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(54) Processing device for an IC card

(57) Two windings (40,104) 15,103 and one magnetic detector such as a Hall detector (34) 16 are provided in each of an IC card (Fig. 2) and a processing device Fig. 1. Using the winding to winding coupling the processing device sends a clock signal and a power supply current to the IC card and transmits a data signal thereto by making use of the coupling between a winding and the magnetic detector. When the data signal is transmitted from one of the IC card and the processing device to the other, the transmission from the other to the one is interrupted.

FIG. I

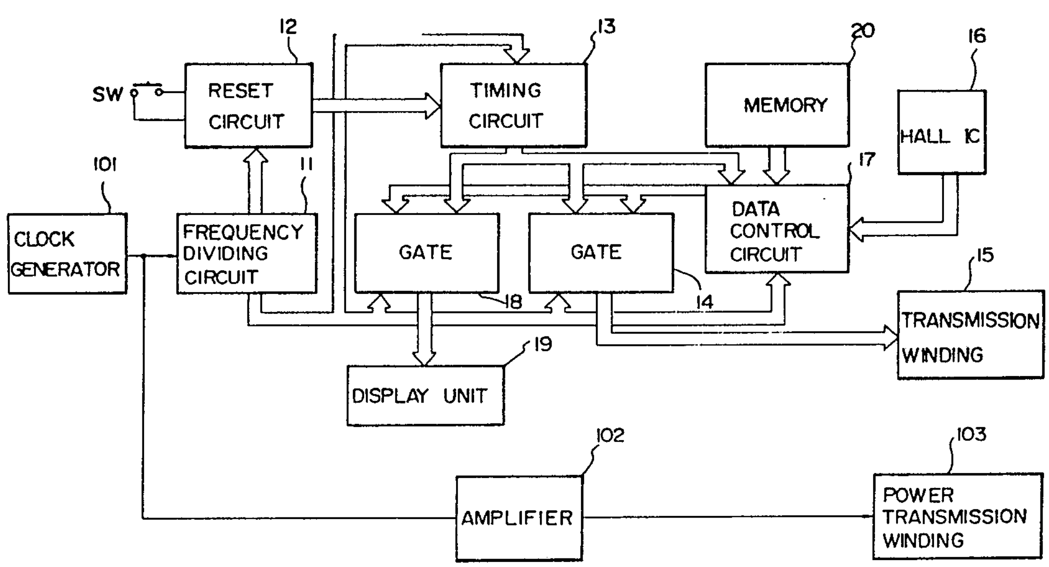

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FIG. 1

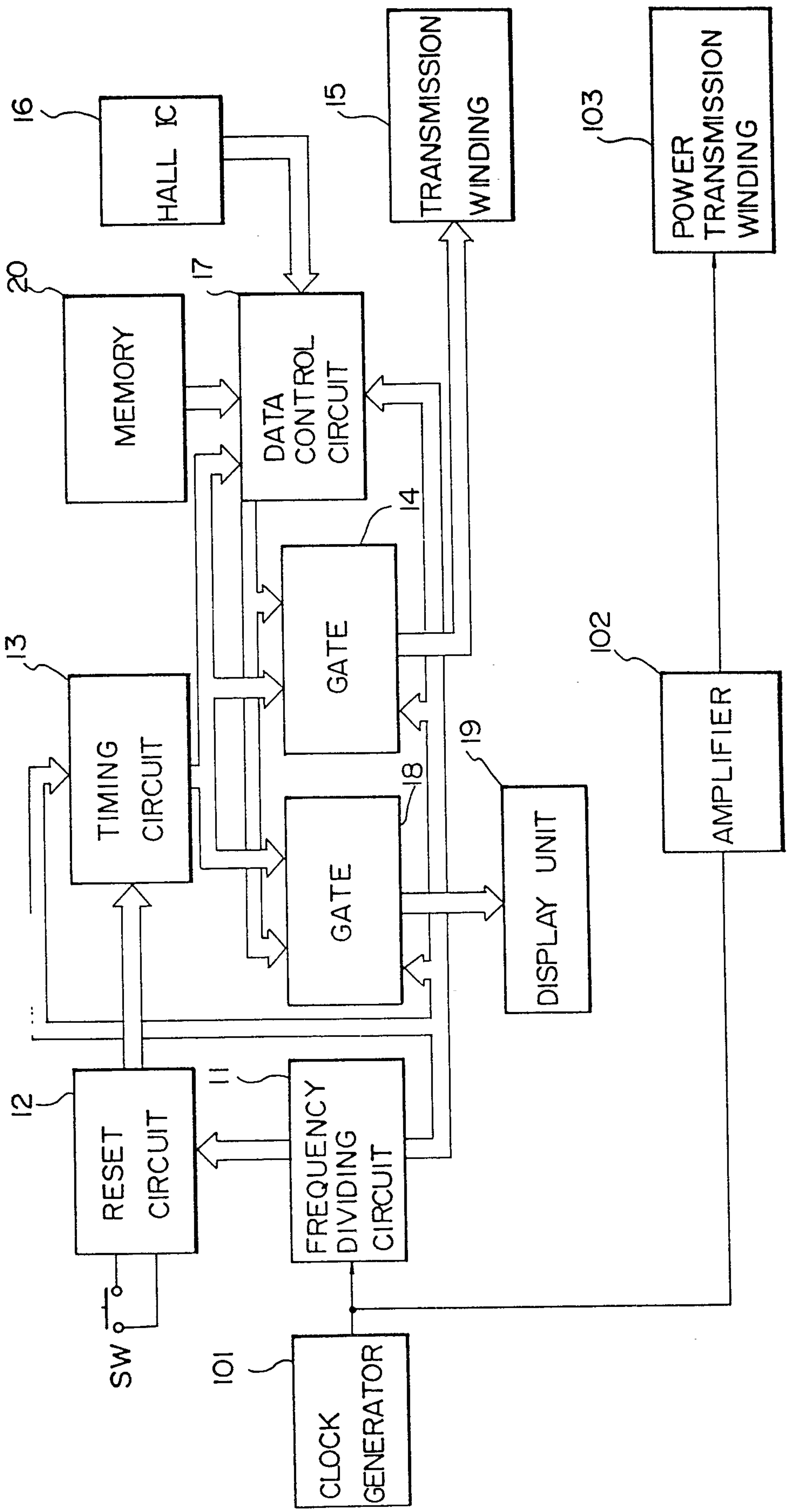
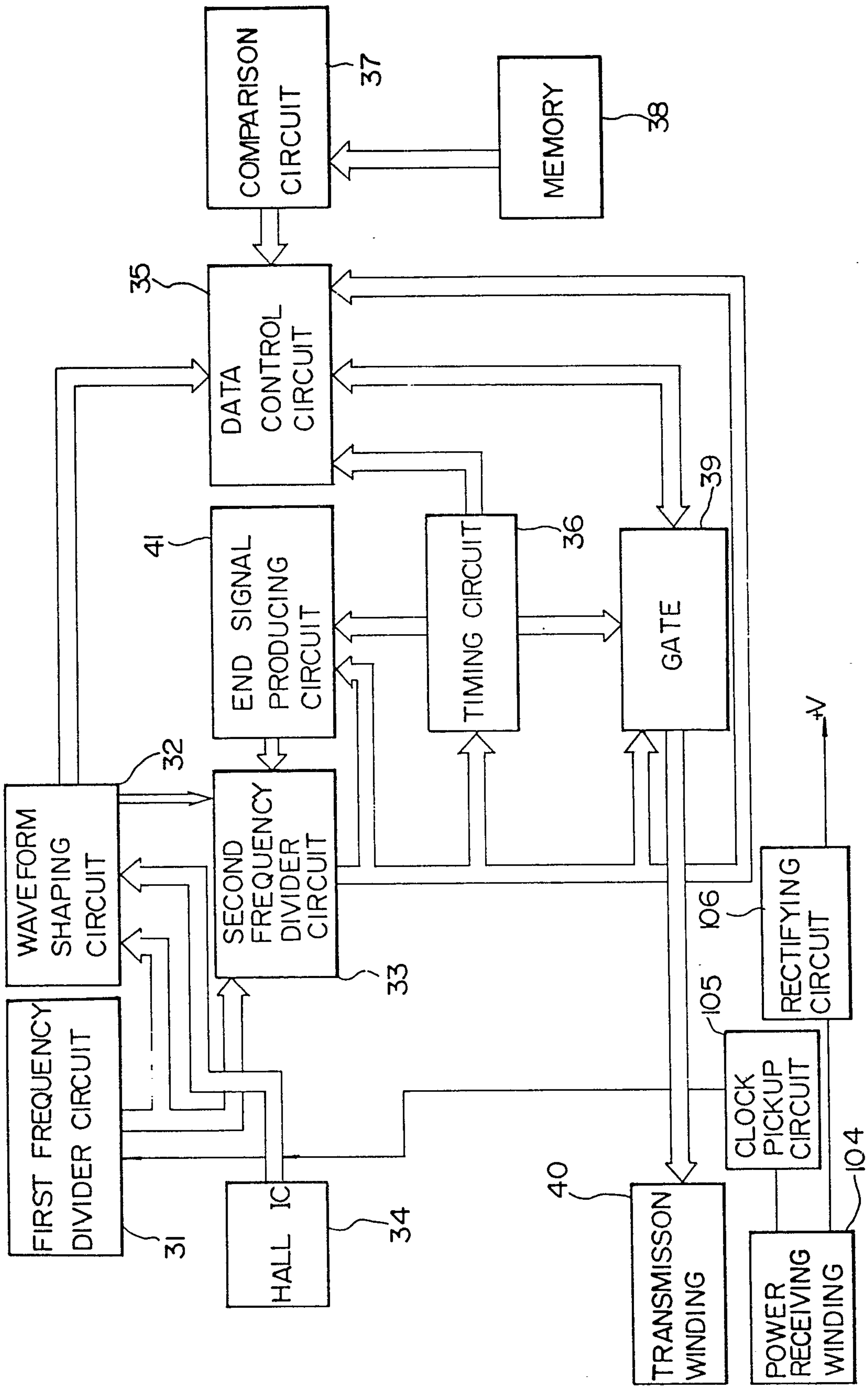

