

[54] DATA RETRIEVAL MEANS HAVING
MULTIPLE POSITION SWITCHES

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[51] Int. Cl. **H04q 1/30**

[58] Field of Search..... **340/150, 151, 209**

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Primary Examiner—Harold I. Pitts

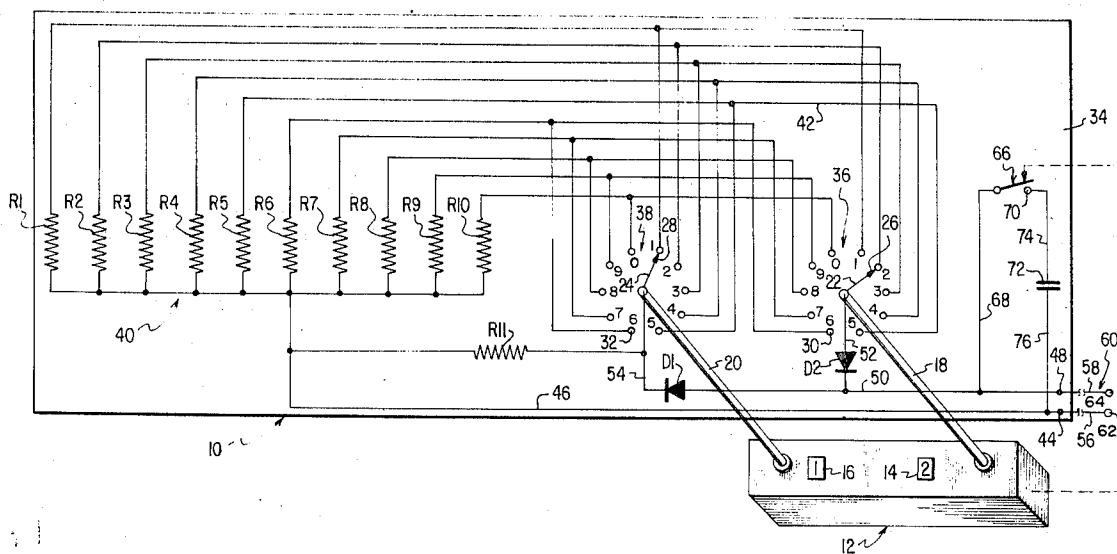
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[57]

ABSTRACT

A data obtaining system wherein the closed contacts of a plurality of multiple position switches are resistively read. Means are provided to distinguish between the resistive readings obtained from different switches. The condition of a separate on-off switch is ascertained.

22 Claims, 18 Drawing Figures



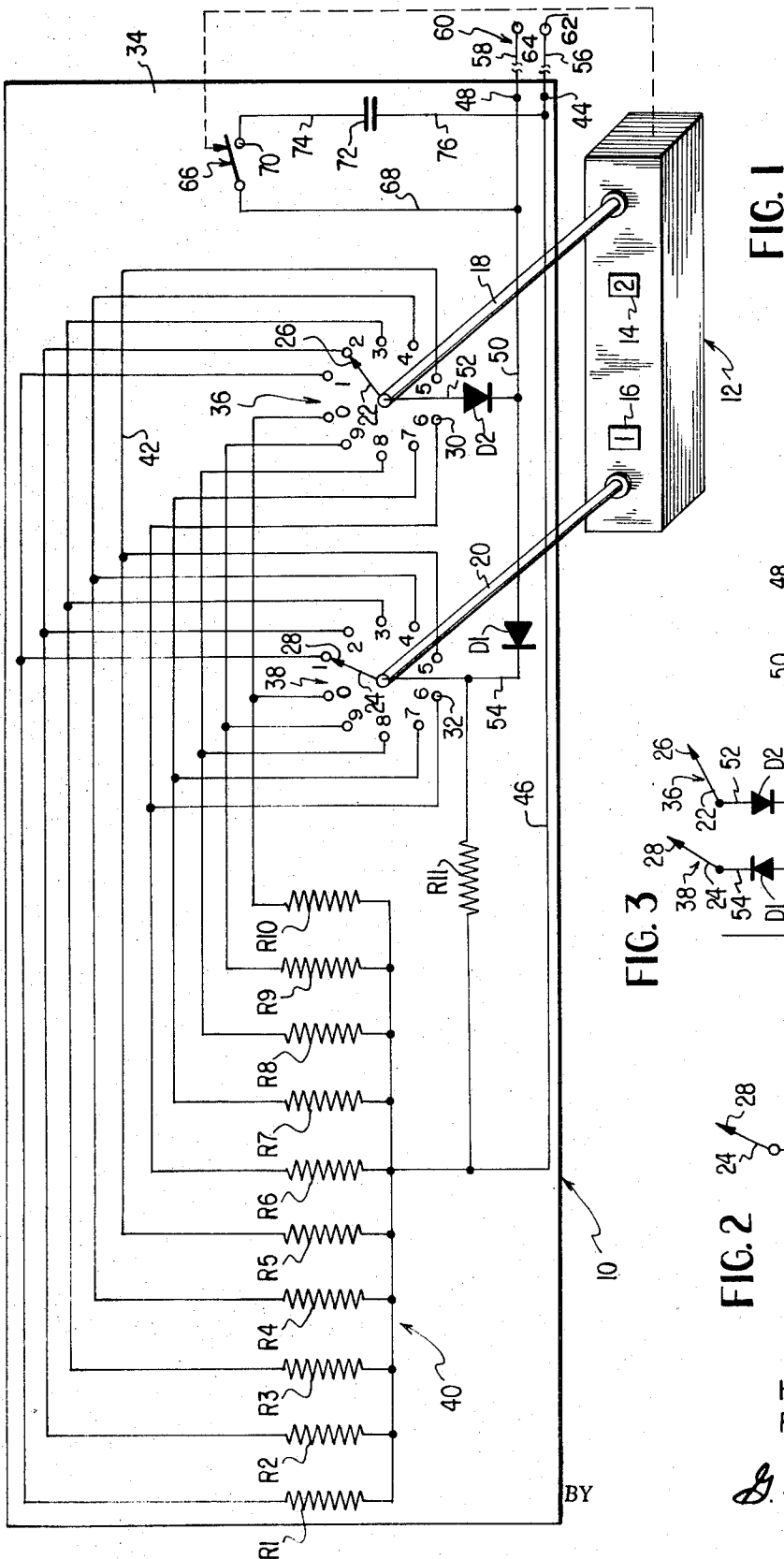


FIG. 1

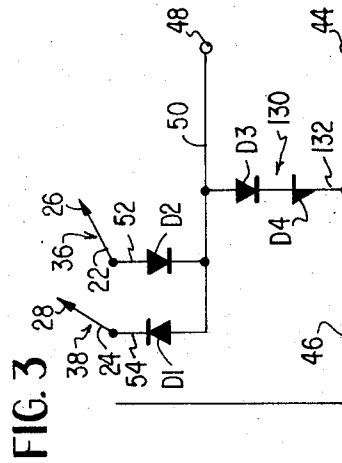


FIG. 3

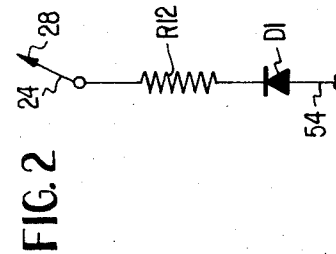


FIG. 2

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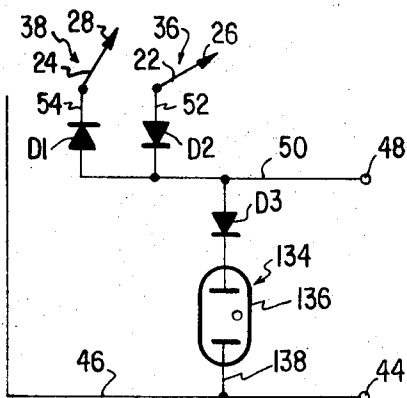


