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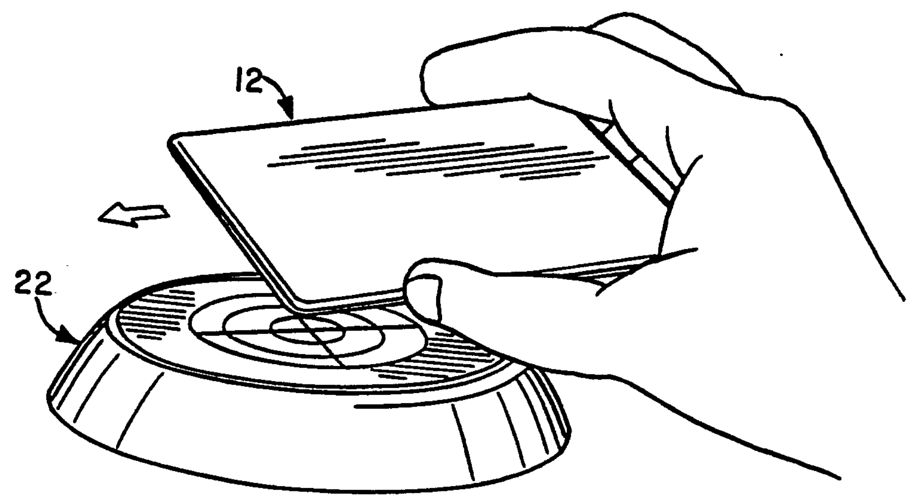
(54) Title: NON-CONTACT AUTOMATIC FARE COLLECTION MEDIUM



(57) Abstract

An electronic transit ticket (12) for use in an automatic fare collection system which is activated to pay the fare when brought in proximity of an antenna (22) mounted at the entrance and exits of transit access equipment, which electronic ticket or card (12) makes a spaced communication contact with an antenna (22) by amplitude modulated carrier and as modulated by impedance modulation by the spaced card (12). While the present invention uses amplitude modulation, other modulation schemes may be used as known to those experienced in the art.

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NON-CONTACT AUTOMATIC FARE COLLECTION MEDIUM

BACKGROUND OF THE INVENTION

Automatic transit systems have progressed from the mere purchase of a single ticket for a single ride to complex automatic fare collection systems. Present automatic fare collection systems use stored ride information that is often stored in magnetic stripe cards, which information is read by a magnetic reading device that reads the card and removes an appropriate fare from the stored fare in the card. The reading circuits also reads other pertinent information from the card and then through a write head, writes information back on the magnetic memory strip on the card, such as the new stored fare information. While these systems work very well and have been highly successful, the systems still require the continual issuance of new cards, and the mechanical reading and writing on the cards, at the point of entry and often times at the point of exit from the transit system. This requires mechanical processing of the stored fare cards which has to contend with mutilated cards, misentry of the cards into the card receiving units, and also mechanical failures in the reading and writing of the information on the cards.

Accordingly it would be of considerable advantage to have an automatic fare collections system in which the stored fare information would be in an electronic card that did not have to mechanically contact the card processing systems at the entry and exit gates of transit systems, but which electronic information could be read by the fare collection apparatus with no contact between the stored fare card and the card information processing systems. With this, a card could merely be passed near an antenna at the entry and exit gates of the transportation system, and all of the appropriate information concerning fare, point of entry, point of exit, identification and verification, and reinserting information into the electronic card, removing the fee for the ride, and other information could be removed and reinserted into the card electronically and without direct physical contact.

There are cards, that may be designated as smart cards, that contain information which may be selectively read by an interrogating RF transmitter. These cards usually have passive information in the card that identifies the card with a particular vehicle, or with an article being shipped, or articles that are to be identified. There are also other cards or articles which resemble cards, that are capable of storing information, and for repeating this information to an RF interrogation signal transmitted from a remotely located antenna. Such cards usually do not contain a processor, and thus are not capable of providing interchange of information from the card memory to the interrogating station, or for having subsequent information written into the card from the interrogating station, or that can use a processor within the card that is capable of doing calculations required for verification of the transmission. Further, such existing smart cards have the limitation of radiating RF signals and of not being adapted for effective use in automatic fare collections systems.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a new and improved electronic fare collection card that is activated without RF radiation when brought into the proximity of a transmitter mounted at the entry and exit gates of a transit exit system. The inventors, recognizing this need, have provided such a new and improved electronic fare card and its coordinated operation in a transit access system.

In this invention, the electronic fare card has a relatively small size, comparable with that of credit cards. The card has an internal winding that innerfaces with a winding in a target winding. The target winding is mounted adjacent to the entry gates or exit gates of a transportation system.

The target winding, hereinafter identified as "target antenna" is continuously driven by a signal that is fed to the antenna winding. The normally inactive electronic card has a similar winding. When the card is passed near, about four inches, to the target antenna, then the winding of the card loads the winding of the target antenna, as in a transformer, and provides impedance modulation, data transmission from the card by amplitude modulation, and data transmission from the target antenna.

In this mode, information is transferred from the card memory to the target antenna circuits providing AM modulation of carrier signal for data verification and for other information transfer such as the amount of stored rides, stored value passes, special fare applications, identification of the cards, point of entry into the transit system and point of exit from the transit system and the other related information used in automatic fare collection systems. The electronic card is also capable of receiving and processing new or corrected information such as the reduction in stored fare for the ride just completed, from the target antenna circuits. This is read into the memory of the electronic fare card.

In making the coupling, the card has means for sensing the magnitude of the coupling with the target antenna, so that the card can normally be inactive, and only be "turned on" when passed near the target antenna. The electronic card has a processor that not only passes the information in memory through the antenna to the target antenna, but also is capable of doing mathematical computations that are necessary to do the error correction method employing 16 bit CRC. The system also retransmits, when an error occurs. The transmissions are normally completed in about 50 miliseconds, which allows the ticket holder to pass the electronic card quickly over the antenna, and still have the entry gate or exit gate released for passage. The fare card may be in a wallet and still make the electrical engagement of the transformer coupling.

The fare card is designed to be transparent to existing magnetic striped tickets and thus not disruptive in use to any existing automatic fare collections sytems that use magnetic striped cards or tickets. The transformer coupling is only between the card and the target, and the coupling can only occur when the two antenna windings are brought into close proximity. Both the card antenna and the target antenna are shielded for RF. This removes interference with other electronic equipment, and also avoids the need for an FCC license for the cards. Further there is no fixed installation of the card required, it can just be left in a persons wallet, as long as it's brought close enough to the target antenna. The electronic card has a processor therein for permitting a highly reliable system for verifying data integrity. This makes for a very low error rate. The card also has a read only transmission, and thus will not be transmitting data other than to the target antenna, and yet has a full read in capability. The target antenna is connected to a computer within the transit system, which makes it possible to identify and verify all card fare information from up to date fare tables, to identify missing fare cards, and to provide other information to central processors relative to such fare cards and their use.

