a rotating metering element 281 associated with meter dial 241 is shown. An opaque member is retrofitted to metering element 281 for rotation therewith. In Fig. 10 the opaque member comprises a radially extending arm 284 which, like metering mark 274, rotates with metering element 281 in a plane parallel to that of meter face 270. Accordingly during each complete revolution of metering element 281, arm 284 passes once through metering gap 278 between other ends 224, 226 of optical fibers 216, 220, respectively. In this manner, the passage of light signals from first optical fiber 216 to second optical fiber 220 is interrupted for a brief interval during each rotation of meter element 281.

Light signal receiver circuit 212 is correspondingly structured to interpret the interruption of light signals as an indication that a predetermined unit of commodity has
been transferred. Where a plurality of such interruptions is desired during each rotation of metering elements 281, a retrofitting assembly possessing a plurality of radially extending arms, such as arm 284, may be used.

The embodiment of an occlusion means shown in Fig. 11 comprises a plate 288 attached to metering element 281 for rotation therewith. Plate 288 is positioned in metering gap 278 blocking the transmission of light signals from first optical fiber 216 to second optical fiber 220. In order to permit periodic passage of light signals across metering gap 278, plate 288 is provided with a metering eye 290 which is alignable once during each rotation of metering element 281 with the optical axis defined by other ends 224, 226 of optical fibers 216, 220, respectively. The devices in Figs. 10 and 11 are in a sense negative counterparts to the occlusion devices shown in Figs. 7-9, in that the device of Fig. 10 cause a short interruption of an otherwise steady transmission of light through metering gap 278. This break in signal transmission is then used by light signal receiver circuit 212 as the stimulus to generate a commodity unit transfer signal. On the other hand, similarly to those occlusion means depicted in Figs. 7-9, in the device of Fig. 11 the nontransmission of light signals through metering gap 278 is the rule, with short periods of transmission being used to indicate the transfer of the metered commodity.

The number of metering apertures 280 in plate 288 will largely be determined by the expected rate of transfer of the commodity monitored by meter 70 and the degree of accuracy desired in the metering data developed from commodity unit transfer signals by controller circuit 82. Most commodity meters include a plurality of meter dials, interconnected so that the digit on each dial identified by the indicator associated therewith will represent a single
digit in a multi-digit number expressing the total quantity of meterable commodity transferred through that meter. Successive on-site readings are compared to determine by way of the differences between readings the quantity of commodity transferred. It is possible through the practice of the present invention, again depending on the accuracy desired and the rate of commodity transfer occurring, to locate the occlusion means of the present invention on any one of such a plurality of meter dials. Nevertheless, it is expected that typically the fastest rotating metering element, which will correspond to the smallest digit in the multi-digit number expressing commodity consumption, will be retrofitted for the purpose of interfacing with data collection circuit 81.

It is possible that light falling by random on meter dial 241 from exterior sources, such as automobiles, street lamps, or flash lights, could be interpreted erroneously by light signal receiver 212 as being light signals from light signal emitter circuit 210. In order to overcome this problem and to render the generation of commodity unit transfer signals additionally secure, in a preferred embodiment of the present invention the light signals generated in light signal emitter circuit 210 comprise an optically encoded bit stream. Any light signal received by light signal receiving circuit 212 is then compared against the optical code employed in order to verify its authenticity as a component of the optically encoded bit stream that originated with light signal emitter circuit 210. Light signals received at light signal receiver circuit 212 not meeting this criteria are precluded from causing the generation of commodity unit transfer signals or the creation of stored metering data.

In controller circuit 82, the receipt on receiver lead 228 of commodity unit transfer signals causes
processor circuit 200 to generate metering data of a
digital nature for storage in random-access-memory circuit
206. The metering data generated in controller circuit 82
from commodity unit transfer signals may take a variety of
forms according to the objectives of control and monitoring
system 50. The metering data could comprise a count of the
number of commodity unit transfer signals received by
controller circuit 82 since it was last interrogated by
polling device 52. Alternatively, or in addition thereto,
the metering data could be created in a form that enables
the implementation of time-based differential metering
rates for the commodity being monitored.

Toward this end, the metering data stored in random-
access-memory circuit 206 would comprise a count of the
number of commodity unit transfer signals received by
controller circuit 82 during each of a plurality of daily
or weekly time intervals that correspond to periods in
which distinct rates are imposed on the consumption of the
commodity transferred. In this manner, the amount of the
commodity consumed during each of the different rate
periods would be tallied separately. A highly specific,
detailed form of this type of metering data would involve
a registry of the time at which each individual commodity
unit transfer signal was received by the controller means.
This type of metering data would permit subsequent analysis
for any purpose desired of metering data retrieved from
remote sites by polling device 52.

It is further preferred that interrogation by polling
device 52 not cause the erasure of metering data stored in
random-access-memory circuit 206. In this manner, that
metering data can serve as a back-up record in the case of
a data loss, either in the transmission of data over the
lines of the telephone network or following the receipt and
storage of data by polling device 52.
Example 1

Figs. 12-17 collectively depict the electrical circuit components of one example of a remote metering and switching module, such as remote metering and switching module 40, for use at a remote site to enable a master device at a central location to both regulate and monitor the transfer of commodities at a remote site. It should be understood, however, that the following is but a single presently preferred embodiment of such a metering and switching module. The disclosed preferred embodiment is considered to be illustrative of devices within the scope of the present invention, whether comprised in part or in total of discreet electrical components or of integrated semiconductor chips.

Throughout Figs. 12-17 reference characters used previously to refer to components of the inventive method or apparatus will continue to be employed. In order to understand how leads leaving individual figures are interconnected, such leads have been labeled with alpha numeric designations. These identify a single point to which all leads having the same designation are connected. In addition, the designation VCC appearing throughout the figures identifies the internal voltage of metering and switching module 40 provided thereto over power connection lines 98 from regulated power source 94 shown in Fig. 2.

Fig. 12 is an electrical schematic diagram of the circuit components of telephone interface control circuit 80 shown in Fig. 4, except that off-hook detection circuit 184 is shown for enhanced clarity at the same level of detail as in Fig. 4. Telephone drop switch 192 comprises a pair of single post, single throw relays 300, such as the LH1056AT solid-state relay marketed by AT&T. Relays 300 are interconnected to tip line 64 and ring line 66 at the pin numbers shown. A shunt line 302 connects the pair of
relays 300 and is coupled in the manner shown to a 2N2222 transistor T₁ which operates as an amplifier and is governed from controller circuit 82.

Thus, signals from controller circuit 82 cause transistor T₁ to open and close relays 300. A high, positive, or +1 signal maintains relays 300 in the normal or open condition thereof. In that open condition relays 300 connect the consumer telephone to the line of the telephone network. A low, or zero signal on the appropriate connector pin in controller circuit 82 will on the other hand close relays 300. In the closed condition of relays 300, telephone 52 is dropped from lines 64, 66 and tip line 64 is shunted to ring line 66 through shunt line 302. In this manner telephone drop switch 192 simultaneously performs the dual functions already described in relation to Fig. 4.

Telephone service control switch 194 is virtually identical to telephone drop switch 192, except for its relative location along lines 64, 66. In contrast to the operation of telephone drop switch 192, however, telephone service control switch 194 is operated to drop consumer telephone 58 and the balance of metering and switching module 40 from the telephone network during testing periods of predetermined duration to facilitate telephone line testing. A timer in controller circuit 82 automatically signals relays 300 of telephone service control switch 194 to reconnect telephone 58 and metering and switching module 40 to lines 64, 66 at the end of such testing periods. Telephone service control switch can be configured, if desired according to the testing methods and objectives of the telephone network involved, so as to not shunt lines 64, 66.

It is the purpose of isolation transformer 162 to insulate electrical activity in metering and switching
module 40 from lines 64, 66. Isolation transformer 162 includes a primary winding 304 and a secondary winding 306. Primary winding 304 is connected as shown to lines 64, 66 by two-way communication leads 164, 166. One end of secondary winding 306 is grounded through transformer lead 170 to the common ground for metering and switching module 40, while the other end of secondary winding 306 is connected by way of transformer lead 168 to ring and access tone detector circuit 176 and to modem circuit 172.

Ring and access tone detector 176 comprises a call progress decoder 308, such as the NE5900 call progress decoder manufactured and marketed by Signetics. Call progress decoder 308 is thus a low-power C-MOS integrated circuit designed specifically to interface with a microprocessor-controlled telephone capable of making preprogrammed telephone calls, such as polling device 52. Call progress decoder 308 provides information to controller circuit 82 by which controller circuit 82 is apprised of the presence on lines 64, 66 of ringing signals and of identifying access tones from polling device 52. Call progress decoder 308 is interconnected with the other components shown at the pin numbers indicated in Fig. 12. A transistor logic gate 310, is for example, connected to pin 14 of call progress decoder 308.

