The remote link unit 30 optionally can have its
own processing unit programmed with various types of
information and also to auto reset to predefined defaults
at the end of a service cycle (with or without auto-reset
5   code input). In respect to inventory, these defaults
preferably are the maximum number of items set as present
in any particular vending slot. The defaults also may
include the various thresholds, temperatures, and/or
conditions for alarms and/or particular indications in the
10   later described computer 15. With the local interface 31,
the service personnel can update the inventory if there is
a discrepancy in any particular individual slot as well as
redefining the other various attributes of the link
controller and/or memory.

15   The remote link unit 30 communicates with the
computer 15 over a network 16. The network 16 is any sort
of communication system which will allow data from the
remote link unit 30 to be provided to the computer 15.
This includes radio, cellular phone, and other known
20   communication systems. Wireless systems are preferred.
Note that due to the limited data which has to be
transferred on the network 16, the requirement for the
speed, clarity, and lack of noise for the network is
minimal. Redundant and relatively slow transmittal is
25   acceptable.

The network 16 can be bidirectional, allowing
communication as well from the computer 15 to the remote
link unit 30 as well. This would also allow the computer
15 to verify that all the information has in fact been
30   received from the remote link unit 30. It would also
allow the computer 15 to initiate transmission of data
from the remote link unit 30, to modify the operation of
the link controller and/or contents of the remote link
unit 30 memory, and to otherwise remotely operate the
35   system 10.

With more sophisticated electronic indication
vending machines, the bidirectional network 16 could also

be utilized to alter the pricing of various commodities.
An example of this would be lowering the cost of coffee at
a particular time as an employee benefit or in order to
get rid of stale inventory. A further example of this
5   would be to increase the cost of particular items during
periods of high demand and/or low inventory.

           A controller 32 is located between the network
16 and the computer 15. The purpose of this controller 32
is to allow the computer 15 to control the network 16. In
10   the particular embodiment disclosed, the controller 32
also converts the incoming and outgoing data into a form
transmittable over the network. This currently would be
serial digital data.

           The controller 32 in addition is interconnected
15   to a separate alarm indicator 33. This alarm indicator
provides a direct indication of the nature and location of
an incoming alarm. This allows the operator to utilize
the computer 15 for other types of independent processing.
It also provides an alarm indication under circumstances
20   when the computer 15 is off line for whatever reason. Note
in the case of multiple tasking computer, the alarm
indication could be provided also by a load and stay
resident program that constantly analyzes the incoming
signal for an alarm indication, becoming active upon the
25   receipt thereof. This would also allow for the generation
of a red alarm dot on any screen of the display (for
example a word processing program).

           The computer 15 communicates with the controller
32 in order to operate the network 16. The particular
30   computer 15 disclosed communicates with the controller 32
over an RS-232 serial cable. In addition, the computer 15
analyzes the incoming data in order to provide a readout
of the status of the various vending machines which are
interconnected thereto. If the common signals are coded,
35   decoding would preferably occur before data processing.

           Normally, the computer 15 obtains the data by
polling the remote communicating master units for vending

21

information. As each individual communicating master unit
has its own ID code, it is possible for a single computer
15 to extract this information from multiple vending
locations without confusion. The computer 15 would
5   normally actively poll or automatically receive data from
the various communicating master units under its control
sequentially at certain set times. Since all of the
incoming data is in a uniform condition due to the data
acquisition unit 20, a single database with uniform
10   parameters can be utilized no matter what the make or
model of the polled vending machine.

            For cost considerations, the computer 15 could
keep track of the inventory located in a particular
machine by the number of vend cycles for a particular item
15   (for example instead of the remote link unit 30 doing so).
These vend cycles would be cumulatively added within the
computer with the result subtracted from the number
programmed into the machine (normally the maximum number
of that item the machine can contain). This programming
20   could occur automatically (for example upon entering a
particular machine make and model) and/or manually. The
computer would preferably reset to the number programmed
into the machine on indication of a service call. The
service person would be under instructions to fill each
25   item to this amount. The computer would thus track
inventory theoretically. Minor deviances would be
accepted as a cost of this simpler system. Optionally
these deviances could be tracked, for example by using the
local interface. One could also use computer or bar coded
30   inventory control to automatically update the number
programmed into the machine to the actual amount of
inventory actually used by service personnel. Under this
system since the computer generates the inventory
requirements, the computer would update its memory based
35   on the inventory actually ordered by the machine. With
such a system, it would be possible to have the computer
generate an inventory requirement by normal container

22

multiples (for example 24 in the case of pop cans) with the inventory reflected in the computer updated by such container multiples.