The achievement of these and other objectives and advantages by the invention will be understood when the detailed description of the invention, given hereinafter, is read with reference to the next summarized illustrations, in which:

Figure 1 is a block diagram of the electronic fare card;

Figure 2 is a block diagram of the target antenna circuit;

Figure 3 is a block and schematic diagram of the transit system that is interfaced with the target antenna circuit and processor;

Figure 4 is a top plan view of the target antenna;

Figure 5 is a sectional view taken along lines 5-5 of Figure 4;

Figure 6 is a top plan view with parts phantom of the electronic fare card;

Figure 7 is a sectional view taken along line 7-7 of Figure 6;

Figure 8 is an illustration of the electronic fare card being moved over the target antenna;

Figure 9 is a schematic diagram of the circuit that processes the transformer coupled signal that turns the electronic fare card on.

Figure 10 is a schematic diagram of the RF generating and processing system of the target.

Referring to Figures 1 through 8, the electronic fare card 12 contains an antenna, see Figures 1, 6 and 7. The card 12 comprises a printed circuit board 18 having circuits 20 thereon, that are surrounded by a faraday shield that comprises mylar embedded with a conductive layer, generally called an anti-static foil. The foil is on the upper side 16 and the lower side 17 of the card. The card is then encapsulated in a plastic container having a topside 14, a lower side 13 and rounded ends. The card size may vary depending upon its construction and intended use, but in general it should have a size comparable with a credit card so that the card may be placed for example in a user's wallet. The wallet and/or the card may then be easily passed over the target antenna 22, see Figure 8, in accordance with the operation of the invention. An example of such a card would have a size of 2.15 inches by 3.4 inches by 0.16 inches, and would weigh approximately 1 ounce. The antenna 19 in the card is a coil having several turns, approximately six, that are laid around the edge of the circuit board 18. Appropriate connections are made with the electronic circuit 20.

The electronic card 12 couples in its operation with a target antenna 22, see Figures 4, 5 and 8. The target antenna, hereinafter target, comprises a plastic dome structure 24 having an inside layer of screening, mylar, anti-static foil, and a single wire coil 28 that is connected to the electronic circuit in Figure 2. The target circuit provides a continuous RF signal or electrical power to the coil continuously.

The card circuit, see Figure 1, which is normally deactivated, is moved by a transit patron over the top of the target 22, as illustrated in Figure 8. The target outline 23 on the top of the target housing 24 illustrates the target area. The antenna winding 19 being in proximity with the RF carrier in the target antenna loop 28, loads the target antenna 28 with an energy transfer to antenna 16 the manner of a transformer. This causes a 3 MHz carrier signal to be generated in antenna 16 that is rectified by the RF rectifier circuit 36 into a DC voltage that is fed to a VCC sensor circuit 38. This is a comparator circuit that detects the magnitude of the DC voltage, and when the voltage reaches a sufficient magnitude, a signal is fed to the reset circuit 40 that in turn sends a reset signal through line 41, turning on the processor 42.

Processor 42 has sufficient power from battery 46 to maintain the read and write memory 52. However, the power for operating the processor is primarily the DC power received through the VCC supply 36.

With the processor 42 in operation, the 3 MHz carrier in antenna 16 is detected by detector 34 that detects any information on the carrier signal. The communication from the target antenna 22 to antenna 16 is by AM modulation as will be described in more detail hereinafter. This AM modulation is detected by detector 34 that converts the modulation into a digital signal that is processed by the processor 32. The processor 32 then proceeds under instructions from ROM 50 to process the input digital information, and after completion of an error correction procedure using a 16 byte CRC error correction calculation, the processor then reads out the digital information in RAM 52 to the impedence modulator 32.

The local oscillator synchronizer 48 receives the input 3 MHz carrier and synchronizes the processor clock. The impedance modulator modulates the impedance of the carrier load that is presented by the card antenna 16 to the target antenna. The resulting change in the amplitude of the carrier signal is detected by the target 22.

The target 22, see Figure 2, has an antenna 16 as previously described. The processor 56 is in continuous operation and is driven by clock 74. The processor uses a clock signal 74 that may be provided by a suitable crystal source, and divides the clock signal to provide a 3 MHz carrier to the modulator 60. The processor also provides digital data information to the modulator 60 for amplitude modulating the carrier signal. The processor obtains this information from a read and write memory 62, and from other sources such as from the data switch 60 that accesses the RS 422 innerface 74 and the RS 232 innerface 70. The RS 232 innerface 70 is connected to gate LPC processor 80, as will be described in more detail later.

The modulator 60 then provides a modulated signal through an RF amplifier 64, through the coil 28, see Figure 5, of the target antenna 16. This RF signal is a constant 3 MHz signal in which the data information is in the modulation of the signal amplitude. When the antenna 16 is in position to load the coil or winding of antenna 28, then antenna 16 circuit in the manner previously described is powered up. The electronic fare card transmits its memory information by means of impedence modulation to the antenna 28. At this time, antenna 28 is not transmitting any modulation through modulator 60. Accordingly the carrier is modulated by the impedance loading of antenna 16 which results in an amplitude modulated output to the detector 54. This is converted by detector 54 to a digital output that is fed to the processor 56. The operation of the processor 56 is controlled by the ROM 58, and is capable of writing information into memory 62 and reading out memory 62 to provide digital modulation information to modulator 60.

The target antenna 22, can have any suitable size. An example of an operational size is about 6 inches in diameter. The preferred location of the target electronics is immediately adjacent to the target antenna. However, the target electronics is separately located in a circuit box. While the target provides an RF carrier signal to the antenna 28, there is little radiated by the antenna 28 because the electric field is shielded. The same applies as previously described relative to the shielded antenna in the electronic card 12. The interfacing between the two antennas is one of a transformer coil coupling in which an amplitude modulation is applied to the carrier of the target antenna and the card applies impedance loading on the coil 28 that is reflected in the carrier signal fed from the RF amplifier 64 to the antenna 28. This causes an amplitude modulation of the carrier in coil 28 that is detected by detector 54. The proximity of the card to the target antenna 28 is such as will facilitate this transformer coupling, and thus limit the range of the transmission between the card and the target to that desired, which is typically 2 to 6 inches.