Modem circuit 172 includes a modem 312 which, in the embodiment shown in Fig. 12 comprises a 300-baud National Semiconductor 74HC943 modem. Such a device provides a bi-directional serial interface for data communication over telephone lines, such as lines 64, 66. Also included in modem circuit 172 is a universal synchronous asynchronous receiving transmitter 314 for receiving from modem 312 serial data and transmitting parallel data to controller circuit 82. In complimentary fashion receiving transmitter 314 converts parallel data from controller
circuit 82 into serial data for transmission after modulation by modem 312 over telephone lines 64, 66 to polling device 52.

Modem 312 and receiving transmitter 314 are interconnected with each other and the other circuit elements of metering and switching module 40 at the pin numbers indicated in Fig. 12. Between pins 8 and 9 of modem 312, for example, is connected a 3.579545 megahertz timing crystal 316. Other elements of Fig. 12 are represented by conventional electrical symbols, and the resistance and capacitance values shown therein have the following values:

**Table I: Component Values in Fig. 12**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Capacitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_1 = 10K \Omega$</td>
<td>$C_1 = 0.1 \mu F$</td>
</tr>
<tr>
<td>$R_2 = 5490 \Omega$</td>
<td>$C_2 = 100 \mu F$</td>
</tr>
<tr>
<td>$R_3 = 2.2K \Omega$</td>
<td>$C_3 = 10 \mu F$</td>
</tr>
<tr>
<td>$R_4 = 600 \Omega$</td>
<td>$C_4 = 1 \mu F$</td>
</tr>
<tr>
<td>$R_5 = 470 \Omega$</td>
<td>$C_5 = 20.1 \mu F$</td>
</tr>
<tr>
<td></td>
<td>$C_6 = 4.7 \mu F$</td>
</tr>
</tbody>
</table>

The electrical components of off-hook detection circuit 184 are shown in detail in Fig. 13, where those components have been organized conceptually into three functional subgroupings. Accordingly it can be appreciated
that off-hook detection circuit 184 comprises an output
driver circuit 320, a ring rejection circuit 322, and a
threshold detection circuit 324. Output driver circuit 320
generates off-hook register signal by which to inform
controller circuit 82 of voltage changes on lines 64, 66
that correspond to an off-hook condition signal. Such off-
hook register signals appear at an output portion of output
driver circuit 320 to which is connected off-hook lead 190,
also shown in Fig. 4. Output driver circuit 320 includes
an opto-isolator 326 for isolating the signals on lines 64,
66 of the telephone network form the output portion of
output driver circuit 320 that is connected through off-
hook lead 190 to controller circuit 82.

Ring rejection circuit 322 is connected between output
driver circuit 320 and off-hook lines 186, 188 by way of
two-way communication leads 162, 164, respectively. It is
the purpose of ring rejection circuit 322 to prevent
ringing signals on lines 64, 66 from activating output
driver circuit 320. Threshold detection circuit 324, also
connected between output driver circuit 320 and off-hook
lines 186, 188, renders output driver circuit 320
insensitive to variations in the voltage on lines 64, 66
between different types of telephone networks.

Working together, the three subgroupings of off-hook
detection circuit 184 enable output driver circuit 320
therof to produce a signal on off-hook lead 190 only when
an off-hook condition signal is present on lines 64, 66.
As discussed earlier, such a signal may result from the
lifting of the headset of telephone 58 or from the shunting
of lines 64, 66 by telephone drop switch 192.

In Fig. 12, the transistors T₂ are N-channel field
effect transistors. The values of the resistors,
capacitors, and zener diodes shown are as follows:
Table II: Component Values in Fig. 13

<table>
<thead>
<tr>
<th>Resistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R₆    = 1M Ω</td>
</tr>
<tr>
<td>R₇    = 22M Ω</td>
</tr>
<tr>
<td>R₈    = 2M Ω</td>
</tr>
<tr>
<td>R₉    = 5K Ω</td>
</tr>
<tr>
<td>R₁₀   = 10K Ω</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₈    = 0.1 μF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zener Diodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z₁    = 10 volt</td>
</tr>
<tr>
<td>Z₂    = 47 volt</td>
</tr>
</tbody>
</table>

The electrical circuit components of controller circuit 82 are shown in detail in Fig. 14. There it can be appreciated that processor circuit 200 includes a microprocessor 328 such as the 80C85 eight-bit C-MOS microprocessor from OKI Semiconductor and a 4.9152 megahertz timing crystal 320 connected together and with other components shown at the pin numbers indicated. Read-only-memory circuit 202 includes an erasable programmable read-only-memory 332, such as the 27C256 erasable programmable read-only-memory marketing by Intel, which is connected to other components by the pin numbers indicated in Fig. 12. In place of an erasable programmable read-only-memory, however, a programmable read-only-memory or a read-only-memory containing burned-in firmware logic may suffice. Random-access-memory circuit 206 includes an 8192-word by eight-bit C-MOS static random-access-memory 334, such as static random-access-memory MSM5165 marketed
by OKI Semiconductor, which is connected to other components shown by the pin numbers indicated.

Interconnecting processor circuit 200, random-access-memory circuit 206, and read-only-memory circuit 202 is a controller component interface logic circuit 336 which regulates the transfer of signals between the other enumerated subgroupings of controller circuit 82. Controller component interface logic circuit 336 includes a decoder/demultiplexer 338, such as that available from Motorola Corporation under the number 74HC139, and a latch 340, such as noninverting transparent latch 74HC377 also available from Motorola Corporation. In additional controller component interface logic circuit 336 comprises an interrupt controller 342, such as the C-MOS priority interrupt controller 82C59 available from Harris Corporation, and a decoder 344, such as the 1-of-8 decoder/demultiplexer available from Motorola Corporation as number 74HC138. These components are interconnected by the numbered pins of each in the manner shown.

Optionally, controller circuit 82 may include a clock circuit 345 which provides a counter for timing events occurring within controller circuit 82. Clock circuit 345 includes a real time clock 346, such as the MSM624 C-MOS clock available from OKI Semiconductor. A 32.768 kilohertz crystal oscillator is connected between pins 16 and 17 of clock 346 and can advantageously be obtained manufactured on the same semiconductor chip therewith.

In the alternative to including a clock circuit, such as clock circuit 345, controller circuit 82 could be provided with a software clock in program form stored with other software in read-only-memory circuit 332. Such other software includes an operating system for controller circuit 82. This software may be entirely custom designed. Alternatively, however, in the preferred embodiment of the
present invention, read-only-memory circuit 372 contains for this purpose a commercially available multi-tasking kernel utilized in combination with appropriate input-output enhancements. One such suitable commercially available software product is the AMX Multi-tasking Executive available from KADAK Products, Ltd., of Vancouver, Canada.

The values of the resistive and the capacitive components of controller circuit 82 shown in the embodiment depicted in Fig. 14 are listed below:

Table III: Component Values in Fig. 14

Resistors

| R₁₁  | 100K Ω |
| R₁₂  | 10K Ω  |

Capacitors

| C₀   | 50pf   |
| C₁₀  | 1 μf   |
| C₁₁  | 22pf   |

The electrical components, in a preferred embodiment of light signal emitter circuit 210 of data collection circuit 81 are shown in Fig. 15. There, a series-connected sequence of three counters 348, such as the 74HC161 presettable counters from Motorola Corporation, divide downwardly a clock frequency received from controller circuit 82. The output of the sequence of counters 348 is supplied to a decoder 350, such as the 74HC259 eight-bit 1-of-8 decoder also available from Motorola Corporation. Decoder 350 in turn stimulates the emission of light signals from individual photodiodes 352 which are coupled to decoder 350 through individual 2N2222 transistors T₃.
Photodiodes 352 of the MF0E71 variety commonly available in the market will suffice in this regard. Light signals from photodiodes 352 are received in one end 218 of first optical fibers 216 for transmission to meter 70 as shown in Fig. 5.

The components of the embodiment of light signal emitter circuit 210 appearing in Fig. 15 are interconnected at the pin numbers in the manner shown. The values of the resistive components of Fig. 15 are as follows:

**Table IV: Component Values in Fig. 15**

<table>
<thead>
<tr>
<th>Resistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{13} = 10K\Omega$</td>
</tr>
<tr>
<td>$R_{14} = 33;\Omega$</td>
</tr>
</tbody>
</table>

The electrical circuit components in a preferred embodiment of light signal receiver circuit 212 of data collection circuit 81 are shown in Fig. 16. As appears therein, light signal receiver circuit 212 includes two pairs of light signal conversion circuits 354, 356 associated individually with first ends 222 each of optical fibers 220. Light signal conversion circuits 354, 356 each contain a pair of operational amplifiers and a timer.

