INSTRUCTION MANUAL FOR

DIGITAL VOLTMETER

MODEL 151

KIKUSUI ELECTRONICS CORP., JAPAN

TABLE OF CONTENTS

1. INTRODUCTION

The Kikusui Model 151 Digital Voltmeter accurately measures a DC voltage for a range of ±0.0000 V to ±1000.0 V. It employs an integration-type pulse width conversion system and incorporates the following advantageous features:

(1) The dynamic range is wide. Measurement can be made to maximum "12000" in a 5-digit system, without switching the range. When an input voltage higher than "12000" is applied, the OVER lamp automatically lights to indicate that an overvoltage is being applied to the input terminal.

(2) When an input voltage of higher than "12000" is applied under the AUTO operation, the measuring range is automatically switched to the next higher range. When that of less than "00980" is applied, the measuring range is automatically switched to the next lower range. Thus, the input voltage is measured always with a range which will present the maximum number of meaningful display digits.

(3) The measuring speed is 3 samplings/sec. Switching for polarity is made automatically. The display circuit incorporates a memory circuit to reduce flicker.

(4) The measuring accuracy is as high as ±(0.05% + 1 digit). The input resistance is higher than 1,000 MΩ. The input terminals can be isolated from the case ground.

(5) The circuits are designed and manufactured for the maximum reliability, employing silicon transistors, linear IC's, and MSI's.

2. SPECIFICATIONS

Measuring system:	Integration-type pulse width conversion system
Total measuring range:	±0.0000 V to ±1000.0 V
Range selector:	AUTO and four ranges of 1 V, 10 V, 100 V, and 1000 V
Maximum display:	"12000"
Accuracy:	(±0.05% of measured value) + (1 least-significant digit); 5°C ~ 35°C
Maximum sensitivity:	100 μV/digit (1 V range)
Sampling rate:	3 samplings/sec.
Input resistance:	1 V and 10 V ranges ... 1,000 MΩ or over 100 V and 1000 V ranges ... 10 MΩ
Input terminals:	Isolatable from case ground, maximum 250 V DC
Input overvoltage protection:	1,000 V DC maximum for all ranges
Normal mode rejection:	60 dB or better (at 50/60 Hz)
Over-range indication:	"12000" as boundary point
Display holding:	Controllable from the front panel
AUTO range operation:	Up-range boundary point ... "12000" Down-range boundary point ... "00980"
Ambient temperature:	0°C to 40°C

Power requirements:	100 V ±10%, 50/60 Hz AC, approx. 25 VA
Major dimensions:	200 mm wide, 140 mm high, 320 mm deep
(Maximum dimensions):	(200 mm wide, 160 mm high, 360 mm deep)
Weight:	Approx. 5 kg.
Documents supplied:	Instruction manual ... 1 copy
	Inspection report ... 1 copy

3. OPERATION METHOD

3.1 DESCRIPTION OF THE FRONT AND REAR PANELS

(See Fig. 3-1.)

(1) POWER: A push-button switch to turn on and off the power. The power is turned on when the button is pressed (locked), and it is turned off when the button is pressed again.

(2) RANGE: Five RANGE selector push-button switches are positioned in a horizontal row. They, from left to right, are the AUTO, 1 V, 10 V, 100 V, and 1000 V range buttons.

(3) INPUT (HI and LO): Terminals to which the input voltage to be measured is applied. The high impedance line must be connected to the HI terminal (red), and the low impedance line to the LO terminal (white).

(4) HOLD: When this button is pressed and locked, the displayed value existed at the instant of pressing is held unchanged, irrespective of subsequent variation of the input voltage. This HOLD state can be released and the normal measuring operation is resumed when this button is pressed again.

(5) ZERO ADJ: A control for zero adjustment of the amplifier. With the input terminals shorted, the control must be adjusted so that the display indicates "00000". The control can be turned from the front panel using a screwdriver.

For highly accurate measurement, apply such an input voltage that the display indicates "00030", switch the polarity, and adjust the control so that the readings are identical for both polarities.

(6) OVER:	A lamp to indicate that the input voltage is of an over-range value. This lamp lights when the input has exceed the maximum value of the set range by 20% or over.
(7) "+" or "-":	Automatically indicates the polarity of the measured voltage.
(8) DISPLAY:	A 4-digit counter (Nixie tubes) with decimal point.
(9) Inclination Support:	A bracket which can be pulled to this side to give an inclination angle to the instrument when it is used being placed on a bench.
(10) Rear Input Terminals (HI, LO, and GND):	These terminals are connected in common with the front input terminals. The input can be applied either through the front or these rear input terminals. Normally, the LO and GND terminals are connected together with the short bar.*
(11) BCD OUTPUT: (Option)	This optional provision provides a BCD output of 8-4-2-1 code, for 5-digit numerical data, decimal point and polarity. An Amphenol 57-40360 Series connector is used for this provision.

(12) PRINT COMMAND: (Option) — This optional provision (with a snap switch) provides a command for printing of the BCD output. Under the PRINT COMMAND mode of operation, an external command signal is required for the HOLD mode but an internal command signal is automatically supplied for each measuring cycle for the AUTO mode.

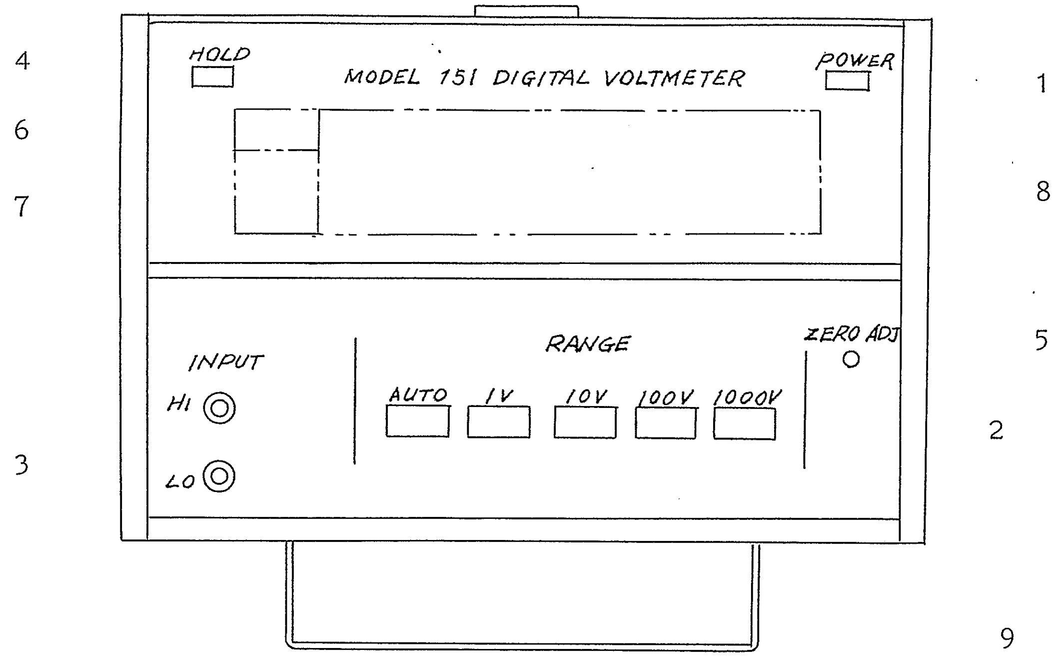
(13) Cord Holder: — The power cord is wound on these holder pieces when the instrument is stored.

(14) Fuse Holder: — Contains a 0.5 A slow-blow fuse.