HALL IC
16
TRANSMISSION WINDING
15
POWER TRANSMISSION WINDING
103
MEMORY
20
DATA CONTROL CIRCUIT
17
GATE
14
TIMING CIRCUIT
13
GATE
18
DISPLAY UNIT
19
AMPLIFIER
102
RESET CIRCUIT
12
FREQUENCY DIVIDING CIRCUIT
11
SW
CLOCK GENERATOR
101

FIG. 2


COMPARISON CIRCUIT
37
MEMORY
38
35
DATA CONTROL CIRCUIT
41
END SIGNAL PRODUCING CIRCUIT
TIMING CIRCUIT
36
GATE
39
32
WAVEFORM SHAPING CIRCUIT
SECOND FREQUENCY DIVIDER CIRCUIT
33
+V
106
RECTIFYING CIRCUIT
105
FIRST FREQUENCY DIVIDER CIRCUIT
31
CLOCK PICKUP CIRCUIT
104
HALL IC
34
40
TRANSMISSON WINDING
POWER RECEIVING WINDING

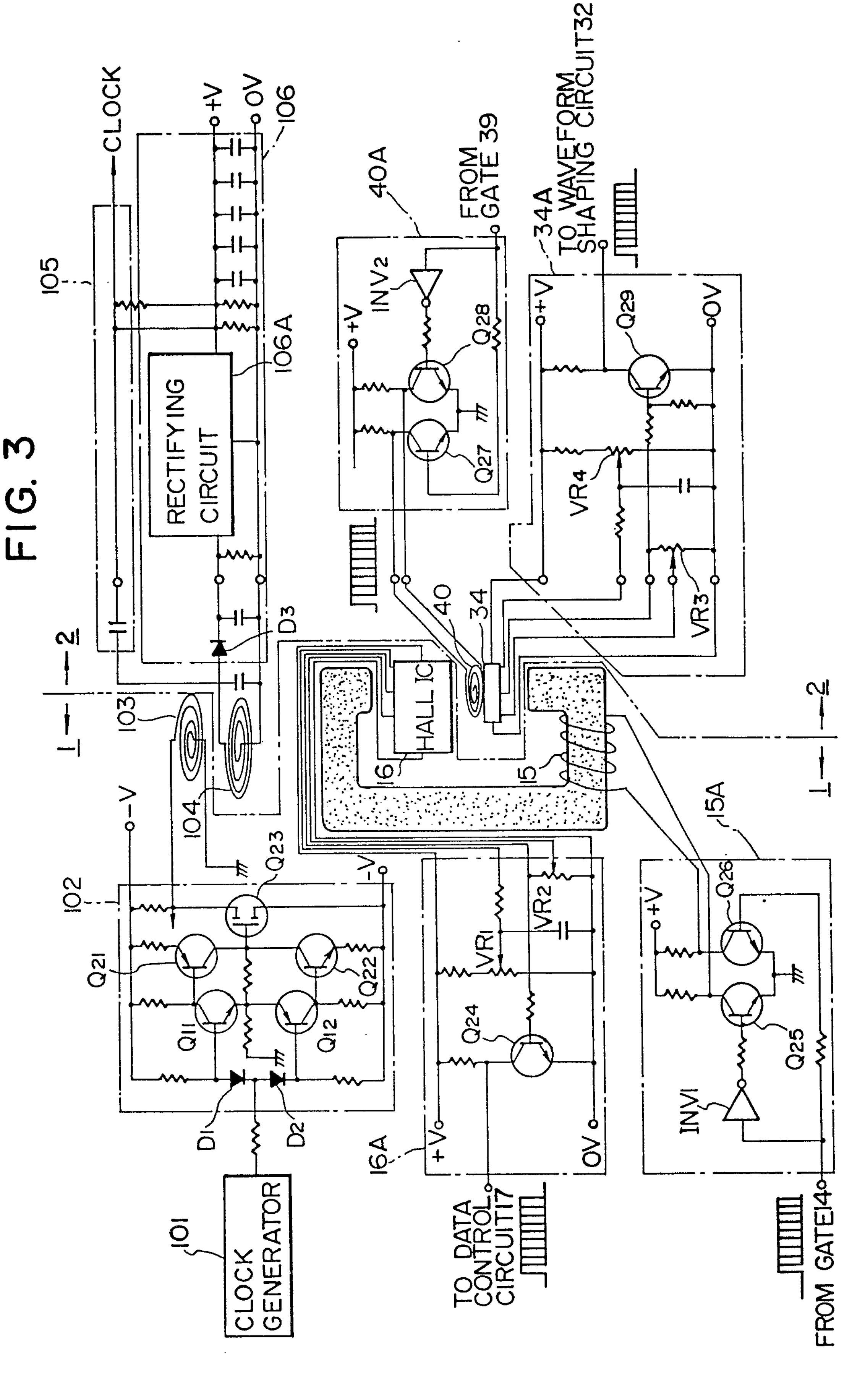


FIG. 3
CLOCK
+V
0V
106
105
106A
RECTIFYING CIRCUIT
D3
2
1
103
104
-V
Q23
102
Q21
Q22
Q11
Q12
D1
D2
101
CLOCK GENERATOR
40A
FROM GATE 39
INV2
Q28
Q27
34A
TO WAVEFORM SHAPING CIRCUIT32
Q29
VR4
VR3
40
34
HALL IC
16
15
15A
Q26
Q25
INV1
FROM GATE14
VR1
VR2
Q24
16A
TO DATA CONTROL CIRCUIT17