Ideally, the computer 15 contains a long term memory into which it archives historical data. This long term memory allows the operator to track what is occurring in the vending machines over a period of time. This allows the operator to determine what is selling and what is not, where it is selling, when he must rotate the stock, the maintenance condition of the vending machine, the problems that any particular vending machine may have had, and other historical attributes of the vending machine and its operation.

The particular system disclosed, in addition to the above, includes a data records system 34 and a paging system 35.

The data records system 34 directly archives data from the controller 32 into a record system independently from the computer 15. This automatically backs up the vending machine status data in the event of damage to the computer and/or vandalism. It also provides for third party acquisition of the data from the vending machines, for example for a university study on the purchasing habits of the American public.

The paging system 35 directly contacts an individual at remote locations with the status of the vending machines, most particularly if an alarm occurs. This allows an individual who is not on-site of the computer 15 to be made aware of an alarm condition so that it may be handled. Preferably, the pager system 35 automatically provides the individual with the location of the vending machine together with the type of alarm. This latter allows the individual to selectively ignore a low inventory alarm while advising him of the seriousness of an intrusion alarm. This prevents the inconvenience to the operator of what might otherwise be considered to be nuisance alarms. The pager transmitter is preferably

23

located at the computer 15. This allows a single paging
transmitter to be utilized for an entire vending route.

   The above block figure is given by way of
example and it is to be understood that the positioning of
5   the parts may be changed and/or combined without deviating
from the overall operation disclosed.

   FIGURE 4 is an example block diagram of a hard
wired sensing and communication circuit 50 representative
of a complex remote link unit 30 according to the present
10   invention. Each remote vending machine shown is equipped
with a sensing and communication circuit 50 in order to
monitor the operation of the vending machine and transmit
data packets to the central computer system over a
network.

15   The sensing and communication circuit 50 shown
includes a plurality of optocouplers 52, which detect the
presence of a 120 volt AC or other power signal within the
vending machine. For example, a typical signal could be a
vend event for one item within the machine. Each
20   optocoupler has five leads 54, 56, 58, 60 and 62. In this
case, the first lead 54 is coupled to the element within
the vending machine at which the application of power is
to be sensed. The second input lead 56 is connected to a
neutral line. An output lead 58 is coupled to an I/O
25   point 80. The lead 58 shown carries a digital logic level
signal that indicates the presence or absence of the 120
volt AC signal on the input lead 54. The optocoupler 52
itself is powered by a DC voltage supplied on the lead 60
and is coupled to ground by the lead 62. In a typical
30   vending machine, all of the motors, the compressor and
indication lights are powered with the power signal, in
this case 120 volts AC. Therefore, a plurality of
optocouplers 52 are used to monitor the operation of these
elements.

35   The sensing and communication circuit 50 also
includes one or more switches 70. These switches
typically are DC. A typical example would be an out of

24

units temperature sensor. In the example given, each
switch includes a lead 72 that is pulled to a logic high
voltage (i.e., +5 volts) by a resistor 74 that is coupled
to the voltage supply (i.e., +V). Closing the switch 70
5   connects the lead 72 to a ground potential through a lead
76. The lead 72 is coupled to the I/O point 80. The
example sensing and communication circuit 50 further
includes other sensors, in this case a temperature sensor
circuit 77, which monitors the temperature of the vending
10   machine. The temperature sensor 77 provides an output
signal on a lead 78 that is coupled to an input of the I/O
port 80. This temperature circuit 77 provides a logic
high level signal if the temperature within the vending
machine exceeds a predetermined maximum. A logic low
15   level signal is produced on the lead 78 if the temperature
is below the predetermined maximum.

