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(54) Two-wire transmission system

Zweidrahtübertragungssystem

Système de transmission à deux fils

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EP 0 266 553 B2

Description

The present invention relates to a two-wire transmission system according to the preamble of claim 1.

In order to transmit outputs from a differential pressure sensor, an electromagnetic flowmeter or the like representing measured values to a remote location according to conventional industrial process measurement techniques, as disclosed in US-A-4,520,488, a unique signal having a current level within a range of 4-20 mA is used. Thus, an analog signal having a current selected from this range represents a measured value.

An output from the sensor represents a nonlinear proportion to the actual measured value of a process variable according to the sensor characteristics. The nonlinear relationship must be often converted to a linear relationship. At the same time, a working range value of the sensor output used in control operations does not always correspond to the possible measurement range of the sensor. A predetermined range of the possible measurement range is established, and a value is relatively determined within the extracted range of 0 to 100%. In a transmitter including a sensor, a conversion. between the working range value and the value in the possible measurement range must be performed.

In order to set or adjust the conversion operation conditions, manual operations are required.

In a conventional sensor signal transmission system, as shown in US-A-4,494,183 the above conversion opeation is performed in the-transmitter, and the measured value transmitted to the receiver is the working range value extracted from the possible measurement range of the sensor. If the working range value is overscaled due to some reason, the degree of overscaling of the detection output from the sensor cannot be detected. Control operation decisions cannot be properly made in the case of an overscaling abnormality. In addition, in order to change a predetemined range of the working range values according to a change in working range conditions, the transmitters which are usually distributed in a wide physical area must be independently readjusted, thus requiring time-consuming, cumbersome operations.

It is therefore the object of the present invention to provide a two-wire transmission system capable of causing a receiver to monitor sensor outputs from a plurality of two-wine transmission lines based on a possible measurement range of each sensor and to discriminate the degree of overscaling of an actual detection output when a working range value is overscaled without requiring a conversion operation in the associated transmitter.

This object is achieved according to the features of claim 1. Further advantageous embodiments of the system may be taken from the sub-claims.

Each transmitter can therefore convert the sensor detection output into digital signals without converting into a working range value used in control operation. The digital signals are converted into the working range values in the receiver. Either the sensor detection output or the working range values can be used in the receiver.

With respect to the figures of the attached drawings the invention shall be described in detail, where

Fig. 1
is a block diagram showing an overall two-wire transmission system configuration,
Fig. 2
is a block diagram of a receiver used in the system shown in Fig. 1,
Fig. 3
is a timing chart showing changes in current for the two-wire transmission system,
Fig. 4
is a block diagram of a communicator used in the system shown in Fig. 1,
Fig. 5
is a circuit diagram of a current controller used in the system shown in Fig. 1,
Fig. 6
is a perspective pictorial view showing the outer appearance of the communicator in Fig. 3,
Fig. 7
is a block diagram of a transmitter used in the system shown in Fig. 1,
Fig. 8(A) and 8(B)
are views showing a conversion operation according to the present invention and
Fig. 9(A) and 9(B)
are timing charts for explaining a second embodiment of the present invention.

Fig. 1 is a block diagram showing an overall two-wire transmission system configuration utilized in the present invention. A direct current (DC) power source (referred to as a PS hereinafter) 2 is connected to one end of a two-wire transmission line (referred to as a transmission line) l consisting of signal lines l_1 and l_2 to supply a current thereto. A transmitter (referred to as a TX hereinafter) 3 such as a pressure difference transmitter and an electromagnetic flowmeter is connected to the other end of the transmission line l. The TX 3 controls a current I in the transmission line l to generate signal pulses. The signal pulses are sent as a digital signal representing a measured value onto the transmission line l, thereby transmitting a detection signal (referred to as a PVF hereinafter) based on the possible measurement range of the sensor.

A resistor RL as a voltage dropping element is inserted in series with the transmission line l. A voltage across the resistor RL is supplied to a receiver (referred to as an RX hereinafter) 4. The RX 4 receives the digital signal and converts the digital signal into a working range value (referred to as a PVW hereinafter) having its predetermined range as 0 to 100%. An output from the RX 4 is sent to a main controller (referred to as an MC hereinafter) 6 such as a computer through a bus 5. Control operations by the MC 6 are performed on the basis of the PVW supplied from the RX 4. Control data is sent to controlled equipment (not shown) through the bus 5, thereby controlling the equipment.

An operation unit (referred to as an OP hereinafter) 7, which can include a CRT display and a keyboard, is connected to a bus 5' through an interface (referred to as an I/F hereinafter) 9, thereby displaying a controlled state of the equipment and inputting a command to the MC 6 and the RX 4. A portable communicator (referred to as a CT hereinafter) 8 is bridged in the transmission line nearer to the TX 3 than the resistor RL. The CT 8 converts the current I into signal pulses and sends them as a digital command signal to the TX 3. The TX 3 receives the command signal and converts the current I into signal pulses as a response signal which is sent to the CT 8 in response to the command signal.

Fig. 3 shows a waveform of changes in current I supplied through the resistor RL as a function of time "t". In this case, the digital signal is a pulse code, the current of which changes in the range of I_1 to I_2, e.g., 4-20 mA. A measured process value word WPV determined by the measured value from the TX 3 comprises 4-byte data consisting of bytes BY0 to BY3 (each byte consists of eight bits). If the length of time for each of the bytes BY0 to BY3 is "t1", e.g., 50 msec, the length of time of the measured value word WPV is "4t1", and the disable period following the word WPV is "t1". The measured value word WPV is repeatedly transmitted by changes in current "It" supplied across the lines of the TX 3,thereby always transmitting the newest measured value to the RX 4.

In this state, a command signal REQ as a pulse code is transmitted within a reception wait period "t2" shorter than the disable period "t1" by changing of a current Ic supplied from the CT 8 to line terminals T1 and T2 at the end of transmission of the measured value word WPV. The change in current causes a change in voltage across the resistor RL. The change in voltage across the resistor RL is sent as a change in voltage between the signal lines l_1 and l_2 to the TX 3. Therefore, the command signal REQ is received by the TX 3.

The TX 3 stops transmitting the measured value word WPV in response to the command signal REQ and sends back both a 4-byte measured value word WPV and a 2-byte response word WRE corresponding to the command signal REQ by means of the current It when a predetermined period "t3" has elapsed. In this case, transmission for a period "6tl" from a start word WRE(S) to an end word WRE(E) is repeated separated by the disable period t1. The measured value word WPV is repeatedly transmitted again. Thus, the voltage between the lines l_1 and l_2 is changed, and this change is received by the CT 8.