FIG. 4

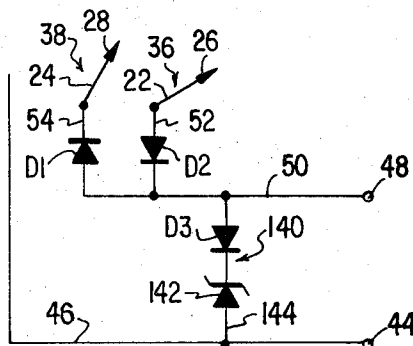


FIG. 5

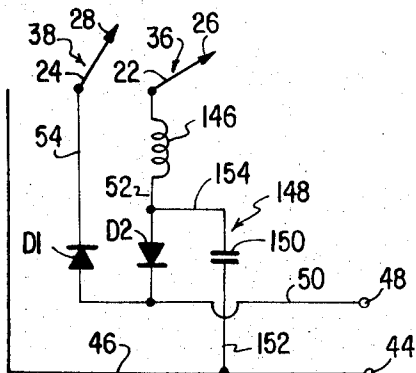


FIG. 6

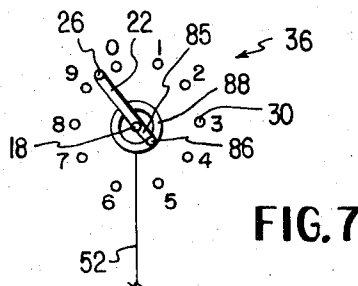


FIG. 7

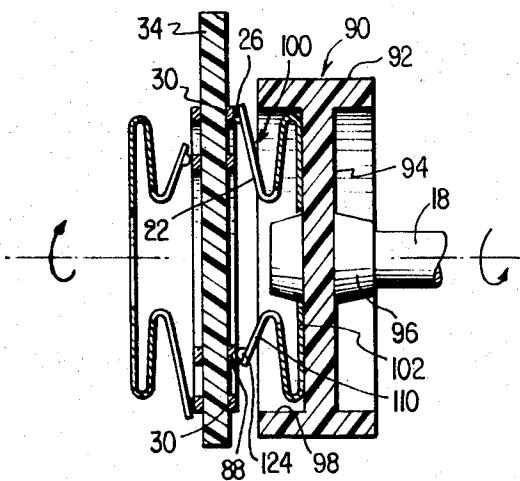


FIG. 8

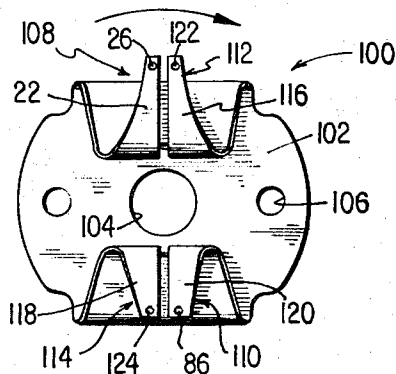


FIG. 9

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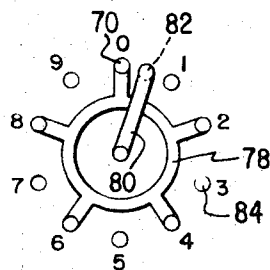
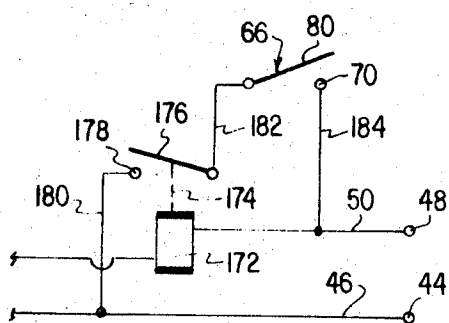
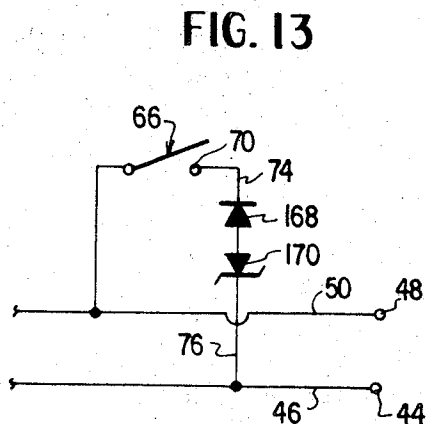
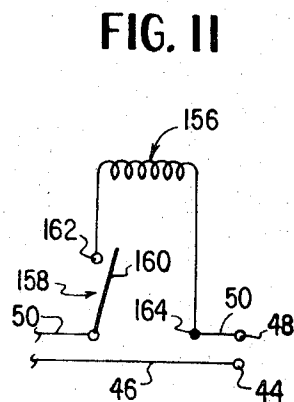
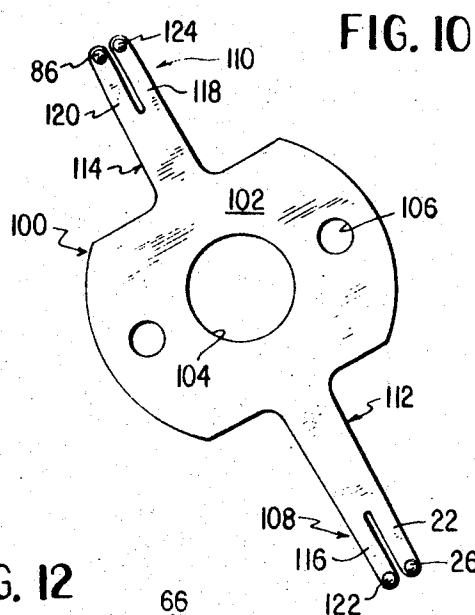


