OPERATION MANUAL

FOR

MODEL 183 AC VOLTMETER

CONTENTS

		Page
1.	General	1
2.	Specifications	3
3.	Operating procedure	6
3.1	Parts on front panel and rear terminal	6
3.2	Preparation for measuring operation	10
3.3	Measurement of AC voltage	11
3.4	Measurement of AC current	13
3.5	Use of Model 183 as output meter	14
3.6	Waveform error	15
3.7	Use of decibel conversion table and charts	16
4.	Operation principle	22
4.1	Input section	23
4.2	Preamplifier	24
4.3	Meter driver	24
4.4	Output section	25
4.5	Power supply	25
5.	Maintenance	26
5.1	Inspection of inside parts	26
5.2	Adjustment and calibration	27
5.3	Reference voltage for troubleshooting	28
*	Circuit diagram	30

1. General

Kikusui Electrics' Model 183 is a 2-pointer type transistorized high-sensitivity voltmeter which measures two input signals simultaneously and responds to the mean values of the AC voltages measured. Using semiconductors in all circuits, Model 183 is compact, lightweight and consumes low power. The measuring range can be changed over, with CH 1 (INPUT 1) and CH 2 (INPUT 2) ganged, when the red button on the range knob is locked by pushing.

When the locked button is released, each measuring range in CH 1 and CH 2 is selected independently. In addition, keeping a certain level difference between CH 1 and CH 2, the measuring range can also be selected simultaneously. Thus, Model 183 allows various types of voltage measurements.

Model 183 comprises an impedance converter having a high input impedance, a voltage divider, a preamplifier, an indicator circuit, an output section, and a voltage regulator circuit. In all circuits CH 1 and CH 2 are separated from each other. The ground of each circuit is in the floating from the cabinet.

Model 183 measures an AC voltage within a range of 0.1mV to 300Vrms (-80 to 50 dB) whose frequency is 10 to 500kHz. It

has twelve measuring fanges in 10 dBm steps, and the meter scale is graduated in equal divisions by the effective value of sine wave. In addition, Model 183 can give an AC voltage output of approximately 1 V at full scale from each output terminal of CH 1 and CH 2. Therefore, measurement can be monitored. The AC voltmeter can also be used as a preamplifier.

2. Specifications

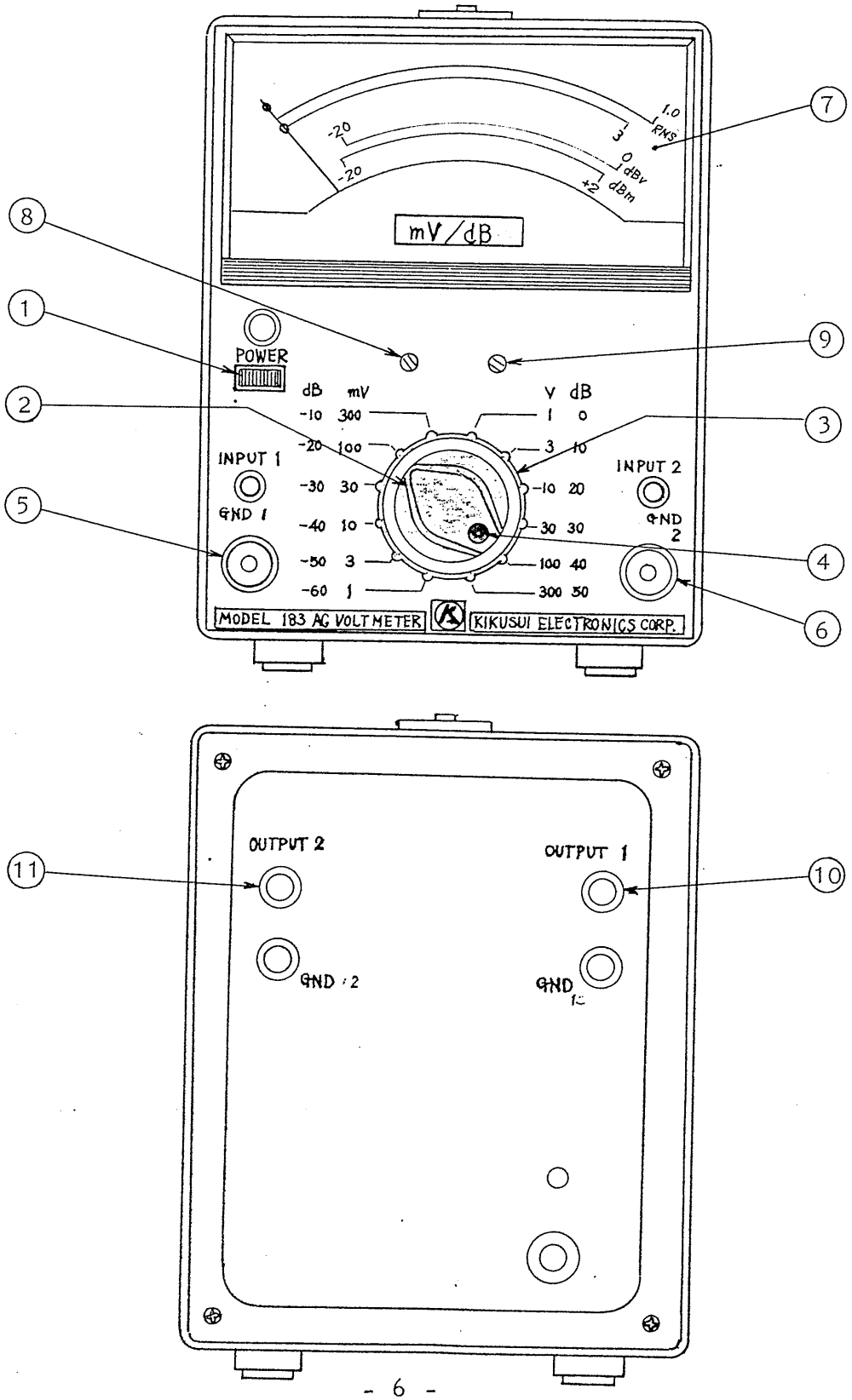
Name of instrument	AC Voltmeter
Model	183
Meter	2-pointer type, 2-colored scale, 1mA full-scale each
Graduation	Effective value of sine wave, and dBm value with reference to 1 mW 600 Ω dBv value with respect to 1 V that is 0 dB
Input terminals	UHF-type receptacle and GND termical 19 mm (3/4") spacing
Input resistance	10 MΩ for each range
Input capacitance	40pF or less for each range
Maximum input voltage	1 mV - 300 mV ranges : AC component 150 V in effective value ± 200 V in peak value DC component; ±400 V 1 - 300 V ranges: AC component; 300 V in effective value ±450 V in peak value DC component; ±400 V
Ranges	12 ranges: On RMS scale; 1/3/10/30/100/300 mV and 1/3/10/30/100/300 V