A start bit B0 of bits B0 to B31 in the start byte BY0 in the measured word WPV represents status ST indicating whether the TX 3 is normally operating. The bit B1 represents a proportional relation L, i.e., a linear relationship between the measured value and the control value according to sensor characteristics, or a squared proportional relationship S, i.e., a relationship representing that the measured value is a square of the control value. The bit B2 represents the number NB of continuous bytes, i.e., that the number of continuous bytes is four or six. The bits B4 to B7 represent the type DA of the measured value transmitted by the bytes BY1 to BY3. In the bytes after byte BY0, the bits represent a measured value DPV. When the measured value is sent together with the response signal in the form of WPV + WRE, the response word WRE is transmitted continuously after the measured value word WPV. The number of bytes of each word and the number of bits of each byte can be determined according to the control states. The periods "t1" to "t3" are also properly determined according to the bit rate.

Fig. 4 is a block diagram of the CT 8. A digital processor (referred to as a CPU hereinafter) 11 such as a microprocessor is used in the CT 8. The CPU 11 is connected to a permanent memory (referred to as a ROM hereinafter) 12, a programmable memory (referred to as a RAM hereinafter) 13, a keyboard (referred to as a KB hereinafter) 14, a display (referred to as a DP) 15, a universal asynchronous reception and transmission unit (referred to as an UART hereinafter) 16, and an interface (referred to an an I/F hereinafter) 17. The above components are connected to each other through a bus 18. A program stored in the ROM 12 is used under the control of the CPU 11, and a control operation is performed while predetermined data is accessed in the RAM 13.

If desired input data is supplied at the KB 14, the CPU 11 controls the UART 16 and sends a gate pulse "Pcgl" as a "H" (high level) signal to the I/F 17. The AND gate 19 is turned on to gate the "H" pulse from the UART 16 to a current controller (referred to as a CC hereinafter) 20. Therefore, a current Ic is supplied from the terminal T1 to the terminal T2.

A voltage between the lines l_1 and l_2 is supplied to a filter (referred to as an FL hereinafter) 21 for filtering only a frequency component of the digital signal. The filtered signal is then supplied to one input terminal of a comparator (referred to as a CP hereinafter) 22. The filtered signal is compared by the CP 22 with a reference voltage Ecs supplied to the other input terminal thereof. The CP 22 extracts as an output a level exceeding the reference voltage Ecs.

For this reason, after the transmission of the command signal REQ, a gate pulse "Pcg2" is sent out as an "H" pulse from the I/F 17 when the reception output representing the start bit B0 of the measured value word WPV is supplied through the I/F 17. The AND gate 23 is turned ON, and then the output representing the bit 81 and the subsequent bits is sent to the UART 16. The resulting data is displayed on the DP 15 in response to this output. Even if the TX 3 repeatedly transmits the measured value word WPV, the reception is normally performed. Therefore, the measured value can be displayed on the DP 15.

Fig. 5 is a circuit diagram of the CC 20. A transmission pulse from the AND gate 19 through a noise reduction low-pass filter consisting of a resistor R1 and a capacitor C1 is amplified by a differential amplifier (referred to as an A hereinafter) 31 to turn on a transistor Q1 such as a field effect transistor. The current Ic is supplied through resistors R2 and R3. A voltage across the resistor R3 is negatively fed back to the A 31 through a resistor R4 so that the current Ic is maintained at a predetermined value.

Fig. 6 is a perspective pictorial view showing the outer physical appearance of the CT 8. The DP 15 and the KB 14 are arranged on a portable case 41. At the same time, a cord 42 extends outside the case 41. Clips 43 as the line terminals T1 and T2 are connected at the distal end of the cord 42. Therefore, the CT 8 can be detachably connected to lines l_1 and l_2.

Fig. 7 is a block diagram of the TX 3. In the same manner as in Fig. 4, a CPU 51 is connected to a ROM 52, a RAM 53, a UART 54, and an I/F 55 through a bus 56. The CPU 51 performs the control operation in the same manner as in Fig. 4. In addition, the TX 3 further includes a multiplexer (referred to as an MPX hereinafter) 59 for selecting a pressure sensor (referred to as a PS hereinafter) 57 for detecting a pressure difference or the like, or a temperature sensor (referred to as a TS) 58 for detecting a temperature of the PS 57, and an analog-to-digital converter (referred to as an ADC hereinafter) 60 for converting an output from the MPX 59 into a digital signal.

A direct current power source circuit (referred to as a PSC hereinafter) 61 is connected to the terminal T1. In this case, a current of 4 mA from the line l_1 is received and stabilized as a local direct current power source Et. The source Et is supplied to the respective components by lines which have been omitted for the sake of clarity. The voltage between the lines l_1 and l_2 is filtered through an FL 62 such as a band-pass filter for filtering only the frequency component of the digital signal therethrough. The filtered output is supplied to a CP 63 in the same manner as in Fig. 4. The filtered output is compared with a reference voltage Ets and the CP 63 generates a reception output. The reception output is supplied to the UART 54 through an AND gate 64.

If the "H" gate pulse "Ptgl" is sent in the reception mode after the measured value word WPV is completely sent, the AND gate 64 is turned on. During the ON state of the AND gate 64, the command signal REQ is sent. In response to the command signal REQ, the reception output from the CP 63 is sent to the UART 54 to receive the command signal REQ. Thereafter, the CC 65 is turned off, and repetitive transmission of the measured value word WPV is interrupted.

Upon reception of the command signal REQ, the CPU 51 sends the "H" gate pulse "Ptg2" through the I/F 55 and at the same time controls the UART 54. The transmission pulse is sent to the CC 65 through the AND gate 66. The current corresponding to the word WRE is supplied through the CC 65.

When transmission of the words WPV and WRE representing the measured value and the response signal as described with reference to Fig. 3 is completed, the CPU 51 repeats sending out the transmission pulse in response to the measured value word WPV, thereby repetitively sending the measured value. The arrangement of the CC 65 is the same as that in Fig. 5. The TX 3 includes a nonvolatile memory 52 such as an EAROM. Necessary data is stored in the nonvolatile memory 52. Thus, even if a power failure occurs, the data can be retained in the nonvolatile memory 52.

The CPU 51 controls the MPX 59 to alternately fetch the outputs from the PS 57 and the TS 58 at every predetermined interval. These outputs are based on the possible measurement ranges of the PS 57 and the TS 58. The fetched data is stored in the RAM 53. The CPU 51 then performs conversion operations of the detection output (representing the PVF) from the PS 57, encodes the measured value and transmits the measured value word WPV representing the PVF. The coded measured value is sent to the UART 54 so that the measured value word WPV is sent. However, depending on the contents of the command signal REQ, the detection output from the TS 58 is sent out in the same manner as described above, or the outputs from the PS 57 and the TS 58 are sent alternately or in a combination thereof.

The start of reception of the command signal REQ is allowed within the short reception wait period "t2" upon completion of transmission of the measured value word WPV. During this period, if the command signal REQ is received, the gate pulse "Ptg1" is continuously present until the end of reception. However, if reception is not performed during the reception wait period t2, the gate pulses "Ptg1" are stopped at the end of this period. In this manner, the reception state is cancelled to prevent erroneous operation by reception of noise or the like.