Operational amplifiers 358, 356 in light signal conversion circuits 354 and operational amplifiers 362, 364 in light signal conversion circuits 356 may as in the embodiment shown in Fig. 16 be advantageously constituted on a single semiconductor integrated circuit chip, such as the LM324 quadraplexed operational amplifier available from Linear Corporation. In such a form, operational amplifiers 358, 360, 362, 364 are interconnected to the other components shown by the pin numbers indicated. Similarly, while timers, such as timers 366, 368, may be
individual components, in the embodiment of light-signal receiver circuit 212 shown in Fig. 16, timer 366 of light signal conversion circuits 354 and timer 368 of light signal conversion circuits 356 are advantageously be formed on a single semiconductor chip, such as a TLC556 dual timer chip available from Texas Instruments Corp.

Each of the light signal conversion circuits 354, 356 includes a transistor T3 operating in a switching capacity and a light detecting transistor 370 which converts light signals from one end 222 of each of second optical fibers 220 into electrical signals. These electrical signals are ultimately converted by light signal conversion circuits 354 or 356 into commodity unit transfer signals for communication to controller circuit 82. Light-detecting transistors 370 of the common MF0D72 variety have been found workable in this role. Where the light signals from optical fibers 220 comprise encoded optical signals, each light signal received at light signal conversion circuits 354, 356 is verified in controller circuit 82 as comprising a component of the optical signals originally generated by light emitter circuit 210.

The values of the resistive and capacitive components shown in Fig. 16 are as follows:

Table V: Component Values in Fig. 16

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R15</td>
<td>100K Ω</td>
</tr>
<tr>
<td>R16</td>
<td>1M Ω</td>
</tr>
<tr>
<td>R17</td>
<td>2.2M Ω</td>
</tr>
<tr>
<td>R18</td>
<td>4.7K Ω</td>
</tr>
</tbody>
</table>
Capacitors

\[ C_{12} = 0.01 \mu F \]
\[ C_{13} = 0.1 \mu F \]

Fig. 17 depicts the electrical components of regulated power source 94 shown in Fig. 2. Alternating current electric power from consumer residence or business 10 is provided to regulated power source 94 at leads 372 for conversion into direct current by a full-wave bridge rectifier 374 comprising four diodes D₁. Other similar diodes D₁ are located throughout the circuitry shown in Fig. 7, which includes a transistor T₅ and a voltage regulator 380 interconnected with other components as shown. Voltage regulator 380 is preferably a 5-volt direct current regulator formed on a single semiconductor integrated chip.

Regulated power source 94 further comprises a rechargeable battery 376 for operating regulated power source 94 in case of a temporary failure of electric utility power to consumer residence or business 10. An operational amplifier 378 connected as shown provides an output signal to controller circuit 82 indicating whenever such utility power fails. In this manner the length of time that metering and switching module 40 is operated from battery 376 can be monitored by controller circuit 82. If the known capacity of battery 376 is thereby exhausted, this fact will be registered in read-only-memory circuit 206 as a warning to verify the accuracy of any metering data developed during periods of inadequate power supply.

The values of the resistors, capacitors, and the zener diode appearing in Fig. 17 are as follows:
Table VI: Component Values in Fig. 17

Resistors
\[ R_{19} = 18K \Omega \]
\[ R_{20} = 10K \Omega \]
\[ R_{21} = 330 \Omega \]
\[ R_{22} = 4.7K \Omega \]
\[ R_{23} = 1K \Omega \]
\[ R_{24} = 100 \Omega \]

Capacitors
\[ C_{14} = 1000 \mu F \]
\[ C_{15} = 1 \mu F \]
\[ C_{16} = 0.01 \mu F \]

Zener Diodes
\[ Z_3 = 6.8 \text{ volt, } 1 \text{ watt} \]

The detailed example described above of a preferred embodiment of the circuitry contained in metering and switching module 40 permits operation of a remote commodity transfer control and monitoring system over the telephone lines of a telephone network. The system requires no direct or special access to the telephone network of the system and is capable of operating successfully without initiating calls from the remote sites at which the metering and switching module is located. Interrogation calls to each metering and switching module are initiated on a regular basis for the retrieval or transmission of metering or control data by a master device at a central location connected to the switching center of the telephone network by nondedicated telephone lines.

This can occur at virtually any time of the day or week, thus permitting the exercise of the switching
function of the disclosed system on a discretionary as-needed basis. The means of collecting metering data from the meters at the remote site permits the development of metering data that reflects information about the time of day during which consumption occurred. This advance is expected to permit the imposition of time-based differential commodity consumption rates. The disclosed method and apparatus may naturally be practiced with regard to the monitoring or metering function alone, or alternatively with regard to the control or switching function alone, without departing from the present invention.

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by United States Letters Patent is:
1. A remote metering system for collecting at a central location over the lines of a telephone network commodity transfer data from a meter of the commodity located at a remote site to which the telephone network extends, the system comprising:

(a) meter interface means coupled to the meter for continuously generating therefrom commodity unit transfer signals, said commodity unit transfer signals being generated at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site;

(b) controller means coupled to said meter interface means for receiving said commodity unit transfer signals and for creating therefrom metering data, said metering data being stored by said controller means pending interrogation thereof;

(c) polling means at the central location for interrogating said controller means to secure therefrom said metering data, said polling means being connected to the switching center of the telephone network and said polling means commencing interrogation of said controller means by attempting to secure access to the telephone lines at the remote site; and

(d) telephone interface control means coupled to the telephone lines at the remote site and connected to said controller means for monitoring the telephone lines at the remote site and for effecting two-way communication between said polling means and said controller means over the lines of the telephone network in response to detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that access has been secured between said polling means and the telephone lines at the remote site.
2. A remote metering system as recited in Claim 1, wherein said polling means transmits an identifying controller means access tone upon securing access to the telephone lines at the remote site, and said telephone interface control means effects two-way communication between said polling means and said controller means upon detecting said access tone.

3. A remote metering system as recited in Claim 2, wherein said polling means secures test trunk access to the telephone lines at the remote site.

4. A remote metering system as recited in Claim 2, wherein said polling means secures dialed access to the telephone lines at the remote site.

5. A remote metering system as recited in Claim 2, wherein said polling means is connected by telephone lines to the switching center at the telephone network.

6. A remote metering system as recited in Claim 5, wherein said polling means is connected by nondedicated telephone lines to the switching center of the telephone network.

7. A remote metering system as recited in Claim 6, wherein said controller means secures dialed access through the switching center to the telephone lines at the remote site.
8. A remote metering system as recited in Claim 4, wherein said telephone interface control means detects ringing signals on the telephone lines at the remote site and shunts the telephone lines at the remote site to produce an off-hook condition thereon upon detecting a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.

9. A remote metering system as recited in Claim 8, wherein simultaneously with shunting the telephone lines at the remote site said telephone interface control means drops therefrom the telephone at the remote site.
10. A remote metering system as recited in Claim 4, wherein said telephone interface control means comprises:

(a) a ring detector circuit coupled to the telephone lines at the remote site and to said controller means, said ring detector circuit notifying said controller means of individual ringing signals on the telephone lines at the remote site;

(b) an off-hook detector circuit coupled to the telephone lines at the remote site and to said controller means, said off-hook detector circuit notifying said controller means of off-hook conditions on the telephone lines at the remote site;

(c) an access tone detector circuit coupled to the telephone lines at the remote site and to said controller means, said access tone detector circuit notifying said controller means of said access tone from said polling means on the telephone lines at the remote site; and

(d) signal transfer means for selectively coupling said controller means to the telephone lines at the remote site to effect two-way communication between said polling means and said controller means over the lines of the telephone network when a ringing signal on the telephone lines at the remote site is closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
11. A remote metering system as recited in Claim 10, wherein said telephone interface control means further comprises a telephone drop switch in the telephone lines at the remote site selectively operable by said controller means to drop the telephone at the remote site from the telephone lines thereat, said controller means operating said telephone drop switch during two-way communication between said polling means and said controller means.

12. A remote metering system as recited in Claim 11, wherein simultaneously with dropping the telephone at the remote site from the telephone lines thereat said telephone drop switch shunts the telephone lines at the remote site.

13. A remote metering system as recited in Claim 12, wherein said controller means operates said telephone drop switch when a predetermined large number of successive ringing signals are detected on the telephone lines at the remote site, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.

14. A remote metering system as recited in Claim 1, further comprising a regulated power source connected to electric utility power at the remote site.