Referring to Figure 9, a schematic diagram illustrates the operation in the target circuit of the modulator 60, the RF amplifier 64, the antenna 28 and the detector 54. The carrier frequency of 3 MHz's is fed through line 100 to a signal squaring circuit 102 to set the right voltage level to about 5 volts. This is the digital level in line 104. The modulated signal from processor 56 is fed through line 106 and is changed from a digital modulated signal in line 105 to an amplitude signal and is mixed at the divider 110 to set the magnitude of the amplitude modulation. The divider circuit 112 adjusts the voltage level of the signal in line 113. The amplifying circuits 114 and 116 amplify the modulated carrier in line 113. A current divider and power amplifier circuit 118 and 119 further processes the RF, AC signal to line 119. The 3 MHz's carrier with the modulated signal from the processor is then fed through line 120 to the single loop winding 28. The power regulator source 122 provides 5 volts VCC power for the logic circuits. The amplitude modulated RF 3 MHz's carrier signal in antenna 28, is a signal that transformer coupled with the antenna 16 of the fare card circuit.

In the receive mode, the nonmodulated 3 MHz's carrier is fed through the previously described circuit to the single loop winding. This 3 MHz signal is then impedanced modulated by transformer coupling with antenna 16 when the fare card 12 is in the readout mode. This impedence modulation, amplitude modulates the RF signal in line 119. This RF signal is fed through capacity divider 124 and the detector circuit 126 to separate the modulator from the carrier. Filter 128 filters out the RF signal, and the amplitude is then fed to line 132. The signal in line 132 is then demodulated by the comparator circuit of the power output from source 133 at a ratio, normally about 10 percent of the modulation percentage, in a comparator that converts a small demodulated signal to a data stream by the circuit detecting when the level is low and high. This pulse stream is then fed through amplifier 130 to provide a standard pulse, digital output in line 134, which is the detector output of detector circuit 54 to the processor 56. This output provides the digital data received by antenna 28 from antenna 16, which transmits the data from the read and write memory 52.

Referring now to Figure 10, a schematic circuit and block diagram illustrates the general operation of the fare card circuit. Winding 16 is moved into the transformer coupling with the primary winding or antenna 28 of the target circuit. The magnetic field of the transformer coupling generates the 3 MHz power in the antenna circuit, with capacitor 150 tuning the circuit to the MHz carrier, allowing the antenna winding 16 to be spaced a greater distance from winding 28 and still have sufficient power and signal transfer to winding 16.

The 3 MHz carrier signal is fed through line 149 and rectified by diode 152 and capacitor 154 to provide a DC output to lines 157 and 159. The DC electrical power in line 159 passes through current limiting resistor 156 and through sense resistor 162 to the diode 180. Resistor 156 has a large resistance. Capacitor 160 removes the amplitude modulation from the DC power and the DC power is also fed through line 163 to the imput to comparator 172 and through line 161 to the comparator circuit 167. There is essentially no current flow initially in line 159 and so the voltage rises rapidly, normally in about 1 to 2 miliseconds, to above five volts. The zener diode 178 is set at five volts, and limits the voltage in line 191 to 5.1 volts, which voltage is then fed through line 190 as the power supply for the operation of processor 42.

In initial operation, comparator 172 senses the voltage drop across sense resistor 162. When the voltage is sufficient to cause the zener diode 178 to conduct, this increased voltage drop across the sense resistor is sensed by comparator 172, which provides a wake up signal or reset signal through line 174 and capacitor 176 to processor 42. Processor 42 then powers up with the voltage supply through line 190.

If the DC power from antenna winding 16 and line 159 is interrupted or decreased below the five volt standard set by zenar diode 178, then this interrupts the current flow through resistor 162. This is sensed by comparator 172 and its operating circuits, which turns off the amplifier and terminates the signal in line 174 turning off the processor 42. There is a sufficient residual charge left in capacitor 176 that discharges back through line 175 and provides the processor 42 with an interrupt signal and sufficient power to cease operation. When this occurs, the power supply through line 190 is also terminated. However, battery 195 provides a sufficient, low current flow through line 192 and line 191 to the processor that maintains the read and write memory 52 of the processor 42.

In normal operation, the DC power in line 159 provides operating power through lines 163, 200 and 202 for the comparators 170, 182 and 194. When the power from battery 195 is low, this is sensed by comparator 194 and a signal is fed through line 196 to the processor 42. The processor 42 then modulates a digital signal notifying the target that the battery 195 in the card is low and needs to be replaced.

In processing data received by antenna winding 16, the DC signal through line 152 that is fed to line 157 still has the amplitude modulation that was data modulated by the target circuit. This amplitude modulated DC voltage then passes through capacitor 168, with the amplitude portion passing on to the comparator circuit 170 that provides a digital data output corresponding to the data modulation received, through line 189 to the processor 42. The processor then processes this information in the manner previously described.

When the processor 42 is instructed to access the data in RAM 50, the digital data is fed through line 196 and through amplifier 182 and line 98 to turn on and off the field effect transistor 158. The FET circuit is in parallel with the large resistance, resistor 156. Accordingly, the opening and closing of the FET 158 changes the impedance in the power circuit of winding 16 providing data impedance modulation to the transformer coupling circuit. The unrectified 3 MHz carrier in winding 16 is also fed through line 188 and lines 184 and 186 to provide a synchronizing signal to the L.O. synchronzier 48 input to the processor 42.

IN OPERATION

In the normal state, the target 22 is generating a 3 MHz carrier in the target antenna 28, and its processor 56 is listening for a response. The processor 42 in the card 12 is asleep with ticket data being retained in the battery supported memory 52. The processor 42 is not being turned on because it has not received sufficient power through its antenna source. The card would normally not see power unless a source was brought close enough to provide the coupling with the card antenna. But even if power were turned on in the card processor, the card would still not see the appropriate modulated information to which it could respond.

The electronic card 12 is then brought into target range and passed over the top of the target antenna as illustrated in Figure 8. The three MHz carrier is coupled into the antenna 16 and the voltage induced is then rectified by the RF rectifier circuit 36. When the VCC power supply reaches the minimum value (for example 5 volts) as determined by VCC sensor 38, the reset circuit 40 turns the microprocessor on by a signal through line 41. A Processor 42 then reads its battery powered memory 50 and starts to follow the program sequence of a 10 miliseconds time gap. The processor transmits through the impedence modulator: 20 miliseconds of ticket data every 30 milisecond.

The target antenna 28 receives the impedence induced ticket data in detector 54 which is fed as digital information to processor 56. Processor 56 then activates through line 75 the light control 76 that turns on a red light at the target, indicating that an information coupling has been made. The target then verifies the data integrity and sends a hold message through modulator 60 and RF amplifier 64 in the form of amplitude modulation to the carrier frequency in the antenna 28, and to the card. The target processor uses the CRC standard method of error checking, which requires computational power both at the target 22 and in the electronic card 12. The computational output for CRC is calculated from the data received from the card, and a verification of the CRC number is then made. If the CRC digital number calculated from the transmitted data stream is not verified, the target 22 repeats the process. If the CRC number is never verified, then eventually the transmission is terminated by the reset interrupt generator 40 as will be explained hereinafter.