Since the disable period t1 and the predetermined period t3 are provided, detection of the disable period "t1" and the predetermined period "t3" which are longer than the reception wait period "t2" allows detection of the start of each word following such a period. The bytes, the number of which is represented by the byte number NB of Fig. 3, are fetched as significant types, thereby receiving only the measured value word WPV.

Fig. 2 is a block diagram of the RX 4. The RX 4 contains a CPU 71 similar with the CPU 11 of Fig. 4, a ROM 72, a RAM 73, and I/Fs 74 and 75. These components are connected to each other through a bus 76. The CPU 71 performs the same operation as that of the CPU 11 so as to achieve reception operation. Inputs IN1 to INn from a plurality of transmission lines are supplied to the I/F 74. Digital signals based on changes in currents of the inputs IN1 to INn are sequentially received, and the CPU 71 stores them in the RAM 73 and performs predetermined processing. The processed results are sent out to the MC 6 and the OP 7 (Fig. 1) through the I/F 75. The CPU 71 stores various types of data in the RAM 73 according to instruction contents and processes them in response to an instruction supplied from the MC 6 or the OP 7 through the I/F 75. Therefore, the CPU 71 performs processing of digital signals.

Figs. 8(A) and 8(B) are flow charts of the control operations for converting PVF to PVW under the control of the CPU 71. More specifically, Fig. 8(A) shows a relationship between a transmitter output PV and a measured value PVF, and Fig. 8(B) shows a relationship between PV and PVW. Referring to Fig. 8(A), the value PVF is increased in direct proportion with PV from a minimum value FL to a maximum saturated value FU. Therefore, the possible measurement range is the one from FL to FU. A predetermined range of F0 to F100 of the PVF corresponding to x0 to x100 of the PV is extracted and is converted to a PVW value having a range of 0 to 100% in the following manner:

$$PVW = m\,PV + B \qquad (1)$$

for

$$m = (F100 - F0)/(x100 - x0) \text{ and}$$
$$B = -m\,x0$$

However, if the PV value does not have a linear relationship with the PVF value, the PVF value is converted into the corresponding PV value according to the sensor characteristics. The resultant PV value is then converted into a corresponding PVW value according to equation (1). The resultant output is sent to the MC 6 and the OP 7 through the I/F 75. The F100, F0, x100 and x0 values in equation (1) may be supplied from the keyboard of the OP 7 or may be prestored in the ROM 72 or the RAM 73. These values may be updated as needed.

At the RX 4, therefore, the PVW and PVF values can be monitored by the OP 7. If the PVW value is overscaled, then whether or not the degree of overscaling of the PV value falls within the practical range can be determined by checking the PVF value. The PVW extraction range updating can be simplified, and control changes can follow changes in actual control state.

As a result, the necessity for conversion in TX 3 can be eliminated, and the working load to be imposed on the CPu 51 can be reduced. At the same time, the memory capacity of the ROM 52 and the RAM 53 can be reduced. Adjustment of the TX 3 which is usually required upon changes in control state can be omitted, thus reducing the number of operations. The TX 3 can transmit the data PVF while communicating with the CT 8. The RX 4 always receives the newest PVF. Control operation is performed using the newest PVF to provide stable operation which immediately follows changes in PVF.

Figs. 9(A) and 9(B) are timing diagrams illustrating a second embodiment of the invention. Fig. 9(A) shows a case wherein the measured value word WPV and the response word WRE are transmitted together within the period "14t1" corresponding to 14 bytes. Fig. 9(B) shows a case wherein upon reception of the command signal REQ, the measured value word WPV based on the newest PVF is transmitted twice, and then the combination of the measured value word WPV and the response signal word WRE is transmitted for a period corresponding to 14 bytes.

If the measured value word WPV is transmitted based on the newest PVF, the RX 4 can accurately monitor the measured value. However, the immediately preceding value may be transmitted for changes in PVF within the allowable range. However, if the change in PVF exceeds the allowable range, the newest value may be transmitted.

Linear conversion may be performed by the TX 3 according to the sensor characteristics, and the results may be sent as PV values. In this case, the type of the sensor is determined according to the given conditions. The arithmetic means in the RX 4 need not be constituted according to Fig. 2 by the CPU 71 but can be constituted by a combination of various types of logic circuits or a conversion table stored in the ROM 72 or the RAM 73. Alternatively, a control operation may be performed in the RX 4 to obtain the same effect as in the above embodiments.

Claims

1. A two-wire transmission system comprising:

a plurality of transmitters (3) for transmitting outputs from at least one sensor correlated to each transmitter as the
outputs through a corresponding plurality of two-wire transmission lines (IN1, IN2,... INn);
a communicator (8) bridged to a two-wire transmission line for transmitting a command signal to a transmitter;
a power source (2) connected to one end of each two-wire transmission line; and a receiver (4) for receiving the outputs from said plurality of transmitters;
whereat each transmitter (3) is adapted to convert the output based on a possible measurement range of said at least one sensor (57, 58) into a digital signal and transmitting the digital signal, and said receiver (4) is provided with arithmetic means (71) for sequentially receiving said digital signals of said plurality of two-wire transmission lines (IN1, IN2,... INn) and converting the digital signals into a working range

value having a predetermined range of 0 to 100%, whereby said predetermined range corresponds to part of said possible measurement range of said at least one sensor.

2. A system according to claim 1, **characterized in that** any of said transmitters (3) comprises a plurality of sensors (57,58).

3. A system according to claim 1, **characterized in that** any of said transmitters (3) transmits a digital signal obtained by a change in current supplied onto is associated said two-wire transmission line.

4. A system according to claim 1, **characterized in that** said arithmetic means (71) serves to calculate a value within the predetermined range in response to an external instruction.

5. A system according to claim 1, **characterized in that** any of said transmitters (3) comprises a digital processor (51).

Patentansprüche

1. Zweidraht-Übertragungssystem aufweisend

mehrere Übertrager (3) zum Übertragen von Ausgängen von wenigstens einem jedem Transmitter zugeordneten Sensor als Ausgänge über eine entsprechende Vielzahl von Zweidraht-Übertragungsleitungen (IN1, IN2, ..., INn);
ein Dialoggerät (8), das zwischen die Zweidraht-Übertragungsleitung geschaltet ist, um ein Befehlssignal zu dem Übertrager zu senden;
eine Spannungsquelle (2), die an ein Ende von jeder Zweidraht-Übertragungsleitung angeschlossen ist; und
einen Empfänger (4) für den Empfang der Ausgänge von den mehreren Übertragern; wobei jeder Übertrager (3) in der Lage ist, den Ausgang, basierend auf einem möglichen Meßbereich des wenigstens einen Sensors (57,58) in ein Digitalsignal umzuwandeln und dieses zu übertragen und daß der Empfänger (4) mit einer Recheneinrichtung (71) ausgestattet ist, um das Digitalsignal auf mehreren Übertragungsleitungen (IN1, IN2, ..., INn) sequentiell zu empfangen und es in einen Arbeitsbereich umzuwandeln, der einen vorbestimmten Bereich von 0 bis 100% aufweist, wobei der vorbestimmte Bereich einem Teil des möglichen Meßbereiches des wenigstens einen Sensors entspricht.