15. A remote metering system as recited in Claim 14, wherein said regulated power source comprises a rechargeable battery for operating said regulated power source in case of a temporary failure of electric utility power to the remote site.
16. A remote metering system as recited in Claim 1, wherein said meter interface means comprises an optical coupling between the meter and said controller means.
17. A remote metering system for collecting at a central location over the lines of a telephone network commodity transfer data from a meter of the commodity located at a remote site to which the telephone network extends, the system comprising:
   
   (a) meter interface means coupled to the meter for continuously generating therefrom commodity unit transfer signals, said commodity unit transfer signals being generated at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site;

   (b) controller means coupled to said meter interface means for receiving said commodity unit transfer signals and for creating therefrom metering data, said metering data being stored by said controller means pending interrogation thereof;

   (c) polling means at the central location for interrogating said controller means to secure therefrom said metering data, said polling means being connected by nondedicated telephone lines to the switching center of the telephone network and said polling means commencing interrogation of said controller means by attempting to secure dialed access to the telephone lines at the remote site and upon securing said dialed access transmitting to the telephone lines at the remote site an identifying controller means access tone;

   (d) a ring detector circuit coupled to the telephone lines at the remote site and to said controller means, said ring detector circuit notifying said controller means of individual ringing signals on the telephone lines at the remote site;

   (e) an off-hook detector circuit coupled to the telephone lines at the remote site and to said
controller means, said off-hook detector circuit notifying said controller means of off-hook conditions on the telephone lines at the remote site;

(f) an access tone detector circuit coupled to the telephone lines at the remote site and to said controller means, said access tone detector circuit notifying said controller means of said access tone from said polling means on the telephone lines at the remote site;

(g) signal transfer means for selectively coupling said controller means to the telephone lines at the remote site to effect two-way communication between said polling means and said controller means over the lines of the telephone network when a ringing signal on the telephone lines at the remote site is closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone; and

(h) a telephone drop switch in the telephone lines to the remote site selectively operable by said controller means to shunt the telephone lines to the remote site and simultaneously therewith to drop the telephone at the remote site from the telephone lines thereto during two-way communication between said polling means and said controller means.

18. A remote metering system as recited in Claim 17, wherein said controller means operates said telephone drop switch when a predetermined large number of successive ringing signals are detected on the telephone lines at the remote site, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereto.
19. A remote metering system as recited in Claim 17, wherein said meter interface means comprises:
   (a) an optical signal source;
   (b) an optical signal detector for generating said commodity unit transfer signals in response to optical signals;
   (c) an optical wave guide for transmitting optical signals from said optical signal source to said optical signal detector; and
   (d) optical signal interrupt means operably interconnected to the meter for temporarily interrupting the transmission of optical signals by said optical signal wave guide when the meter indicates that the transfer of a preselected unit of the metered commodity has occurred at the remote site.

20. A remote metering system as recited in Claim 19, wherein said optical signal source comprises a light emitting diode and said optical signal detector comprises a light sensitive transistor.

21. A remote metering system as recited in Claim 19, wherein said optical signals from said optical signal source comprise an optically encoded bit stream.

22. A remote metering system as recited in Claim 21, wherein optical signals transmitted to said optical signal detector are verified as being components of said optically encoded bit stream.
23. A remote metering system as recited in Claim 20, wherein said light emitting diode is activated by said controller means to produce an optically encoded bit stream, and optical signals received by said optical signal detector are verified by said controller as comprising a component of said optically encoded bit stream.

24. A remote metering system as recited in Claim 19, wherein said optical wave guide comprises an optical fiber.

25. A remote metering system as recited in Claim 19, wherein said optical signal interrupt means comprises an opaque member periodically moveable by operation of the meter to temporarily occlude said optical wave guide.

26. A remote metering system as recited in Claim 17, wherein said metering data created by said controller means comprises digital data.

27. A remote metering system as recited in Claim 17, wherein said metering data created by said controller means comprises a count of the number of said commodity unit transfer signals received by said controller means.

28. A remote metering system as recited in Claim 26, wherein said metering data created by said controller means comprises a count of the number of said commodity unit transfer signals received by said controller means during each of a plurality of successive time intervals of individually predetermined duration.
29. A remote metering system as recited in Claim 28, wherein said time intervals correspond to periods in which distinct rates are imposed on consumption of the commodity transferred at the remote site.

30. A remote metering system as recited in Claim 28, wherein said time intervals are de minimus, whereby said metering data created by said controller means comprises a registry of the time at which each of said commodity unit transfer signals was received by said controller means.

31. A remote metering system as recited in Claim 26, wherein said metering data created by said controller means comprises a registry of the time at which each of said commodity unit transfer signals was received by said controller means.

32. A remote metering system as recited in Claim 31, wherein said metering data created by said controller means further comprises a count of the number of said commodity unit transfer signals received by said controller means.

33. A remote metering system as recited in Claim 26, wherein said controller means comprises:

   (a) a microprocessor coupled to said data collection means and to said telephone interface control means;

   (b) a read-only-memory accessible to said microprocessor; and

   (c) a random-access-memory coupled to said meter interface means and accessible to said microprocessor for storage of said metering data pending interrogation by said polling means.
34. A remote metering system as recited in Claim 26, further comprising a gatekeeper mechanism at the remote site for regulating the transfer of the commodity thereat, and wherein said controller means comprises a switching circuit coupled to said gatekeeper mechanism for selective operation of said gatekeeper mechanism in response to signals communicated by said polling means to said controller means during two-way communication therebetween.

35. A remote metering system as recited in Claim 26, further comprising a telephone service control switch in the telephone lines at the remote site, and wherein said controller means comprises a switching circuit coupled to said telephone service control switch for selective operation of said telephone service control switch in response to signals communicated by said polling means to said controller means during interrogation thereof.

36. A remote metering system as recited in Claim 26, wherein said meter interface means comprises security means coupled between said controller means and the meter for periodically investigating the integrity of the meter housing and reporting any breach of said integrity to said controller means for communication to said polling means during two-way communication therewith.
37. A remote metering system as recited in Claim 36, wherein said security means comprises:

(a) a voltage and impedance monitor coupled to said controller means; and

(b) a zener diode circuit in series with said monitor and mechanically interacting with the housing of the meter, whereby the housing may be entered only by either opening or shorting said zener diode circuit.
38. A remote switching system for controlling from a central location over the lines of a telephone network the transfer of a commodity at a remote site to which the telephone network extends, said system comprising:

(a) a gatekeeper mechanism located at the remote site for regulating the transfer of the commodity thereat;

(b) switching means for selectively operating said gatekeeper mechanism;

(c) polling means at the central location connected to the switching center of the telephone network for controlling said switching means, said polling means commencing to control said switching means by attempting to secure access to the telephone lines at the remote site; and

(d) telephone interface control means coupled to the telephone lines at the remote site and connected to said switching means for monitoring the telephone lines at the remote site and effecting two-way communication between said polling means and said switching means over the lines of the telephone network upon detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that access has been secured between said polling means and the telephone lines at the remote site.

39. A remote switching system as recited in Claim 38, wherein said polling means transmits an identifying controller means access tone on the telephone lines at the remote site upon securing access thereto, and said telephone interface control means effects two-way communication between said polling means and said switching means upon detecting said access tone.
40. A remote switching system as recited in Claim 39, wherein said polling means secures test trunk access to the telephone lines at the remote site.

41. A remote switching system as recited in Claim 39, wherein said polling means secures dialed access to the telephone lines at the remote site.

42. A remote switching system as recited in Claim 39, wherein said polling means is connected by telephone lines to the switching center of the telephone network.

43. A remote metering system as recited in Claim 42, wherein said polling means is connected by nondedicated telephone lines to the switching center of the telephone network.

44. A remote metering system as recited in Claim 43, wherein said controller means secures dialed access through the switching center to the telephone lines at the remote site.

45. A remote switching system as recited in Claim 44, wherein said telephone interface control means detects ringing signals on the telephone lines at the remote site and shunts the telephone lines at the remote site to produce an off-hook condition thereon upon detecting a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.
46. A remote metering system as recited in Claim 45, wherein simultaneously with shunting the telephone lines at the remote site said telephone interface control means drops therefrom the telephone at the remote site.

47. A remote metering system as recited in Claim 44, wherein said telephone interface control means comprises:

(a) a ring detector circuit coupled to the telephone lines at the remote site and to said switching means, said ring detector circuit notifying said switching means of individual ringing signals on the telephone lines at the remote site;

(b) an off-hook detector circuit coupled to the telephone lines at the remote site and to said switching means, said off-hook detector circuit notifying said switching means of off-hook conditions on the telephone lines at the remote site;

(c) an access tone detector circuit coupled to the telephone lines at the remote site and to said switching means, said access tone detector circuit notifying said switching means of said identifying switching means access tone on the telephone lines at the remote site; and

(d) a telephone drop switch in the telephone lines at the remote site selectively operable by said switching means to drop the telephone at the remote site from the telephone lines thereat, said controller operating said telephone drop switch when a ringing signal on the telephone lines at the remote site is closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
48. A remote metering system as recited in Claim 47, wherein simultaneously with dropping the telephone at the remote site from the telephone lines thereat said telephone drop switch shunts the telephone lines at the remote site.