FIG. 5

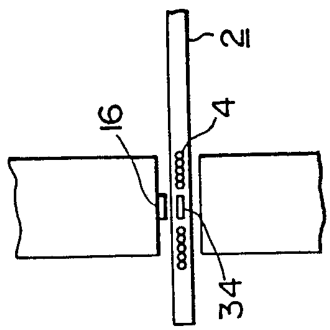


FIG. 4

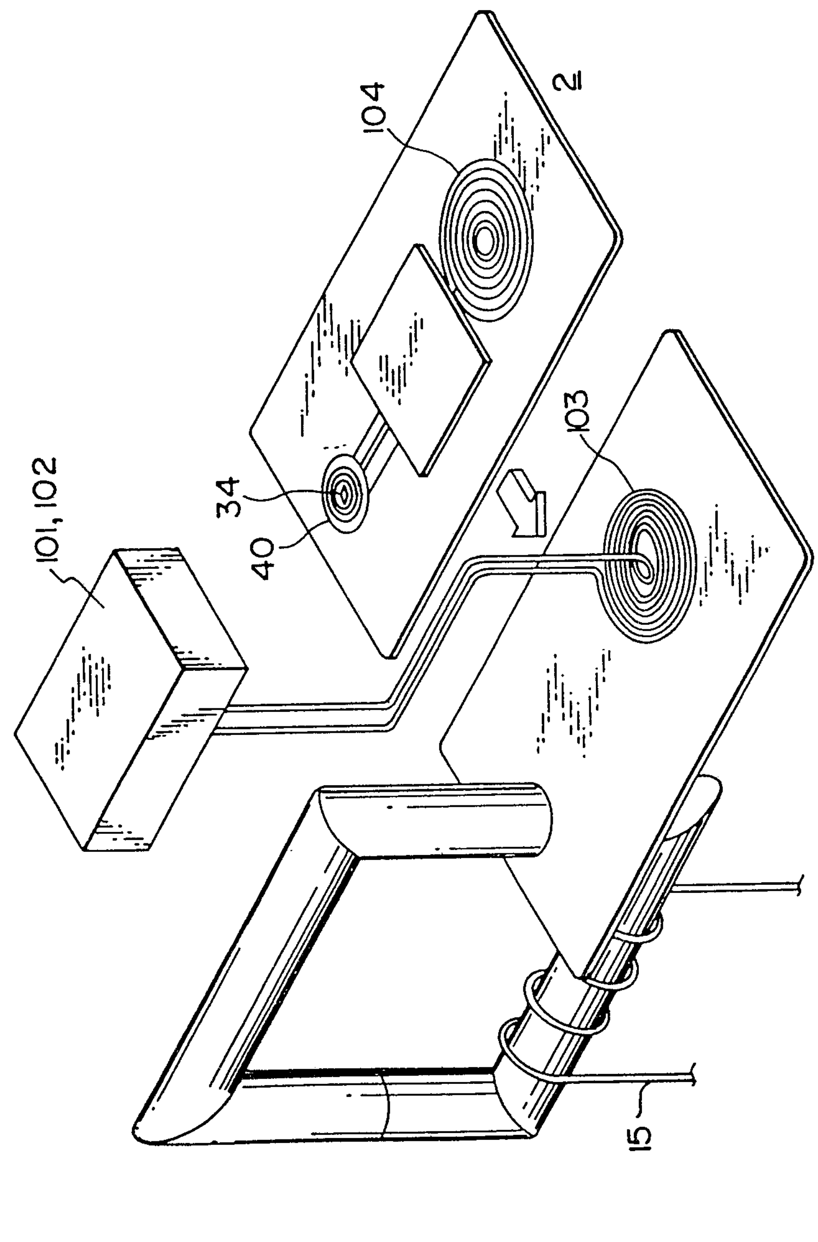


FIG. 6

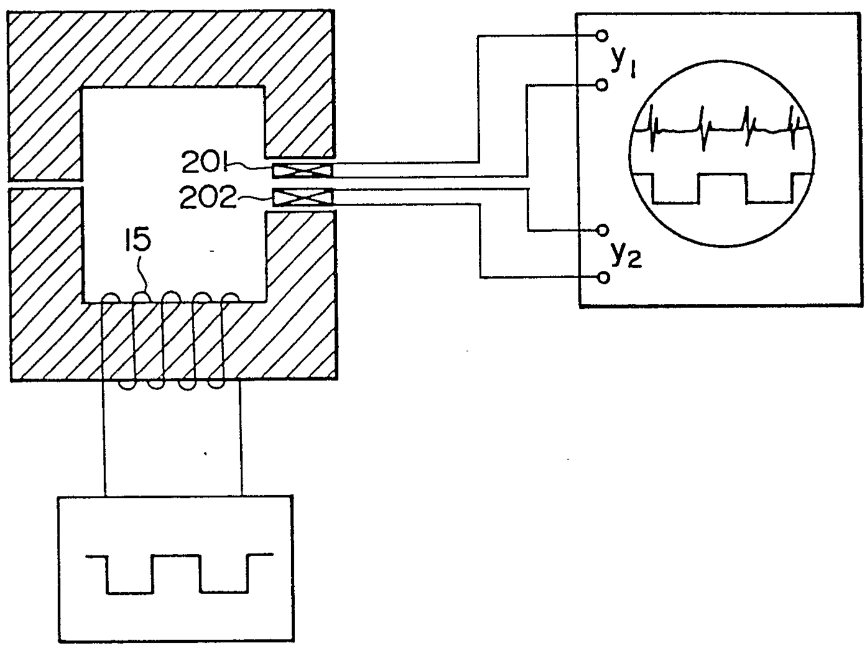


FIG. 7

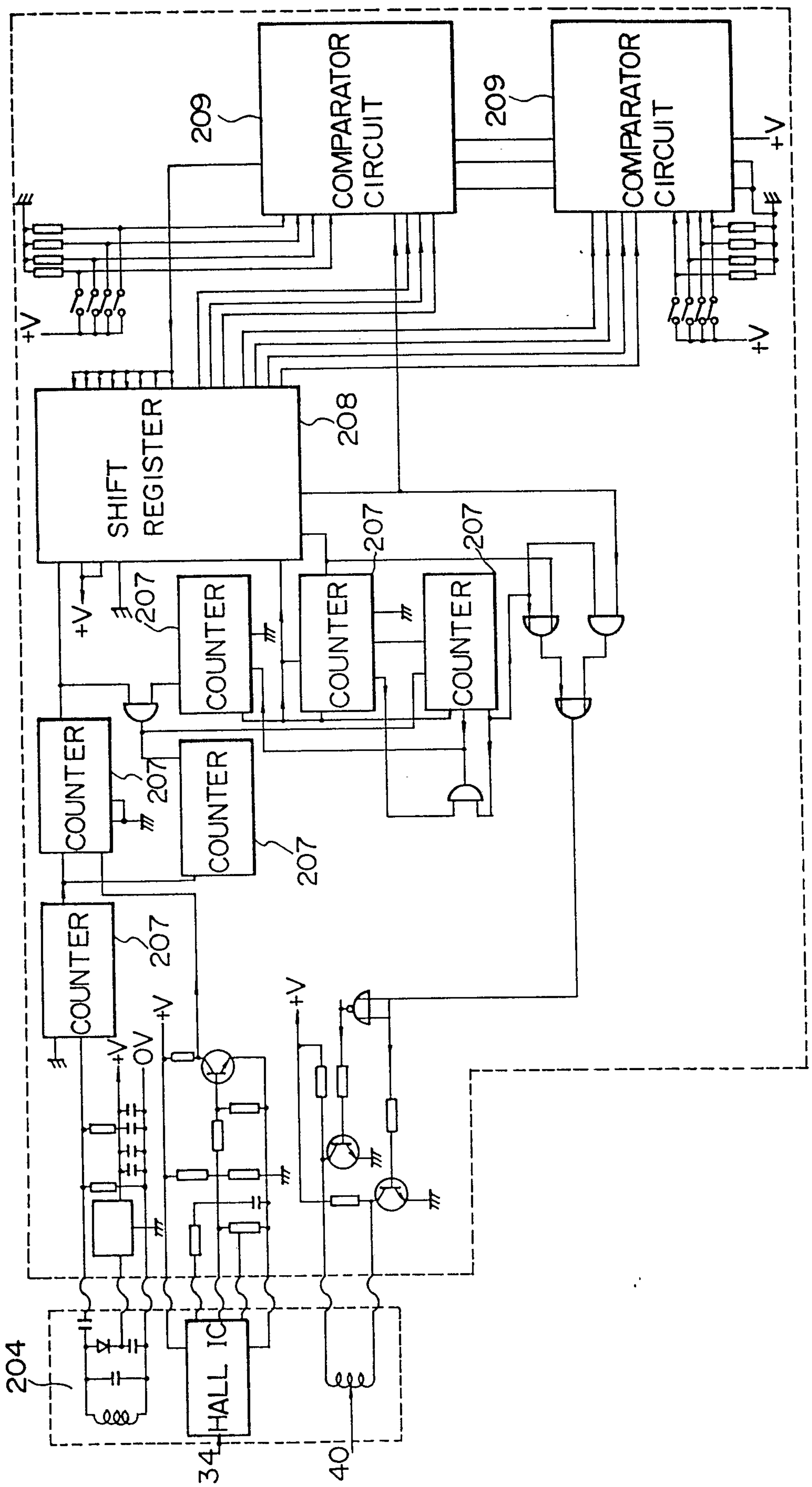

COMPARATOR CIRCUIT
COMPARATOR CIRCUIT
209
209
SHIFT REGISTER
208
COUNTER
COUNTER
COUNTER
COUNTER
COUNTER
COUNTER
207
+V
0V
HALL IC
204
34
40