2. System nach Anspruch 1, **dadurch gekennzeichnet,** daß irgendeiner der Übertrager (3) mehrere Sensoren (57, 58) aufweist.

3. System nach Anspruch 1, daß irgendeiner **dadurch gekennzeichnet** der Übertrager (3) ein Digitalsignal überträgt, das durch eine Stromänderung erhalten wird, die an die zugeordnete Zweidraht-Übertragungsleitung geliefert wird.

4. System nach Anspruch 1, **dadurch gekennzeichnet**, daß die Recheneinrichtung (71) der Berechnung eines Wertes innerhalb des vorbestimmten Bereiches auf Grund eines externen Befehles dient.

5. System nach Anspruch 1, **dadurch gekennzeichnet**, daß irgendeiner der Übertrager (3) einen digitalen Prozessor (51) aufweist.

Revendications

1. Système de transmission à deux fils comprenant :

plusieurs d'émetteurs (3) pour transmettre des sorties en provenance au moins d'un capteur coordonné à chaque émetteur en tant que sorties traversant d'une multiplicité des lignes de transmission à deux fils (IN1,IN2, ..., INn);
un communicateur (8) branché en dérivation sur ladite ligne de transmission à deux fils pour transmettre un signal de commande audit émetteur;
une source d'alimentation (2) raccordée à une extrémité de chaque ligne de transmission à deux fils ; et
un récepteur (4) pour recevoir les sorties en provenance de ces plusieurs d'emetteurs;
où chaque émetteur (3) est prévu pour convertir la sortie sur la base d'une plage de mesures possibles au moins d'un capteur (57, 58) en un signal numérique et pour transmettre le signal numérique, et ledit récepteur (4) est muni d'un moyen de traitement arithmétique (71) pour recovoir séquentiellement ledit signal numérique d'une pluralité de lignes transmission (IN1, IN2 ..., INn) et pour convertir le signal numérique en une valeur s'inscrivant dans une plage de fonctionnement, cette valeur étant définie par une plage prédéterminée qui va de O à 100% et ainsi, ladite plage prédéterminée correspond à une partie de ladite plage de mesures possibles au moins d'un capteur.

2. Système selon la revendication 1, caractérisé en ce que une de ces émetteurs (3) comprend une pluralité de capteuers (57, 58).

3. Système selon la revendication 1, caractérisé en ce que une de ces émetteurs (3) transmet un signal numérique obtenu au moyen d'une variation du courant appliqué sur ladite ligne de transmission à deux fils.

4. Système selon la revendication 1, caractérisé en ce que ledit moyen de traitement arithmétique (71) sert à calculer une valeur s'inscrivant dans la plage prédeterminée en réponse à une instruction externe.

5. Système selon la revendication 1, caractérisé en ce que une de ces émetteurs (3) comprend un processeur numérique (51).

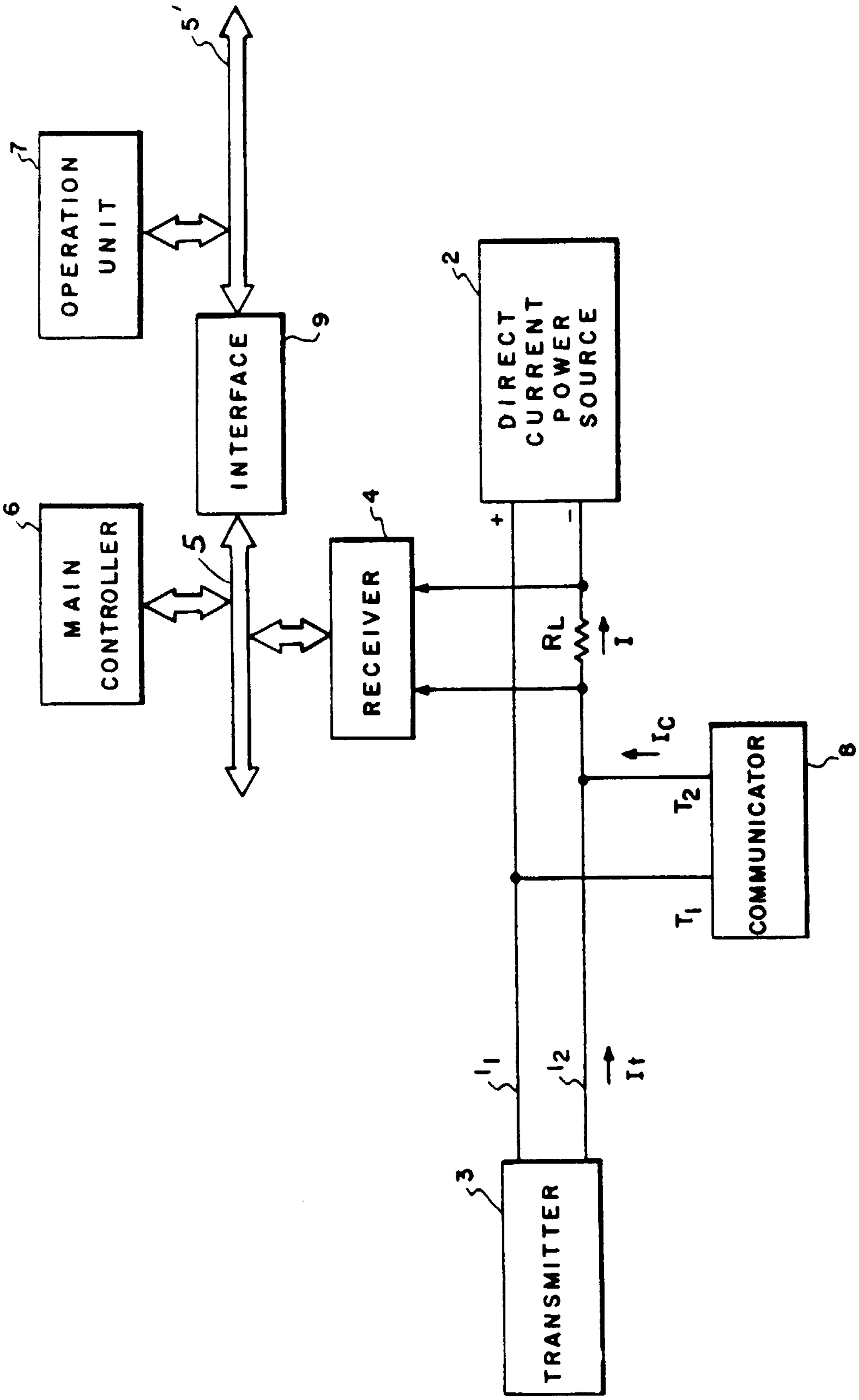

OPERATION UNIT
INTERFACE
MAIN CONTROLLER
RECEIVER
DIRECT CURRENT POWER SOURCE
COMMUNICATOR
TRANSMITTER
R_L
I
I_C
T_2
T_1
I_t
l_1
l_2
+
−
2
3
4
5
5'
6
7
8
9