	On dB scale; -60/-50/-40/-30/-20/ -10 and 0/10/20/30/40/ 50 dB
Accuracy	±3% of full scale at 1 kHz
Stability	Less than 0.5% of full scale against ±10% fluctuation of line voltage
Rated temperature range	Within 0 to 50°C
Rated humidity range	Less than 85%
Temperature coefficient	0.04% / °C TYP
Frequency response	10 Hz - 500 kHz, ± 5% at 1 kHz 20 Hz - 200 kHz, ±3% at 1 kHz
Noise	Less than 1.5% with input terminal shorted
Output terminals	5 - way type binding post, 19mm(3/4") spacing
Output voltage	1 Vrms ±5% at full scale of "1" scale
Distortion factor	Less than 1% at full scale and 1 kHz
Frequency response	10 Hz to 200 kHz $^{+1dB}_{-3dB}$ With 10MΩ input resistance and 30pF input capacitance connected to output terminal
Power requirement	___V, 50/60 Hz, approx. 4.5 VA
Dimensions	131(W) x 160 (H) x 265(D) mm
(Maximum dimensions)	131(W) x 180 (H) x 300(D) mm

Weight	Approx. 3kg	
Accessories	Type 941B terminal adapter	2
	Operation manual	1

3. Operating procedure

3.1 Parts on front panel and rear terminals



(1) POWER

The pushbutton switch turning on and off power supply. When the button is locked by pushing, the power supply is switched on. It is switched off by repushing. For about 10 seconds after the switch is turned on, the meter the switch is turned on, the meter pointer may possibly deflect irregularly.

(2) INPUT 1 (CH 1) range switch

(3) INPUT 2 (CH 2) range switch

Dial in the center of the panel. 1mV to 300V in 12 ranges are arranged in clockwise direction. Markings for the dial denote the following; Inner black markings represent full-scale voltages.

Number on left side mV

Number on right side V

Outer blue number represents dBm.

The center arrow type knob is used for changing over the range of INPUT 1. The outer round knob changes over the range of INPUT 2.

(4) Range switch lock button

Red button on the center knob. When this button is locked by pushing, the

range can be changed over with CH 1 and CH 2 ganged. With this button unlocked, the range in each channel can be changed over independently.

(5) INPUT 1 terminal
(6) INPUT 2 terminal

Terminals for connecting the voltage to be measured. They comprise a UHF receptacle and a GND terminal. For connection, a UHF-type (5/8"-24) or M-type (16-1P) plug, or a standard (spacing: 3/4"=19mm) dual banana plug is suitable. A banana plug may be connected to the center conductor of the receptacle.
Also, by inserting the accessory "Kikusui Type 941B Terminal Adapter", a banana plug, spade lug, alligator clip, 2 mm tip or a lead 2 mm or less in diameter can be connected.
The outer conductor of the receptacle and the GND terminal are in the floating to the panel and chassis.

(7) Meter

Model 183's meter is the 2-pointer type. The red pointer indicates voltage

applied to INPUT 1, and the black pointer a voltage of INPUT 2.

The meter has the following three scales;

1) "1.0-scale"

This scale is used with 1/10/100mV and 1/10/100V ranges. The "1.0" on the scale denotes 1mV when the 1mV range is selected, and 100V when the 100 range is selected.

2) "3-scale"

This scale is used with 3/30/300mV and 3/30/300V ranges. The numeral on the scale denotes a value as with that of the "1.0"-scale.

3) "dBm-scale"

This scale is used to read the measured voltage in the dBm value with respect to 1mW, 600Ω. This is used for all 12 ranges, -60 — +50 dBm.

(8)(9) Zero adjustment

(8) is a screw for adjusting the zero point of the meter for INPUT 1. This

screw is hemmed with red. The red meter pointer can be shifted by turning this screw by and justing screwdriver. (9) is a screw for adjusting the zero point of the meter for INPUT 2. It is hemmed with black. It is interlocked with the black pointer.

(10)(11) OUTPUT terminal

Output terminals for using Model 183 as an amplifier. They are provided at the rear of the voltmeter. (10) are the output terminals for CH 1, and (11) the output terminals for CH 2. The black terminals standard are the ground one. For connection, a standard dual banana plug with a coaxial cable is convenient. A banana plug, spade lug, alligator clip, 2-mm tip or lead 2mm or less in diameter can be used as with that for the input terminals.

3.2 Preparation for measuring operation

1) Turn off the power switch on the left side of the panel.

2) Check if the meter pointer is at the center of the zero

point on the scale. If not, correct zero adjustment. The zero adjustment during use should be effected more than five minutes after the power switch is turned off so that the pointer settles near the zero point.

3) Connect the power cord to the required power source.

4) Set the range knob to 300 V.

5) Trun on the power switch, and the AC voltmeter is energized and the pilot lamp above the switch lights up. For about 10 seconds after the power switch is turned on, the meter pointer may possibly deflect irregularly. This irregular pointer deflection may also occur when the power switch is turned off.