FIG. 15

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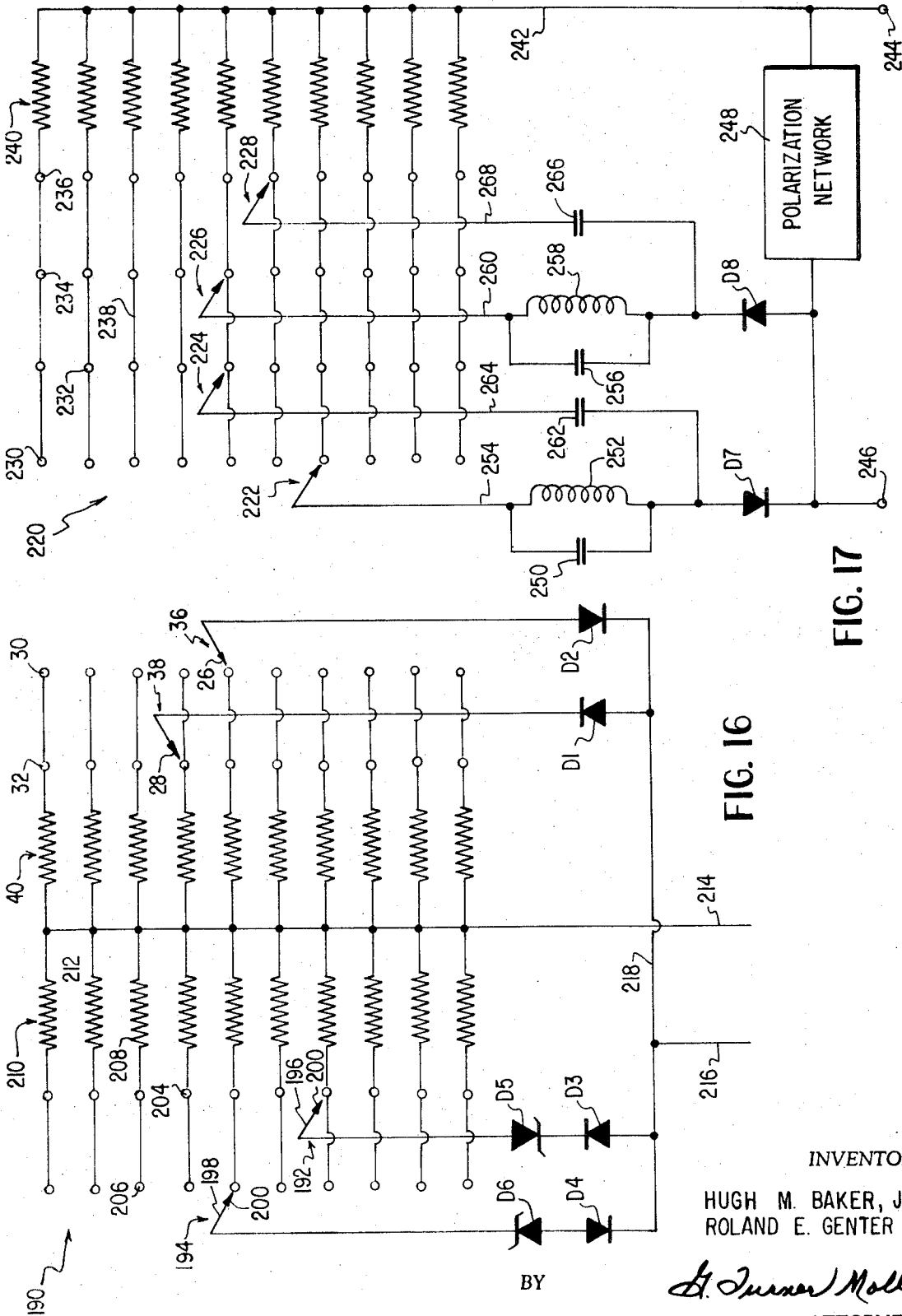


FIG. 16

FIG. 17

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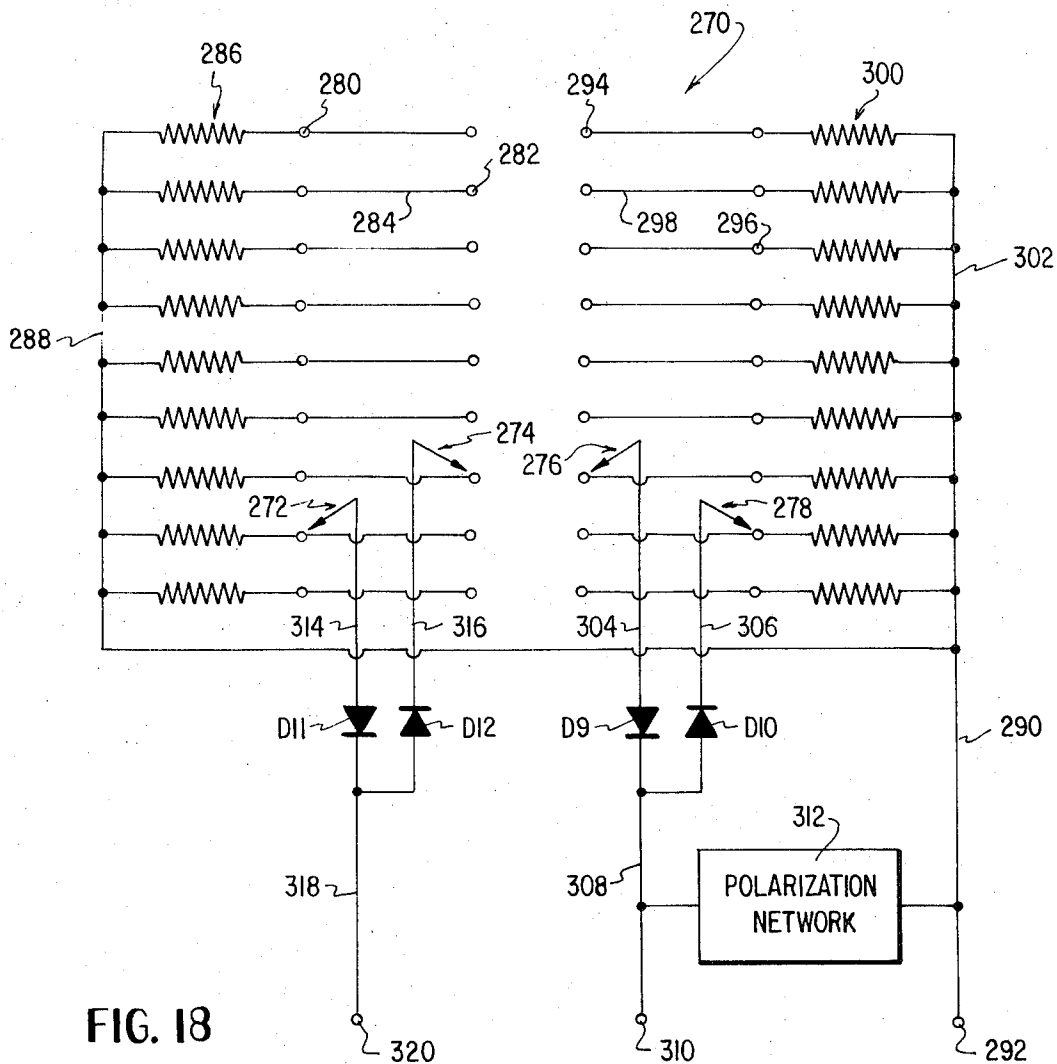


FIG. 18

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DATA RETRIEVAL MEANS HAVING MULTIPLE POSITION SWITCHES

Although this invention is described in terms of a system used to resistively determine the reading of a multiple decade meter, it is to be understood that the applicability of the invention is not so limited.

Many gas, water and electric meters of the type customarily found in residential areas are located within the house, thus requiring the homeowner to admit the meter reader. Since several studies have shown that no one is home in 20 to 30 percent of the residences approached by meter readers, it is economically attractive to the utility to provide some means of reading the meter within the house from a location out of the house.

The optimum meter reading situation from a technical standpoint is to read all of the meters in a given area from a central location over a pair of wires such as telephone wires. This approach not only avoids the problem of people not being home but also eliminates the necessity for meter readers. Although the technical problems associated with such a system can be overcome, the cost per meter of providing such systems is presently rather high. There is also some reluctance on the part of utilities to accept such systems, primarily because of the unusually long life of utility meters and the unproven longevity of central station meter reading systems.

An intermediate approach to the remote reading of meters is to provide a sensor at the meter to sense the meter reading and a communication link between the meter and a location on the outside of the house. Thus, the meter reader can take readings of a meter whether the homeowner is present or not.