When the integrity of the data is verified, then the target 22 sends a hold message from processor 56 instructing the card to shut off the transmission from the card so the terminal can calculate the data stream information received about fare, identification of the card, and other transit information. The card 12 in receiving the hold message ceases data transmission for 100 miliseconds. During this period of time, the processor 56 through its memory 62, and in interface with the gate LPC processor 80, calculates the fare data and transmits this data along with other data to the card 12. Such information should include the new stored value in the card, which could be reduced five dollars paid for the ride. This information is received by the antenna 16, processed by detector 34 and fed through processor 42 to the RAM 52. Again, this transmission is subject to the CRC verification of data integrity, which is done in each transmission. This time, the calculation of the CRC number from the data stream, is made by processor 42 in the card 12.

The target then passes the received data from the processor 56 through the data switch 60 and innerface 70 to the gate LPC processor 80. The LPC processor checks that the data follows fare table rules and generates new data to be written into the card memory 52. The LPC processor 80 also passes new data to the target, which transmits these data to the card's ROM 52.

The electronic card receives the new data and places these data in the battery powered memory 52 in the read mode, after the card verifies the received data under the CRC verification system. The processor 42 then initiates and sends an acknowledgement message (ACK) back to the target and the processor 42 and the electronic card goes to sleep.

The target 22 receives the ACK message and through line 75 to light control 76, switches the light from red to green, and then passes a credit information signal to the gate LPC processor, which opens the gate. The green light generally turns off after about one second. The electronic card 12 is moved from the target range and power is removed from the card, which is already asleep. The target 22 circuit continues to generate the 3 MHz carrier and the target receiver continues to listen for responses.

The system of the electronic card and the target 22 of this invention are particularly adapated for use in fare collections systems such as illustrated in Figure 3 where a gate processor 80 receives the information as previously described through line 79 from the target 22. The processor sends appropriate information to the station computer 94(a), of station computers 94(n), to initiate the opening or closing of automatic gate 92(a), of automatic gates 92(n). This information may also be fed through line 85 to the operations control center computer 84, where the information may be used in ticket generator 88, stored in medium 82, or displayed at a terminal 86.

The reset circuit 40 receives a sensor signal and turns on the processor 42. If the time on target is less than 50 miliseconds, then this is sensed through sensor 38 by the interrupt generator 40 that then shuts off the processor 42 and accordingly the gate does not open. Because the card 12 is always being moved past the target 22, the system does not continue to operate when the card is moved away from the antenna 22. The interrupt generator 40 will generate an interrupt signal that will turn off the processor 42, even though the processor has not completed its operation. If the processor has completed its operation, then by its own data control, it will shut itself off as previously described.

WE CLAIM:

CLAIMS

1. A spaced fare card processing system comprising:

a transit gate target having a winding and means for supplying a continuous RF signal to said winding;

a fare card having stored fare data in memory and a winding movable over said target winding making a momentary transformer coupling circuit;

processor means in said fare card for transmitting said fare data in impedance modulation of said transformer coupling circuit, and

said target having detector means responsive to said impedance modulation of said transformer coupling circuit for demodulating said fare card data.

2. A spaced fare card processing system as claimed in Claim 1 including:

processor means at said target for transmitting interrogation data in amplitude modulation of said RF signal to said transformer coupling circuit.

3. A spaced fare card processing system as claimed in Claim 2 including:

detector means in said fare card for detecting said amplitude modulation data and transmitting said data to the fare card processor.

4. A spaced fare card processing system as claimed in Claim 1, in which:

said fare card processor means including modulating means for modulating said stored fare data in impedence modulating transmission to said transformer coupling circuit.

5. A spaced fare card processing system as claimed in Claim 4, including:

oscillator means in said fare card for generating an oscillating signal synchronized to the frequency of said RF carrier signal.

6. A spaced fare card processing system as claimed in Claim 5, including:

means for synchronizing said impedance modulation to said synchronized oscillating signal.

7. A spaced fare card processing system as claimed in Claim 4, in which:

said RF signal including electrical power in said fare card winding during said transformer coupling;

sense means for sensing the voltage of said electrical power and providing an output signal when said voltage reaches a set magnitude; and

reset means responsive to said output signal of said sensing means, for energizing said fare card processor by said electrical power.

8. A spaced fare card processing system as claimed in Claim 7, in which:

said reset means having means responsive to an interruption of said output signal from said sensing means, for de-energizing said processor.

9. A spaced fare card processing system as claimed in Claim 8, including:

sense means for sensing a decrease in said electrical power and providing an interrupt signal that de-energizes said processor.

10. A spaced fare card processing system as claimed in Claim 1, in which:

said fare card having electrical power means responsive to said target RF signal in said fare card winding, for rectifying said power and providing operating power to said fare card processor when said power reaches a given magnitude.

11. A spaced fare card processing system as claimed in Claim 1 including:

RF shielding for shielding electrical RF transmission from said transit gate target winding.

12. A spaced fare card processing system as claimed in Claim 11 including:

RF shielding for shielding statically generated fare card winding.

13. A spaced fare card processing system as claimed in Claim 1 in which:

said fare card having a battery power source for providing the sole power for said read and write memory.

14. A spaced fare card processing system as claimed in Claim 4, in which:

said fare card processor having means for providing a verification signal to said modulating means for modulating said verification signal as amplitude modulation on said RF signal in said target winding; and

said target processor responsive to data in said modulated RF signal, having means for calculating and verifying said verification signal.

15. A spaced fare card processing system as claimed in Claim 14, in which:

said target processor having means for providing a verification signal to said transformer coupling circuit;

detector means in said fare card for detecting said verification data signal and transmitting said verification data to said fare card processor; and

said fare card processor, responsive to said detected verification signal data, having means for calculating and verifying said target verification signal.

16. A spaced fare card processing system as claimed in Claim 15, in which:

said target processor providing a verification acknowledgement signal to said fare card processor on calculation and verification of the verification signal from said fare card processor; and

said fare card processor, responsive to said verification acknowledgement signal, for providing stored fare data to said target processor.

17. In a spaced fare card processing system:

a fare card having a read and write memory for storing fare data, and a winding antenna circuit for making a momentary coupling with a transformer circuit carrying an RF signal, and

processor means in said fare card for accessing said memory data and impedance modulating said data on said winding antenna circuit.