6) When the meter pointer settles, Model 183 is ready for a measuring operation.

3.3 Measurement of AC voltage

1) When the voltage to be measured is low or the impedance of the power source to be measured is comparatively high use a shielded wire or coaxial cable, considering frequency, to avoid induction from outside. When the voltage to be measured is low in frequency and high in level or the impedance of the power source is low, the accessory type 941B terminal adapter can be used conveniently.

Caption: When using the 1mV range, it is recommended to employ a shielded wire or coaxial cable to prevent the coupling caused by the radiation from the meter.

2) To protect Model 183 from an overload, measurement should be start with the maximum voltage range, and then lower voltage ranges will be selected in sequence according to the display on the meter.

3) Using the 1.0 and 3-scales of the meter as appropriate, read the display as in Table 3-1.

Table 3-1

Range	Scale	Multiplier	Voltage Unit	Amplification Degree(dB)
1mV -60dBm	1.0	x 1	mV	60
3 " -50 "	3	"	"	50
10 " -40 "	1.0	x 10	"	40
30 " -30 "	3	"	"	30
100 " -20 "	1.0	x100	"	20
300 " -10 "	3	"	"	10
1 V 0 "	1.0	x 1	V	0
3 " 10 "	3	"	"	-10
10 " 20 "	1.0	x 10	"	-20
30 " 30 "	3	"	"	-30
100 " 40 "	1.0	x100	"	-40
300 " 50 "	3	"	"	-5

4) When measuring a voltage by the dBm value with respect to 1mW, 600Ω, use the dBm scale common to all ranges, and read the display as follows;

The "0" marked in the middle of the dBm scale denotes the level the range represents; therefore, the measured value will be the meter readout plus the dBm value the range represents. For example, when the "30 dBm (30 V) range is selected and "2" is read from the dBm scale, the measured value is

$$2 + 30 = 32(\text{dBm})$$

When the "-20" dBm(100 mV) range is used and the meter indicates "1" dBm, then

$$1 + (-20) = 1 - 20 = -19(\text{dBm})$$

3.4 Measurement of AC current

When using Model 183 to measure an AC current, let the current(I) flow through a known non-inductive resistance(R), measure the voltage across the resistance, and calculate $I = E/R$. Note that the negative(-) terminal of the input terminals of Model 183 is grounded.

For the convenience of current measurement, Type 921 Shunt Resistors which have standard resistances of 0.1, 1, 10, 100 and 1000Ω, respectively, are available as optional accessories. Also, available are 4, 8, 16 and 600Ω resistors.

Each resistor can be connected to the input terminals of Model 183 by using banana plug.

Example: To measure the heater current (nominal: 6.3V, 0.3A) of a vacuum tube, connect the circuit to Model 183 as in Fig. 3-2 by using Type 921-0.1 (resistance: 0.1Ω) as the standard resistance. If 29mV is read on Model 183, the heater current will be

$$I = \frac{29 \times 10^{-3}}{0.1} = 290 \times 10^{-3}(A) = 290\ mA$$

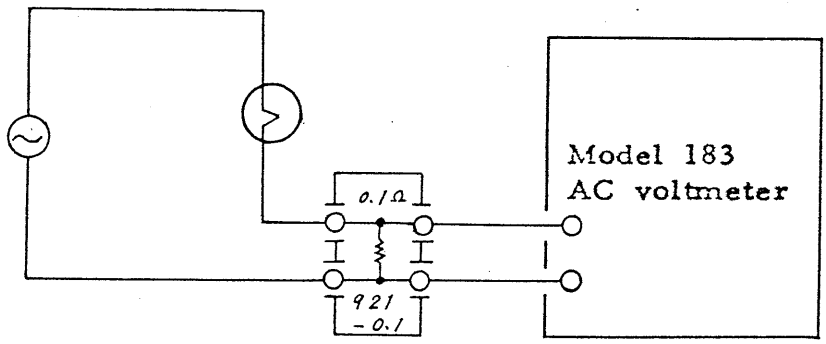


Fig. 3-2

3.5 Use of Model 183 as output meter

The voltage (E) applied across an impedance (X). The apparent power (VA) of the impedance can be obtained by solving $VA=E^2/X$.

If the impedance (X) is pure resistance(R), the power(P) consumed in the resistance will be

$$P = E^2/R$$

Since Model 183 has a dBm scale, the power can be read in decibels as it is, provided $R=600\Omega$.

If the load resistance is within the range of 1Ω to 10 $K\Omega$, the power can be read in decibels by adding the value obtained from the decibel conversion charts, Figs. 3-3 and 3-4.

Type 921 Shunt Resistors having resistances of 4, 8 and 16Ω , respectively, which are identical with the voice coil impedances of the loudspeakers in general use, are available. They can be utilized as a load resistance of small capacity (0.3W) when using Model 183 as an output meter.

3.6 Waveform error

Model 183 is a "mean value" voltmeter that indicates a value proportional to the mean value of the measured voltage. Since the meter scale is calibrated by the effective value of sine wave, however, the correct effective value may not be displayed, giving rise to an error, when a voltage distorted in waveform is measured. Table 3-2 shows this relationship.

Table 3-2

Measured voltage	Effective Value	Model 183 Display
100%-amplitude fundamental	100 %	100%
100% fundamental + 10% second harmonic	100.5	100
100% fundamental + 20% second harmonic	102	100 - 102
100% fundamental + 50% second harmonic	112	100 - 110
100% fundamental + 10% third harmonic	100.3	95 - 104
100% fundamental + 20% third harmonic	102	94 - 108
100% fundamental + 50% third harmonic	112	90 - 116

3.7 Use of decibel conversion table and charts

1) Decibel

"Bel" is a common-logarithmic unit (with 10 as base) expressing the ratio of two powers. One "decibel" (abbreviated dB) is one-tenth of a Bel. The dB is defined as follows:

$$dB = 10 \log_{10} \frac{P_2}{P_1}$$

That is, how large the power P_2 is in comparison with the

power P_1 is represented with 10 times the common logarithm. If the impedances at the places where P_1 and P_2 exist are equal to each other, the ratio of powers may be expressed with the ratio of voltages or currents as follows:

$$dB = 20 \log_{10} \frac{E_2}{E_1} \quad \text{or} \quad 20 \log_{10} \frac{I_2}{I_1}$$

Decibel is originally the ratio of power as described above. However, the common logarithm of the ratio of other values has also been called "decibel" for a long time.