Most utility meters are equipped with visual dials or odometers registering five or six decades of information. Using water meters as exemplary, it has been found that the annual usage of a typical residence does not exceed 99,000 gallons or the capacity of two of the lower decades. Unfortunately, it has been found that a small but significant percentage of households exceed, in one reading period, the capacity of these two lower decades, for example if a swimming pool is filled several times during a summer or if a water line breaks. It has been found, however, that the doubling of the capacity of the remote reading equipment, i.e. from 99,000 to 199,000 gallons will accommodate the relatively few high users almost without exception.

A resistive matrix is used to enable resistive reading of the closed contact of one multiple position switch. The matrix is also in circuit with a second multiple position switch. Means are provided to distinguish the resistive value obtained through one of the switches with that obtained through the other.

In accordance with another feature of the invention, the condition of a third on-off switch in a separate circuit is ascertained by maintaining the separate circuit inactive while the multiple position switches are being read.

It is an object of this invention to provide a data obtaining system using a single resistive matrix to determine the closed contact of a pair of multiple position switches and means for distinguishing between the

Another object of this invention is to provide a data obtaining system in which a first signal is used to deter-

mine the condition of a multiple position switch and a second signal is used to determine whether an on-off switch is open or closed thereby doubling the remote reading capability of the system.

A further object of the invention is to provide a circuit board which may be readily inserted into the meter to provide numerical information from a pair or multiple position switches.

Another object of the invention is to provide a contact mechanism which may be readily and inexpensively manufactured.

FIG. 1 is a schematic view of the invention;

FIG. 2 is a schematic view of an additional resistor usable in series with the resistive matrix shown in FIG. 1;

FIG. 3 is a schematic view of another embodiment of the invention used to distinguish readings obtained from the two multiple position switches of FIG. 1;

FIG. 4 is a further modification of the invention which might also be used to distinguish between readings obtained from the multiple position switches of FIG. 1;

FIG. 5 is still another embodiment of the invention used to distinguish between the readings obtained from the multiple position switches of FIG. 1;

FIG. 6 is another embodiment of the invention usable to distinguish between readings obtained from the multiple position switches shown in FIG. 1;

FIG. 7 is a schematic view of one type of switch which may be used in the circuitry of FIG. 1;

FIG. 8 is an enlarged cross sectional view of the switch of FIG. 7;

FIG. 9 is a bottom view of the electrical contact comprising a part of the switch of FIG. 8;

FIG. 10 is a blank from which the contact of FIG. 9 may be made;

FIG. 11 is a schematic view of another type of reactive element usable in circuit with the on-off switch of FIG. 1;

FIG. 12 is another embodiment of the invention usable in circuit with the on-off switch;

FIG. 13 is a further embodiment of the invention usable in circuit with the on-off switch;

FIG. 14 is a schematic view of a current responsive element in circuit with the on-off switch;

FIG. 15 is a schematic view of one form of on-off switch which may be used in the invention;

FIG. 16 is a schematic view of the invention used to obtain readings from four multiple position switches;

FIG. 17 is a schematic view of another embodiment of the invention used to obtain readings from four multiple position switches; and

FIG. 18 is a schematic view of another embodiment of the invention used to obtain readings from four multiple position switches.

Attention is directed to FIG. 1 wherein a data retrieval system 10 is illustrated in conjunction with a meter 12 having a pair of odometer type indicators 14, 16 representing adjacent decades of information which display the quantity measured by the meter 12. Operatively associated with each of the indicators 14, 16 is a shaft 18, 20 which is movable concurrently with the movement of the indicators 14, 16. It will be seen that the position of the shafts 18, 20 is an indication of the reading of the indicators 14, 16.

A pointer or movable arm 22, 24 is associated with each of the shafts 18, 20 and carries a first movable

contact 26, 28 for periodically engaging one of a plurality of stationary contacts 30, 32 provided on a circuit board 34. It will be seen that there is provided a pair of multiple position switches 36, 38 having a stationary contact for each of the digits of the indicators 14, 16.

Each of the stationary contacts 30, 32 is connected to a resistive matrix 40 through a conductive path 42 on the circuit board 34. The stationary contacts 30, 32 and the conductive paths 42 may be formed on the circuit board 34 by any suitable means, for example, by photoetching. As illustrated in FIG. 1, the resistive matrix 40 provides a separate resistor for identical contacts of the multiple position switches 36, 38. It will be apparent to those skilled in the art, that the number of resistors in the matrix 40 may be reduced by the provision of a conventional binary coded decimal arrangement for selectively coupling separate ones of the resistors in the matrix 40 in circuit with the switches 36, 38.

The resistive matrix 40 is connected to a terminal or input 44 through a conductive path 46. A second terminal or input 48 is provided on the circuit board 34 and is connected through conductive paths 50, 52, 54 to each of the multiple position switches 36, 38. A diode D2, D1 is positioned in each of the paths 52, 54 so that direct current of one polarity passes through the switch 36 while direct current of opposite polarity passes through the switch 38. The terminals 44, 48 are connected through a pair of wires 56, 58 to a receptacle 60 comprising a pair of terminals 62, 64. The receptacle 60 is preferably placed at some place accessible to the person obtaining data and in the case of a residential meter, the receptacle 60 is preferably placed outside the residence. It will be seen that the terminals 44, 48 operate as a mere connection between the wires 56, 58 and the conductive paths of 46, 50. Consequently, the terminals 44, 48 may be drops of solder or any other suitable connection.

Since it is necessary to determine which of the stationary contacts 30, 32 is closed, the resistor means of the matrix 40 provide values distinguishable from each other. Exemplary values of the resistor means are shown in the following table:

TABLE OF RESISTIVE VALUES

R1: 249K ohms	R6: 45.3L ohms
R2: 140K ohms	R7: 38.3K ohms
R3: 95.3K ohms	R8: 32.4K ohms
R4: 71.5K ohms	R9: 28.0K ohms
R5: 56.2K ohms	R10: 24.3K ohms

The resistive values of each of the resistor means R1 to R10 should be placed sufficiently far apart to accommodate manufacturing tolerances and changes in resistance due to temperature differentials.

Since the contacts of a pair of multiple position switches are being read, some means is preferably provided to distinguish between the decades, i.e., to distinguish between similarly located contacts on the switches 36, 38. With the resistive values shown in the table, an additional resistor R11 may be placed in parallel with the resistive matrix 40 to shift the resistive value of any circuit including the switch 38 out of the range of resistive values of the circuits including the switch 36. For example, using the tabulated values in the table, the resistance of R11 may be 24.9K ohms. If the stationary contact 30 representing the digit one in the switch 36 is closed, it will be apparent that the resistance of the circuit is 249K ohms. If the stationary con-

tact 32 representing the digit one in the switch 38 is closed, the resistive value of the circuit is 22.6K ohms. It will thus be apparent that the provision of the additional resistor R11 shifts the resistive value of the circuit including the switch 38 wholly out of the range of the resistances provided by R1 to R10.

In order to read the multiple position switches 36, 38, an individual connects a direct current source of predetermined voltage and an ammeter to the terminals 62, 64. Assuming that the voltage source is connected to pass current through the diode D2, the current passes through the conductive paths 50, 52, the arm 22, the movable contact 26, the stationary contact 30 representing the digit two and the conductive path 42 to resistor R2 and then through the conductive path 46. The current value passing through the circuit is recorded either manually or automatically. The polarity of the voltage applied to the terminals 62, 64 is reversed so that current passes through the conductive path 50, the diode D1, the conductive path 54, and then through the parallel circuits including R11 on the one hand and including the switch 38 and the resistive matrix 40 on the other and then through the conductive path 46. Since the resistor R11 shifts the resistive value of any circuit including the switch 38 wholly out of the predetermined range of the resistance R1 to R10, the values which are read at the terminals 62, 64 may be readily translated into the numerical values corresponding to the position of the arms 22, 24.