FIG. 1

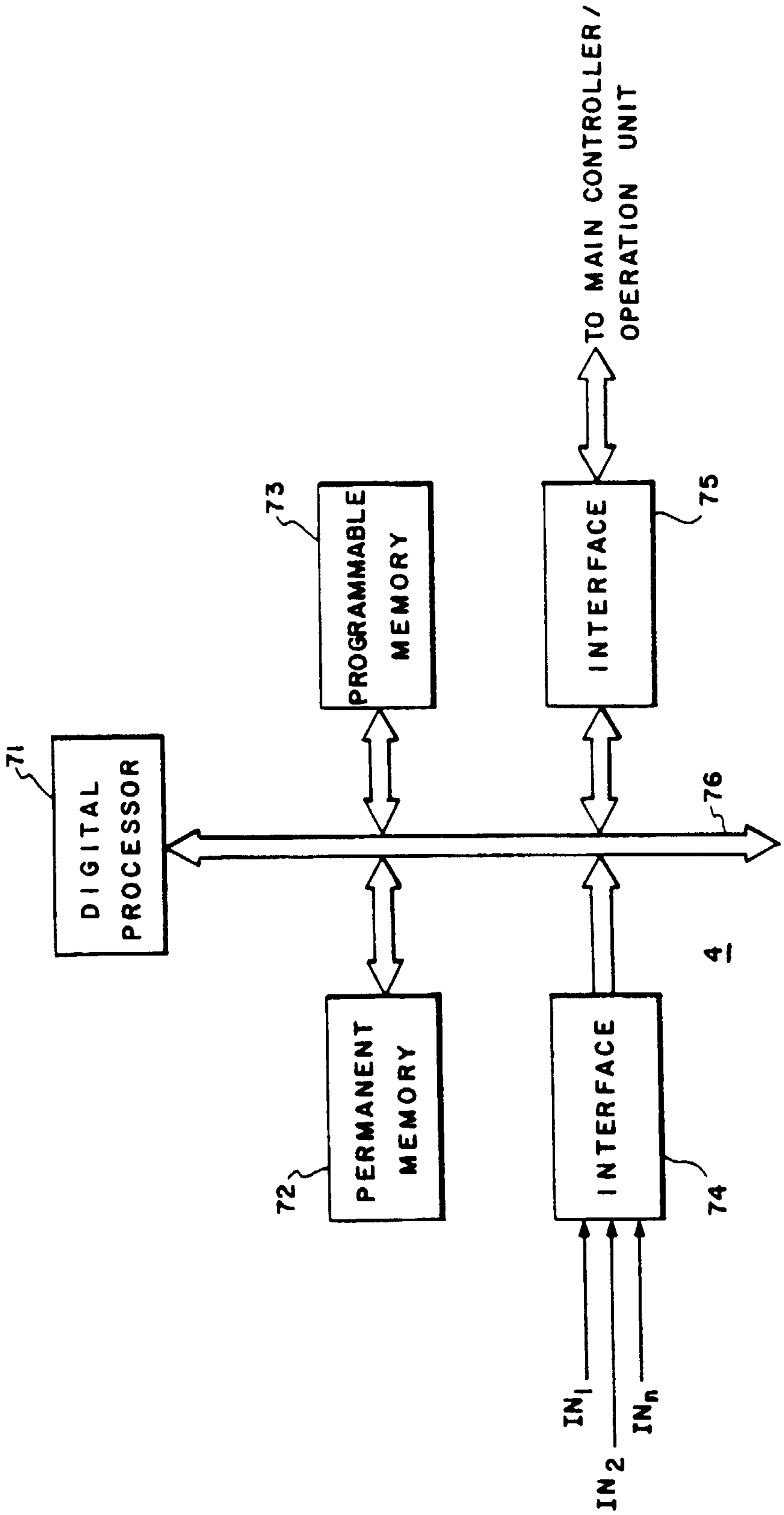