FIG. 8

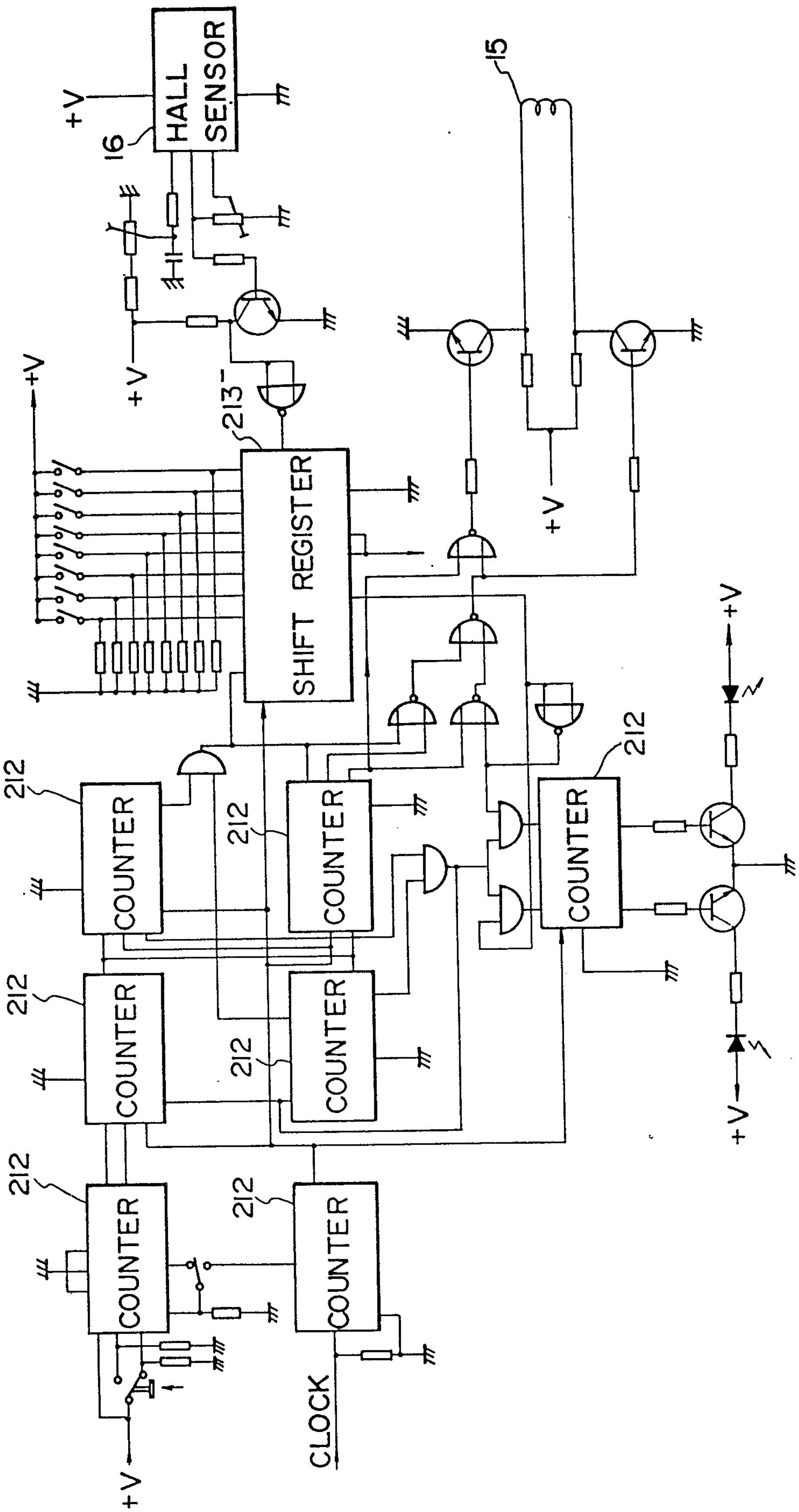


FIG.9

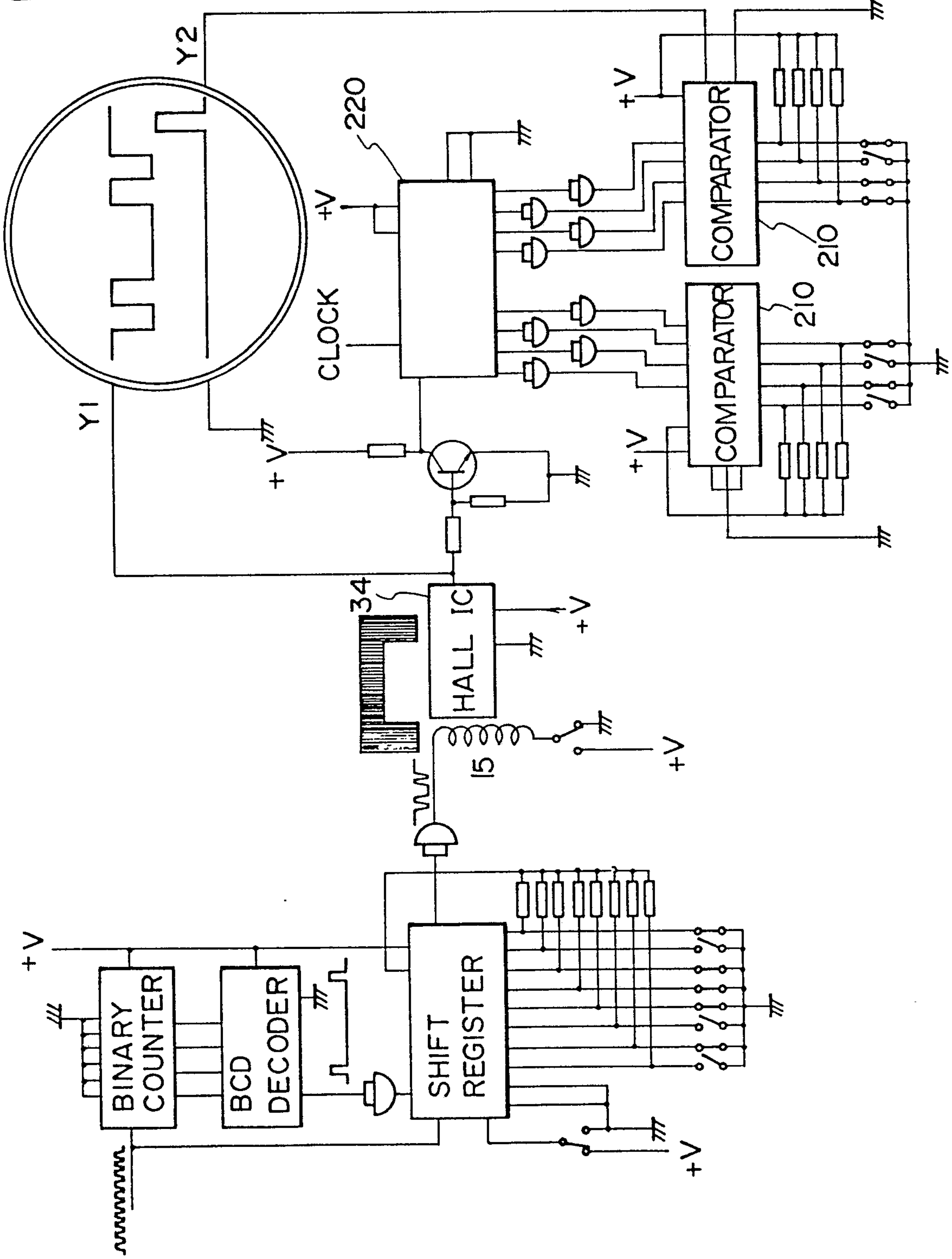
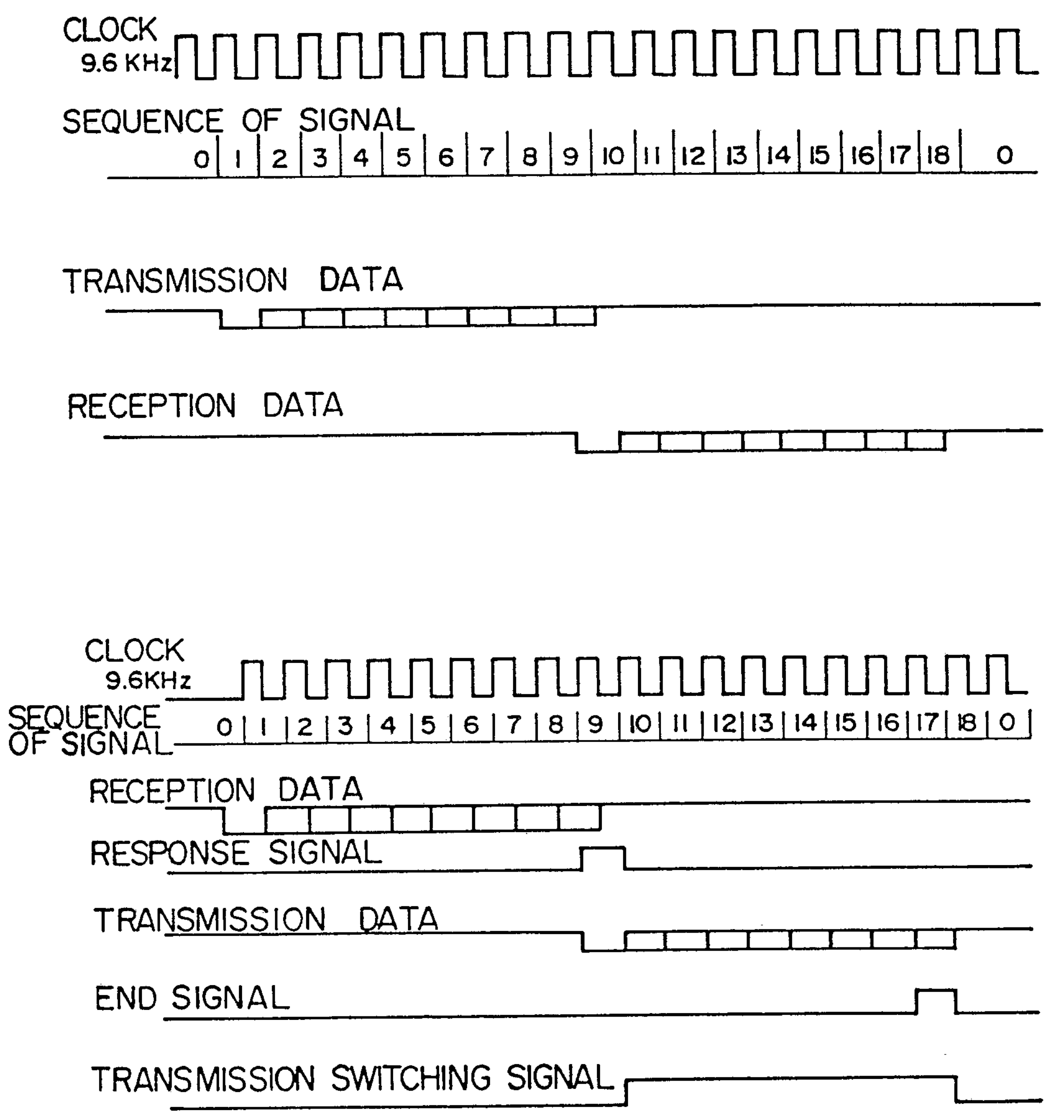

Y1
Y2
220
+V
CLOCK
COMPARATOR
210
COMPARATOR
210
HALL IC
34
15
BINARY COUNTER
BCD DECODER
SHIFT REGISTER

FIG. 10


CLOCK
9.6 KHz
SEQUENCE OF SIGNAL
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 0
TRANSMISSION DATA
RECEPTION DATA
CLOCK
9.6KHz
SEQUENCE OF SIGNAL
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 0
RECEPTION DATA
RESPONSE SIGNAL
TRANSMISSION DATA
END SIGNAL
TRANSMISSION SWITCHING SIGNAL

SPECIFICATION

Processing IC cards

The present invention relates to the processing of IC cards.