18. In a spaced fare card processing system as claimed in Claim 17 including:

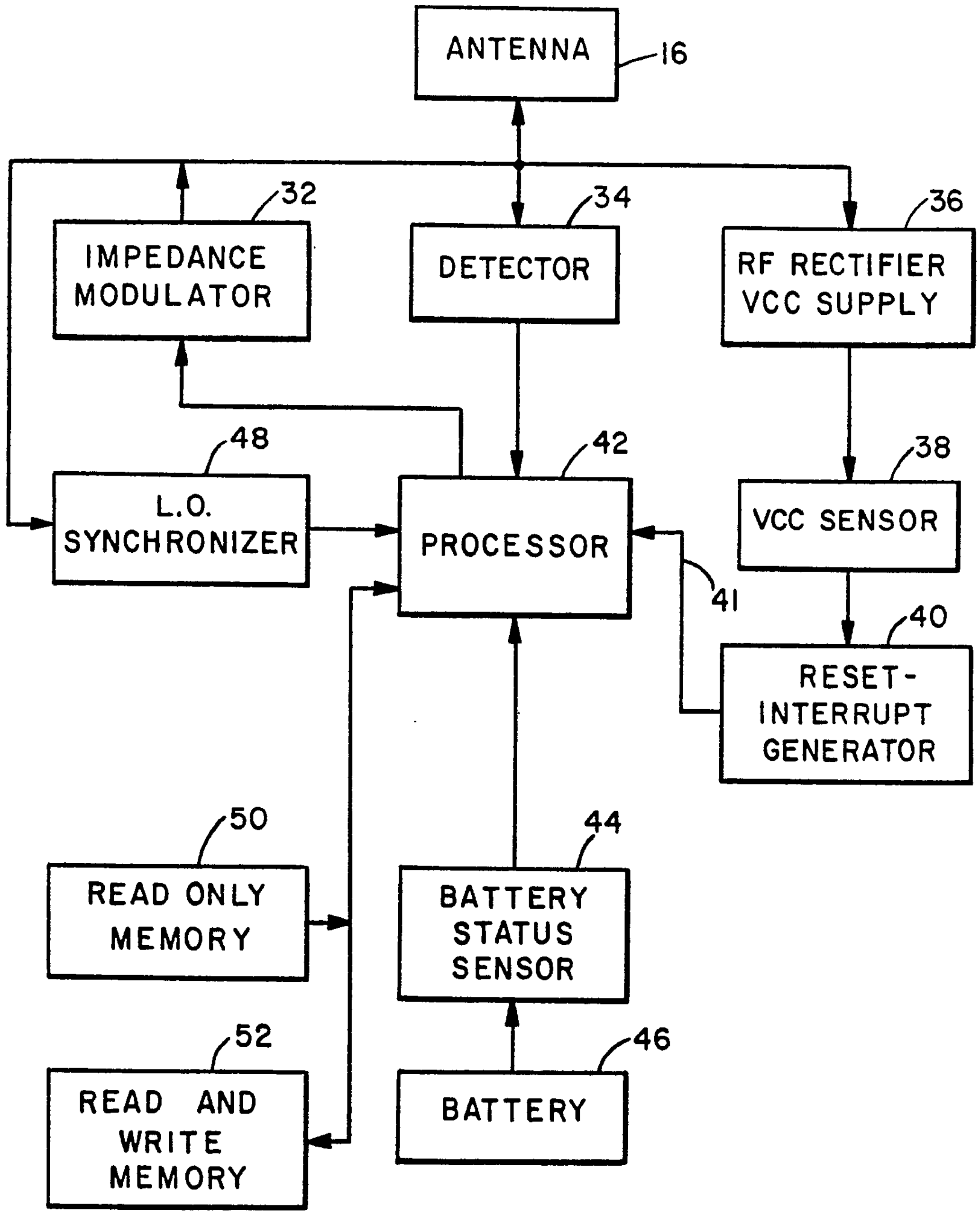
means in said fare card for synchronizing said impedance modulating with the frequency of the RF signal.

19. In a spaced fare card processing system as claimed in Claim 17, in which:

said processor means including means for reading out the fare data in said memory and writing new fare date into said memory.

20. In a spaced fare card processing system as claimed in Clai 17, in which:

said processor means including means for calculating a verification number sequence from data received from a source outside said fare card.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READ AND WRITE MEMORY
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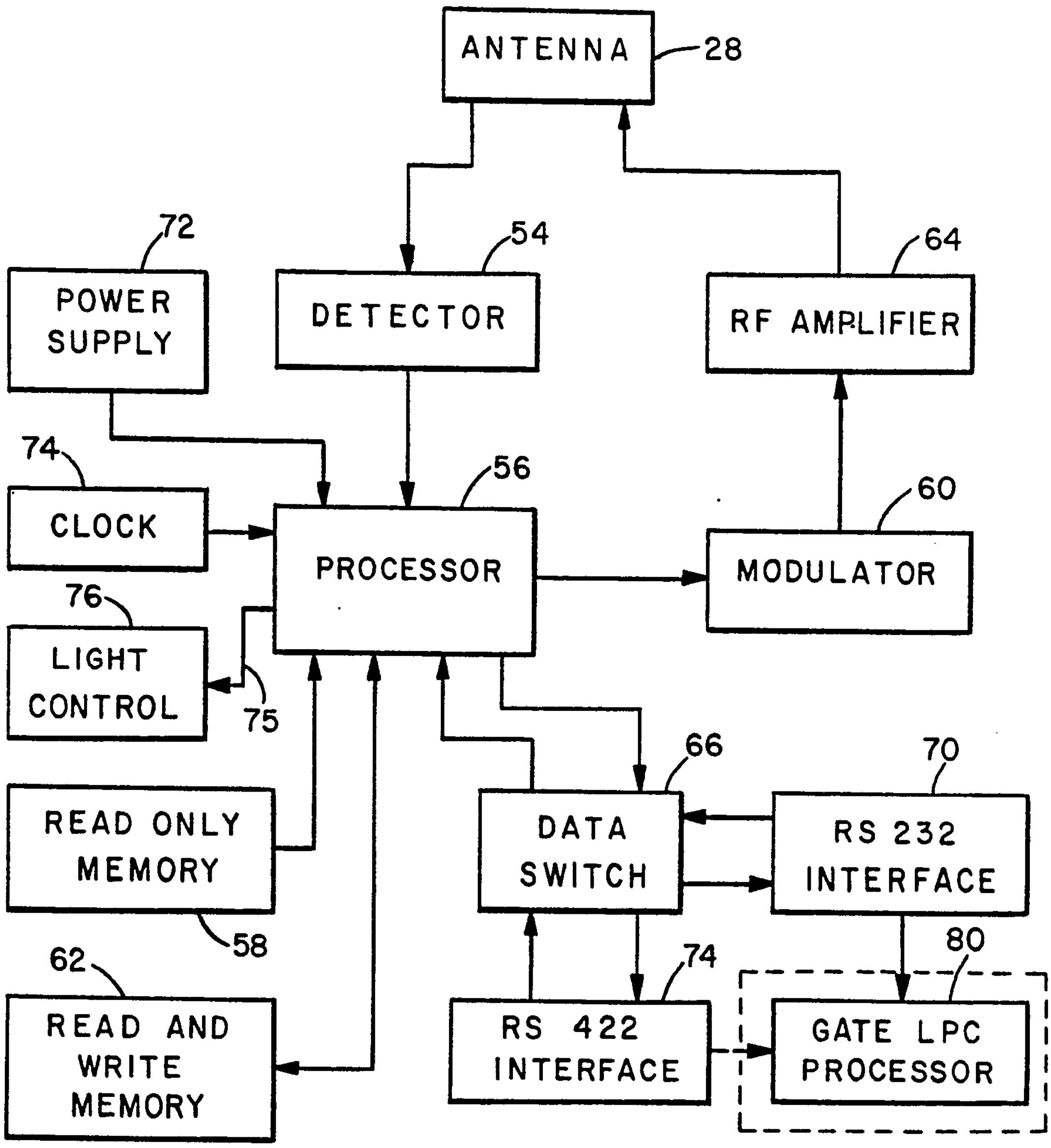
BATTERY