Since any resistive value from a circuit including the switch 36 is distinguishable from any resistive value of a circuit including the switch 38, it will be seen that it is immaterial which polarity is first applied to the terminals 62, 64. The meter reader merely needs to insure that both polarities have been applied to the terminals 62, 64. Thus the provision of the additional resistor R11 eliminates the need for polarized wires or control of the polarity at the receptacle 60.

A peculiarity in the circuitry of FIG. 1 is revealed when the indicators 14, 16 register identical digits. Assuming that the movable contact 26 engages the stationary contact 30 representing the digit 1, it will be seen that an electrical path is provided from the switch 36 through one of the paths of 42 and the movable contact 28 to the resistor R11. Consequently, when the movable contacts 26, 28 are associated with corresponding stationary contacts, the resistor R11 is in circuit with both movable contacts. Consequently, the resistive values measured at the terminals 62, 64 with voltages of opposite polarity is the same and corresponds to the resistance of a circuit comprised of resistors R1 and R11. In practice, this has provided no difficulty since simple logic dictates that both digits are the same and it is immaterial which digit represents which decade of information. Of course, if the resistors R1 to R10 represented unlike digits on the separate decades, additional provisions would be required.

As mentioned previously, it is desirable to determine whether the next highest decade has changed value thereby increasing the capability of the information retrieval system 10 from 99 to 199 units. This is accomplished by the provision of an on-off switch 66 connected to the conductive path 50 by another conductive path 68. A stationary contact 70 of the switch 66 is connected to one side of a capacitor 72 by a conductive path 74 with another conductive path 76 connecting the capacitor 72 to the path 46.

The switch 66 may take any desirable form depending on the environment in which it is used. There is shown in FIG. 15 a more detailed but still schematic view of a preferred type of switch used with the shaft (not shown) of the next higher decade of information from the meter 12. The switch 66 comprises a plurality of spaced stationary contacts 70 representing alternate digits coupled to a common conductive path 78. The switch 66 also includes a movable arm 80 carrying a movable contact 82. Blank stationary contacts 84 may be provided for the remaining alternate digits if desired. The movable arm 80 is operatively controlled by a shaft (not shown) similar to the shafts 18, 20 and representative of the next higher decade of information from the meter 12.

As is well known, a capacitor presents a low impedance to alternating current and an extremely high resistance to direct current. When the switch 66 is open, the capacitor 72 obviously has no effect on any circuit through the system 10. Because of the high resistance to direct current of a capacitor, there is no discernible change in resistance of any of the circuits including the switches 36, 38 when the switch 66 is closed.

The impedance of the capacitor 72 is selected to shift the impedance of any circuit in the system 10 below either of the predetermined ranges provided by the resistive matrix 40 and the resistive matrix 40 in parallel with the resistor R11. In one device constructed in accordance with the invention, the capacitor 72 has a capacitance of 0.1 microfarad and an impedance of 20 ohms at 70 kilocycles, which is the frequency of the applied alternating current in the constructed device.

At some time during the remote reading of the meter 12, the meter reader applies alternating current through the terminals 62, 64 to determine whether the switch 66 is open or closed. From the resistive values obtained by applying direct current of opposite polarity through the terminals 62, 64 numerical values for the two lower decades of information are obtained. By applying alternating current to the terminals 62, 64 an odd-even determination is made from the next higher decade. With successive sets of readings, it is a simple matter to calculate the quantity measured by the meter 12 in the time interim between the two readings. It will be seen that the capacity of the remote reading equipment is 199 units. Since this capacity is substantially all that is required under many circumstances, it will be apparent that the system 10 provides a reliable and inexpensive means of recording the quantity passed through the meter 12.

Referring to FIG. 7, there is shown a more detailed but still schematic view of the multiple position switch 36. The movable arm 22 is illustrated as carrying the movable contact 26 which periodically engages the stationary contacts 30. Movable with the arm 22 is an arm 85 carrying a movable contact 86 which is in continuous engagement with a conductive ring 88 provided on the circuit board 34. The conductive path 52 is in communication with the ring 88 to provide continuous electrical connection between the movable contact 26 and the terminal 48.

Referring to FIG. 8, a preferred type of switch is illustrated in conjunction with a conventional odometer type indicator. FIG. 8 constitutes a more detailed view of FIG. 7 from which common reference characters are used. An odometer wheel 90 is comprised of a cylindrical annulus 92 and a central web 94. The wheel 90 is

secured to the shaft 18 by conventional collars 96. It will be seen that the wheel 90 provides a recess 98 opposite from the shaft 18 for receiving a contact mechanism 100. It will be apparent that indicia provided on the periphery of the annulus 92 are exposed through a suitable window to provide the indicator 14.

The contact mechanism 100 comprises a flat base 102 having therein an enlarged opening 104 to receive the shaft 18 and a pair of openings 106 through which suitable fasteners extend to secure the mechanism 100 to the central web 94. The mechanism 100 also comprises first and second contact arm assemblies 108, 110 integral with the base 102. The contact arm assemblies 108, 110 comprise long and short elongate bifurcated extensions 112, 114 comprised of legs 22, 116, 118, 120 having thereon contacts 26, 122, 124, 86.

It will be apparent that the blank of FIG. 10 may be stamped from suitable material. The extensions 112, 114 are formed on suitable dies into an arcuate configuration to provide spring characteristics necessary to bias the contacts 26, 122, 124, 86 into engagement with the stationary contacts 30, 88. As will be noted from FIG. 8, the extensions 112, 114 are bent so as to position the contacts 26, 122 at one radius of rotation and the contacts 124, 86 at a second radius of rotation.

An important feature of the contact mechanism 100 is that the contact arm assemblies 108, 110 extend radially from the center of rotation 126. Consequently, the contact mechanism 100 is bidirectional by which is meant that the frictional forces opposing rotation, contact pressure and other operating parameters are equal regardless of the direction of contact rotation. This is of substantial importance as will be pointed out hereinafter.

Another important feature of the contact mechanism 100 is that there are two contacts on each extension which move on the same radius of rotation. As shown in FIGS. 8 and 9 with rotation in the direction shown by the arrows, the forward contacts 122, 124 act as scrapers to condition the stationary contacts 30, 88 to make reliable electrical engagement with the rear contacts 26, 86.

The importance of the bidirectional aspect of the contact mechanism 100 is most clearly shown in FIG. 8 where the circuit board 34 is provided with identical stationary contacts 30, 30', 88, 88' on opposite sides thereof. The circuit board 34 is positioned between adjacent odometer wheels having contact mechanisms 100 secured thereto. Because the direction of rotation of the left contact mechanism 100 is opposite with respect to the right contact mechanism 100, it will be apparent that the bidirectional feature of the invention allows a single contact mechanism to be used thereby obviating the difficulties of making two opposite and unidirectional contact mechanisms and insuring their correct assembly on the odometer.