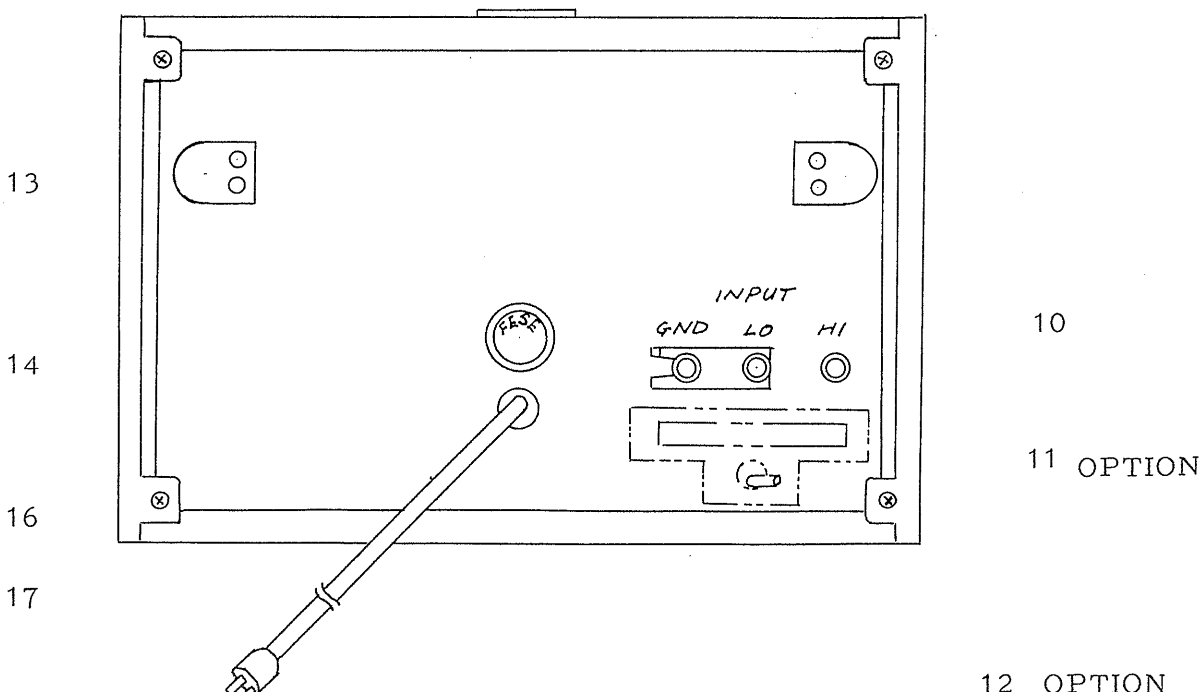
(15) Housing Clamping-screws: — These four screws clamps the feet of the instrument.

(16) Feet: — The two feets are clamped to the instrument housing with the four clamping-screws. When the feets are removed, the housing is ready to be removed.

*The front input terminals are connected in common with respective rear terminals. Note that, when a high voltage is applied to the front input terminals, the high voltage appears also at the rear terminals.



Front panel



Rear panel

Fig. 3-1

3.2 PREPARATIONS

(1) Connect the power cord to an AC line receptacle of the rated voltage (100 V, 50/60 Hz).

(2) Turn on the power switch. For approximately 10 seconds after the power is turned on, the displayed value may vary. This variation is a transiential phenomenon caused by the turning on the power and is the normal state for the instrument.

(3) The instrument operation is stabilized in approximately 15 minutes after turning on the power. For a highly accurate measurement, allow about an hour of stabilization period.

(4) Set the HOLD button in the OFF state. The measurement will be unsuccessful unless the button is set in the OFF state.

(5) Connect the high impedance line of the input voltage to the HI input terminal (red) and the low impedance line to the LO input terminal (white). When the distance from the signal source to the instrument is long, use an appropriate shielded wire.

3.3 MEASURING OPERATION

(1) If the level of the voltage to be measured is known, select the range as shown in Table 3-1 in order to eliminate the use of unrelevant ranges. If the level is unknown, use at first the 1000 V range and, then, gradually lower the range until the display indicates a value lower than "12000", or use the AUTO mode of measuring operation. Range selection under the AUTO mode is as shown in Table 3-2.

Note: The instrument incorporates such a protective circuit that the circuit is not damaged even when the maximum voltage (1,000 V) is erroneously applied to the instrument set at the 1 V range. However, avoid application of over-voltage to the input circuit whenever avoidable.

Range	Measured voltage (V)
1 V	0.0000 ~ 1.2000
10 V	1.200 ~ 12.000
100 V	12.00 ~ 120.00
1000 V	120.0 ~ 1000.0

Table 3-1

Range	Range switching voltage (V)	
	Down-range	Up-range
1 V	-	1.2000
10 V	0.0980	12.000
100 V	0.980	120.00
1000 V	9.80	-

Table 3-2

(2) To maintain the measured result constant, turn on the HOLD button (depress the button to its locked position). For more accurate measurement, taking the response time of the instrument into consideration, depress the HOLD button at approximately three seconds after the voltage to be measured is applied to the input terminal.

4. OPERATING PRINCIPLE

4.1 GENERAL OPERATION DESCRIPTION

The Model 151 Digital Voltmeter employs an integration-type pulse width conversion system. The input voltage is converted into a current signal, the current signal is integrated, then the current signal is disconnected by a reset pulse, a reference current is integrated to produce a pulse width which is proportional to the input voltage, and the pulse width is measured with a pulse width counter. This system effectively eliminates the noise superimposed on the input signal and ensures stable measurement.

A block diagram and a timing chart of this instrument are shown in Figs. 4-2 and 4-1, respectively. The timing chart is for the full scale input (12000).

The input voltage applied to the input terminal is divided in accordance with range setting, is applied to the DC amplifier of a high input impedance type, and is converted into a constant-current signal having a high output impedance. The constant-current signal (which is proportional to the input voltage) and the reference current (fed from the internal standard signal source) are integrated alternately. The pulse converter produces a pulse signal, the width of which is accurately proportional to the input voltage. The produced pulse width is compared with the standard pulse width. The result of comparison is fed through a memory circuit to the display unit which indicates the result in 5-column decimal digits.