Hitherto, passive data carriers of the perforated type, metallic insert type, visible or invisible optical coded pattern type, or magnetic strip type have been widely used as cards in which various kinds of data are recorded.

Recently, as a result of an advance in microelectronics, it has been possible to incorporate an active electronic circuit, eg, a microprocessor, a ROM, and a RAM, into a card. Thus, IC (integrated circuit) cards of bidirectional data exchangeable type have been realised which can not only output data recorded in the card to a terminal equipment (processing unit), but also write data into the card from the terminal equipment.

When such IC cards are used, it is necessary to provide an electrical transmission system between the card and the terminal equipment capable of transmitting not only the bidirectional data but also a power supply to the card. Some known systems have included electrical contacts both on the card and at the terminal equipment.

However, such electrical contacts are likely to be degraded due to stains caused by usage of cards, or are readily broken if cards are bent, resulting in poor reliability,.

For this reason, non-contact electrical transmission systems have been proposed such as capacitive transmission, optical or thermal transmission, modulated high frequency transmission, and inductive transmission. Some of these systems permit transmission from the terminal equipment to the card, but are invalid for transmission from the card to the terminal equipment. This is because a memory card which meets the ISO standard has only a limited amount of available space and/or because analogue circuits such as a special signal wave shaper are required in order to convert a transmitted signal to an original waveform.

According to the present invention there is provided a processing device for an IC card, the device being configured to supply a power signal and a clock signal to the card and to transmit data to the card and receive it therefrom, and the device comprising: a clock generator producing a clock signal, a power transmission winding for transmitting to the IC card an electromagnetic field based on the clock signal, a first memory in which predetermined data is recorded, a transmission winding for transmitting data as an electromagnetic signal to the IC card, a magnetic detection element responsive to an electromagnetic data signal received from the IC card to produce a corresponding electric signal, a display unit for displaying the electric signal from the magnetic detection element, and a data processing circuit for transmitting a data signal from the memory to the data transmission winding in response to the clock signal, and thereafter providing a data signal from the magnetic detection element to the display unit.

In one embodiment, the power transmission winding is formed as a flat winding. The data transmission winding is preferably wound on an annular ferrite core having a gap through which the IC card is inserted, and the associated magnetic detector of the processing device is then located in the gap.

The IC card may also include two flat windings and a magnetic detector, the configuration thus formed enabling mutual transmission of data including control commands between the IC card and the processing device without using electrical contacts.

By way of example only, an embodiment of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a block diagram illustrating a card processing device embodying the invention;

Figure 2 is a block diagram illustrating an IC card for use with the device of Fig. 1;

Figure 3 is a circuit diagram illustrating mutual circuit relationship between the processing device and the IC card shown in Figs. 1 and 2;

Figures 4 & 5 are explanatory views illustrating insertion of the IC card in the processing device;

Figure 6 is an explanatory view illustrating an example of the signal waveforms obtained during the transmission from one winding to the other winding and from a winding to a Hall sensor;

Figure 7 is a circuit diagram illustrating a discriminator employed in a modified IC card;

Figure 8 is a circuit diagram illustrating terminal equipment for use with the modified card of Fig. 7;

Figure 9 is a circuit diagram illustrating how the ferrite core is disposed to form a magnetic transmission route in the equipment of Fig. 8; and

Figure 10 shows a timing waveform of signals in the terminal equipment and the IC card.

Referring to Fig. 1 a clock generator 101 produces a clock having a frequency of 4.9152 MHz. The clock is on one hand amplified by an amplifier 102 and the clock thus amplified is fed to a power transmission winding 103 thereby to be transmitted toward an IC card (not shown). The clock from the clock generator 101 ison the other hand supplied to a frequency dividing circuit 11 to form two kinds of clocks having frequencies of 300 Hz and 9.6 KHz. The clock having frequency of 300 Hz is fed to a reset circuit 12 to serve as a timing signal for successively effecting a plurality of data transmitting and receiving operations. The reset circuit 12 functions to reset a gate 18 for data to be received, a gate 14 for data to be transmitted, and a data control circuit 17, as well as circuit components connected thereto through a timing circuit 13. It is to be noted that such reset operation may be carried out based on the detection of the insersion of the IC card.

The other clock having frequency of 9.6 MHz is fed to the timing circuit 13, the gate 18 for data to be received, the gate 14 for data to be transmitted and the data control circuit 17, and serves as each basis of operating timings for these circuit components. The data control circuit 17 thereamong is operative so as to control to add a start signal to the data from a memory 20 through the gate 14 for transmission data to feed it to a transmission winding 15, or to feed the data from the data control circuit 17 input from a Hall IC 16 to a display unit 19 through the gate 18 for receiving data.

Fig. 2 schematically illustrates an example of internal circuitry of the IC card wherein when it is inserted into the processing device, an electromagnetic field for both clock and power supply is given from the processing device to effect data transmission to the processing device and therefrom.

An electric field having clock frequency (4.9152 MHz) transmitted from the power transmission winding 103 of the processing device is received by a power receiving winding 104. Thus, a clock signal is picked up by a clock pickup circuit 105 to feed the clock signal thus picked up to a first frequency divider circuit 31. At this time, a power supply voltage +V is picked up by a rectifying circit 106 from the power receiving winding 104 to provide a power thus picked up to each circuit component.

The first frequency divider circuit 31 frequency-divides the clock signal of 4.9152 MHz to form a clock signal of 153.6 KHz which is supplied to a waveform shaping circuit 32 and to a second frequency divider circuit 33. The waveform shaping circuit 32 functions to pick up a start signal to feed it to a second frequency divider circuit 33, and pick up data on the basis of the clock signal and the received data from a Hall IC 34 to feed it to a data control circuit 35. The second frequency divider circuit 33 forms a clock signal of 9.6 KHz from the clock signal of 153.6 KHz to feed it to an end signal producing circuit 41, a timing circuit 36, a gate 39 for transmission data and the data control circuit 35. The timing circuit 36 determines the operational timings for the data control circuit 35, the gate for transmission data and the end signal producing circuit 41. More particularly, the timing circuit 36 first allows the data control circuit 35 to be operative thereby to feed the received data from the waveform shaping circuit 32 to a comparison circuit 37 to collate it with storage data in a memory 38. Then, the timing circuit 36 causes the data control circuit 35 and the gate 39 for transmission data to be operative to feed the compared result from the comparison circuit 37 to a transmission winding 40 through the gate 39 for transmission data to transmit it toward the processing device (Fig. 1). Thereafter, the timing circuit 36 allows the end signal producing circuit 41 to be operative, thereby ceasing the operation of the second frequency divider circuit 33.