For example, when the input voltage of an amplifier is 10 mV and its output voltage is 10 V, the degree of amplification is 10 V/10 mV = 1000 times. This is also expressed in dB as follows:

$$\text{Degree of amplification} \quad 20 \log_{10} \frac{10\,V}{10mV} = 60(dB)$$

Also, the output voltage of a standard RF signal generator is expressed in dB to represent how many times of 1 μV the output voltage is. An output of 10 mV, for example, is

$$10\,mV = 20 \log_{10} \frac{10mV}{1\,\mu V} = 80(dB)$$

Such a decibel notation must have the reference, namely, 0 dB, clarified. For example, the output voltage of the above signal generator should be expressed, using parentheses

For the reference, as follows; 10 mV = 80 dB (1μV = 0 dB)

2) dBm, dBv

"dBm" is abbreviation for dB (mW). This decibel value expresses the power ratio with respect to 1 mW that is 0 dB. Normally, "dBm" implies the condition that the power exists in an impedance of 600Ω. Thus, "dBm" generally means "dB (mW 600Ω)".

As mentioned before, if the power and impedance are definite, the decibel can be express voltage and current as well as power. Therefore, " 0 dBm " signifies the following:

0 dBm = 1 mW or 0.775 V or 1.291 mA

The decibel value "dBv" expresses the voltage ratio with respect to 1 V that is 0 dB. "dBv" is utilized in acoustics and audio technology for characteristic of easy conversion.

The decibel scale of Model 183 is graduated by the dBm value and the dBv value as explained above.

Therefore, when measuring a decibel value that is expressed with respect to other than "1 mW 600Ω or 1 V ", the reading on the Model 183 should be corrected. Because of the character of logarithm, this correction can be effected by adding a value to the reading, referring to Fig. 3-3, Table 3-3 and Fig. 3-4.

3) Use of decibel conversion table and charts

Fig. 3-3 is used to convert the ratio of values into a decibel value. Different decibel scale are provided for power (or equivalent) and voltage (or current) ratios.

Example 1 : How many decibels in 5 mW with respect to 1 mW? Since this is a power ratio, the left scale is used. From the power ratio of 5 mW/1 mW=5, 7 dB(mW) is obtained as shown with a dotted line in Fig. 3-3.

Example 2 : How many decibels are 50 and 500 mW with respect to 1 mW? When the ratio is 0.1 or less, or 10 or more, the decibel value is obtained by using Fig. 3-3 and Table 3-3 as follows;

50 mW = 5 mW x 10 = 7 + 10 dB = 17 dB

500 mW = 5 mW x 100 = 7 + 20 dB = 27 dB

Table 3-3

Ratio		Decibel	
		Power Ratio	Voltage or Current Ratio
10,000	$=1x10^4$	40 dB	80 dB
1,000	$=1x10^3$	30 "	60 "
100	$=1x10^2$	20 "	40 "
10	$=1x10^1$	10 "	20 "
1	$=1x10^0$	0 "	0 "
0.1	$=1x10^{-1}$	-10 "	-20 "
0.01	$=1x10^{-2}$	-20 "	-40 "
0.001	$=1x10^{-3}$	-30 "	-60 "
0.0001	$=1x10^{-4}$	-40 "	-80 "

Example 3: What is 15 mV in dB(V)? Since 1 V is the reference, 15mV/1 V = 0.015 is calcurated first. By using the voltage (current) scale of Fig. 3-3, and Table 3-3,

$0.015 = 1.5 \times 0.01 \longrightarrow 3.5 + (-40) = 36.5$ dB(V)

or

$1V/15mV = 66.7 \times 10 \longrightarrow 16.5 + 20 = 86.5$ dB(V)

4) Use of decibel addition chart

Fig. 3-4 is used for obtaining the power from the dBm value read out from Model 183.

Example 1 : When the voltage across the voice coil, having an impedance 8 Ω, of a loudspeaker is measured by Model 183, the meter indicates -4.8 dBm. What is the power (more precisely, apparent power) in watts supplied to the speaker? By using Fig. 3-4, the value to be added, corresponding to 8 Ω, is obtained to be +18.8 as shown with a dotted line in Fig. 3-4. The power expressed in dB(mW 8 Ω) is obtained by adding the +18.8 to the meter reading, as follows:

dB(mW 8 Ω) = -4.8 + 18.8 = +14

This 14 dB(mW 8 Ω) is converted, by using

Fig. 3-3, into the following wattage :

18 dB (mW 8 Ω) ⟶ 25 mW

Example 2 : What voltage in volts should be applied to supply a power of 1 W to a load of 10 kΩ? Since 1 W is 1000 mW, it is 30 dB(mW); therefore, the voltage corresponding to 30 dB(mW 10 kΩ) is the value being sought. A value of -12.2 to be added for the 600Ω - 10 kΩ conversion is obtained from Fig. 3-4. Therefore, the meter indication on Model 183 should be 30 -(-12.2) = 42.2 on the dB(mW 600Ω) scale.

The voltage with which Model 183 indicates 42.2 - 40 = 2.2 dBm on the 40 dBm range (0 - 100 V) is the value sought. That is, 42.2 dBm = 100 V.

4. Operation principle

Model 183 comprises an input section, a preamplifier, a meter driver, an output section, and a power supply.