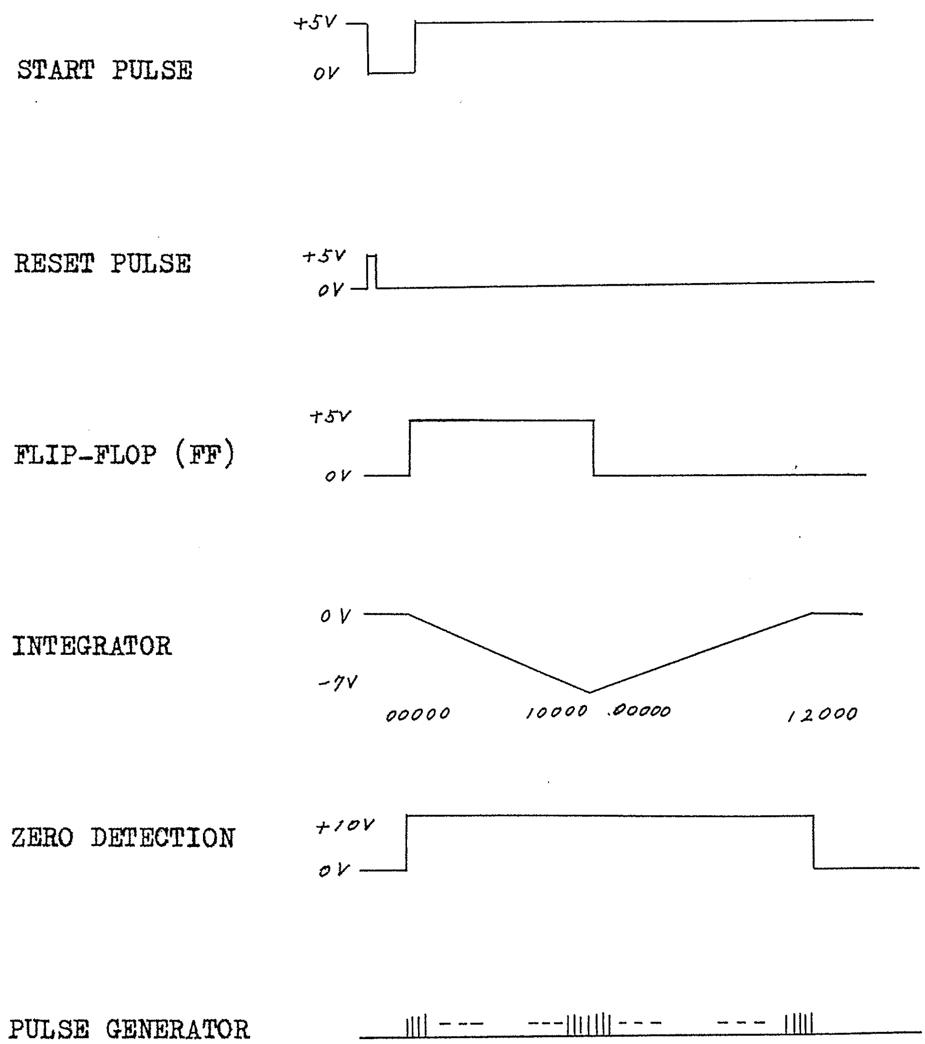


Fig. 4-1 Timing chart

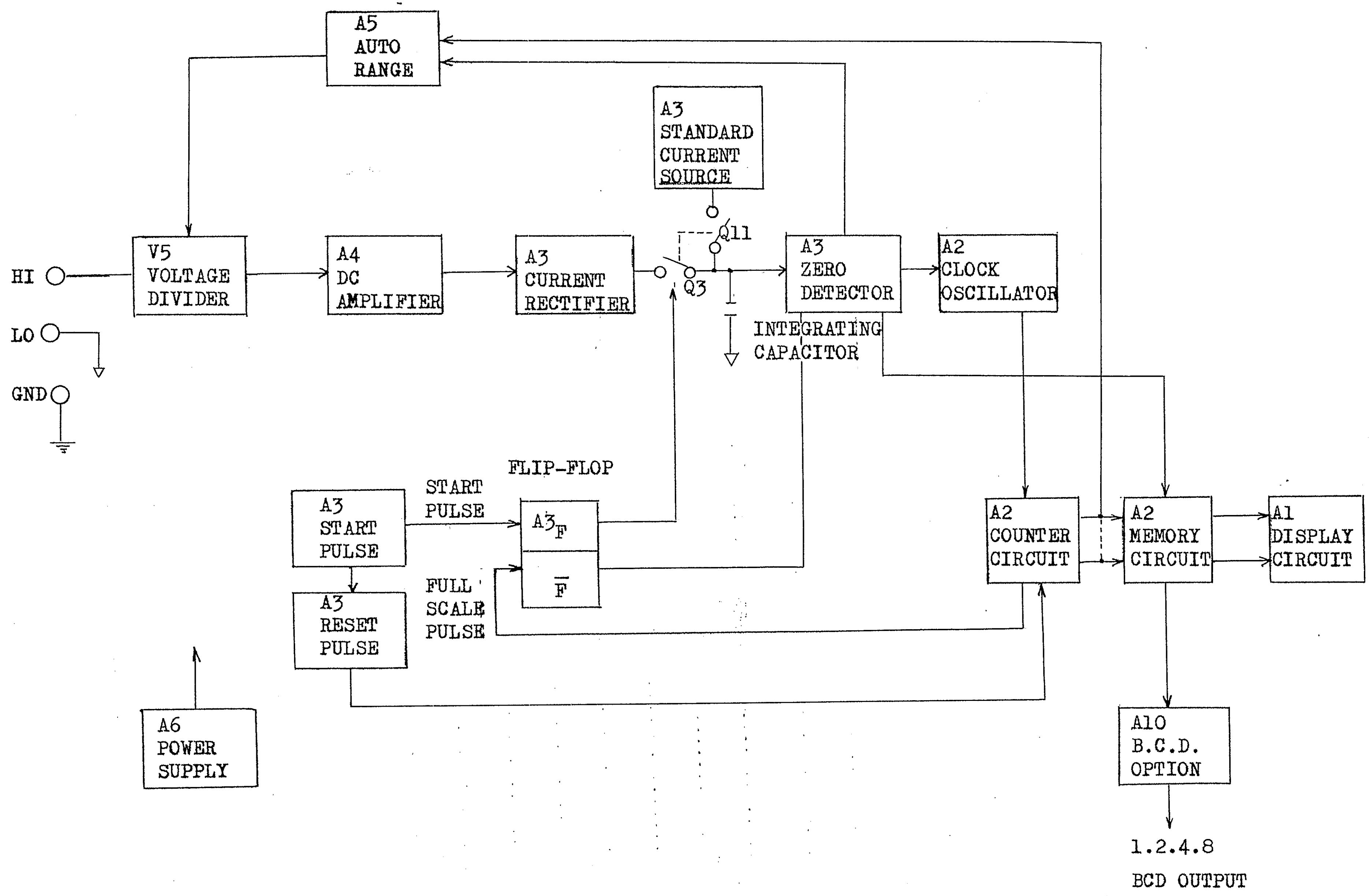
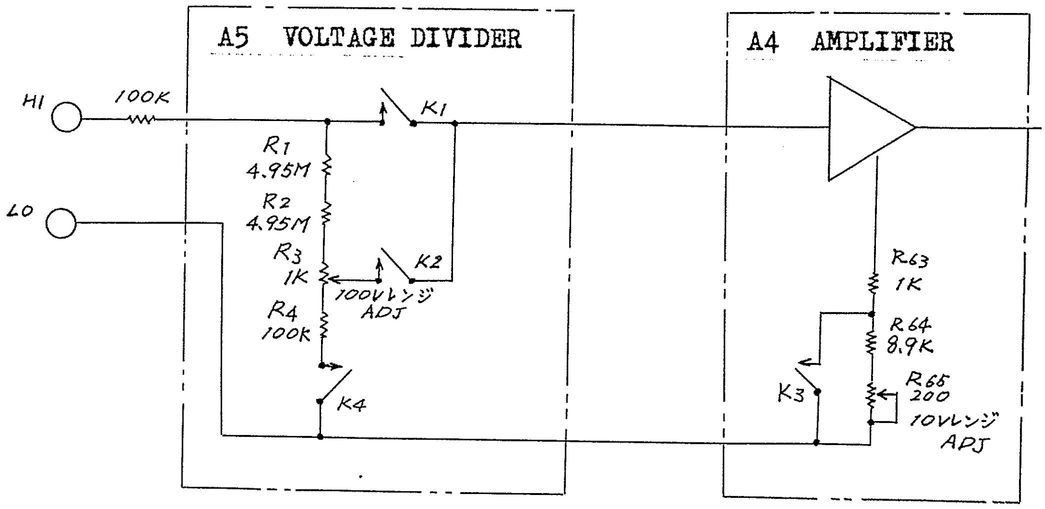


Fig. 4-2 Block diagram of Model 151 Digital Voltmeter

4.2 VOLTAGE DIVIDER (A5)

The voltage divider circuit provides the 1 V and 10 V ranges with an input resistance of 1,000 MΩ or higher, and the 100 V and 1,000 V ranges with an input resistance of 10 MΩ. The output resistance is almost constant. The output voltage of the divider circuit is 1 V for the 1 V and 100 V ranges and it is 10 V for the 1 V and 1,000 V ranges.



Range	K1	K2	K3	K4
1 V	X	O	X	O
10 V	X	O	O	O
100 V	O	X	X	X
1000 V	O	X	O	X
X: Closed contact		O: Open contact		

Fig. 4-3 Voltage divider and relay switch actions

Fig. 4-3 illustrates the voltage divider circuit and its relay switch actions. For the 1 V and 10 V ranges, K1 is closed and the input signal is directly applied to the chopper amplifier. The input impedance of the chopper amplifier is as high as more than 1,000 MΩ. Since K4 is open, the impedance of the amplifier itself represents the input impedance of the instrument for the 1 V and 10 V ranges. Relay switch K3 closes for the 1 V range but it opens for the 10 V range, in order that the output current of the amplifier is maintained at 1 mA full scale.

For the 100 V and 1,000 V ranges, K2 and K4 are closed, shunting the input circuit with the voltage divider of a resistance of 10 MΩ. Therefore, the input impedance of the instrument becomes 10 MΩ. The input voltage is divided by a factor of 1/100. The dividing ratio is adjustable with R3 (1 kΩ) mounted on Printed Board A5. Relay switch K3 closes for the 100 V range but it opens for the 1,000 V range, in order that the output current of the amplifier is maintained at 1 mA full scale.

4.3 AUTO-RANGE CIRCUIT (A5)

Under the AUTO-RANGE mode of operation, the range is automatically switched up or down by actions of the relay switches. The switching points (boundary values) are "12000" for up-ranging and "00980" for down-ranging. The signals required for these automatic relay switch control actions are derived from the decade counter.

The AUTO-RANGE circuit basically is a reversible ring counter. It consists of four blocks. Each block has two inputs. With this construction, the AUTO-RANGE circuit automatically selects an appropriate range in response to the up-range and down-range pulse signals.

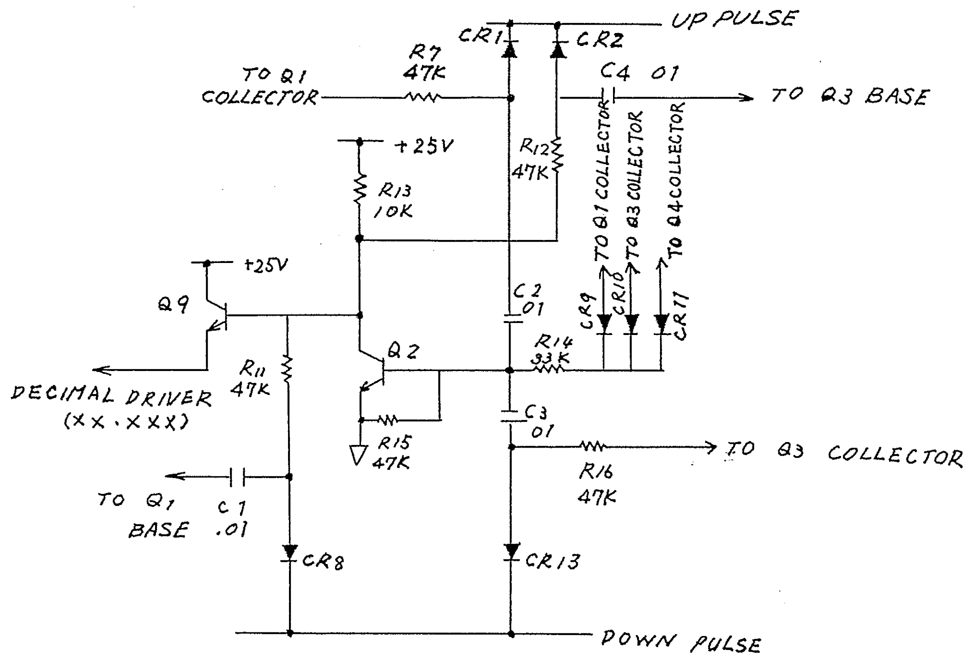


Fig. 4-4 The ring counter circuit (A5)