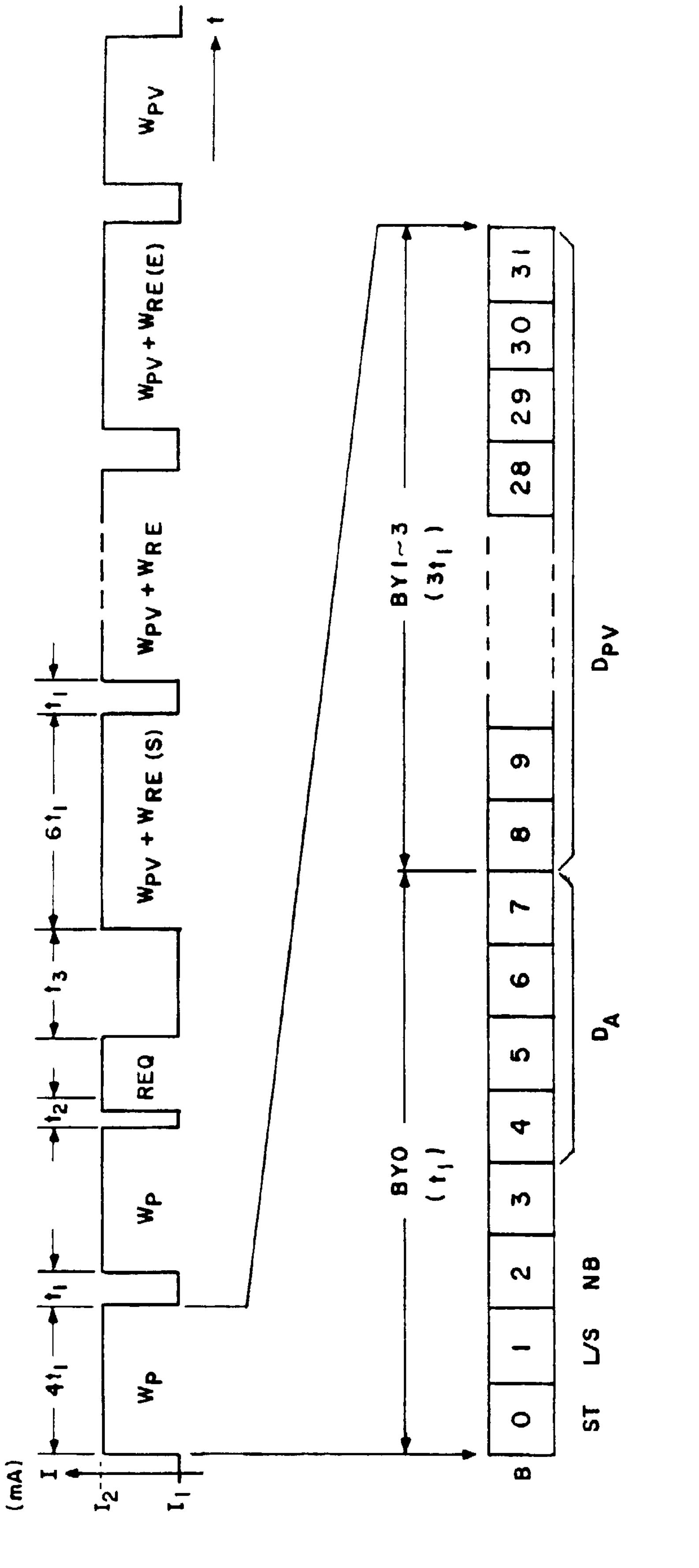
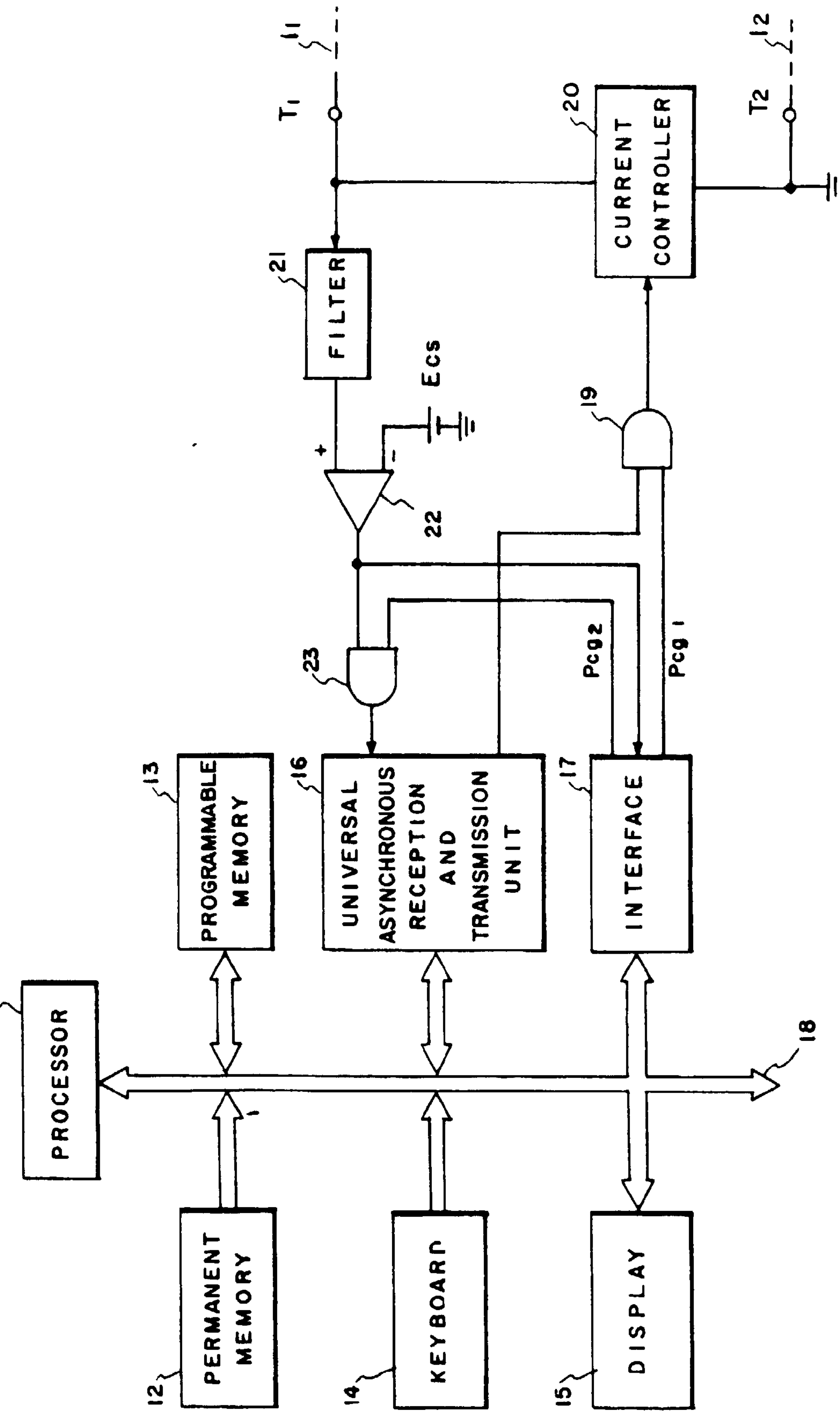