49. A remote metering system as recited in Claim 47, wherein said switching means operates said telephone drop switch when a predetermined large number of successive ringing signals on the telephone lines at the remote site are not closely succeeded by an off-hook condition in the telephone at the remote site, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.

50. A remote switching system as recited in Claim 38, wherein said switching means comprises:
(a) a switching circuit for operating said gatekeeper mechanism;
(b) a microprocessor coupled to said switching circuit and to said telephone interface control means; and
(c) a read-only-memory accessible to said microprocessor.

51. A remote switching system as recited in Claim 38, wherein said gatekeeper mechanism comprises a telephone service control switch in the telephone lines at the remote site.
52. A remote switching system as recited in Claim 38, further comprising:
   (a) a meter of the commodity transferred at the remote site;
   (b) meter interface means coupled to the meter for continuously generating therefrom commodity unit transfer signals, said commodity unit transfer signals being generated at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site; and
   (c) a memory device coupled to said meter interface means and accessible to said switching means, said switching means receiving said commodity unit transfer signals and creating therefrom metering data for storage by said memory device pending interrogation thereof by said polling means during two-way communication between said polling means and said switching means.
53. A method for collecting at a central location over the lines of a telephone network commodity transfer data from a meter of the commodity located at a remote site to which the telephone network extends, said method comprising the steps:

(a) equipping the meter with a meter interface, said meter interface continuously generating commodity unit transfer signals from the meter at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site;

(b) connecting to said meter interface a controller, said controller creating from said commodity unit transfer signals metering data for storage by said controller pending interrogation thereof;

(c) installing at the central location a polling device connected to the switching center of the telephone network;

(d) coupling between said controller and the telephone lines at the remote site a telephone interface control means for monitoring the telephone lines at the remote site and for effecting two-way communication between said controller and said polling device over the lines of the telephone network;

(e) securing access between said polling device and the telephone lines at the remote site;

(f) coupling said controller to the telephone lines at the remote site to effect two-way communication between said controller and said polling device over the lines of the telephone network in response to detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that access has been secured between said polling device and the telephone lines at the remote site; and
(g) interrogating said controller with said polling device to secure said metering data.

54. A method as recited in Claim 53, wherein said polling means transmits an identifying controller access tone on the telephone lines at the remote site upon securing access thereto, and said telephone interface control means effects two-way communication between said polling means and said controller means upon detecting said access tone.

55. A method as recited in Claim 53, wherein said polling device is connected by nondedicated telephone lines to the switching center of the telephone network and said polling device secures dialed access to the telephone lines at the remote site.

56. A method as recited in Claim 55, wherein said sequence of gateway conditions on the telephone lines at the remote site comprises a ringing signal closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.

57. A method as recited in Claim 55, wherein said telephone interface control means detects ringing signals on the telephone lines at the remote site and shunts the telephone lines at the remote site to produce an off-hook condition thereon upon detecting a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.
58. A method as recited in Claim 55, wherein step (d) comprises the steps:

(h) coupling a ring detector circuit between said controller and the telephone lines at the remote site, said ring detector circuit notifying said controller of individual ringing signals on the telephone lines at the remote site;

(i) coupling an off-hook detector circuit between said controller and the telephone lines at the remote site, said off-hook detector circuit notifying said controller of off-hook conditions on the telephone lines at the remote site;

(j) coupling an access tone detector circuit between said controller and the telephone lines at the remote site, said access tone detector circuit notifying said controller of said identifying controller access tone on the telephone lines at the remote site; and

(k) installing a signal transfer circuit for selectively coupling the electronic device to the telephone lines at the remote site to effect two-way communication between said polling device and the controller over the lines of the telephone network when a ringing signal on the telephone lines at the remote site is closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.

59. A method as recited in Claim 58, wherein step (d) further comprises the step of connecting in the telephone lines at the remote site a telephone drop switch selectively operable by said controller to shunt the telephone lines to the remote site.
60. A method as recited in Claim 55, further comprising the step of installing a gatekeeper mechanism for regulating the transfer of the commodity at the remote site, said gatekeeper mechanism being selectively operable in response to signals communicated to said controller from said polling means.

61. A method as recited in Claim 53, further comprising the step of decoupling said controller from the telephone lines at the remote site following two-way communication between said controller and said polling device.
62. A method for collecting at a central location over the lines of a telephone network commodity transfer data from a meter of the commodity located at a remote site to which the telephone network extends, the method comprising the steps:

(a) generating commodity unit transfer signals at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site;
(b) converting said commodity unit transfer signals into metering data;
(c) storing said metering data in a memory device pending interrogation thereof;
(d) installing at the central location a polling device connected by nondedicated telephone lines to the switching center of the telephone network;
(e) securing dialed access between said polling device and the telephone lines at the remote site;
(f) transmitting from said polling device to the telephone lines at the remote site an identifying access tone upon securing said dialed access;
(g) monitoring the telephone lines at the remote site for a sequence of gateway conditions indicating that access has been secured between said polling device and the telephone lines at the remote site;
(h) coupling said memory device to the telephone lines at the remote site to effect two-way communication between said polling device and said memory device over the lines of the telephone network upon detecting said sequence of gateway conditions; and
(i) interrogating said memory device with said polling means to secure said metering data; and
(j) decoupling said memory device from the telephone lines at the remote site following two-way
communication between said polling device and said memory device.

63. A method as recited in Claim 62, wherein said sequence of gateway conditions on the telephone lines at the remote site comprises a ringing signal closely succeeded by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
64. A method as recited in Claim 62, wherein step (g) comprises the steps:

(k) detecting ringing signals on the telephone lines at the remote site;

(l) counting the number of successive ringing signals detected on the telephone lines at the remote site;

(m) registering off-hook conditions on the telephone lines at the remote site;

(n) determining instances when off-hook conditions on the telephone lines at the remote site occur in response to ringing signals; and

(o) monitoring the telephone lines at the remote site for said access tone.

65. A method as recited in Claim 62, wherein step (h) comprises the steps:

(p) shunting the telephone lines at the remote site;

(q) dropping the telephone at the remote site from the telephone lines thereat during two-way communication between said polling device and said memory device.

66. A method as recited in Claim 62, wherein step (e) comprises the steps:

(r) sending ringing signals from the switching center of the telephone network to the telephone lines at the remote site; and

(s) answering the telephone at the remote site in response to said ringing signals.
67. A method as recited in Claim 62, wherein step (e) comprises the steps:

(r) sending ringing signals from the switching center of the telephone network to the telephone lines at the remote site; and

(t) shunting the telephone lines at the remote site to produce an off-hook condition thereon when said number of successive ringing signals detected equals a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.
68. A method for controlling from a central location over the lines of a telephone network the transfer of a commodity at a remote site to which a telephone network extends, said method comprising the steps:

(a) equipping the remote location with a gatekeeper mechanism for regulating the transfer of the commodity thereat;

(b) coupling to said gatekeeper mechanism a switching means for selectively operating said gatekeeper mechanism;

(c) installing at the central location a polling device connected to the switching center of the telephone network;

(d) coupling between said switching means and the telephone lines at the remote site a telephone interface control means for monitoring the telephone lines at the remote site and for effecting two-way communication between said switching means and said polling device over the lines of the telephone network;

(e) securing access between said polling device and the telephone lines at the remote site;

(f) coupling said switching means to the telephone lines at the remote site to effect two-way communication between said polling device and said switching means over the lines of the telephone network in response to detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that access has been secured between said polling device and the telephone lines at the remote site; and

(g) controlling said switching means from said polling device to operate said commodity transfer means.
69. A method as recited in Claim 68, wherein said polling device transmits an identifying switching means access tone on the telephone lines at the remote site upon securing access thereto, and said telephone interface control means effects two-way communication between said polling means and said controller means upon detecting said access tone.

70. A method as recited in Claim 69, wherein said controller means secures test trunk access to the telephone lines at the remote site.

71. A method as recited in Claim 69, wherein said controller secures dialed access to the telephone lines at the remote site.

72. A method as recited in Claim 69, wherein said polling means is connected by telephone lines to the switching center of the telephone network.

73. A method as recited in Claim 72, wherein said polling means is connected by nondedicated telephone lines to the switching center of the telephone network.

74. A method as recited in Claim 73, wherein said controller means secures dialed access through the switching center to the telephone lines at the remote site.