FIG. I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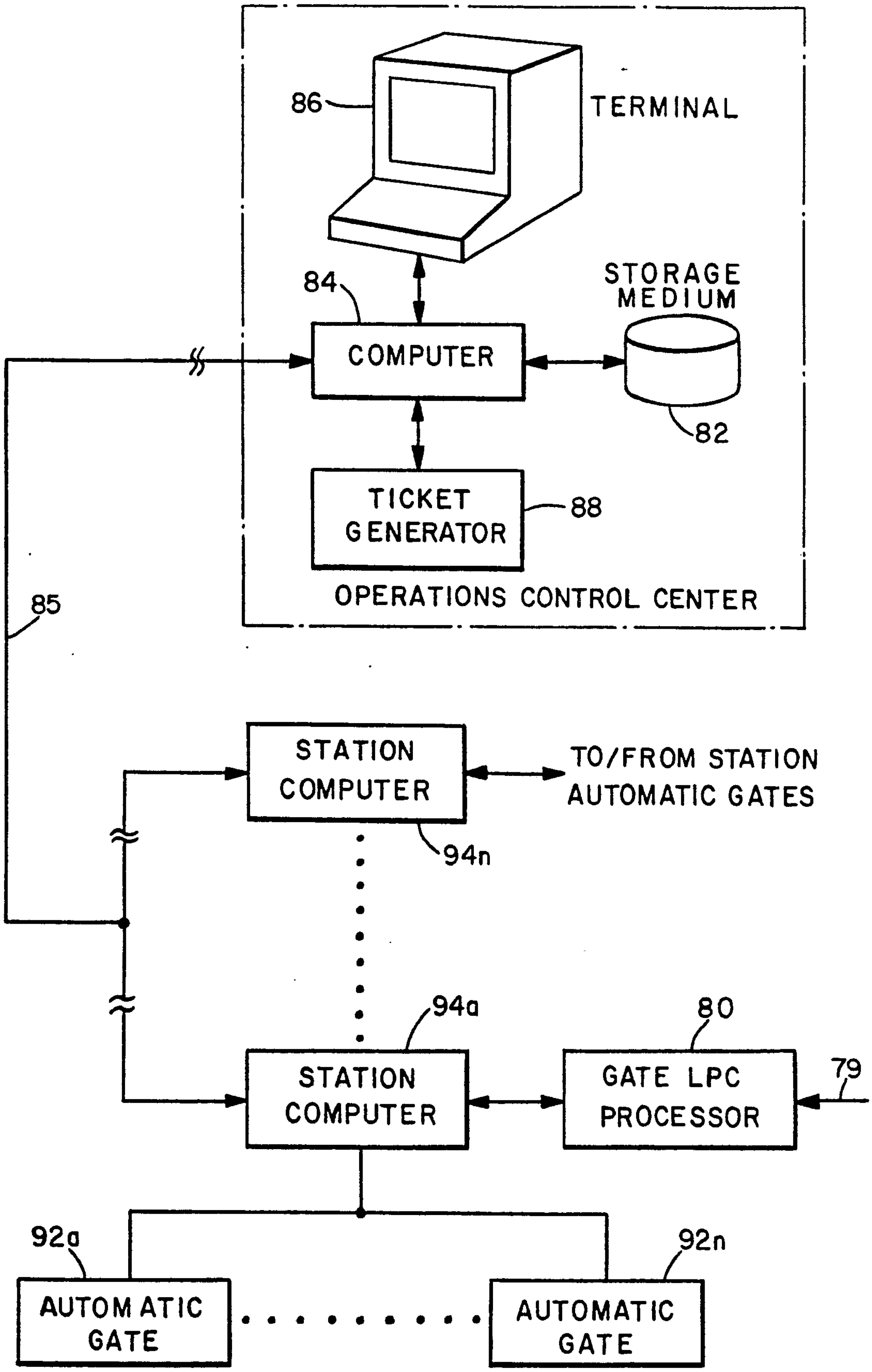
READ AND WRITE MEMORY
RS 422 INTERFACE
GATE LPC PROCESSOR

FIG. 2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OPERATIONS CONTROL CENTER
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STATION COMPUTER
TO/FROM STATION AUTOMATIC GATES
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94a
80
79
STATION COMPUTER
GATE LPC PROCESSOR
92a
92n
AUTOMATIC GATE
AUTOMATIC GATE