DIGITAL PROCESSOR
71
PERMANENT MEMORY
72
PROGRAMMABLE MEMORY
73
INTERFACE
74
INTERFACE
75
76
4
TO MAIN CONTROLLER / OPERATION UNIT
IN1
IN2
INn

FIG. 2


(mA)
I
I2
I1
4t1
t1
t2
t3
6t1
t1
WP
WP
REQ
WPV + WRE (S)
WPV + WRE
WPV + WRE (E)
WPV
t
BY0 (t1)
BY1~3 (3t1)
B
0
1
2
3
4
5
6
7
8
9
28
29
30
31
ST
L/S
NB
DA
DPV

F I G. 3


PROCESSOR
11
PERMANENT MEMORY
12
PROGRAMMABLE MEMORY
13
KEYBOARD
14
DISPLAY
15
UNIVERSAL ASYNCHRONOUS RECEPTION AND TRANSMISSION UNIT
16
INTERFACE
17
18
19
CURRENT CONTROLLER
20
FILTER
21
22
23
Ecs
Pcg2
Pcg1
T1
T2
l1
l2

F I G. 4

FIG. 5

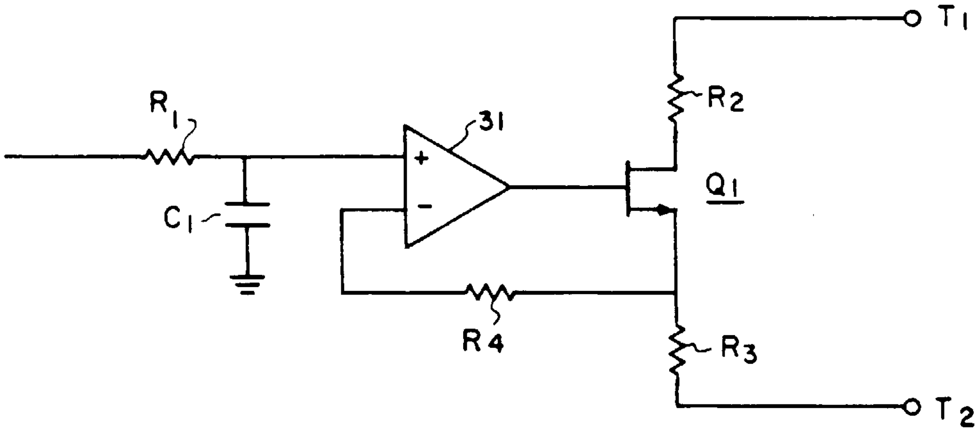
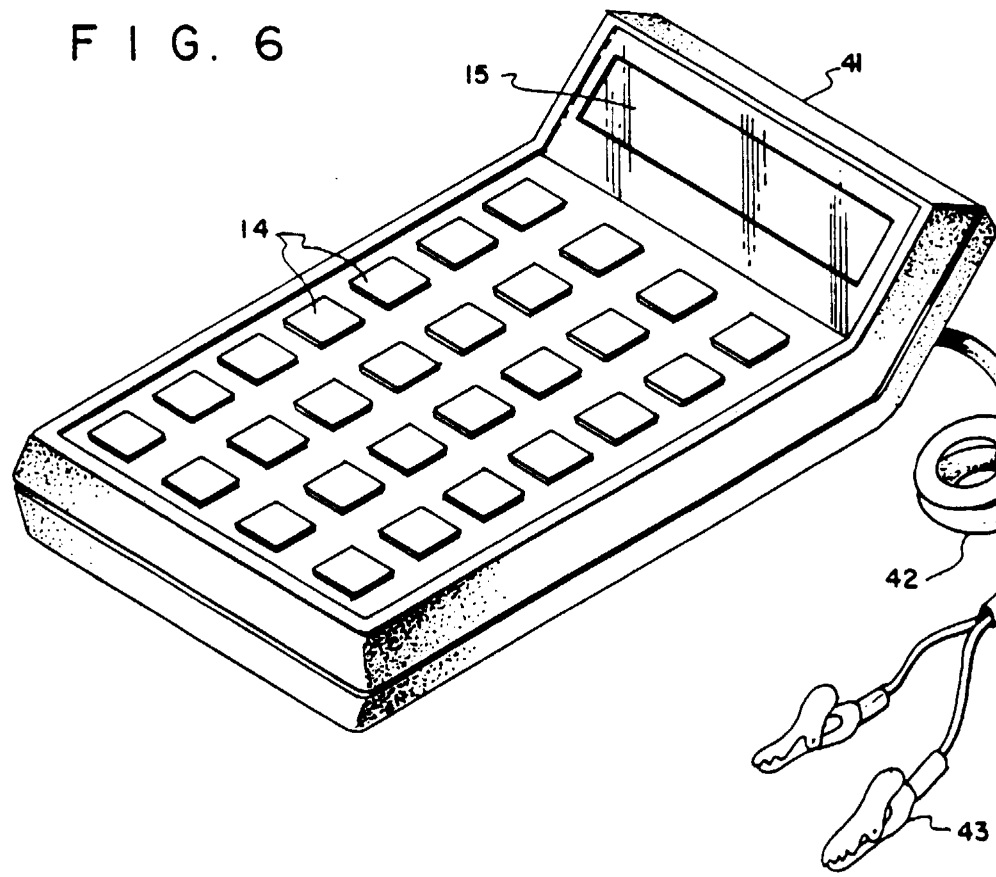


FIG. 6



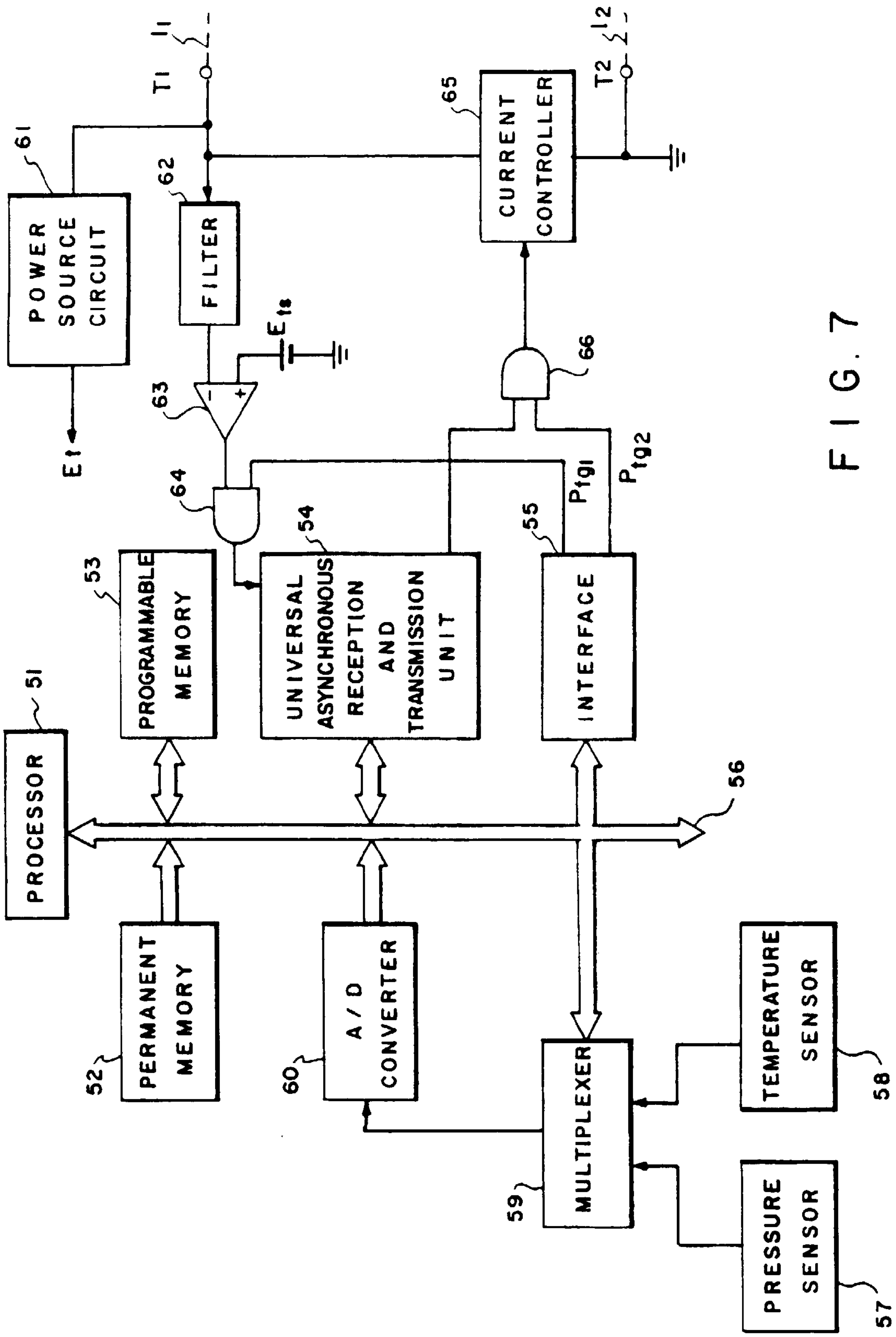

PROCESSOR
51
PERMANENT MEMORY
52
PROGRAMMABLE MEMORY
53
UNIVERSAL ASYNCHRONOUS RECEPTION AND TRANSMISSION UNIT
54
INTERFACE
55
56
PRESSURE SENSOR
57
TEMPERATURE SENSOR
58
MULTIPLEXER
59
A / D CONVERTER
60
POWER SOURCE CIRCUIT
61
FILTER
62
63
64
CURRENT CONTROLLER
65
66
E1
Efs
T1
l1
T2
l2
Ptg1
Ptg2