Fig. 4-4 illustrates the ring counter circuit for driving the 10 V range. The ring counter consists of four blocks. For any given time, only one of the blocks is in the OFF state and all three remaining blocks are in the ON state. Let us assume here that Q2 is OFF. In this case, Q9 is ON and the display indicates as "XX.XXX". C4 is for up-ranging operation and C1 for down-ranging. When Q2 is OFF, the collectors of Q1, Q3 and Q4 are at the ground potential. When an up-range pulse is applied to the ring counter, the negative pulse applied to the input capacitor of each block through CR1 - CR3 tends to drive all blocks instantaneously into the OFF state. However, since C2 has been charged in the positive polarity, Q3 is driven into the OFF state faster than the other stages. As Q3 is driven into the OFF state and the collector potential of Q3 becomes positive, the base current of Q2 flows through CR10 and consequently Q2 conducts (turned on). In a similar manner, the other stages also are turned on. Therefore, the display for the 100 V range becomes "XXX.XX".

4.4 DC AMPLIFIER (A4)

The DC amplifier employs a high-stability chopper-type operational amplifier. It provides an amplified DC output which is proportional to the input voltage. The output current of the amplifier is charged in the integrating capacitor of the A-D converter (A4) and is integrated for the first half cycle. (The second half cycle is used for integration of the standard current or it is used as the discharge cycle.)

The input circuit of the DC amplifier is shown in Fig. 4-5. A signal of 1 V or 10 V is applied to the input circuit. The output current is 1 mA full scale for either input voltage.

The output current is determined by Rf which feeds the DC amplifier output back to the LO input terminal. The resistance of Rf for the 1 V range is 1 kΩ as relay switch K3 is closed; that for the 10 V range is 10 kΩ as relay K3 is open.

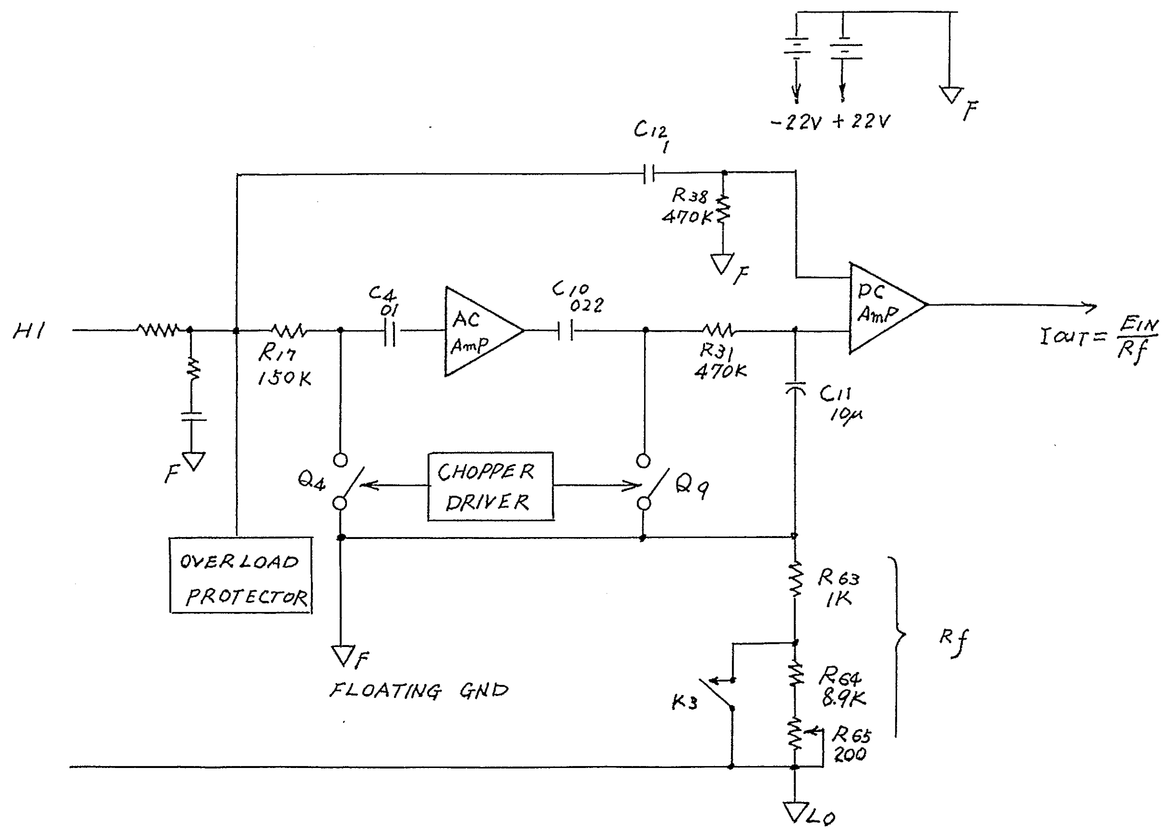


Fig. 4-5 Amplifier circuit (A4)

The DC amplifier circuit consists of a chopper amplifier and a DC amplifier as shown in Fig. 4-5. The former, which employs a MOS FET chopper (Q4), provides a high input impedance and a high operation stability.

The DC input signal is converted into an AC signal (square wave) of 250 Hz by the switching action of the chopper (Q1). This AC signal is amplified by a 3-stage AC-coupled amplifier. The amplified AC signal is converted back to the DC signal in response to input polarity by the synchronized demodulator transistor (Q9), and the restored DC signal is applied to one input of the differential DC amplifier. To the other input, to improve the response speed, the signal is AC-coupled from the pre-stage of the chopper amplifier.

The input overvoltage protective circuit clamps the abnormal voltage at approximately ±2 V for the 1 V and 100 V ranges or at approximately ±16 V for the 10 V and 1000 V ranges.

The above-described DC amplifier provides a constant-current output. The current value is determined by Rf as $I_{OUT} = E_{IN}/Rf$.

4.5 CURRENT RECTIFIER (A3)

The output of the DC amplifier is fed to the current rectifier (A3). The current rectifier converts the positive and negative output currents of the DC amplifier into a unipolar current, or it has a function as an absolute-value current converter.

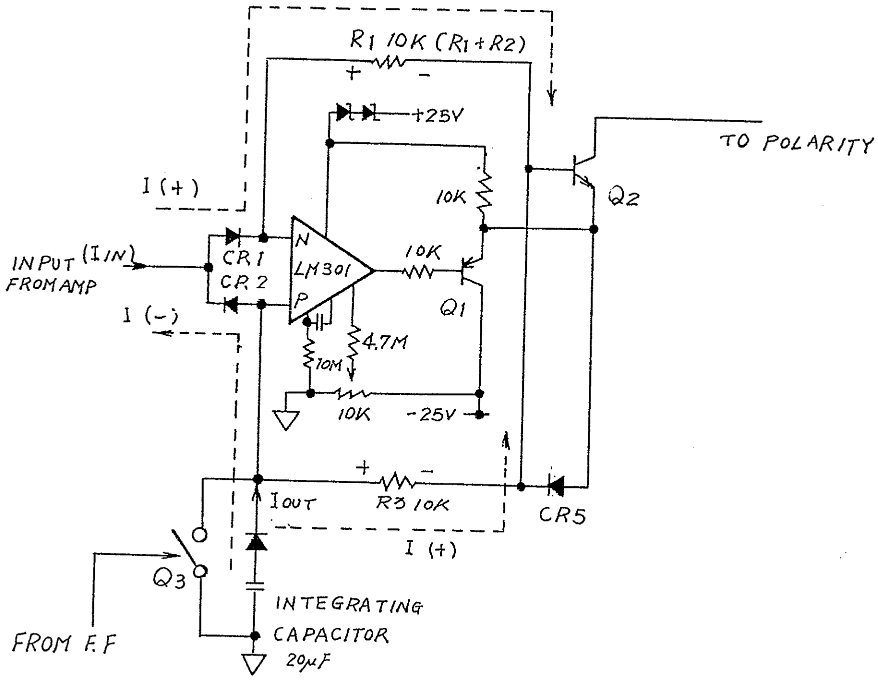


Fig. 4-6 Current rectifier (A3)

The basic circuit of the current rectifier is shown in Fig. 4-6. When input current I_{IN} is negative, the current is fed through CR2 or it is converted into output current I_{OUT} which charges the integrating capacitor in the negative polarity. When input current I_{IN} is positive, the current flows through CR1 into R1, developing a voltage drop of $VR1 = I_{IN} \cdot R1$. By the negative feedback loop, the relationship of $VR5 = -VR1 = -I_{IN} \cdot R1$ is obtained. The current which flows in R5 is supplied from the integrating capacitor. Therefore, the following equation yields:

$$I_{OUT} = -\frac{VR5}{R6}$$

Diode CR5 and transistor Q2 switch the polarity of the display circuit. When the input signal is negative, CR5 is reverse-biased and is cut off; when the input signal is positive, CR5 is forward-biased and conducts.