75. A method as recited in Claim 74, wherein said sequence of gateway conditions on the telephone lines at the remote site comprises a ringing signal closely succeeded by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
76. A method as recited in Claim 74, wherein said telephone interface control means detects ringing signals on the telephone lines at the remote site and shunts the telephone lines to the remote site to produce an off-hook condition thereon upon detecting a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.
77. A method as recited in Claim 74, wherein step (d) comprises the steps:

(h) coupling a ring detector circuit between said switching means and the telephone lines at the remote site, said ring detector circuit notifying said switching means of individual ringing signals on the telephone lines at the remote site;

(i) coupling an off-hook detector circuit between said switching means and the telephone lines at the remote site, said off-hook detector circuit notifying said switching means of off-hook conditions on the telephone lines at the remote site;

(j) coupling an access tone detector circuit between said switching means and the telephone lines at the remote site, said access tone detector circuit notifying said controller means of said identifying controller means access tone on the telephone lines at the remote site; and

(k) installing a signal transfer circuit for selectively coupling the electronic device to the telephone lines at the remote site to permit two-way communication between said polling device and said control means over the lines of the telephone network when a ringing signal on the telephone lines at the remote site is closely succeeded by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
78. A method as recited in Claim 77, wherein step (d) further comprises the step of connecting to the telephone lines at the remote site a telephone drop switch selectively operable by said switching means to drop the telephone at the remote site from the telephone lines thereto during two-way communication between said polling device and said switching means.
79. A method for controlling from a central location over the lines of a telephone network the transfer of a commodity at a remote site to which the telephone network extends, said method comprising the steps:

(a) equipping the remote location with a gatekeeper mechanism for regulating the transfer of the commodity thereat, said gatekeeper mechanism being selectively operable by an electronic switch;

(b) installing at the central location a polling device connected by nondedicated telephone lines to the switching center of the telephone network;

(c) securing dialed access between said polling device and the telephone lines at the remote site;

(d) transmitting from said polling device on the telephone lines to the remote site an identifying access tone upon securing said dialed access;

(e) monitoring the telephone lines at the remote site for a sequence of gateway conditions indicating that access has been secured between said polling device and the telephone lines at the remote site;

(f) coupling said electronic switch to the telephone lines at the remote site upon detecting said sequence of gateway conditions to effect two-way communication between said polling device and said electronic switch over the lines of the telephone network; and

(g) controlling said electronic switch from said polling device to operate said gatekeeper mechanism.
80. A method as recited in Claim 79, wherein said sequence of gateway conditions on the telephone lines at the remote site comprises a ringing signal closely succeeded by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.

81. A method as recited in Claim 80, wherein step (e) comprises the steps:

(h) detecting ringing signals on the telephone lines at the remote site;

(i) counting the number of successive ringing signals detected on the telephone lines at the remote site;

(j) registering off-hook conditions on the telephone lines at the remote site;

(k) determining instances when an off-hook condition on the telephone lines at the remote site is in response to ringing signals; and

(l) monitoring the telephone lines at the remote site for said access tone.

82. A method as recited in Claim 80, wherein step (f) comprises:

(m) shunting the telephone lines at the remote site;

(n) dropping telephone at the remote site from the telephone lines thereat during two-way communication between said polling device and said memory device.
83. A method as recited in Claim 80, wherein step (d) comprises the steps:

(o) sending ringing signals from the switching center of the telephone network to the lines at the remote site; and

(p) answering the telephone at the remote site in response to said ringing signals.

84. A method as recited in Claim 80, wherein step (d) comprises the steps:

(o) sending ringing signals from the switching center of the telephone network to the lines at the remote site; and

(q) shunting the telephone lines at the remote site to produce an off-hook condition thereon when said number of said successive ringing signals detected equals a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.

85. A method as recited in Claim 80, further comprising the step of decoupling said electronic switch from the telephone lines at the remote site following two-way communication between said polling device and said electronic switch.
86. An apparatus for use in a commodity transfer system at a remote site to which a telephone network extends, the commodity transfer system including at the remote site a meter of the commodity and a gatekeeper mechanism for regulating the transfer of the commodity, and the apparatus enabling a master device at a central location to monitor and to control over the lines of the telephone network the transfer of the commodity at the remote site when the master device attempts through the switching center of the telephone network to secure dialed access to the remote site, the apparatus comprising:

(a) meter interface means coupled to the meter for continuously generating therefrom commodity unit transfer signals, said commodity unit transfer signals being generated at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site;

(b) controller means coupled to said meter interface means for receiving said commodity unit transfer signals and for creating therefrom metering data, said metering data being stored by said controller means pending interrogation thereof;

(c) telephone interface control means coupled to the telephone lines at the remote site and connected to said controller means for monitoring the telephone lines at the remote site and for effecting two-way communication between said master device and said controller means over the lines of the telephone network in response to detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that access has been secured between the master device and the telephone lines at the remote site; and
(d) switching means for selectively operating the gatekeeper mechanism to regulate the transfer of the commodity.

87. An apparatus as recited in Claim 86, wherein said master device means transmits an identifying controller means access tone upon securing access to the telephone lines at the remote site, and said telephone interface control means effects two-way communication between said master device and said controller means upon detecting said access tone.

88. An apparatus as recited in Claim 87, wherein said master device secures dialed access to the telephone lines at the remote site.

89. An apparatus as recited in Claim 88, wherein said telephone interface control means detects ringing signals on the telephone lines at the remote site and shunts the telephone lines at the remote site to produce an off-hook condition thereon upon detecting a predetermined large number of successive ringing signals, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.

90. A remote metering system as recited in Claim 89, wherein simultaneously with shunting the telephone lines at the remote site said telephone interface control means drops therefrom the telephone at the remote site.
91. An apparatus as recited in Claim 88, wherein said telephone interface control means comprises:

(a) a ring detector circuit coupled to the telephone lines at the remote site and to said controller means, said ring detector circuit notifying said controller means of individual ringing signals on the telephone lines at the remote site;

(b) an off-hook detector circuit coupled to the telephone lines at the remote site and to said controller means, said off-hook detector circuit notifying said controller means of off-hook conditions on the telephone lines at the remote site;

(c) an access tone detector circuit coupled to the telephone lines at the remote site and to said controller means, said access tone detector circuit notifying said controller means of said access tone from said master device on the telephone lines at the remote site; and

(d) signal transfer means for selectively coupling said controller means to the telephone lines at the remote site to effect two-way communication between said master device and said controller means over the lines of the telephone network when a ringing signal on the telephone lines at the remote site is closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
92. An apparatus as recited in Claim 91, wherein said telephone interface control means further comprises a telephone drop switch in the telephone lines at the remote site selectively operable by said controller means to drop the telephone at the remote site from the telephone lines thereat, said controller means operating said telephone drop switch during two-way communication between said master device and said controller means.

93. An apparatus as recited in Claim 92, wherein simultaneously with dropping the telephone at the remote site from the telephone lines thereat said telephone drop switch shunts the telephone lines at the remote site.

94. An apparatus as recited in Claim 92, wherein said signal transfer means comprises an isolation transformer having primary and secondary windings, said primary windings being connected to the telephone lines at the remote site and said secondary windings being coupled to said controller means.

95. An apparatus as recited in Claim 94, wherein said signal transfer means further comprises a modem connected between said secondary windings and said controller means.
96. An apparatus as recited in Claim 89, wherein said off-hook detection means comprises:
   (a) an output driver circuit for generating at an output portion thereof an off-hook register signal
   by which to inform said controller means of voltage changes on the telephone lines at the remote site that
   correspond to an off-hook condition; and
   (b) a ring rejection circuit connected between said output driver circuit and the telephone lines at
   the remote site for preventing ringing signals thereon from activating said output driver circuit.

97. An apparatus as recited in Claim 96, wherein said off-hook detection means further comprises a threshold
   detection circuit connected between said output driver circuit and the telephone lines at the remote site, said
   threshold detection circuit rendering said output driver circuit insensitive to line voltage variations between
   different telephone networks.