ALTERNATE EMBODIMENTS FOR DISTINGUISHING BETWEEN THE MULTIPLE POSITION SWITCHES

Referring now to FIG. 2, there is shown a partial schematic view of another embodiment of the invention. Instead of positioning the additional resistor R11 in parallel with the movable contact 28, an additional resistor R12 is shown in series therewith. The resistance of resistor R12 is sufficient to shift the resistive value of a circuit including the movable contact 28 out

of the predetermined range provided by the matrix 40. Using the resistive values tabulated previously, the resistive value of the resistor R12 may be anything in excess of about 225K ohms but is preferably at least about 240K ohms. The operation of the embodiment of FIG. 2 is substantially the same as the operation of the embodiment of FIG. 1 with one difference. As pointed out previously, the embodiment of FIG. 1 has the peculiarity of providing the same resistive values for circuits including the switch 36 and the switch 38 if the arms 22, 24 are positioned on contacts representing the same digit. Since the resistor R12 is in series with the diode D1 in the resistive matrix 40, this peculiarity does not occur in the operation of the embodiment of FIG. 2.

An additional alternative means of distinguishing between the multiple position switches is possible with the embodiment of FIG. 2 merely by changing the resistive values of the resistors in the matrix 40 and the value of the resistor R12. The resistive values in the matrix 40 may be widely spaced and the value of the resistor R12 may be used to shift the resistive values of circuits including the switch 38 between resistive values of the circuits including the switch 36. For example, if the resistive values of R1 through R10 are spaced apart by 100K ohms and the value of the resistor R12 is 50K ohms, the resistance of any circuit including the switch 38 would be readily distinguishable from any circuit including the switch 36.

Referring to FIG. 3, there is shown a partial view of another embodiment of the invention. The embodiment of FIG. 3 is the same as the embodiment of FIG. 1 except that the resistor R11 has been deleted and a shunt 130 has been added. The shunt 130 comprises a diode D3 and a breakdown diode D4 which may be either of the bilateral or unilateral type. The diodes D3, D4 are connected in series by a conductive path 132 between the paths 46, 50. The breakdown voltage of the diode D4 is selected to be substantially higher than the voltage used in reading the resistive values of the matrix 40.

Using a voltage less than the breakdown voltage, the meter reader records the polarity of the voltage applied to the terminals when obtaining resistive values of the matrix 40. For example, the data obtained may be 249K ohms with negative polarity and 46.3K ohms with positive polarity. Direct current voltage spikes of both polarities greater than the breakdown voltage of the diode D4 are then applied to the terminals 44, 48. The polarity of the voltage spike which causes breakdown of the diode D4 is recorded. It will be apparent that the polarity of the spike which passes through diode D3 is the polarity of the voltage that passes through D1. Simple logic will reveal which of the resistive values corresponds to the switch 36 and which corresponds to the switch 38.

Referring now to FIG. 4, there is shown a further embodiment of the invention for distinguishing between the multiple position switches 36, 38. The embodiment of FIG. 4 is quite similar to the embodiment of FIG. 3 and, in lieu of the shunt 130, there is provided a shunt 134 comprised of a diode D3 and a gas discharge bulb 136 connected in series by a conductive path 138 between the paths 46, 50. The gas discharge bulb 136 is selected to provide a breakdown voltage substantially greater than the voltage used to read the resistive values of the matrix 40. It will be apparent that the mode

of operation of the embodiment of FIG. 4 is substantially the same as that of the embodiment of FIG. 3.

Referring now to FIG. 5, there is shown a further embodiment of the invention for distinguishing between the multiple position switches 36, 38. The embodiment of FIG. 5 is quite similar to the embodiments of FIGS. 3 and 4 and comprises a shunt 140 having a diode D3 and a Zener diode 142 connected in series by a conductive path 144 between the conductive paths 46, 50. The breakdown voltage of the Zener diode 142 is selected to be substantially greater than the voltage used in obtaining resistive values through the switches 36, 38. It will be apparent that the mode of operation of the embodiment of FIG. 5 is substantially the same as the embodiments of FIGS. 3 and 4.

Referring now to FIG. 6, there is shown another embodiment of the invention for distinguishing between the multiple position switches 36, 38. In the conductive path 52 there is located an inductor 146. The shunt 148 comprises a capacitor 150 connected by a first conductive path 152 to the conductive path 46. The other side of the capacitor 150 is connected by a conductive path 154 to the path 52 between the diode D2 and the inductor 146. The position of the switch arms 22, 24 are obtained in the manner previously described by applying direct current of opposite polarity to the terminals 44, 48. The resistive values and the corresponding polarity are recorded. To determine which value is associated with the appropriate switch 36, 38, an alternating current signal with a DC bias voltage of one polarity is applied to the terminals 44, 48. Assuming that the polarity of the bias voltage causes the diode D1 to break down, a resistive value is obtained which will correspond to the previously obtained value for the switch 38. Assuming that the polarity of the bias voltage causes the diode D2 to break down, the alternating current signal passes through the shunt 148, which has a very low impedance to alternating current. It will be noted that the capacitor 150 prevents the shunt 148 from conducting any significant amount of direct current. It will also be seen that the inductor 146 has a very high impedance to AC thereby preventing substantial alternating current flow through the resistive matrix 40. It will be apparent that, by this technique, the decades represented by the switches 36, 38 may be readily distinguished.

ALTERNATE EMBODIMENTS FOR DETERMINING THE CONDITION OF A SEPARATE ODD-EVEN SWITCH

As mentioned previously, it is desirable to determine whether the next highest decade of the meter 12 has changed value since the last reading thereby increasing the capacity of the system 10 from 99 to 199 units. It will be apparent to those skilled in the art that many different approaches may be used to this end. FIGS. 11-14 illustrate four acceptable modifications.

Referring to FIG. 11, the embodiment of FIG. 11 includes an inductor 156 which is alternately placed in circuit with the switch 36 and out of circuit therewith depending on whether an odd-even switch 158 is sensing an odd or even number on the odometer wheel associated therewith. In lieu of a single pull-single throw switch as in the embodiment of FIG. 1, the switch 158 is of the single pull-double throw variety having an arm 160 disposed in one position to make electrical engagement with a contact 162 placing the inductor 156 in

circuit with the switch 36. The other position of the arm 160 provides electrical engagement with a contact 164 placing the switch 36 in circuit with the input 48 and bypassing the inductor 156.

It will be apparent to those skilled in the art that the inductor 156 provides a relatively low resistance to the direct current and an extremely high impedance to alternating current. In use, the meter reader alternately applies direct current of opposite polarity to the terminals 62, 64 to obtain the resistive readings of the switches 36, 38. At some time during the meter reading operation, alternating current is applied to the terminals 62, 64. If an extremely high impedance reading is obtained thereby, it is apparent that the arm 160 is in engagement with the contact 162 and the inductor 156 is in circuit with the switch 36. If an impedance value is obtained which is rather low, it is apparent that the arm 160 is in engagement with the contact 164 and the inductor 156 is not in circuit with the switch 36. Since the position of the arm 160 is indicative of the value appearing on the associated odometer, it is simple task to determine whether the next highest decade had advanced since the last reading.

Referring now to FIG. 12, there is shown another embodiment of the invention for determining the condition of an on-off or odd-even switch. The embodiment of FIG. 12 is structurally quite similar to the embodiment of FIG. 1 and differs only in the provision of a gas discharge bulb 166 in lieu of the capacitor 72. The gas discharge bulb 166 acts as a voltage responsive element and is selected to break down at a voltage substantially greater than that used to read the resistive values of the matrix 40. At some time during the reading operation, a voltage spike in excess of the breakdown voltage of the bulb 166 is applied to the terminals 44, 48. If the switch 66 is closed, a short circuit is created across the terminals 44, 48 having a very low resistance. If the switch 66 is open, a resistive value is obtained corresponding to that received through one of the switches 36, 38. The voltage spike may be either AC or DC.