        The example I/O port 80 is coupled to a
microprocessor 84 by a conventional set of bus and control
leads 82. The I/O point 80 shown includes at least three
20   8-bit registers (not separately shown) that can be coupled
to the output signals provided by up to 24 sensors. The
status of these sensors is thus determined by reading one
bit of one of the 8-bit registers. For example, assume
bit two of a register is coupled to an optocoupler sensor
25   that detects when a power 120 volt AC signal is applied to
an "exact change required" light in the vending machine.
By reading bit two, the microprocessor can tell if exact
change is required. This type of long term or length
signal is easily detected at a single time. Other
30   parameters in the vending machine can only be detected by
keeping track of the sensor inputs over time. For
example, assume bit three of a register in the I/O port is
coupled to an optocoupler that senses when power is
applied to a compressor in the vending machine. By
35   reading bit three and keeping track of when it is a logic
and when it is a logic zero over a period of time, the

25

microprocessor can determine how many times the compressor
cycles. Excessive cycling indicates a faulty compressor.

Also coupled to the example microprocessor
shown, through the set of bus and control leads 82 is a
5   nonvolatile random access memory (RAM) 86 and a read only
memory (ROM) 88. The ROM 88 shown has encoded thereon a
suitable computer program that causes the microprocessor
to read the signals produced by the plurality of sensors
and transmit the status of the sensors to the central
10   computer 20 as will be described.

The example sensing and communication circuit
also preferably includes a universal asynchronous
receiver/transmitter (UART) 90 and a modem 94. The UART
90 converts parallel data transmitted on the bus 82 to
15   asynchronous serial data that is in turn transmitted on a
lead 92 to the modem 94 as well as converting serial data
received by the modem 94 to parallel data that can be read
by the microprocessor 84. The modem 94 shown is a 1200
baud modem that is designed to transmit and receive
20   digital signals using a modulated analog carrier signal
that is transmitted over a network. Other transmission
standards could also be utilized. Coupled to the example
modem 94 is a suitable antenna 96 that transmits and
receives signals oven the network. For ease of
25   programming and compatibility, the modem 94 shown is a
Hayes compatible and transmits and receives digital data
using a well defined protocol. Other modems and speeds
could also be utilized as well as other communication
techniques. Programming such a modem will be readily
30   apparent to one of ordinary skill in the computer
communications art.

The sensing and communication circuit 50 shown
includes an infrared serial port 100 which is coupled by a
lead 102 to an infrared transmitter 104 and an infrared
35   receiver 106. The infrared serial point is used to
transmit and receive data from a handheld data entry
terminal carried by a service technician.

26

        Additionally, in this unit a serial jack 108 is
coupled to the lead 102 in order to transmit and receive
data from a handheld data entry terminal that is plugged
directly into the serial jack.

5   Finally, a battery backup circuit 110 can be
used to operate a communication circuit if power to the
vending machine is interrupted.

        FIGURE 5 is an example state diagram 150 showing
a plurality of modes in which the example microprocessor
10   that runs the sensing and communication circuit 50 could
operate. The example microprocessor has at least five
distinct modes: a control mode 160, a communications mode
190, a service mode 250, an analyze mode 290 and an alarm
mode 340.

15   Upon powering up of the sensing and
communication circuit, the example microprocessor
immediately enters the control mode 160. Here the
microprocessor polls the modem for a connect signal
received from the central computer system. Once a connect
20   signal is received, the microprocessor leaves the control
mode and enters the communication mode 190 in order to
transmit and receive data packets to and from the central
computer system. If there is excessive noise on the
communication link or the modem detects a disconnect
25   signal, the microprocessor leaves the communication mode
190 and returns to the control mode 160.

        If no signal is received, the example
microprocessor shown polls the I/O point 80 shown in
FIGURE 4 to determine the status of the plurality of
30   sensors disposed in the vending machine. If one of the
sensor inputs indicates an alarm condition, the
microprocessor leaves the control mode and enters an alarm
mode 340.

        In the example alarm mode, it is determined if
35   the alarm condition is critical. If the alarm is not
critical, the microprocessor returns to the control mode
and will inform the central computer system of the alarm

condition the next time the central computer system shown
contacts by a call to the remote vending machine. If the
alarm is critical, the remote vending machine initiates a
call to the central computer system and immediately

5   informs it of the alarm condition.