The cooperative operation between the processing device shown in Fig. 1 and the IC card shown in Fig. 2 will now be described.

When the IC card is inserted into the processing device, an electromagnetic field having a clock frequency is transmitted from the power transmission winding 103 to the power receiving winding 104 of the IC card. Thus, the IC card is ready for providing power supply and forming a clock.

On the other hand, card inserting detection means (not shown) operates the reset circuit 12 to provide a reset signal to the timing circuit 13, allowing each circuit connected to the timing circuit 13 to be reset. Thereafter, the timing circuit 13 enables to operate the data control circuit 17, thus transmitting storage data in the memory 20 to the transmission winding 15 through the gate 14 for transmission data. In this instance, the gate 14 for transmission data transmits the transmission data with a start signal being added to the head thereof.

The data transmitted by the transmission winding 15 is detected by the Hall IC 34 provided in the IC card, thereby to be supplied to the waveform shaping circuit 32. This circuit 32 detects the start signal originally added at the head of the received data signal to feed it to the second frequency divider circuit 33 thereby to start the operation of the second frequency divider circuit 33. Thus, this circuit 33 starts to transmit the clock having frequency of 9.6 KHz.

Then, the waveform shaping circuit 32 supplies the data signal to the data control circuit 35. On this condition, the timing circuit 36 causes to feed the data fed to the data control circuit 35 to the comparison circuit 37 thereby to compare it with the data from the memory 38. Thus, the compared result is picked up by the data control circuit 35. Then, the timing circuit 36 opens the gate 39 for transmission data to feed the compared result from the data control circuit 35 to the transmission winding 40.

The compared result transmitted from the transmission winding 40 provided in the IC card is received by the Hall IC 16 provided in the processing device 1 thereby to be supplied to the data control circuit 17. At the time when the compared result is supplied, the timing circuit 13 feeds the compared result in the data control circuit 17 to the display 19 through the gate 18 for receiving data to indicate it thereon. Such indication is read by an inspector or an operator, thereby to provide a suitable action with respect to the user of the IC card.

Fig. 3 is a circuit including the power system and data transmitter/receiver system of the processing device 1 and the IC card 2 shown in Figs. 1 and 2, respectively. This figure is partitioned by the double dotted line in the central portion thereof wherein the processing device 1 is located on the left hand thereof while the IC card 2 is located on the right hand thereof, and it is assumed that the IC card 2 is inserted into the processing device 1.

Referring to the power supply system, the RF oscillator 102 provides a high frequency power supply to the plane winding 103 for power supply in accordance with the clock signal having a frequency of 4.9152 MHz from the clock signal generator 101. Namely, when the clock signal is "H", the diode D_1 becomes nonconductive while the diode D_2 becomes conductive. As a result, the transistor Q_{11} turns on, so the transistor Q_{21} turns on. On the contrary, when the clock signal becomes "L", in a sense opposite to the above operation, the diode D_1 becomes conductive while the diode D_2 becomes nonconductive. As a result, the transistor Q_{11} turns off, so the transistor Q_{21} turns off, whereas the transistor Q_{12} turns on, so the transistor Q_{22} turns on. As a result, FET Q_{23} provided at the output stage thereof effects on-off operation at the frequency of 4.9152 MHz to energize the winding 103.

Thus, high frequency current is induced in the winding for receiving power provided in the IC card 2. The induced current is on the one hand picked up as a clock signal, and is on the other hand rectified by the diode D_3 and then is supplied to a constant voltage circuit 106A via a smoothing circuit thereby to be converted into a constant voltage output. The constant voltage output thus obtained is fed to each circuit provided in the IC card 2 via a noise eliminating circuit.

The operation of the data transmitter/receiver system will be described. Reference is first made to the data transmission system from the IC card 2 to the processing device 1. When a data signal of 9600 BPS is supplied from the gate 39 for transmitting data to an output amplifier 40A, the data signal is on the one hand supplied to a transistor Q_{28} through an invertor INV_2, and on the other hand is directly supplied to a transistor Q_{27}. Thus, this allows these transistors Q_{27} and Q_{28} to be turned on and off with these transistors being 180° out of phase to each other, thus energizing the winding 40 for data output in the forward and reverse directions. As a result, there is produced an electric field varying in the forward and reverse directions in the winding 40. The magnetic field thus produced is detected by the Hall element 16. Accordingly, a signal indicative of the magnetic field is amplified by a transistor Q_{24} constituting an input amplifier 16A, and then the signal thus amplified is supplied to the data control circuit 17. The input amplifier 16A is provided with a variable resistor VR_1 for adjusting the zero point of the Hall element 16A and a variable resistor VR_2 for adjusting the gain of the input amplifier 16A.

Then, the operation of the data transmission system from the processing device 1 to the IC card 2 will be described.

When a data signal of 9600 BPS is supplied from the gate 14 for transmission data to the output amplifier 15A, this data signal is on the one hand fed to the transistor Q_{25} through an invertor INV_1 and is on the other hand directly fed to the transistor Q_{26}. Thus, this allows the transistors Q_{25} and Q_{26} to be turned on and off with these transistor being 180° out of phase, thereby energizing the winding 15 for data output in the forward and reverse directions. Thus, there is produced a magnetic field varying in the forward and reverse directions in the winding 15, respectively. The magnetic field thus produced is detected by the Hall element 34 provided in the IC card 2. A signal indicative of the magnetic field is amplified by a transistor Q_{29} constituting an input amplifier 34A, and then the signal thus amplified is output to the waveform shaping circuit 32. Similar to the input amplifier 16A provided in the processing device 1, the input amplifier 34A is provided with a variable resistor VR_3 for adjusting the gain of the input amplifier 34A and a variable resistor VR_4 for adjusting the zero point of the Hall element.

Figs. 4 and 5 show the condition that the IC card is put in the processing device therefor to effect a processing operation. In these figures, instead of the indication of the whole processing device 1, there are illustrated as a representative of the processing device 1, a power supply system comprising a winding 103 for power transmission and power transmission circuits 101 and 102, and a data transmitter/receiver system comprising a ferrite core, the winding 15 and the Hall element 16. The winding 103 for power transmission and a magnetic gap provided in the ferrite core are disposed so that they are coplanar with each other, and the Hall element 16 is provided in the central portion of the end surface of the ferrite core facing the magnetic gap. In correspondence with this, a winding 104 for receiving power, the Hall element 34 for data input and the winding 40 for data output are provided in the IC card 2.

When the IC card 2 is inserted into a predetermined position of the processing device 1, the power supply system and the data transmitter/receiver system are coupled to each other therebetween. Namely, each of the power supply system and the data transmitter/receiver system forms a particular magnetic circuit.

Another embodiment of the invention will be described with reference to Figs. 6 to 10.

This embodiment makes it possible to transmit and receive electric signals, preferably a series of digital signals in the form of a magnetic signal between the terminal equipment and the IC card by making use of the combination of the magnetic winding and the Hall sensor, and to return such magnetic signals to a series of electric states corresponding thereto without distortion. When the transmission between the windings 15 and 201 is carried out (Fig. 6), signals to be transmitted is differentiated in accordance with the induction rule. Accordingly, these signals are required to be returned to the original form using an electronic circuit. Further, a Hall sensor 202 provides a voltage proportional to a magnetic field. The voltage thus provided regenerates a magnetic field without distortion.