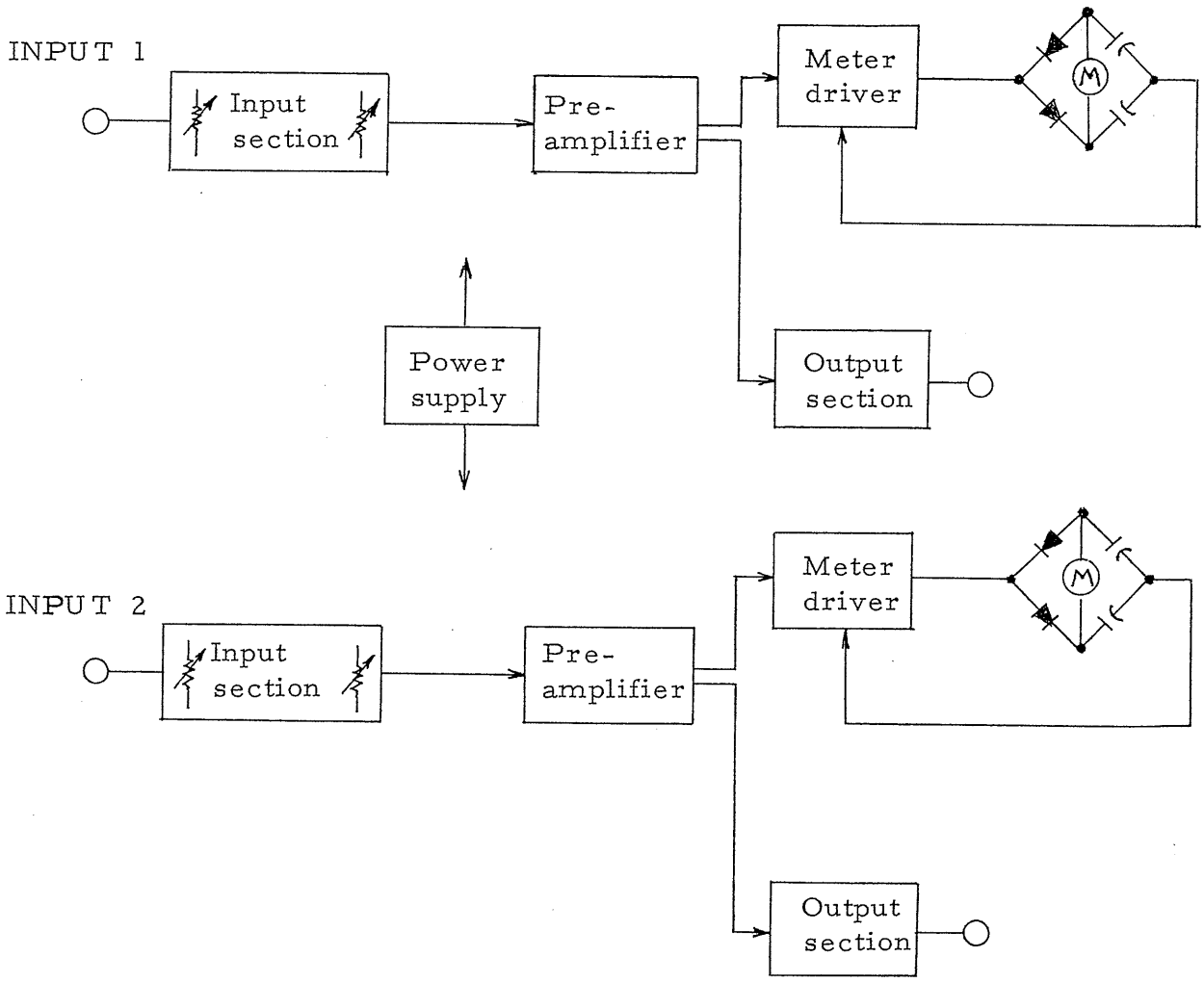


Fig. 4-1

4.1 Input section

The input section comprises a voltage predivider(0/60 dB), an impedance converter, and a main voltage divider composed of six ranges in 10 dB steps(0/10/20/30/40/50 dB) as shown in Fig. 4-2.

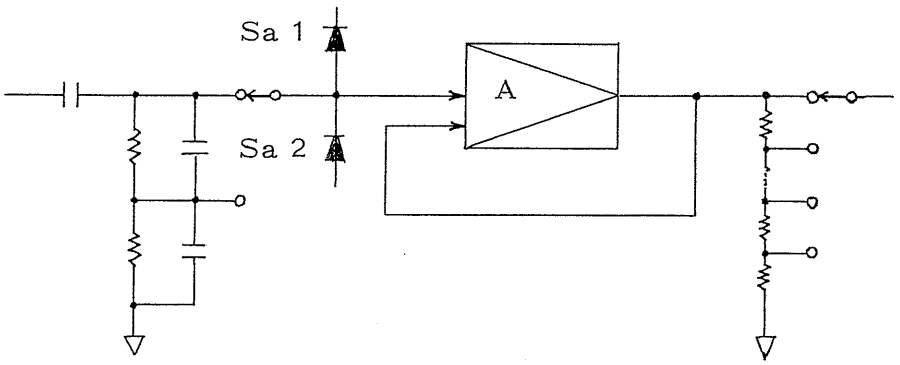


Fig. 4-2

For 1-300 mV ranges, the range switch is connected to contact Sa 1; for 1 -300 V ranges, to contact Sa 2. The input having been divided in the voltage predinider as specified enters the impedance converter. The converter comprises transistors Q1 and Q2, with the FET in the first stage. The high-impedance signal is converted into low-impedance output and then supplied to the main voltage divider.

The main voltage divider divids the signal to approximately 1 mV according to the signal level. Diodes CR_1 and CR_2 are

provided for protecting the AC voltmeter from an excessive input.