            Another condition the example microprocessor
looks for (by reading the sensor inputs) is a service call
made by a service technician. Upon detecting that a
switch disposed in the door of the vending machine has

10   been activated by someone opening the door, the
microprocessor shown waits for a code or predetermined
amount of time for a service technician to enter a
predetermined Personal Identification Number (PIN). If
this is entered within the predetermined time, the

15   microprocessor leaves the control mode 160 and enters a
sensor mode 250. In the service mode, the service
technician could typically enter data regarding the amount
of product added to the machine, the amount of money
removed from the machine and the amount of change placed

20   in the change maker. Once the example microprocessor
detects that the service call is complete, a check is
preferably made whether the remote vending machine should
initiate a call to or otherwise contact the central
computer system immediately or should wait until the

25   central computer system calls the remote vending machine
in order to inform the central computer that a service
call has been completed. If the remote vending machine is
instructed to contact the central computer system upon
completion of the service call, the microprocessor leaves

30   the service mode 250 and enters the communications mode
190. Otherwise, the microprocessor leaves the service
mode 250 and returns to the control mode 160.

            In the example communication mode 190, the
example microprocessor transmits and receives data packets

35   to and from the central computer system over the network
16. After all the data packets have been sent from the
remote vending machine to the central computer system, the

28

vending machine might query the central computer system to
see if the central computer needs to transmit any data to
the remote vending machine. If a data packet is received
from the central computer system, the microprocessor
5   leaves the communication mode 190 and enters an analyze
mode 290.

In the example analyze mode, the data packet
shown received is tested to determine the appropriate type
of action the microprocessor should take. Possible
10   actions include transmitting the contents of the
microprocessor's memory, reprogramming the
microprocessor's memory, testing the alarm system,
reprogramming the communications to the central computer
system, and resetting the alarm criteria and/or a set of
15   alarm response bits that define which alarm conditions are
critical. Once the received data packet is analyzed and
the example microprocessor has performed the task required
by the data packet, the microprocessor shown leaves the
analyze mode and returns to the communications mode in
20   order to wait for an additional data packet to be
transmitted. If the microprocessor was instructed by the
received data packet to test the alarm system, the
microprocessor leaves the analyze mode 290 and enters the
alarm mode 340.

25   FIGURE 6 is an example flow chart showing in
greater detail the steps that might be taken by the
example microprocessor as it is operating in the control
mode 160 described above. Starting at a step 162, the
microprocessor proceeds to set up the modem in a standard
30   protocol at step 164, a Hayes 1200 baud protocol shown.
In the example, the data transmitted by the modem is
transmitted using a modulated analog carrier signal over
an ordinary communications medium. As will be described
in this example in further detail below, this is possible
35   because the amount of data transmitted between the remote
vending machine and the central computer system is
relatively small and the data is retransmitted if it is

29

not received correctly. Thus, the present invention is
able to withstand errors that may occur during
transmission and does not require the use of a modem that
is specifically designed for transmitting high speed
5   digital data.

        Once the example modem has been set up, the
microprocessor shown then polls the modem for a connect
signal to be generated by a call received from the central
computer over the network at a step 166. If the connect
10   signal has been received, the modem is instructed to go
"off hook" at a step 170 and the microprocessor enters the
communications mode at a step 172. If no connect signal
is received, the example microprocessor reads the I/O port
80 to determine the status of the plurality of sensor
15   inputs at a step 174. At a step 176, it is determined if
an alert condition exists. In some cases this is
accomplished simply by reading the status of the sensor
output signals. For example, if the output signal of the
temperature sensor is a logic 1, then a temperature alarm
20   exists. Other alarm conditions can be determined by
following the changes in the sensor output signals over
time such as the compressor cycles example described
above. If an alarm condition exists, the microprocessor
leaves the control mode and enters the alarm mode at a
25   step 178.