FIG. 3

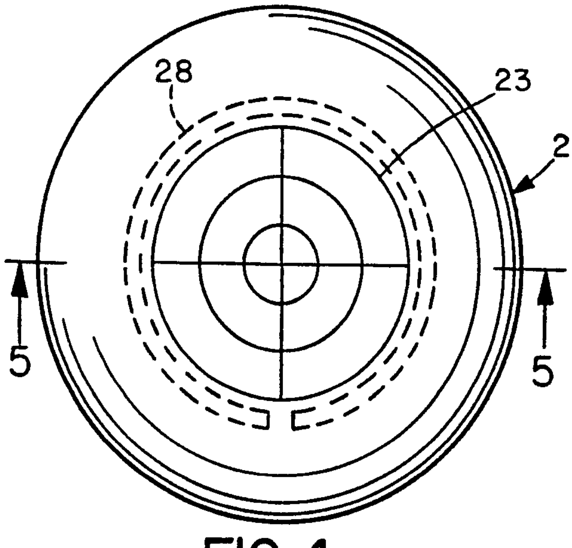

FIG. 4

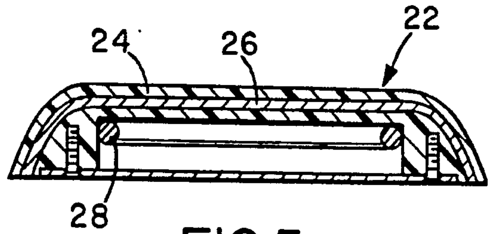

FIG. 5

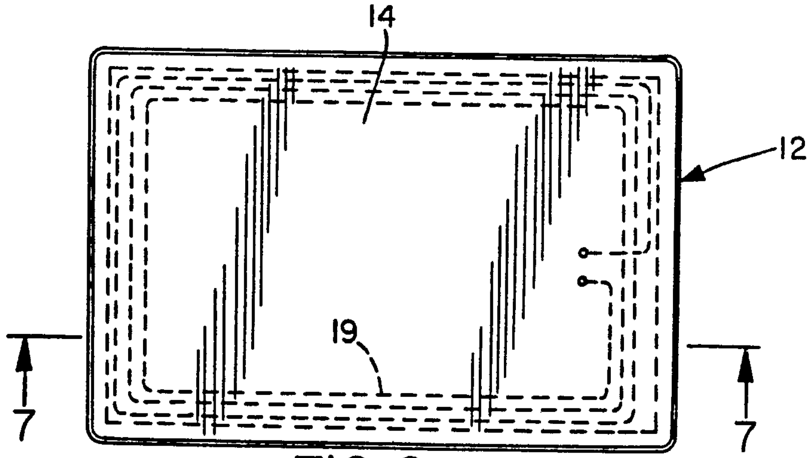

FIG. 6

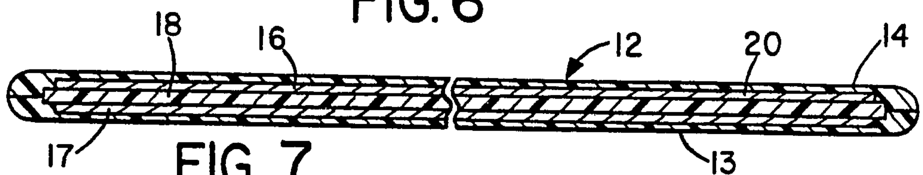

FIG. 7

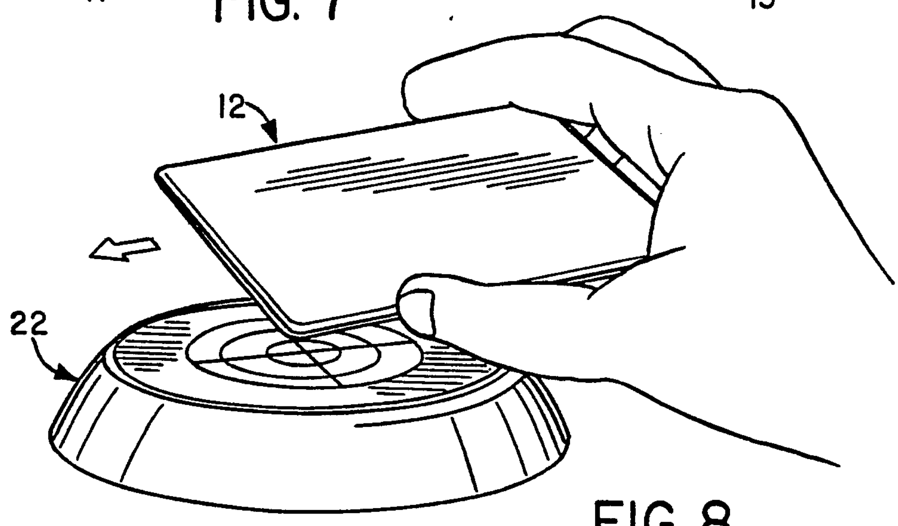

FIG. 8

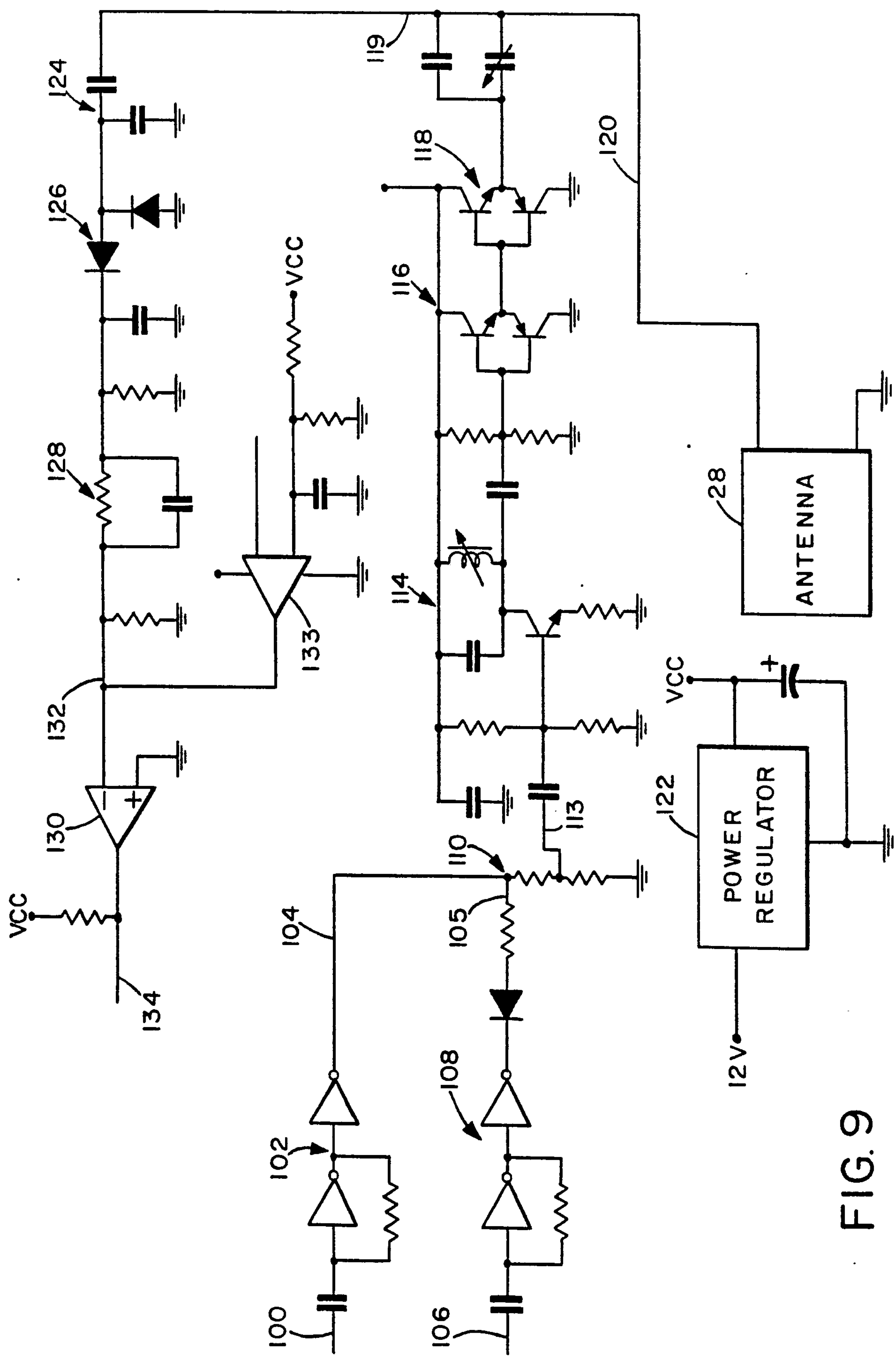
124
126
128
130
132
133
134
VCC
119
118
116
114
113
110
105
104
102
100
106
108
120
28
ANTENNA
POWER REGULATOR
122
12V