98. An apparatus as recited in Claim 86, further comprising a regulated power source connected to electric
   utility power at the remote site and comprising a rechargeable battery for operating said regulated power
   source in case of a temporary failure of electric utility power to the remote site.
99. An apparatus for use in a commodity transfer system at a remote site to which a telephone network extends, the commodity transfer system including at the remote site a meter of the commodity and a gatekeeper mechanism for regulating the transfer of the commodity, and the apparatus enabling a master device at a central location connected by nondedicated telephone lines to the switching center of the telephone network to monitor and control over the lines of the telephone network the transfer of the commodity at the remote site when the master device attempts through the switching center of the telephone network to secure dialed access to the telephone lines to the remote site and upon securing such dialed access transmits to the telephone lines at the remote site an identifying access tone, the apparatus comprising:

(a) meter interface means coupled to the meter for continuously generating therefrom commodity unit transfer signals, said commodity unit transfer signals being generated at a rate corresponding to the simultaneous rate of transfer of the metered commodity at the remote site;

(b) controller means coupled to said meter interface means for receiving said commodity unit transfer signals and for creating therefrom metering data, said metering data being stored by said controller means pending interrogation thereof;

(c) a ring detector circuit coupled to the telephone lines at the remote site and to said controller means, said ring detector circuit notifying said controller means of individual ringing signals on the telephone lines at the remote site;

(d) an off-hook detector circuit coupled to the telephone lines at the remote site and to said controller means, said off-hook detector circuit
notifying said controller means of off-hook conditions on the telephone lines at the remote site;

(e) an access tone detector circuit coupled to the telephone lines at the remote site and to said controller means, said access tone detector circuit notifying said controller means of said access tone from said master device on the telephone lines at the remote site;

(f) signal transfer means for selectively coupling said controller means to the telephone lines at the remote site to effect two-way communication between said master device and said controller means over the lines of the telephone network in response to detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that access has been secured between said master device and the telephone lines at the remote site; and

(g) a telephone drop switch in the telephone lines at the remote site selectively operable by said controller means to shunt the telephone lines at the remote site and simultaneously therewith to drop the telephone at the remote site from the telephone lines thereat during two-way communication between said master device and said controller means; and

(h) switching means for selectively operating said gatekeeper mechanism to regulate the transfer of the commodity.

100. An apparatus as recited in Claim 99, wherein said sequence of gateway conditions comprises a ringing signal on the telephone lines at the remote site closely succeeded thereon by the onset of an off-hook condition signal and thereafter within a predetermined period of time by said access tone.
101. An apparatus as recited in Claim 99, wherein said meter interface means comprises:

(a) an optical signal source;
(b) an optical signal detector for generating said commodity unit transfer signals in response to optical signals;
(c) an optical wave guide for transmitting optical signals from said optical signal source to said optical signal detector; and
(d) optical signal interrupt means operably interconnected to the meter for temporarily interrupting the transmission of optical signals by said optical signal wave guide when the meter indicates that the transfer of a preselected unit of the metered commodity has occurred at the remote site.

102. An apparatus as recited in Claim 99, wherein said meter interface means comprises security means coupled between said controller means and the meter for periodically investigating the integrity of the meter housing and reporting any breach of said integrity to said controller means for communication to said master device during two-way communication therebetween.

103. An apparatus as recited in Claim 101, wherein said optical signal source is activated by said controller means to produce an optically encoded bit stream, and optical signals received by said optical signal detector are verified by said controller as comprising a component of said optically encoded bit stream.

104. An apparatus as recited in Claim 101, wherein said optical wave guide comprises an optical fiber.
105. An apparatus as recited in Claim 101, wherein said optical signal interrupt means comprises an opaque member periodically moveable by operation of the meter to temporarily said optical wave guide.

106. An apparatus as recited in Claim 99, wherein said metering data created by said controller means comprises digital data.

107. An apparatus as recited in Claim 99, wherein said controller means comprises:

(a) a microprocessor coupled to said data collection means and to said telephone interface control means;

(b) a read-only-memory accessible to said microprocessor; and

(c) a random-access-memory coupled to said meter interface means and accessible to said microprocessor for storage of said metering data pending interrogation by said master device.

108. An apparatus as recited in Claim 107, wherein said switching means comprises a switching circuit coupled to said microprocessor and controllable thereby during two-way communication between said controller means and said master device to operate the gatekeeper mechanism and regulate the transfer of commodity at the remote site.
109. A remote metering system as recited in Claim 99, wherein said controller means operates said telephone drop switch when a predetermined large number of successive ringing signals are detected on the telephone lines to the remote site, thereby effecting dialed access at the remote site in the absence of the answering of the telephone thereat.
110. An apparatus for enabling a master device connected to the lines of a telephone network to control an electronic device at a remote site to which the telephone network extends when the master device attempts through the switching center of the telephone network to secure dialed access to the remote site, the apparatus comprising:

(a) ring detection means for notifying the electronic device of individual ringing signals on the telephone lines at the remote site;

(b) off-hook detection means for notifying the electronic device of off-hook conditions on the telephone lines at the remote site;

(c) access tone detection means for notifying the electronic device of an identifying access tone on the telephone lines at the remote site, said access tone being sent from the master device to the telephone lines at the remote site after dialed access thereto has been secured; and

(d) signal transfer means for selectively coupling the electronic device to the telephone lines at the remote site to effect two-way communication between the master device and the electronic device over the lines of the telephone network and control of the electronic device by the master device when a ringing signal on the telephone lines at the remote site is closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.
111. An apparatus as recited in Claim 110, further comprising a telephone drop switch in the telephone lines to the remote site between the telephone thereat and said signal transfer means, said telephone drop switch being selectively operable to drop the telephone at the remote site from the telephone lines thereat during two-way communication between the master device and the electronic device.

112. A remote metering system as recited in Claim 111, wherein simultaneously with dropping the telephone at the remote site from the telephone lines thereat said telephone drop switch shunts the telephone lines at the remote site.

113. An apparatus as recited in Claim 111, wherein said telephone drop switch is selectively operable to shunt the telephone lines at the remote site to produce an off-hook condition thereon when a predetermined large number of successive ringing signals are detected on the telephone lines at the remote site, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat.

114. An apparatus as recited in Claim 110, wherein said signal transfer means comprises an isolation transformer having primary and secondary windings, said primary windings being connected to the telephone lines at the remote site and said secondary windings being coupled to the electronic device.

115. An apparatus as recited in Claim 114, wherein said signal transfer means further comprises a modem connected between said secondary windings and said electronic device.
116. An apparatus as recited in Claim 110, wherein said off-hook detection means detects voltage changes on the telephone lines at the remote site that correspond to an off-hook condition in the telephone thereat.

117. An apparatus as recited in Claim 116, wherein said off-hook detection means comprises:

(a) an output driver circuit for generating at an output portion thereof an off-hook register signal by which to inform the electronic device of voltage changes on the telephone lines at the remote site that correspond to an off-hook condition; and

(b) a ring rejection circuit connected between said output driver circuit and the telephone lines at the remote site for preventing ringing signals thereon from activating said output driver circuit.

118. An apparatus as recited in Claim 117, wherein said off-hook detection means further comprises a threshold detection circuit connected between said output driver circuit and the telephone lines at the remote site, said threshold detection circuit rendering said output driver circuit insensitive to variations in the voltage on the telephone lines at remote sites between different telephone networks.

119. An apparatus as recited in Claim 117, wherein said off-hook detection means is powered from the telephone lines at the remote site.

120. An apparatus as recited in Claim 117, wherein said output portion of said output driver circuit is optically isolated from the telephone lines at the remote site.
121. An interface for deriving commodity transfer data from a meter of the commodity, the meter having a rotating metering element which indicates the simultaneous transfer of the commodity at the meter, the interface comprising:

(a) an optical signal source;

(b) an optical signal detector for generating commodity unit transfer signals in response to optical signals;

(c) an optical wave guide for transmitting optical signals from said optical signal source to said optical signal detector, said optical wave guide comprising:

(i) a first optical fiber connected at one end thereof to said optical signal source;

(ii) a second optical fiber connected at one end thereof to said optical signal detector;

(iii) a metering gap between the other ends of said first and second optical fibers, said other ends of said first and second optical fibers being aligned on an optical axis at opposite sides of said metering gap, whereby optical signals transmitted along said first optical fiber from said optical signal source are capable of passing from said first optical fiber across said metering gap to said second optical fiber for transmission to said optical signal detector; and

(d) occlusion means located in said metering gap and coupled to the metering element of the meter for temporarily interrupting the passage of optical signals from said first optical fiber to said second optical fiber as transfer of the metered commodity causes movement in the metering element.
122. An interface as recited in Claim 121, wherein said occlusion means comprises an opaque member attached to said metering element for rotation therewith, said opaque member being so disposed as to pass through said metering gap periodically with each rotation of said metering element.

123. An interface as recited in Claim 121, wherein said occlusion means comprises a plate disposed in said metering gap and attached to said metering element, said plate having formed therein a metering aperture periodically alignable with said optical axis by rotation of said metering element.

124. An interface as recited in Claim 123, wherein said plate is disposed normal to the axis of rotation of said metering element.

125. An interface as recited in Claim 121, wherein said occlusion means comprises a shaft attached to said metering element, the longitudinal axis of said shaft being aligned with the axis of rotation of said metering element, and said shaft having formed therein a metering aperture periodically alignable by rotation of said metering element with said optical axis.

126. An interface as recited in Claim 125, wherein said metering aperture passes through said longitudinal axis of said shaft.