        If no alarm condition is present, the example
microprocessor reads the status of a switch connected to
the door of the vending machine at step 180 in order to
determine whether the door of the vending machine has been
30   opened. If the door has been opened, the microprocessor
shown enters a service mode at a step 182. If the door is
not open, the microprocessor loops back to step 166 where
the modem is again polled to determine if a connect signal
has been received.

35   FIGURE 7 is an example flow chart showing the
steps taken by the microprocessor shown when operating in
the communications mode 190. Upon entering the

30

communications mode from the control mode, the
microprocessor polls the modem to determine if there is
excessive noise or if a carrier is no longer present over
the network at a step 192. If the answer at step 192 is
5   yes, the microprocessor returns to the control mode at a
step 194. Assuming that the noise on the communications
link is not excessive and the carrier signal is still
present, the microprocessor polls the modem to determine
if a recognizable signal, a "not acknowledge" (NAK) signal
10   shown has been received at step 196. Under the
communications protocol followed by the remote vending
machines and the central computer system, the central
computer system indicates to the remote vending machines
that any data packets are to be transmitted by first
15   sending the NAK signal. If no NAK signal is received, the
microprocessor returns to the control mode at a step 198.

        Each data packet to be sent to the central
computer is maintained on a queue within the example
microprocessor's RAM. Each data packet has generally the
20   same structure. Data packets are differentiated by a
"packet type" byte in the data packet.

        FIGURE 11 shows an example structure of the data
packets transmitted between the central computer system
and the remote vending machines in the above example
25   system of figure 4. Each data packet 360 preferably
begins with a marker byte 362. The ASCII symbol for a
colon is used for the marker byte shown. Following the
marker byte shown, is a packet length byte 364 indicating
the entire length of the data packet excluding the marker
30   byte. A pair of bytes 366 indicate the unit ID. Each
vending machine within the monitoring and communication
system has a unique unit ID. Following the unit ID bytes
shown is a sequence number byte 368. This byte is
incremental each time a unit transmits a data packet to
35   the central computer system. By keeping track of the
sequence number, the central computer is able to determine
if a data packet has been missed. Following the sequence

number shown is a packet type byte 370, which indicates
the type of data to be transmitted. It is the packet type
which informs either the central computer or the vending
machine how to interpret the data which follows in a
5   series of bytes 372. Following the data, the data packet
shown includes a pair of checksum bytes 374 that allow the
receiving microprocessor to determine if an error occurred
during transmission of the data packet. The following
illustrates the sequence of bytes that are inserted into a
10   specific data section of five types of data packets
transmitted between the vending machine and the central
computer. The type of data packet shown is specified in
the packet type bytes as described above. The following
example packet types can be used to transmit information
15   regarding a soft drink vending machine having eight
columns filled with cans of product. Those skilled in the
art will recognize that the data packet types can be
easily modified depending on the particular type of
machine being monitored. Note that although the example
20   system utilizes only eight columns, it technically has 23
sensor inputs. It thus is able to provide data for
inventory items in excess of the eight columns shown.

DATA PACKETS TRANSMITTED FROM THE VENDING
25   **MACHINE TO CENTRAL COMPUTER SYSTEM**
TYPE 1
(Illustrates Status of Vending Machine)

Byte Name	Description
B1	value of sensor inputs 0-7
B2	value of sensor inputs 8-15
B3	value of sensor inputs 16-23
C1	total product in column 1
C2	total product in column 2
C3	total product in column 3
C4	total product in column 4

32

	C5	total product in column 5
	C6	total product in column 6
	C7	total product in column 7
	C8	total product in column 8
5	CP	number of compressor cycles

TYPE 2
(Service Packet)

10

Byte Name	Description
C1	column 1 product added
C2	column 2 product added
C3	column 3 product added
C4	column 4 product added
C5	column 5 product added
C6	column 6 product added
C7	column 7 product added
C8	column 8 product added
CARM	cash removed
CHLF	change left

15 ... 20 appear to the left of C3, C8.

TYPE 3
(Alarm Bits)

0x0001	total product level below criterion
0x0002	column product level below criterion
0x0004	change depleted
0x0008	temperature limit exceeded
0x0010	intrusion alarm
0x0020	compressor cycles exceed criterion
0x0040	checksum RAM program area bad

25 ... 30 ... 35