4.6 REFERENCE CURRENT SOURCE (A3)

The reference current source (constant-current source) supplies a standard current of +1 mA. The current is integrated in the integrating capacitor for the second half of each measuring cycle. The reference current source circuit is shown in Fig. 4-7.

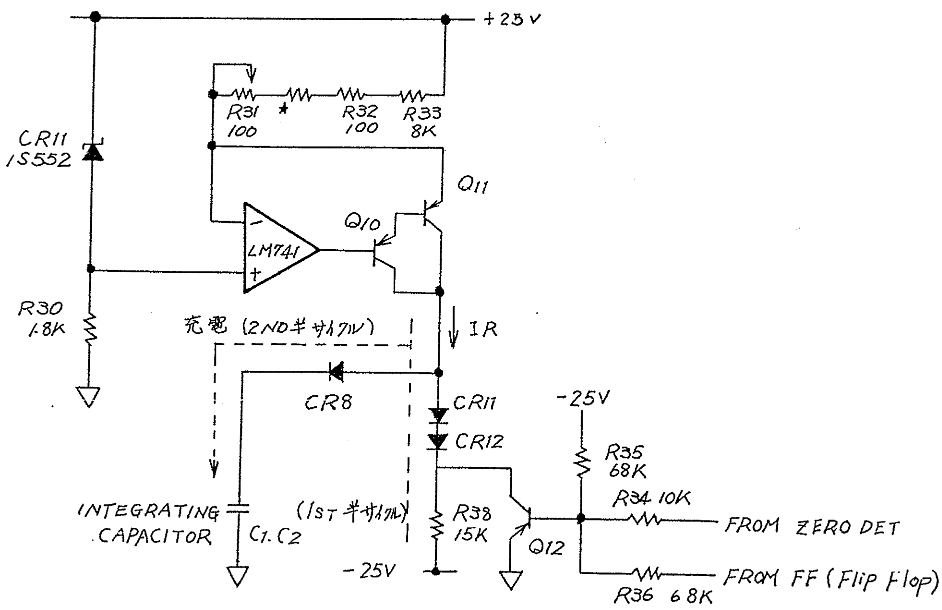


Fig. 4-7 Reference current circuit (A3)

Zener diode IS552 (zener voltage 8.5 V) is used as the reference voltage generator. The constant voltage generated by this diode is applied to the input circuit of the differential amplifier which consists of IC (LM741) and provides a feedback loop. The output of the differential amplifier is amplified by a Darlington amplifier consisting of Q10 and Q11, and the output of Q11 is fed back to the inverting input of LM741. The output circuit (emitter) of Q11 is connected to the +25 V supply line through series resistors R31, R*, R32 and R33 which are of a metallic film type having a very low temperature coefficient. The reference current (I_R) is determined by the total resistance of the series resistors (R31 ~ R33), and is adjusted at 1 mA by variable resistor R31.

Q12 is a switching transistor used for gating the charging period of I_R into the integrating capacitor. For the 1st half of the measuring cycle, the FF is cut off and the voltage is +5 V and, consequently, the base of Q12 is reverse-biased. Q12 is cut off, the reference current (I_R) flows to the -25 V line through CR11, CR12 and R12, the collector voltage of Q11 becomes -9 V, and CR8 is reverse-biased and is cut off. The charging current flows into the integrating capacitor.

When the counter has counted to its full scale (10,000 pulses), the full-scale pulse inverts the flip-flop, and Q12 conducts. This action occurs in the 2nd half of the measuring cycle.

The collector of Q12 becomes the GND potential and the integrating capacitor is charged in the negative polarity for the 1st half of the measuring cycle. CR8 conducts, CR11 and CR12 are reverse-biased and are cut off, and I_R charges the integrating capacitor towards zero volts.

When the integrating capacitor has become zero volts, the output of the zero detector ($\overline{\text{ZERO DET}}$) becomes positive and Q12 is again cut off, ceasing to charge the integrating capacitor.

4.7 ZERO DETECTOR (A3)

The zero detector controls the clock pulse generator which drives the decade counter. The clock signal generator operates for the period from the start of the 1st half of the measuring cycle to the end of the 2nd half, or for the period the integrating capacitor is charged towards zero volts and the potential becomes zero volts. The zero detector circuit is shown in Fig. 4-8.

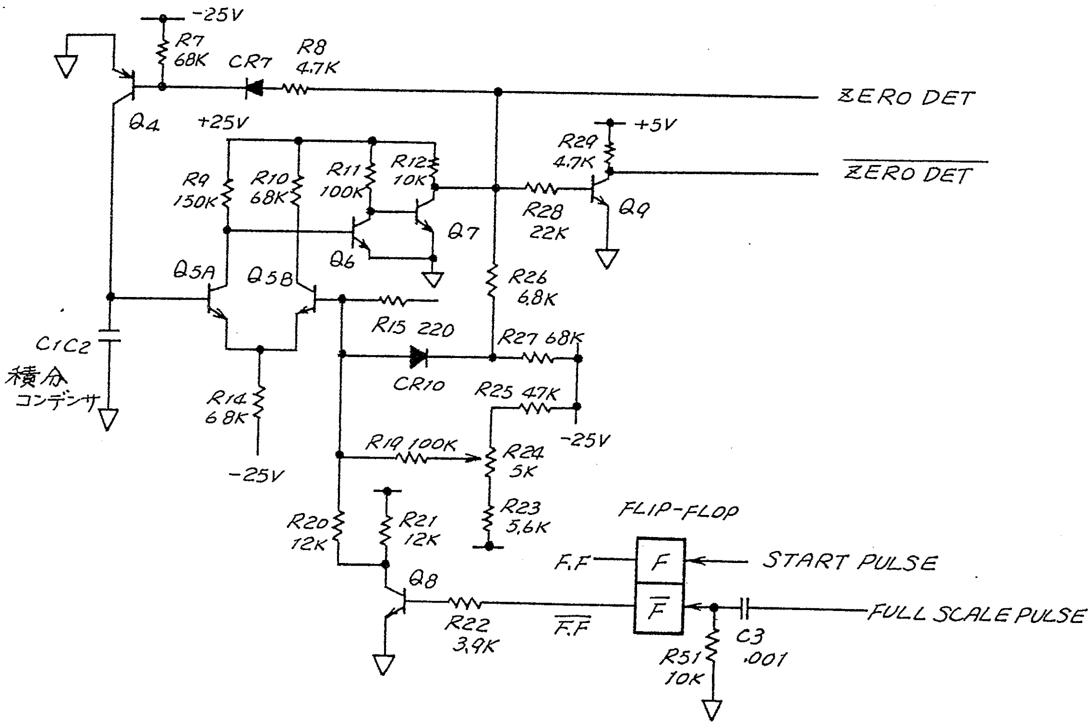


Fig. 4-8 Zero detector

The integrating capacitor is connected to the inverting input of differential amplifier Q5A. Its output voltage is divided and fed to the non-inverting input of Q5B. Diode CR10 is used to provide a feedback circuit between the amplifier output and non-inverting input.

For the 1st half of the measuring cycle, the flip-flop output ($\overline{FF}$) is zero volts and Q8 is cut off. For the period Q5A is cut off, Q5B conducts. Consequently, Q6 conducts but Q7 is cut off producing a high potential in its collector and providing a reverse-bias voltage for CR10.

When the counter has counted to its full scale, it generates the full-scale pulse (r). This pulse resets the FF, making its output voltage +5 V. In this case, Q7 is maintained cut off since the integrating capacitor is charged to the negative maximum value.
As the 2nd half of the measuring cycle starts, the integrating capacitor starts to be charged towards the positive polarity. As the capacitor potential becomes zero volts, Q5A starts conducting. Q7 also starts conducting, CR7 is reverse-biased, Q4 conducts, and the integrating capacitor and the base of Q5A is maintained at zero volts. As Q7 starts conducting, the NAND gate of the oscillator circuit is made zero volts in order to stop oscillation.