Referring now to FIG. 13, there is shown another embodiment of the invention for ascertaining the condition of the on-off switch 66. The embodiment of FIG. 13 is quite similar to the embodiment of FIG. 12 and a pair of back-to-back Zener diodes 168, 170 are provided in lieu of the bulb 166. The Zener diodes 168, 170 act as a bilateral voltage responsive element and are selected to break down at a voltage substantially in excess of that used to obtain readings from the matrix 40. Because the Zener diodes are back-to-back, these elements pass current only above the breakdown voltage but in either direction. The mode of operation of the embodiment of FIG. 13 is substantially the same as that of the embodiment of FIG. 12.

Referring now to FIG. 14, there is shown another embodiment of the invention for determining the condition of the on-off switch 66. The embodiment of FIG. 14 utilizes a current responsive electromagnetic coil 172 in the conductive path 50. The coil 172 operates a solenoid plunger 174 to position a switch arm 176 in engagement with a contact 178 to provide a shunt across the conductive paths 46, 50. The shunt comprises a conductor 180 from the path 46 to the contact 178, a conductor 182 from the switch arm 176 to the switch arm 80 and a conductor 184 from the contact 170 to the conductive path 50. The coil 172 is selected to maintain the arm 176 in the switch open position

until current passing through the coil 172 is substantially greater than that occurring during the reading of the matrix 40. At some time during the meter reading operation, the voltage applied to the terminals 44, 48 is increased to increase current passing through the coil 172 to move the arm 176 into the switch closed position. If the switch 66 is closed at this time, a shunt is achieved across the paths 46, 50 having substantially no resistance. On the other hand, if the switch 66 is open, the resistance of the circuit is that of the matrix 40 and the coil 172.

Referring to FIG. 16, there is illustrated another embodiment 190 of this invention used to obtain numerical values for the position of four multiple position switches. The right half of the figure corresponds in large part to the embodiment of FIG. 1 where like reference characters are used for purposes of brevity. The left hand side of FIG. 16 comprises third and fourth multiple position switches 192, 194 comprising switch arms 196, 198 having movable contacts 200, 202 for engaging a plurality of stationary contacts 204, 206. The contacts 206 are connected through suitable conductive paths 208 to a resistive matrix 210. The matrices 40, 210 are placed in parallel by a conductive path 212. The path 212 is connected to suitable input through a conductive path 214.

Another conductive path 216 is connected to a branch path 218 leading to the diodes D1, D2. The branch 218 also leads to diodes D3, D4 which are oppositely arranged to pass direct current of opposite polarity to the switches 192, 194. In series with each of the diodes D3, D3 is a Zener diode D5, D6. The Zener diodes D5, D6 act as voltage responsive elements and conduct only upon the application of a potential above the breakdown voltage. It will be apparent to those skilled in the art that any types of voltage responsive elements may be operable with the embodiment 190.

The judicious selection of the values for the individual resistors in the matrices 40, 210 is desirable. It is desirable that the resistors in the matrix 40 be of quite high resistance but separated sufficiently to allow for normal temperature drift and the manufacturing tolerances. The values of the individual resistors in the matrix 210 should be substantially lower, for example by a factor of 100 or 1000, and separated sufficiently far from each other to accommodate temperature drift and manufacturing tolerances. The resistance values of the individual resistors in the matrix 40 may, for example, be in the range 300K-3000K ohms while three resistive values of the individual resistors in the matrix 210 may be in the range 300K-3000K ohms.

When reading the decades of information corresponding to the switches 36, 38, direct current of opposite polarity below the breakdown voltages of the Zener diodes D5, D6 is applied alternately to the conductive paths 214, 216. It is apparent that diode D2 passes direct current of one polarity while the diode D1 passes direct current of opposite polarity. Accordingly, the meter reader obtains two amperage readings from which suitable calculations or calibrations may be made to determine which of the contacts 30, 32 are closed.

FIG. 16 does not disclose a suitable means for distinguishing between the switches 36, 38. Although any of the embodiments of FIGS. 1-6 may be used for this purpose, the embodiments of FIGS. 3-6 are preferred to obviate the possibility of ambiguous readings. If the

embodiments of FIG. 3-5 are used for this purpose, the breakdown voltage of the voltage responsive element should be selected to be between the voltage used to read the switches 36, 38 and the breakdown voltage of the Zener diodes D5, D6.

When reading the decades of information corresponding to the switches 192, 194, direct current of opposite polarity above the breakdown voltages of the Zener diodes is applied alternately to the conductive paths 214, 216 it is apparent that diode D3 passes direct current of one polarity while the diode D4 passes direct current of opposite polarity. Accordingly, the meter reader obtains two amperage readings from which suitable calculations or calibrations may be made to determine which of the contacts 204, 206 are closed.

Above the breakdown voltage, the matrix 210 is in parallel with the matrix 40. It will be apparent that if the resistive values of the matrix 40 are in the same range as the resistive values of the matrix 210, unreliable readings would be obtained when reading switches 192, 194. Since the resistive values in the matrix 40 are substantially higher, for example by a factor of 100 to 1000, the effect of the parallel arrangement between the matrices 40, 210 is negligible.

Referring to FIG. 17, there is shown another embodiment 220 of this invention for obtaining data from four multiple position switches 222, 224, 226, 228. The switches 222, 224, 226, 228 respectively comprise a plurality of stationary contacts 230, 232, 234, 236. A plurality of suitable electrical paths 238 connect the contacts 230, 232, 234, 236 to a resistive matrix 240. A conductive path 242 connects the matrix 240 to a terminal 244.

A second terminal 246 is connected to a pair of oppositely facing diodes D7, D8 with a polarization network 248 of the type shown in FIG. 3-6 is provided to distinguish between the switches 222 and 226 and between the switches 224 and 228 as will be apparent. The connections to the switches 222, 226 are substantially identical as are the connections to the switches 224, 228.

A capacitor 250 and an inductor 252 are disposed in parallel in a conductive path 254 leading from the diode D7 to the switch 222. A similar capacitor 256 and an inductor 258 are disposed in a conductive path 260 leading from the diode D8 to the switch 226. A capacitor 262 is disposed in a conductive path 264 leading from diode D7 to the switch 224. A similar capacitor 266 is disposed in a conductive path 268 leading from the diode D8 to the switch 228.

In use, the meter reader applies direct current of opposite polarity to the terminals 244, 246 during the meter reading operation. The inductors 252, 258 have negligible direct current resistance so that current flows through the switches 222, 226 in accordance with the polarity applied to the terminals 244, 246. The switches 222, 226 may, for example, represent the 1000's and the 10's. Also during the reading operation, the meter reader applies an AC signal superimposed on direct current applied to the terminals 244, 246. The frequency of the alternating current signal is such that the elements 250, 252 and 256, 258 present open circuits to the alternating current signal. The alternating current signal accordingly passes through the capacitors 262, 266 depending upon the polarity of the direct current voltage applied to the terminals 244, 246. The

switches 224, 228 may, for example, represent the 100's and the 1's. The polarization network 248 may be used to distinguish between the decades represented by the switches having analogous element.