127. An interface as recited in Claim 125, wherein said metering aperture is radially remote from said longitudinal axis of said shaft.
128. A method for enabling a master device connected by non-dedicated telephone lines to the switching center of a telephone network to control an electronic device at a remote location to which the telephone network extends, the method comprising the steps:

(a) attempting to secure dialed access between the master device and the telephone lines to the remote site, whereupon the switching center of the telephone network sends ringing signals on the telephone lines at the remote site;

(b) detecting ringing signals on the telephone lines at the remote site;

(c) counting the number of successive ringing signals detected on the telephone lines at the remote site;

(d) shunting the telephone lines at the remote site to produce an off-hook condition thereon when said number of successive ringing signals detected equals a predetermined large number, thereby effecting dialed access to the remote site in the absence of the answering of the telephone thereat;

(e) registering off-hook conditions on the telephone lines at the remote site;

(f) transmitting from the master device on the telephone lines to the remote location an identifying access tone upon securing said dialed access between the master device and the telephone lines at the remote site;

(g) monitoring the telephone lines at the remote site for said access tone; and

(h) coupling said electronic device to the telephone lines at the remote site to effect two-way communication between master device and the electronic device over the lines of the telephone network upon
detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that dialed access has been secured between the master device and the telephone lines at the remote site.

129. An apparatus as recited in Claim 128, wherein said sequence of gateway conditions on the telephone lines at the remote site comprises a ringing signal closely succeeded by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.

130. A method as recited in Claim 128, further comprising the step of dropping the telephone at the remote site from the telephone lines thereat during the time the electronic device is coupled thereto.
131. A method for deriving commodity transfer data from a meter of the commodity, the method comprising the steps:

(a) generating an optically encoded bit stream;
(b) transmitting said optically encoded bit stream through an optical wave guide to an optical signal detector;
(c) temporarily interrupting the transmission of optical signals by said optical signal wave guide when the meter indicates that the transfer of a preselected unit of the metered commodity has occurred;
(d) verifying that optical signals received at said signal detector are components of said optically encoded bit stream; and
(e) generating commodity unit transfer signals from optical signals received at said optical signal detector and verified as being components of said optically encoded bit stream.

132. A method as recited in Claim 131, wherein the meter has a rotating metering element which indicates a simultaneous transfer of the commodity, and wherein said step of temporarily interrupting comprises the steps:

(a) forming a metering gap in said optical wave guide; and
(b) securing to said metering element for rotation therewith an opaque member disposed so as to pass through said metering gap periodically with each rotation of said metering element.
133. A method as recited in Claim 132, wherein said opaque member comprises a plate disposed in said metering gap and attached to said metering element, said plate having formed therein a metering aperture periodically alignable by rotation of said metering element with said optical wave guide.

134. A method as recited in Claim 133, wherein said plate is disposed normal to the axis of rotation of said metering element.

135. A method as recited in Claim 132, wherein said opaque member comprises a shaft attached to said metering element, the longitudinal access of said shaft being aligned with the axis of rotation of said metering element and said shaft having formed therein a metering aperture periodically alignable by rotation of said metering element with said optical wave guide.

136. A method as recited in Claim 135, wherein said metering aperture passes through said longitudinal axis of said shaft.

137. A method as recited in Claim 135, wherein said metering aperture is radially remote from said longitudinal axis of said shaft.
138. A method for distinguishing among the incoming telephone calls at a remote site those telephone calls originating at a distinct central location, the method comprising the steps:

(a) attempting to secure dialed access from the central location to the telephone lines at the remote site;

(b) detecting ringing signals on the telephone lines at the remote site;

(c) counting the number of successive ringing signals detected on the telephone lines at the remote site;

(d) shunting the telephone lines at the remote site to produce an off-hook condition thereon when said number of successive ringing signals detected equals a predetermined large number, thereby effecting dialed access to the remote site in the absence of the answering of any telephone thereat;

(e) registering off-hook conditions on the lines at the remote site;

(f) transmitting from the central location an identifying access tone upon securing dialed access between the central location and the telephone lines at the remote site; and

(g) monitoring the telephone lines at the remote site for said access tone.

139. A method as recited in Claim 138, further comprising the step of detecting a sequence of gateway conditions on the telephone lines at the remote site indicating that dialed access has been secured between the central location and the telephone lines at the remote site.
140. A method as recited in Claim 139, wherein said sequence of gateway conditions on the telephone lines at the remote site comprises a ringing signal closely succeeded thereon by the onset of an off-hook condition and thereafter within a predetermined period of time by said access tone.

141. A connector for electrically coupling a first and a second electrical conductor, said connector comprising:
   (a) first connection means for mechanically engaging and electrically coupling an end of the first electrical conductor;
   (b) second connection means for mechanically engaging and electrically coupling an end of the second electrical conductor; and
   (c) a zener diode in series between said first and second connection means.

142. A connector as recited in Claim 141, further comprising a housing enclosing said zener diode and said first and second connection means.

143. A connector as recited in Claim 142, wherein said housing includes entrance passageways for conducting said ends of said first and second conductors from the outside of said housing for insertion into said first and second connection means, respectively.

144. A connector as recited in Claim 143, wherein said first and second connection means are made to simultaneously mechanically engage and electrically couple with said first and second conductors by the application of mechanical force to the exterior of said housing.
INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/00913

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. Cl(4) H04M 11/00; H04Q 9/00; G01D 5/36
U.S. Cl. 379/92, 102, 107; 340/870.28; 250/231SE

II. FIELDS SEARCHED

Minimum Documentation Searched 7

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<td>379/92, 102, 104-107;</td>
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Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document, 11 with indication, where appropriate, of the relevant passages 12</th>
<th>Relevant to Claim No. 13</th>
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<td>X</td>
<td>US, A, 4,495,596 (SCIULLI) 22 January 1985, See column 6, line 65, to column 7, line 16, column 7, lines 29-43, column 8, lines 13-29, column 11, line 35, to column 12, line 22, and column 13, lines 18-33.</td>
<td>1, 14, 15, 53, 61</td>
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<td>Y</td>
<td>US, A, 4,654,869 (SMITH ET AL) 31 March 1987 See column 3, lines 27-37.</td>
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<tr>
<td>Y</td>
<td>US, A, 4,006,316 (BOLGIANO) 01 February 1977, See column 5, lines 1-11.</td>
<td>9, 65, 90, 99, 101-109</td>
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<td>Y</td>
<td>US, A, 3,662,368 (FARNSWORTH ET AL) 09 May 1972, See Cont'd</td>
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IV. CERTIFICATION

Date of the Actual Completion of the International Search: 09 June 1989
Date of Mailing of this International Search Report: 30 June 1989

International Searching Authority: ISA/US
Signature of Authorized Officer: [Signature]

Form PCT/ISA/210 (second sheet) (Rev.11-87)
V. CHECKLIST OF CLAIMS OR PATENT RIGHTS CLAIMED IN THE INTERNATIONAL APPLICATION

1. □ Claim numbers ___________, because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claim numbers ___________, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claim numbers ___________, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 8.4(a).

VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This International Searching Authority found multiple inventions in this international application as follows:

I. Claims 1-37 and 53-67, drawn to method and apparatus for reading commodity transfer meters via telephone line.

II. Claims 38-52, 68-85, 110-120 and 128-130, drawn to method and apparatus for remote control via telephone line. Cont'd

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims: 1-37, 53-67, 86-109, 121-127 and 131-137 (Groups I, III and IV).

3. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. □ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

□ The additional search fees were accompanied by applicant's protest.

□ No protest accompanied the payment of additional search fees.
### INTERNATIONAL SEARCH REPORT

**International Application No.** PCT/US89/00913

### III. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document</th>
<th>Relevance to Claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US, A, 4,466,340 (Fryer) 01 May 1984.</td>
<td>136, 35</td>
</tr>
<tr>
<td>A</td>
<td>WO, A, 87/03446 (Naish et al) 04 June 1987.</td>
<td>34, 60, 86-109</td>
</tr>
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<td>A</td>
<td>US, A, 4,720,851 (Smith) 19 January 1988.</td>
<td>8, 36, 57, 102</td>
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<td>A</td>
<td>US, A, 4,807,277 (Perry) 21 February 1989.</td>
<td>35</td>
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<td>A</td>
<td>US, A, 4,500,870 (Knohn et al) 19 February 1985.</td>
<td>16, 19-25, 101-105, 121-127, 131-137</td>
</tr>
</tbody>
</table>
VI. Cont'd

III. Claims 86-109, drawn to a system for providing both remote control and meter reading via telephone line.

IV. Claims 121-127 and 131-137, drawn to a method and apparatus for optically deriving data from a rotating meter element.

V. Claims 138-140, drawn to a method of recognizing and receiving calls from a central station.

VI. Claims 141-144, drawn to a connector.