4.8 START/RESET CIRCUIT (A3)

An free-run multivibrator is used for the start circuit which produces pulses at a rate of 5 pulses/sec. The falling part of the start pulse is used to set the counter to "00000". The start/reset circuit is shown in Fig. 4-9.

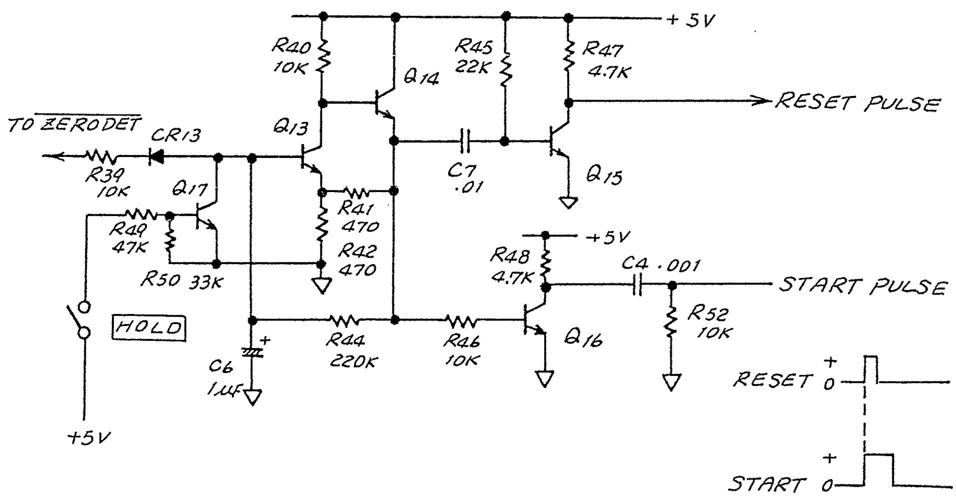


Fig. 4-9 Start/reset circuit (A3)

The oscillation frequency is determined by the time constant of R39 and C6. Q13 is held cut off since its emitter is maintained at 2.5 V by the voltage divider consisting of R41 and R42.

When the charging current flows into C6 through R39, the potential of the base of Q13 gradually rises. When the potential has reached 2.5 V, Q13 starts conducting. Q14 is cut off and its emitter voltage falls. The emitter voltage of Q13 also falls and, consequently, the charge of C6 is discharged through the base of Q13.

When the base potential of Q13 has become zero volts, Q13 is again cut off and its emitter potential becomes 2.5 V. As a result, charging of C6 starts again.

Transistor Q17 is used to stop oscillation of the free-run multivibrator. When the HOLD button on the front panel is depressed (is set in the ON state), the base current of Q17 flows. Consequently, Q17 conducts and no charging current flows into C6.

4.9 CLOCK PULSE GENERATOR (A2)

The clock pulse generator employs a crystal-controlled oscillator circuit which provides a high frequency stability and a high normal mode rejection ratio. To improve the rise-up characteristics, a TTL (M-5340) is used as the driver.

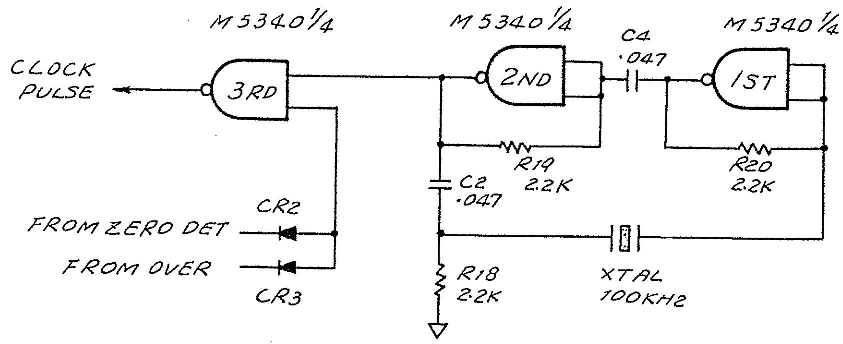


Fig. 4-10 Clock pulse generator

The oscillator circuit has two stages of 2 NAND gates. The oscillation frequency is crystal-controlled. The oscillator output is fed to the 2 NAND gates of the 3rd stage. The 2 NAND gates of the 3rd stage is used to control oscillation. The control action is made in response to the output of the zero detector and to the display overflow pulse (which is generated when the display has exceeded 12000).

4.10 COUNTER AND ITS ASSOCIATED CIRCUITS (A2)

The counter and its associated circuits are shown in Figs. 4-11 and 4-12.

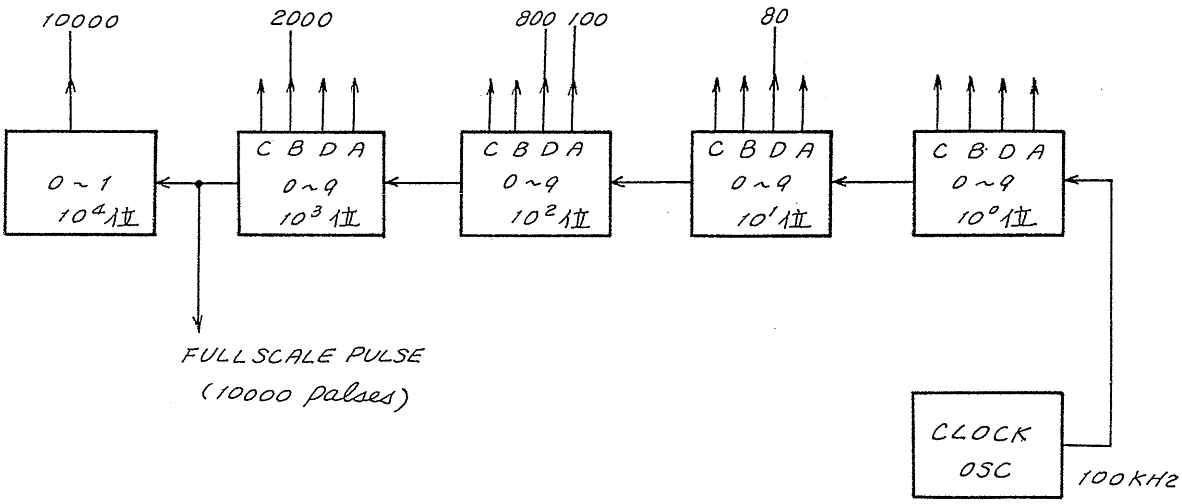


Fig. 4-11 Counter (A2)

The crystal-controller clock pulse generator produces a clock pulse signal of 100 kHz. The counter employs a decade counter for four columns of 1-order to 1,000-order. The most significant column (10,000-order) employs a flip-flop for binary counting of "0" and "1".

For the AUTO-RANGE mode of operation, to set the up-range and down-range levels, signals are taken out from the binary and decade counter outputs as follows: For the up-range signal, "1000" is taken from the 10^4 column and "2000" from the 10^3 column for the boundary value of "12000"; for the down-range signal, "900" is taken from the 10^2 column and "80" from the 10^1 column for the boundary value of "00980".

Counters of individual columns are connected to respective memory circuits, display drive circuits, and display circuits as shown in Fig. 4-12. When a transfer pulse is applied to the gate, the measured value of the instant of the pulse application is stored in the memory circuit. The measured value is a binary number of 8-4-2-1 code. This binary number is converted into a decimal number by the matrix fabricated in the display drive circuit. The display drive circuit controls the discharge-type display tubes through transistors.

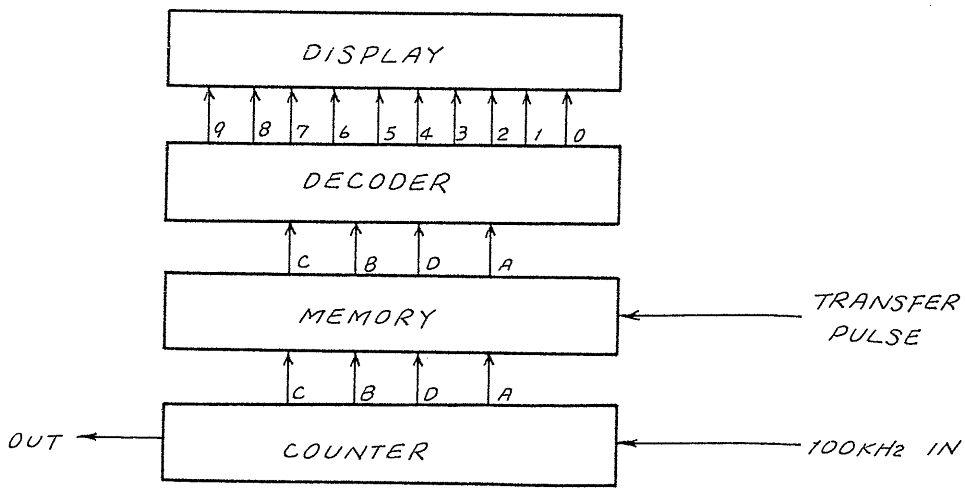


Fig. 4-12 Counter and its related circuits (A1 and A2)

A block diagram of the counter and its related circuits are shown in Fig. 4-12. This block diagram represents a setup for one column of the counter. The counter, memory, and decoder circuits are fabricated with IC's. A chart giving the relationship between the binary output and decimal output is given in Table 4-1.