5 The resistive values of the individual elements in the matrix 240 may be comparable to that suggested in the embodiment of FIG. 1. In addition, the elements of the matrix may be arranged in series rather than in parallel. The only other requirements for proper operation are that the impedance of the capacitors 262, 266 should be substantially less than the impedance afforded by the smallest value in the resistive matrix 240 and that the network afforded by the elements 250, 252 and by the elements 256, 258 should be such to provide an open circuit at the frequency of the alternating current signal.

Referring to FIG. 18, there is shown another embodiment 270 of this invention for obtaining data from a plurality of multiple position switches 272, 274, 276, 278. The switches 272, 274 respectively comprise a plurality of stationary contacts 280, 282 connected in series by a plurality of conductive paths 284 to a resistive matrix 286. The resistive elements of the matrix 286, which may be either in parallel or in series, are connected by conductive paths 288, 290 to a first terminal 292. The switches 276, 278 respectively include a plurality of stationary contacts 294, 296 connected by a plurality of conductive paths 298 to a resistive matrix 300. The resistive elements of the matrix 300, which may be either in parallel or in series, are connected by a conductive path 302 to the path 290 and to the terminal 292.

The switches 276, 278 are connected to respective conductive paths 304, 306 to oppositely facing diodes D9, D10 which are connected by a common conductive path 308 to a second terminal 310. A polarization network 312 of the type shown in FIGS. 3-5 is disposed between the terminals 292, 310 to distinguish between the switches 276, 278. The switches 272, 274 are connected to a conductive path 314, 316 where oppositely facing diodes D11, D12 are located. A common conductive path 318 connects the diodes D11, D12 to a third terminal 320.

At the outset of the reading operation, a direct current voltage in excess of the breakdown voltage in the polarization network 312 is applied to the various combinations of two terminals afforded by the system 270. In this manner, the terminals 292, 310 may be readily determined since the polarization network 312 provides substantially no resistance. After the terminals 292, 310 are identified, readings may be taken of the switches 276, 278 in a manner now familiar.

As soon as the readings obtained from the switches 276, 278 this procedure accomplishes another important function. The polarity applied to the terminals 292, 294 and the polarization network 312 effectively determines the direction of the diodes D9, D10. Since the diodes D9, D10 are arranged in the same direction as diodes D11, D12, the application of direct current voltage across the terminals 292, 320 of both polarities enables the switches 272, 274 to be read and distinguished.

We claim:

1. Apparatus for retrieving numerical information, comprising at least a pair of multiple position switches, each said switch including a plurality of contacts, each said contact being associated with a particular value of

said numerical information; a matrix including a plurality of impedance elements having distinct impedance values associated with particular values of said numerical information, each said impedance element being electrically connected to one contact of each of said multiple position switch, and input circuit means electrically connected to said matrix and to said pair of multiple position switches for retrieving said numerical information, said input circuit means including a pair of input leads and blocking means electrically connected in series with said multiple position switches and with said matrix means across said input leads for permitting electrical conductance only through one said multiple position switch upon application of a first signal to said input leads and for permitting electrical conductance only through a second multiple position switch upon application of a second signal to said input leads, said second signal being electrically distinct from said first signal.

2. Apparatus as in claim 1, wherein said blocking means includes a first diode connected in series with said one multiple position switch for passing said first signal and a second diode connected in series with said second multiple position switch for passing said second signal and wherein said first signal is a direct current signal of a predetermined polarity and said second signal is a direct current signal of opposite polarity from said first signal.

3. Apparatus as in claim 1 including additional impedance means connected in circuit with one of said multiple position switches for discriminating between the impedance values associated with said multiple position switches.

4. Apparatus as in claim 3 wherein said additional impedance means is connected in parallel with said matrix.

5. Apparatus as in claim 1 including discriminating means connected to said input leads for discriminating between said impedance values associated with said multiple position switches, said discriminating means including means for shunting said input leads in response to a third signal.

6. Apparatus as in claim 5 wherein said third signal is of predetermined voltage and polarity and said discriminating means comprises a diode and a voltage responsive breakdown element connected in series across said input leads.

7. Apparatus as in claim 1 including registering means connected to said multiple position switches for changing the position of said multiple position switch in response to changes in the numerical information, said registering means including a numerical information register.

8. Apparatus as in claim 5 wherein said third signal comprises a pulsating direct current signal of predetermined polarity and said discriminating means comprises a diode and a low impedance element.

9. Apparatus as in claim 8 wherein said low impedance element comprises a capacitor.

10. Apparatus as in claim 8 wherein said diode is in series with one input lead, said discriminating means includes a high impedance-low resistance element connected between said first multiple position switch and said diode, said low impedance element is electrically connected to the other said input lead and to a point between said diode and said high impedance element.

11. Apparatus as in claim 1 wherein said input circuit means includes an on-off switch means for indicating additional information and a conductive path connecting said on-off switch means across said input leads; and means electrically connected in said conductive path for rendering the conductive path nonconductive except upon application to said input leads of a switch signal distinct from said first and second signals.

12. Apparatus as in claim 1 wherein said impedance elements are resistors.

13. Apparatus as in claim 1, and further including impedance modifying circuit means connectable across said input leads for modifying the impedance across said input leads, said impedance modifying circuit means including switch means for connecting said impedance modifying circuit means across said input leads when said numerical information exceeds a predetermined limit.

14. Apparatus as in claim 13, wherein said impedance modifying circuit means includes blocking means for rendering said impedance modifying circuit inactive except upon application of a predetermined signal to said input leads.

15. Apparatus as in claim 14 wherein said predetermined signal is an alternating current signal, and said blocking means is a capacitor.

16. Apparatus as in claim 14 wherein said blocking means includes a normally open relay switch, said relay switch being closed upon a predetermined voltage being applied across said input leads.

17. An information retrieval system, comprising a plurality of multiple position switches, each said switch having an electrical contact associated with each position thereof; matrix means for determining the position of each switch of a first group of said switches, said matrix means including a plurality of impedance elements electrically connected to one contact of each multiple position switch of said first group of multiple position switches; and input means electrically connected to said multiple position switches and to said matrix means for applying a signal to said first group of multiple position switches for determining the position of said switches by determining the impedance associated with the contact of each said switch, said input means including at least a pair of input leads; first means connected in series with said input leads and said multiple position switches for distinguishing between said first group of multiple position switches and the remainder thereof and second means connected in series with said input leads and said first group of multiple position switches for distinguishing between said switches in said first group of multiple position switches.

18. The system of claim 17 wherein the remainder of the multiple position switches include a second group of at least two switches and further include a third means for distinguishing between said switches in said second group.

19. The system of claim 17 wherein the remainder of the multiple position switches are connected to a second matrix means for determining the position of each switch of the remainder of switches, said second matrix means including a plurality of impedance elements electrically connected to one contact of each multiple position switch of the remainder of multiple position switches; and said first means includes means for isolating said first group of multiple position switches from said remaining multiple position switches.

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20. The system of claim 19 wherein said input means comprises a two path input; said impedance elements of said second matrix being substantially more conductive than said impedance elements of said first matrix; and said isolating means comprising voltage responsive means.

21. The system of claim 19 wherein said input means comprises a three path input; and means responsive to a predetermined signal for shunting two of said input

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paths for identifying the inputs thereto.

22. The system of claim 18 wherein said first means includes a plurality of Zener diodes in series with the multiple position switches of said first group of multiple position switches respectively and said second means includes a plurality of diodes each said diode is connected in series with one said multiple position switch of said first group of multiple position switches.

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