FIG. 7

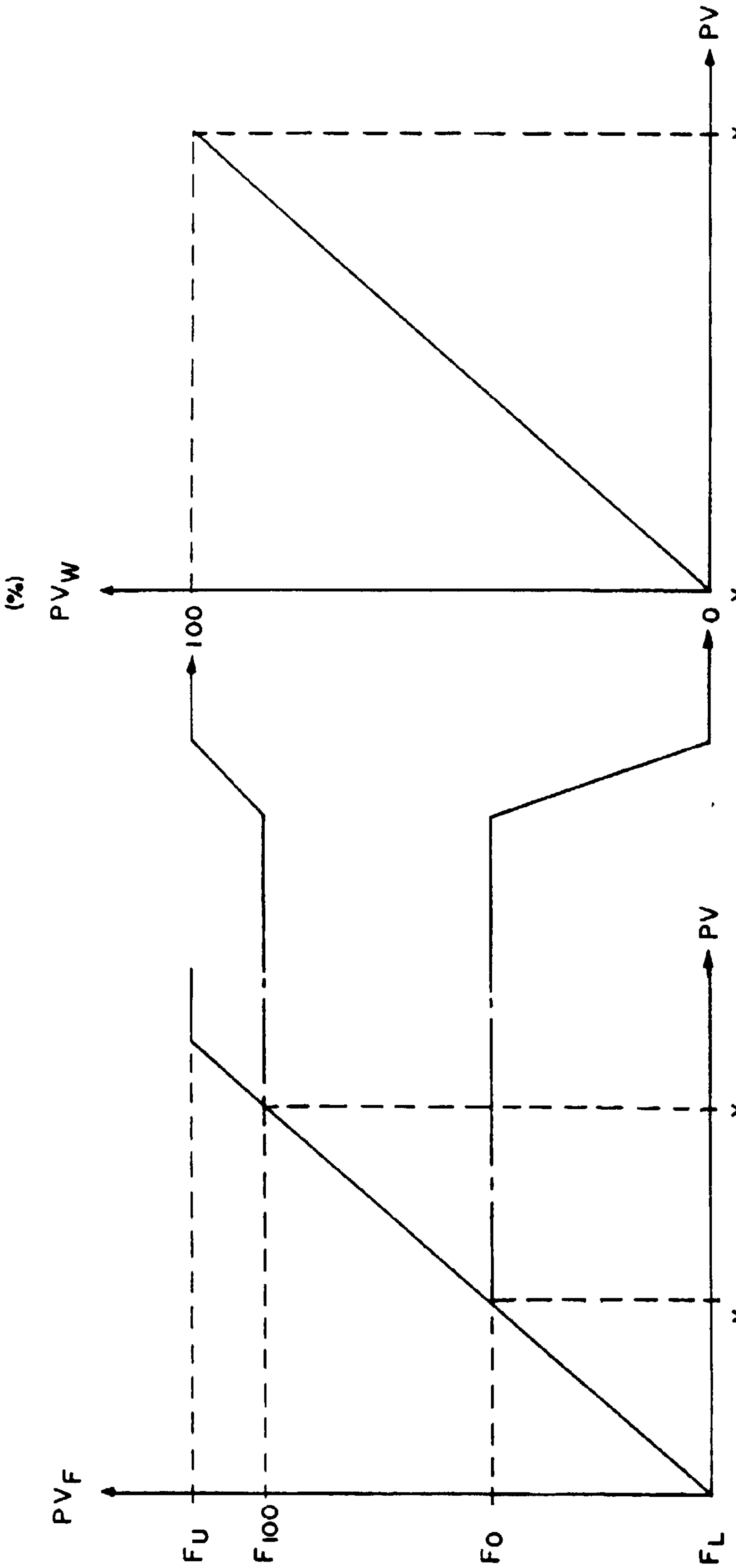
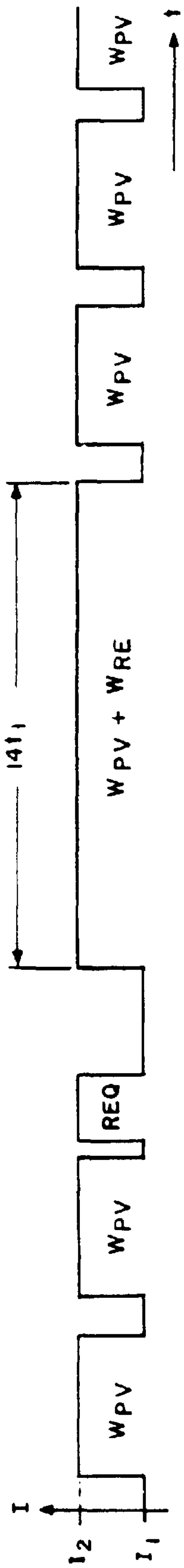
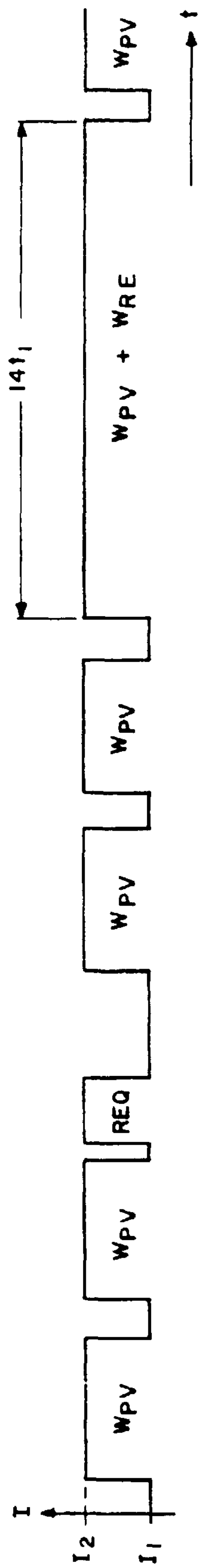


FIG. 8(A)

FIG. 8(B)


I
I2
I1
WPV
WPV
REQ
WPV + WRE
1411
WPV
WPV
WPV
t

F I G. 9 (A)


I
I2
I1
WPV
WPV
REQ
WPV
WPV
1411
WPV + WRE
WPV
t

F I G. 9 (B)