Decimal output \ Binary output	A 1	B 2	C 4	D 8
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	1
8	0	0	0	1
9	1	0	0	1
"0": Low level		"1": High level		

Table 4-1. Relationship between binary output and decimal output

4.11 POWER SUPPLY (A6)

The power supply provides non-regulated +200 V, regulated ±25 V, +24 V, +5 V, and ±22 V. A schematic diagram of the power supply is shown in Fig. 4-13.

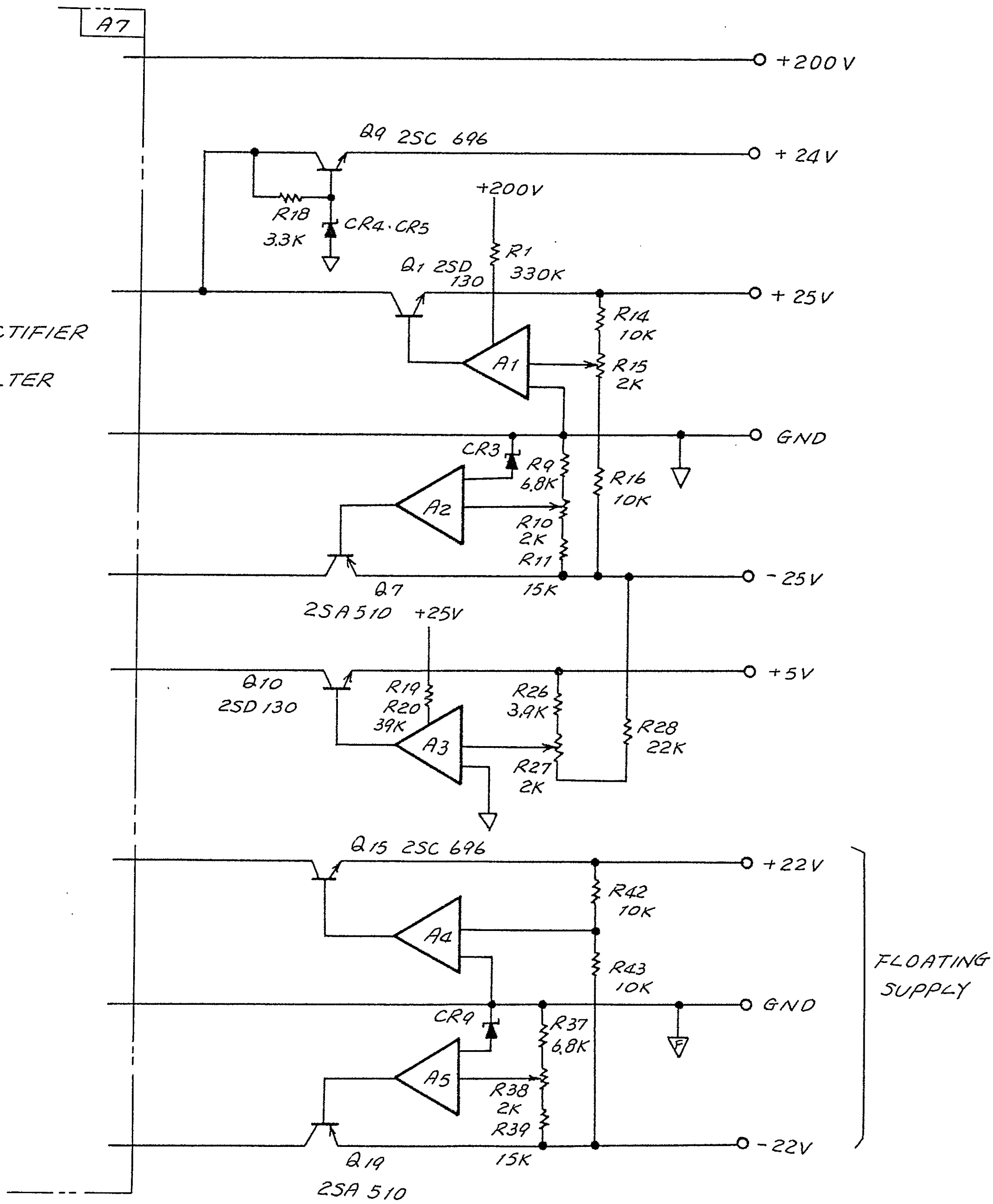


Fig. 4-13 Power supply

The +200 V supply and -25 V supply are independent from the other supplies. The +25 V supply and +5 V supply are related to other supplies. The +25 V supply provides the bias voltage for the error amplifier from the +200 V supply. The +24 V supply is regulated with a zener diode, is independent in operation, and provides the power to drive the relays. The +5 V supply obtains its reference voltage from the -25 V supply, and the bias voltage of the amplifier is obtained from the +25 V supply.

The floating supply provides bias voltages for the DC amplifier. This supply is isolated from the other supplies. The -22 V supply operates independent; the +22 V supply obtains its reference voltage from the -22 V supply.

5. MAINTENANCE

5.1 REMOVING THE HOUSING

Ensure that the power cord is disconnected from the AC line outlet. Remove the four clamping-screws of the studs located at right and left of the rear of the housing. Then, slowly pull backwards the top, side, and bottom plates of the housing.

5.2 LOCATIONS OF COMPONENTS

Major components of the instrument are located as shown in Fig. 5-1.

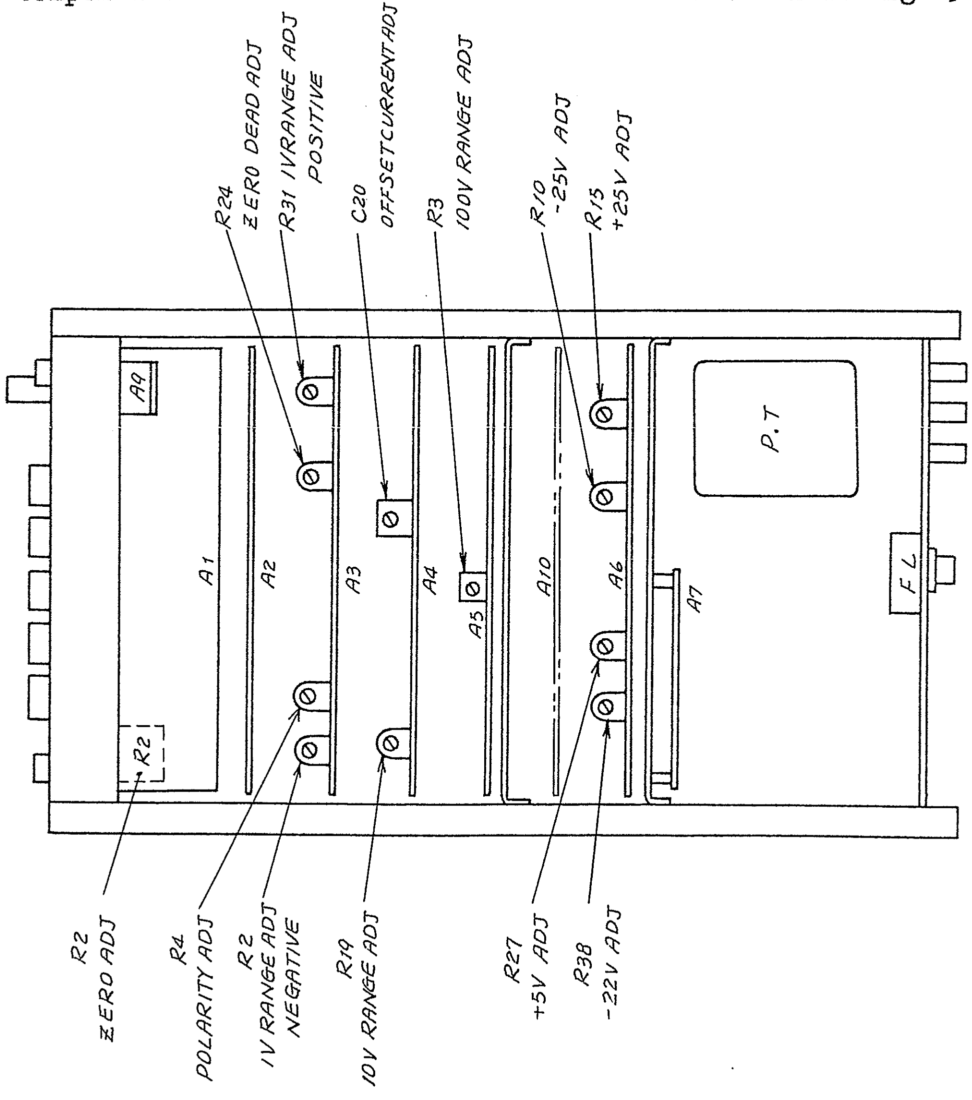


Fig. 5-1 Locations of components

Nine printed boards, A1 through A9, are used in this instrument.