4.2 Preamplifier

The preamplifier is a negative feedback amplifier, composed of three transistors, for amplifying the weak signal fed from the input section.

4.3 Meter driver

This is an amplifier using Q_5 and Q_6. A feedback current is applied from the collector of transistor Q_5 to the emitter of transistor Q_6 through rectifier diodes.

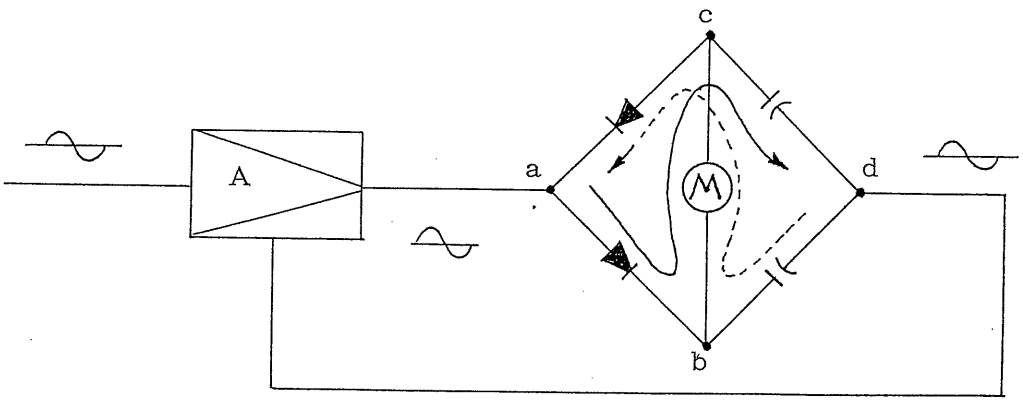


Fig. 4-3

Therefore, the diodes are driven with nearly constant current, improving the non-linearity of diodes and allowing linear meter indication. Fig. 4-3 illustrates the performance. When the output voltage of the amplifier is in the positive, cycle, current

flows a → b → c → d as shown with a solid line; during the negative cycle, current flows d → b → c → a as shown with a dotted line. This causes the meter to be driven according to the mean value of the current flow.

4.4 Output section

The collector voltage of transistor Q_2 in the preamplifier is amplified by transistor Q_4 and is taken off. The output terminal gives an output of approximately 1 V in the full-scale meter indication.

4.5 Power supply

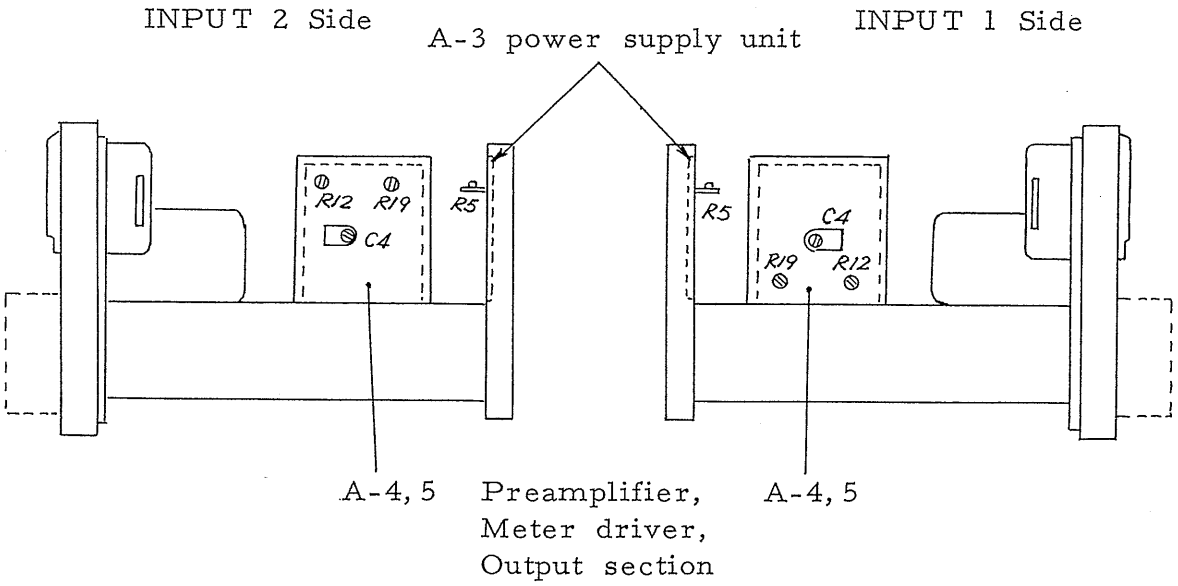
The power supply has regulated +11 and +25 V outputs. The +25 V voltage regulator circuit uses the reference voltage produced by utilizing the zener characteristic of CR_3, amplifies the error by transistor Q_3, and conducts series control by transistor Q_1 to obtain the regulated voltage. The regulated 11 V output is obtained by utilizing the reference voltage.

5. Maintenance

5.1 Inspection of inside parts

When it is necessary to inspect parts inside the cabinet, remove the four screws from the rear of the cabient, and the rear frame and case can be detached.

Fig. 5-1 shows the location of components with the rear frame and case removed.