FIG. 9

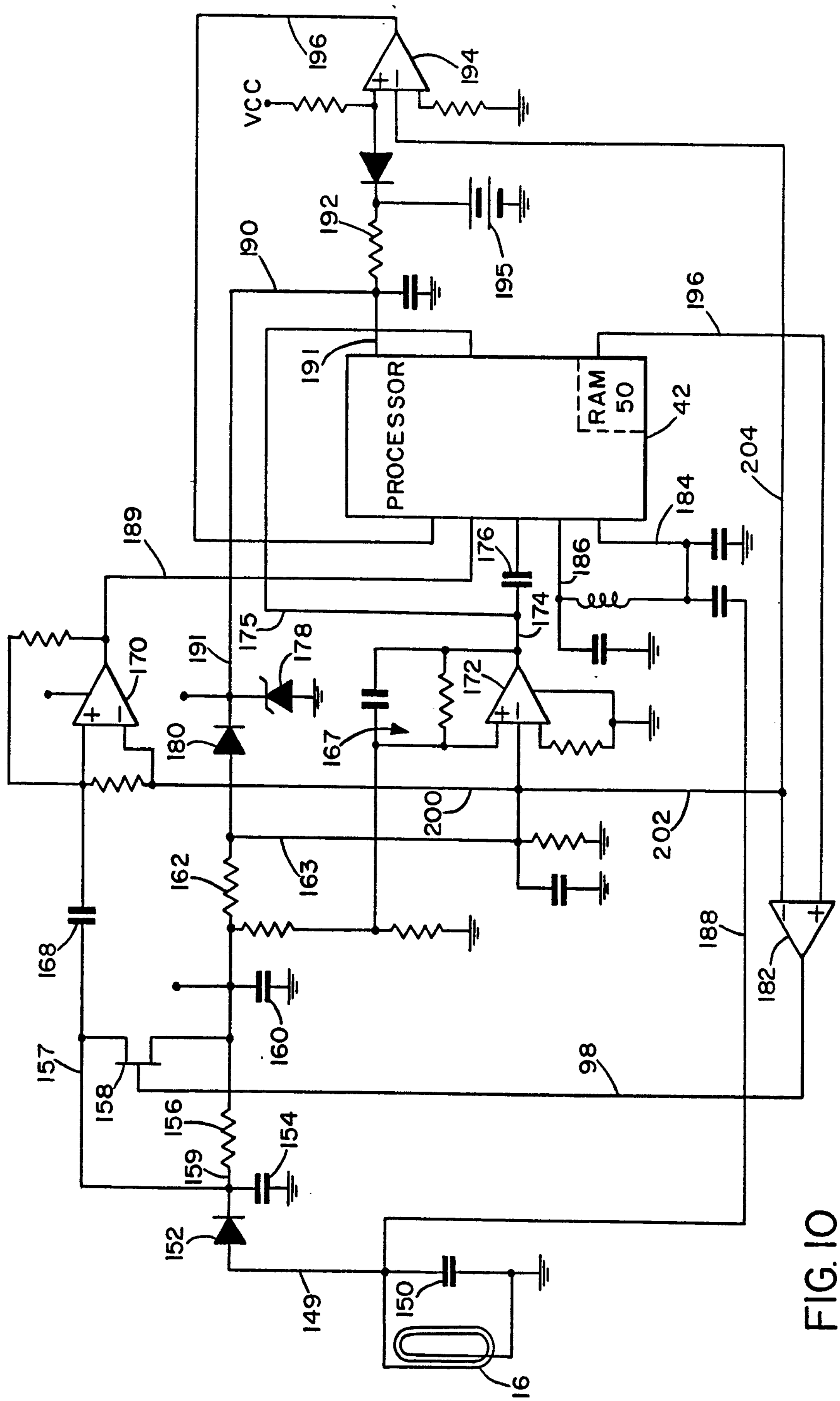
VCC
PROCESSOR
RAM
50
42
16
98
149
150
152
154
156
157
158
159
160
162
163
167
168
170
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FIG.10

INTERNATIONAL SEARCH REPORT

International Application No PCT/US91/01510

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

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

US CL : 235/384,439,492,449 IPC 5 G07B 15/02; G06K 7/00,7/08, 19/06

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
US CL	235/384,449,492,439

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X Y	US, A, 4,899,036 (McCRINDLE ET AL.) 06 FEBRUARY 1990 SEE COL. 1, LINES 37-46, 61-68. COLUMN 3, LINES 23-40. COLUMN 4,all.	1,4-5,7-10,17 2-3,6,11-16,18-20
Y	US, A, 4,818,855 (MONGEON ET AL) 04 APRIL 1989 SEE COLUMN 5, LINES 45-47, and FIG 7	2-3,6,11-16,18-20
A,P	US, A, 4,918,416 (WALTON ET AL) 17 APRIL 1990	
A	US, A, 4,827,115 (UCHIDA ET AL) 02 MAY 1989	
A	US, A, 4,692,604 (BILLINGS) 08 SEPTEMBER 1987	
A	US, A, 4,650,981 (FOLETTA) 17 MARCH 1987	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
26 MARCH 1991	22 APR 1991
International Searching Authority [1]	**Signature of Authorized Officer** [20]
ISA/US	EDWARD SIKORSKI

Form PCT/ISA/210 (second sheet) (May 1986)