- A1: Display
- A2: Counter and oscillator
- A3: Current rectifier, zero detector, and reference current source
- A4: DC amplifier
- A5: Voltage divider and AUTO-RANGE circuit
- A6: Power supply
- A7: Rectifier
- A8: Extender
- A9: Polarity selector and display overflow indicator

5.3 ADJUSTMENTS

Adjustment of -25 V supply:

Connect a DC voltmeter between Pin 15 and Pin 10 (GND) of the connector of Printed Board A6, and adjust R10 so that the voltage is made -25 V ±1%.

Adjustment of +25 V supply:

Connect a DC voltmeter between Pin 22 and Pin 10 (GND) of the connector of A6, and adjust A15 so that the voltage is made +25 V ±1%. Do not omit to check this voltage before calibrating the instrument.

Adjustment of +5 V supply:

Connect a DC voltmeter between Pin 12 and Pin 10 (GND) of the connector of A6, and adjust R27 so that the voltage is made +4.9 V to +5.0 V.

Adjustment of -22 V supply (floating supply):

Connect a DC voltmeter between Pin 1 and Pin 4 (GND) of the connector of A6, and adjust R38 so that the voltage is made -22 V ±1%.

5.4 CALIBRATION

To ensure the high accuracy of the instrument for a long period, the instrument must be periodically calibrated. Calibration must be made at an ambient temperature constant at approximately 25°C. An example of calibration setup is shown in Fig. 5-2. As for the DC voltage standard, one with an accuracy of 0.01% or better must be used.

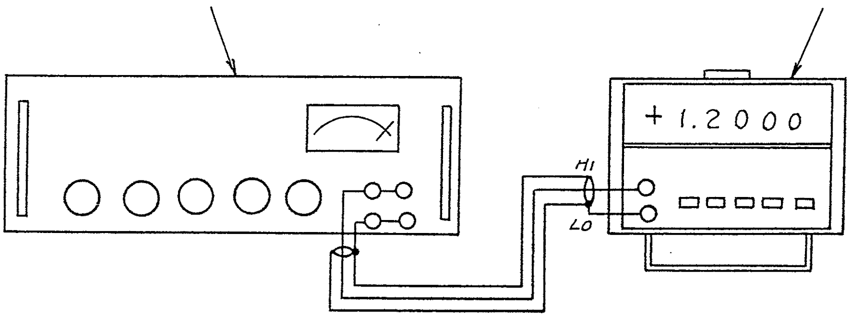


Fig. 5-2 Calibration setup

The calibration procedure is as follows:

(1) Turn on the power of the instrument, and allow about an hour of stabilization period.

(2) Check the voltages of the power supply and other circuits (refer to Section 5.5) to ensure that the instrument is operating normally.

(3) Adjustment of offset current:

Set the instrument for the 1 V range, connect a 10-MΩ resistor between the input terminals (with the lead wires as short as possible), and adjust C20 of Printed Board A4 so that the display indicates zero. Next, short the input terminals and adjust the ZERO ADJ on the panel. Repeat alternately the above two adjustments until the display indicates zero for both cases.

(4) Connect the output terminals of the DC voltage standard to the input terminals of the instrument.

(5) Adjustment of ZERO ADJ:

Set the instrument for the 1 V range. Adjust the output voltage of the voltage standard at 3 mV, and adjust the ZERO ADJ on the front panel of the instrument so that the voltage readings are identical when the polarity is changed.

(6) Adjustment of zero erase:

After adjustment of the preceding paragraph (5) is complete, Adjust R24 of Printed Board A3 so that the display indicates "0.0000" when the input circuit is shorted. If over-correction is made, the resolution in measurement is degraded. In order to guard against over-correction, repeat the procedure of the preceding paragraph (5) and ensure that the display indicates "00030".

(7) Adjustment of polarity switching:

Set the instrument for the 1 V range and the output of the DC voltage standard at 0.05 mV. Adjust R4 of Printed Board A3 so that the polarity is correctly displayed.

(8) Calibration of the 1 V range:

Set the instrument for the 1 V range and ensure that the ZERO ADJ has been correctly adjusted. Set the output of the DC voltage standard at +1 V, and adjust R2 of Printed Board A3 so that the display indicates +1.0000 V.

Next, change the output of the DC voltage standard to -1 V, and adjust R31 of Printed Board A3 so that the display indicates -1.0000 V.

(9) Calibration of the 10 V range:

Set the instrument at the 10 V range, and ensure that the ZERO ADJ has been correctly adjusted. Set the output of the voltage standard at +10 V, and adjust R19 of A4 so that the display indicates +10.000 V.

(10) Calibration of the 100 V range:

Set the instrument for the 100 V range, and ensure that the ZERO ADJ has been correctly adjusted. Set the output of the voltage standard at +100 V, and adjust R3 of A5 so that the display indicates +100.00 V

5.5 INSPECTION AND SERVICE

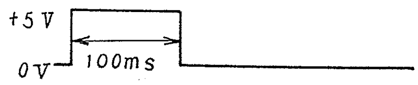
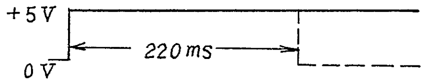
For inspecting and servicing the instrument, refer to Section 4 "OPERATING PRINCIPLE." The voltages mentioned below are as measured with respect to the GND potential, unless specified otherwise. For inspecting and servicing the instrument referring to the below-mentioned values, set the instrument for the 1 V range and the HOLD button in the OFF state.

Power Supply (A6)

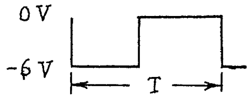
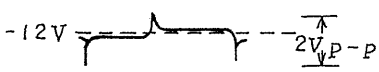
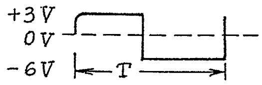
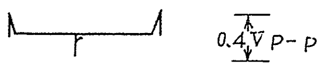
Test point	DC voltage	Ripple (p-p)
1	+42 V	0.5 V
2	-44 V	0.2 V
3	+ 9 V	3 V
4 (Floating	+38 V	0.1 V
5 GND as reference)	-37 V	0.15 V

Connector Pin No.		Ripple (rms)
	+25 V	0.15 mV
	+24 V	0.4 mV
	-25 V	0.15 mV
	+ 5 V	0.75 mV
(Floating	+22 V	0.7 mV
GND as reference)	-22 V	0.7 mV

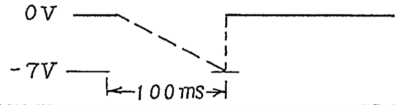
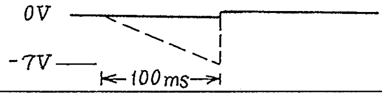
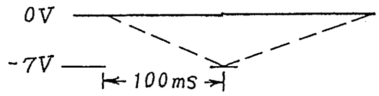
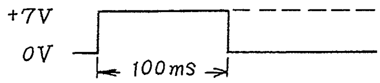
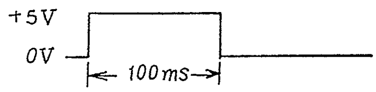
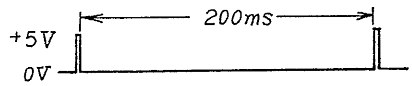
AUTO-RANGE Circuit (A5)

Test point	Normal waveform
1	
2	 When above "12000"
3	

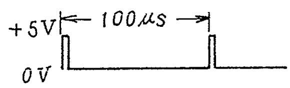
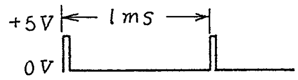
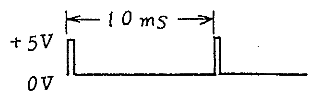
DC Amplifier (A4)

Test point	Normal waveform
1	 T = 4 msec.
2	
3	 T = 4 msec.
4	

A-D Converter (A3)

Test point	Normal waveform
1	 At "12000"
2	 At "12000"
3	 At "12000"
4	 At "12000"
5	
6	

Counter (A2)

Test point	Normal waveform
1	
2	
3	
4