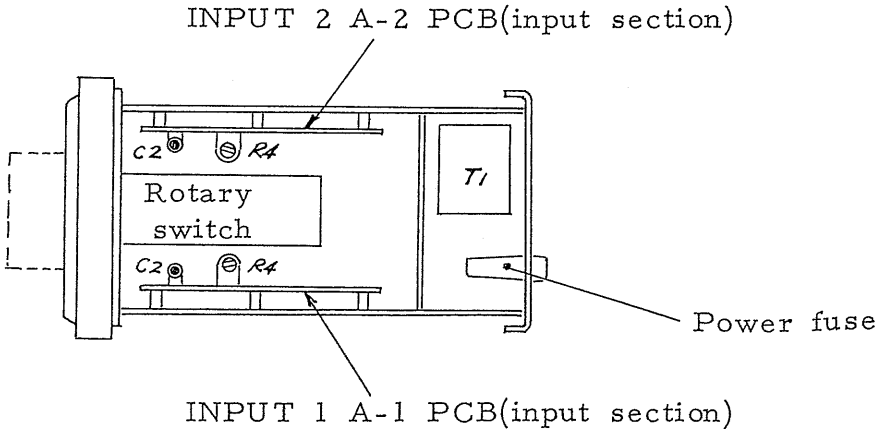


Fig. 5-1 Bottom view

5.2 Adjustment and calibration

When adjustment is needed during a long period of use or after repair, follow the instructions below:

1) Adjustment of voltage regulator circuit

Connect a DC voltmeter between the emitter of transistor Q_1 in the power supply circuit, and the ground. Turn variable resistor R_5 until the DC voltmeter indicates +25V.

2) Calibration of preamplifier for high and low frequencies

Prior to calibration, conduct the zero-adjustment of the meter as described in Item 3.2-2).

Set the range switch to the 30 mV range, apply a calibration voltage (sine wave having low distortion factor) of 30 mV, 400 Hz, to the input terminal.

Turn variable resistor R_{12} until the meter has the precise full-scale indication.

Change the frequency of the calibration voltage to 500 kHz and adjust trimmer capacitor C_4 for the full-scale meter indication.

3) Adjustment of voltage pre-divider

Set the range switch to 1 V, apply a calibration voltage of 1 V, 400 Hz, to the input terminal, and adjust variable resistor R_4 of the voltage divider for the full-scale meter indication.

Change the frequency of the calibration voltage to 40 kHz and adjust trimmer capacitor C_2 for the full-scale meter indication.

Repeat the 400 Hz and 40 kHz, 1 V adjustments two or three times for the complete calibration.

4) Adjustment of output amplifier

Set the range switch to 1 V, apply a calibration voltage of 1 V, 400 Hz, to the input terminal, and turn varriable resistor R_{10} until the voltage at the output terminal is 1 V.

The adjusting procedures described in Items 2) through 4) are common to INPUT 1 (red pointer) and INPUT 2 (black pointer).

5.3 Reference voltage for troubleshooting

Model 183 is carefully assembled and adjusted, and then inspected under strict control before shipment.

If it should fail because of an accident or parts life, check the voltage distribution at various points against the following tables.

Tables 5-1, 5-2 and 5-3 show the no-signal voltage distribution measured with respect to the ground by means of Kikusui's Model 107A VTVM(input resistance: 11MΩ).

1) Impedance converter(A - 1, A-2 PCB's)

Table 5-1

Transistor	Emitter Source (V)	Base Gate (V)	Collector Drain (V)
Q_1 2SK-30	6.7		20.0
Q_2 2SC372	6.0	6.6	25

2) Preamplifier, meter driver and output section (A-4,5 PCB's)

Table 5-2

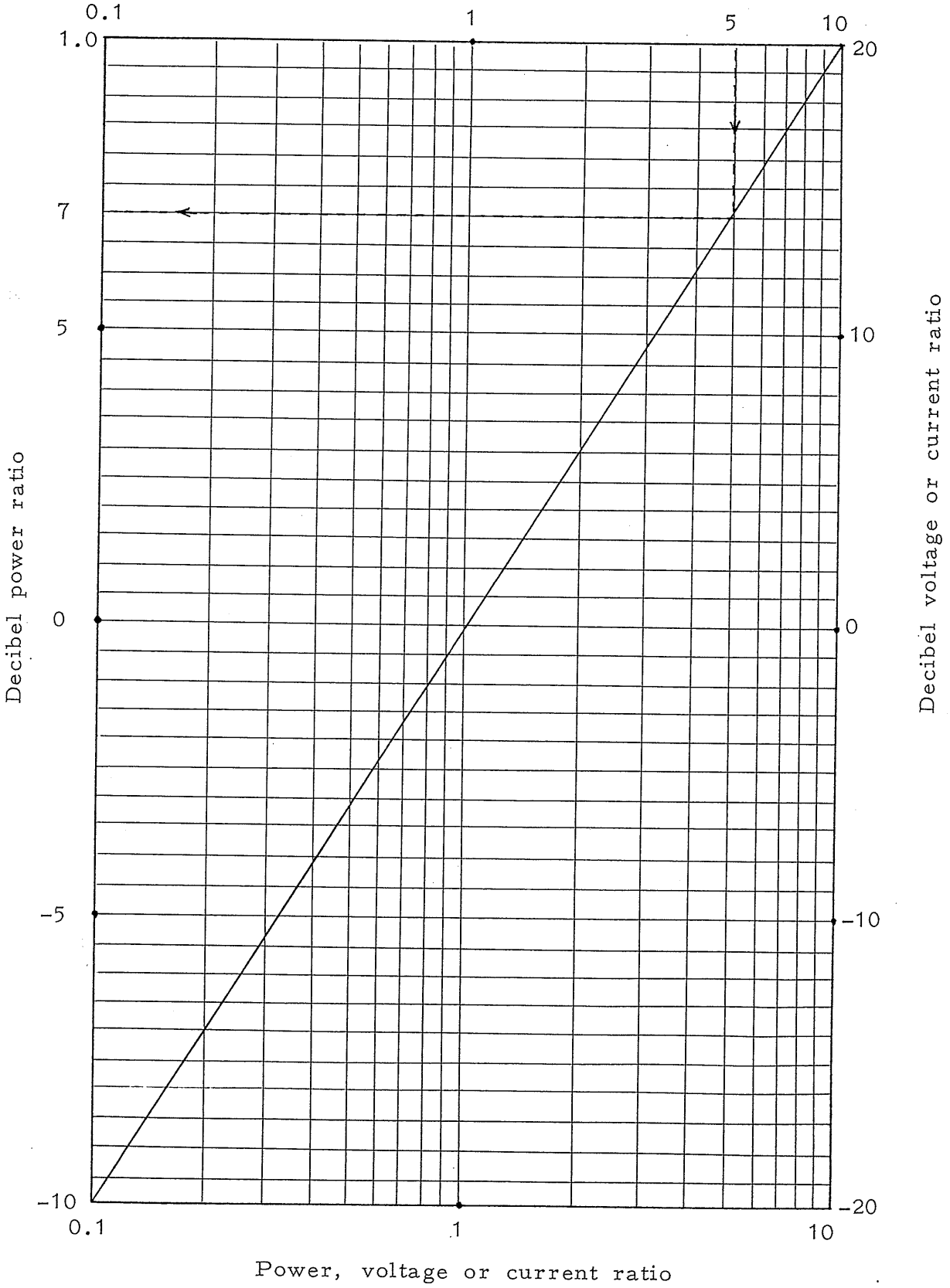
Transistor	Emitter (V)	Base (V)	Collector(V)
Q_1 2SC372			4.4
Q_2 2SA495	5.5	6.1	10.4
Q_3 2SA495	5.0	4.4	3.0
Q_4 2SC372	9.8	10.4	20.2
Q_5 2SC372	4.8	5.5	11.2
Q_6 2SC372			5.5