As shown in Fig. 7, a discriminator is provided as major circuit components with a power source 204, a Hall sensor 34, a winding 40 for writing, logic circuits 207, 208 and 209 and a memory. The power source 204 is configured as a resonance circuit producing a frequency tuned to a frequency of the terminal equipment, and includes a rectifier and a voltage regulator. Instead of this, in the other example, the power source may comprise a solar cell or a usual battery. An integrated circuit includes a plurality of counters 207, a shift register 208 and two comparators 209. In the circuitry provided in the IC card, the logic circuits and memories including a Hall sensor may be configured by a single integrated circuit. When the discriminator is in the form of a flat card, the resonance circuit constituting the power source is most readily fabricated by print/etching technology. A flat writing winding is coaxially disposed directly on the Hall sensor. The discriminator can be formed in a manner to sandwich parts thereof with plastic or paper etc., thus eliminating contacts exposed to the external.

As seen from Fig. 8, the most important units in the terminal equipment correspond to the units of the discriminator. The terminal equipment is also provided with writing winding 15, Hall sensor 16, a plurality of counters 212, and a shift register 213.

In this example, a magnetic transmission route is configured using an annular ferrite core. As shown in Fig. 9 illustrating an example of transmission from the terminal equipment to the IC card, the magnetic transmission route is provided within an arrangement including windings and the Hall sensor provided in the terminal equipment and the card. The ferrite core functions to concentrate magnetic field for increasing efficiency and to eliminate the influence of an external magnetic field by which transmission might be interferenced. The writing winding 15 provided in the terminal equipment is wound directly on the ferrite core. The IC card is inserted into the terminal equipment so that the Hall sensor 34 is eventually positioned between magnetic poles of the ferrite core. On the other hand, the Hall sensor 16 provided in the terminal equipment is attached directly on the magnetic poles of the ferrite core. Thus, when the card is inserted into the terminal equipment, the Hall sensor 16 is positioned above the writing winding 40 or the Hall sensor 34 of the card. To the writing winding 15 wound on the ferrite core provided in the terminal equipment, a rectangular shaped electric signal is supplied, thereby producing magnetic signal corresponding thereto. The magnetic signal thus produced is received by the Hall sensor 34, and then the magnetic signal thus received by the Hall sensor 34 is converted to a rectangular shaped electric signal. The rectangular shaped electric signal is serially supplied to the shift register, and is serial/parallel converted thereby. The parallel rectangular electric signals thus converted are compared with the preselected signal in the comparators 210. As a result of this comparison, when the both signals are equal to each other, the comparators 210 will produce a response signal which can be created according to need, e.g. y2, in this example.

When the discriminator is inserted into the terminal equipment, the high frequency generator configured so as to provide a power to the discriminator becomes operative, thereby producing high frequency electromagnetic field. Thus, pulse signals (not shown) are derived from the high frequency electromagnetic field in the terminal equipment and the discriminator.

When the system is not activated, the writing winding 15 provided in the terminal equipment is energized, i.e. there exists a magnetic field. When a start command is given, the magnetic field produced in the writing winding 15 becomes zero. The IC card detects changes in the magnetic field, starting to produce pulses in the discriminator. In synchronism with the frequency of the pulses, binary data stored in the terminal equipment is serially fed to the Hall sensor 34 provided in the card per byte (8 bits) through the writing winding 15 in the form of magnetic pulses. The magnetic pulses corresponding to the binary data are converted to electric signals by the Hall sensor 34. These electric signals are serially stored in the shift register 220 provided in the card. Upon completion of the transmission (i.e., after the transmission of each 8 bits), these electric signals are compared with the recorded data stored in the card. When all the transmission is finished, the energization of the writing winding 15 provided in the terminal equipment is set to zero. In this instance, if the data supplied from the terminal equipment is equal to the record stored in the card, a signal indicative of "YES" (e.g., 1 bit) is fed to the shift register 220 of the card. In contrast, if the data supplied from the terminal equipment is not equal to the record, a signal indicative of "NO" (e.g., 8 bits) is supplied to the shift register 220 provided in the card. Such a signal is transmitted to the terminal equipment in the form of pulse through the writing winding of the card and the Hall sensor 16 of the terminal equipment, whereby desired processing and display is carried out therein.

Fig. 10 shows a waveform of signals in the card and the equipment terminal. Signals shown on the upper side of Fig. 10 denote pulses common with the terminal equipment and the card. In this embodiment, a series of signals including 18 clock pulses, which comprises two sets of 8 bit data transmission, a single start bit and a rest time of about one bit length at the end of transmission, is used for transmission and answer. A start bit is always indicated with respect to the data to be transmitted followed by 8 data bits. When the start bit is transmitted, the terminal equipment is ready to receive response signal, having 8 bit length in maximum, transmitted from the card back thereto. In the card, the comparator produces a response signal after the data is received. The comparator determines kinds of response and at the same time operates data transmitter provided in the card. When the occurrence of the response is finished, an end signal is provided. The end signal finishes the operation of the data transmitter provided in the card, thus allowing the card to receive a subsequent data set.

As stated above, the data transmission system transmits and receives data between the terminal equipment and the IC card in a noncontact manner. The absence of electrical contacts on the card surface eliminates the risk of faults due to the poor condition of such contacts or a break in electric parts provided in the card due to static electricity which would be otherwise encountered with the prior art contact scheme. The data transmission system further makes it possible to exchange data even if the card is bent to some extent. Moreover, prior art non-contact schemes require complicated circuits with a large number of parts occupying the available card space. In contrast, the present data transmission system has a magnetic route consisting of a Hall sensor and a plane winding for both transmitting and receiving, so that the transmitter/receiver unit is relatively small. Further, since the Hall sensor and the plane winding are concentric, or a micro-processor, logic circuits and memories including the Hall sensor are incorporated into a single integrated circuit, further miniaturization is possible. Also, by using a Hall sensor to receive a magnetic signal, the signal is converted to an electric signal without distortion, eliminating the necessity of analog electrical parts in the circuit. This simplifies the operation of the circuit and provides high reliability, thereby making it possible to effect widely applicable bidirectional data exchange between the terminal equipment and the IC card.

CLAIMS

1. A processing device for an IC card, the device being configured to supply a power signal and a clock signal to the card and to transmit data to the card and receive it therefrom, and the device comprising:

a) a clock generator producing a clock signal,

b) a power transmission winding for transmitting to the IC card an electromagnetic field based on the clock signal,

c) a first memory in which predetermined data is recorded,

d) a transmission winding for transmitting data as an electromagnetic signal to the IC card,

e) a magnetic detection element responsive to an electromagnetic data signal received from the IC card to produce a corresponding electric signal,

f) a display unit for displaying the electric signal from the magnetic detection element, and

g) a data processing circuit for transmitting a data signal from the memory to the data transmission winding in response to the clock signal, and thereafter providing a data signal from the magnetic detection element to the display unit.

2. A device according to claim 1 wherein the data processing circuit adds a start signal to the data signal from the memory before transmitting the data signal.

3. A device according to claim 1, wherein the data transmission winding is wound on a core having a gap into which the IC card is inserted.

4. A device according to claim 3, wherein the magnetic detection element is provided in the gap provided in the said core.

5. A processing device for an IC card, the device being substantially as herein described with reference to Fig. 1 or Fig. 8 of the accompanying drawings.

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