3) Power supply

Table 5-3

Transistor	Emitter (V) Cathode	Base (V) Anode	Collector (V)
Q_1 2SC515	25.0	25.7	40.0
Q_2 2SC372	32.3	25.0	25.0
Q_3 2SC372	11	11.6	25.7
CR_3 RD11A or 02Z11A	11	0	

Fig. 3-3


0.1
1
5
10
1.0
20
7
5
10
0
0
-5
-10
-10
-20
0.1
1
10
Decibel power ratio
Decibel voltage or current ratio
Power, voltage or current ratio

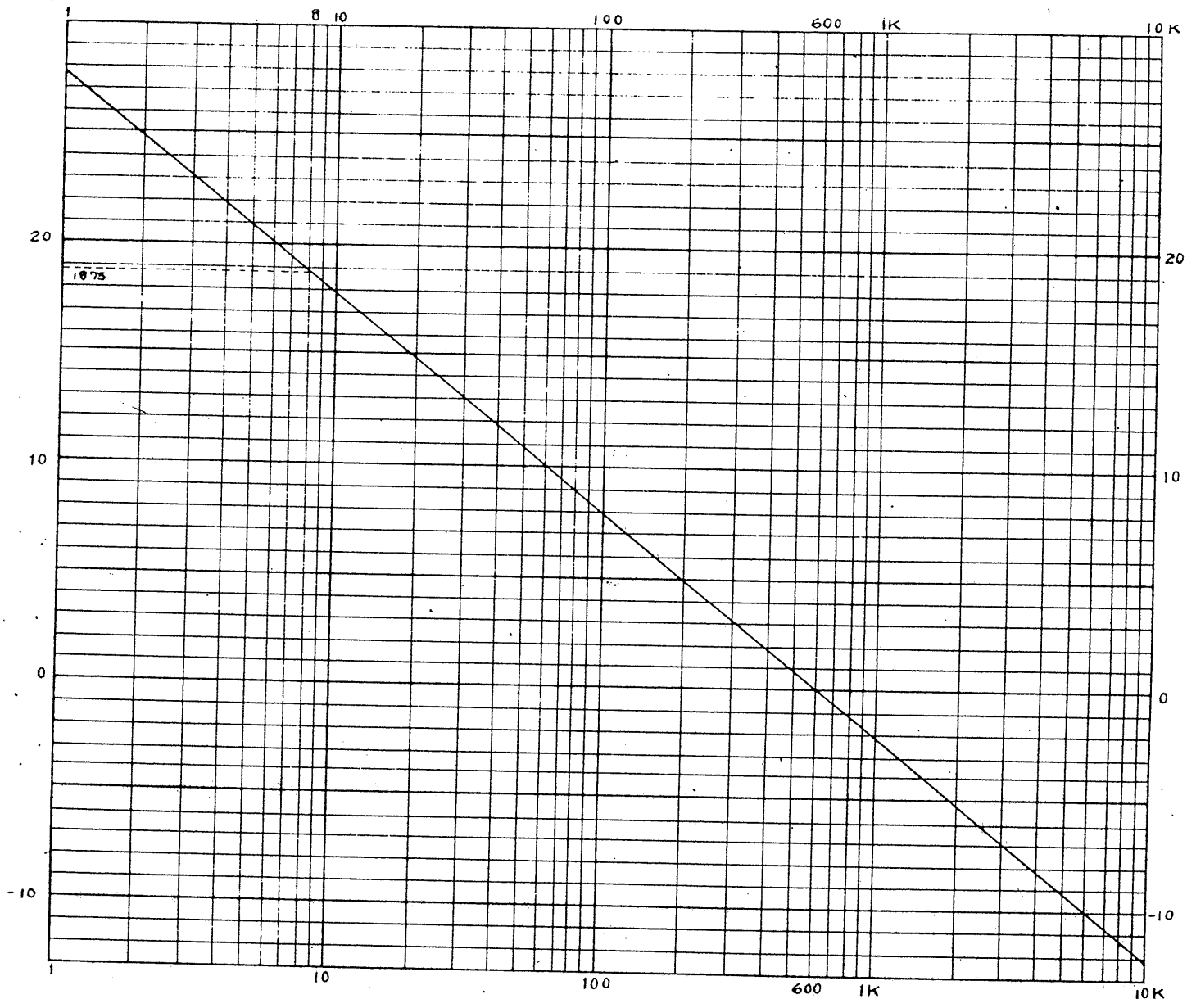

1
8
10
100
600
1K
10K
20
10
0
-10
10.75
1
10
100
600
1K
10K
Added value (dB)
Load resistance (Ω)

Fig. 3-4