OPERATION MANUAL

DPM-600 series

DYNAMIC STRAIN AMPLIFIERS

KYOWA

KYOWA ELECTRONIC INSTRUMENTS CO., LTD.

TABLE OF CONTENTS

Important notice before you read this operation manual

Thank you for purchasing a DPM-600 series dynamic strain amplifier.
The DPM-600 series has six models which differ in their balance adjusting method, frequency response, and whether a self-check function is provided or not. This operation manual includes instructions for the six models in one volume. Please read this manual through carefully and use the instrument correctly so that you can take full advantage of its outstanding features. This manual provides you with good advice for your strain measurement to ensure the best results.
If you should find anything wrong with this instrument, please contact your nearest dealer.

The following accessories are available as options for the DPM-600 series strain amplifiers, and are specially designed for use with your instrument.

- Portable Housing Cases, Type YA
  Portable cases for multi-channel use of the DPM-600 series strain amplifiers.
  YA-503A (for 3-channel use)
  YA-504A (for 4-channel use)
  YA-506A (for 6-channel use)
  YA-508A (for 8-channel use)

- Bridge Boxes, Type DB
  Used for forming a Wheatstone bridge with strain gages; 1-gage, 2-gage, 4-gage methods and 1-gage, 3-lead wire methods available.
  DB-120P (for 120 Ω)
  DB-350P (for 350 Ω)
  DB-120L (for 120 Ω, small size)

- Noise Filters, Type F
  Filters for eliminating high-frequency noise; designed for direct connection to input and output connectors.
  F-7B (for input)
  F-BNC (for output)

- Extension Cables, Type N
  Used for extension of transducer cables and bridge box cables.
  N-81 (5 m)
  N-82 (10 m)
  N-83 (20 m)
  N-84 (30 m)
  N-85 (50 m)

INTRODUCTION

The DPM-600 series dynamic strain amplifiers are designed to measure strain or stress at arbitrary points on various materials, structures and machines and find applications in all industrial fields including shipbuilding, aircraft manufacturing, civil engineering, construction, mining, railway operation, vehicle manufacturing, spinning, etc.

Measurement of dynamic strain can be made by interfacing them to a Kyowa RMV or RMS Oscillograph or RTP Data Recorder, or to a pen-writing oscillograph, CRT oscilloscope, electronic computer as well as other instruments. Since they exhibit highly stable performance, they can also be used for measurement of static strain and control of a production line.

Besides stress measurements in general, these amplifiers can be used as an amplifier or indicator for strain-gage based transducers such as a torque transducer, pressure transducer and load cell. For multi-point measurement, SS type switch boxes are available. These boxes permit measurement of 12 or 24 points (or a multiple of 12 or 24 points in the case of cascade connection) with manual switching. (Only one-point measurement is possible on a continuous basis.)

The built-in low-pass filter effectively eliminates unwanted high frequency components to provide a high SN ratio.

The DPM-600 series amplifiers use a sine-wave carrier to apply voltage to the bridge. In conventional amplifiers, initial capacitive balancing has been achieved by a multi-turn potentiometer. In our amplifiers, however, capacitive balancing is achieved completely electronically at all times (CST method). Therefore, the zero drift due to capacitive variations by the input cord connecting the amplifier to a sensor is minimized to ensure a zero point stability far superior to that in conventional amplifiers. This greatly improved stability to capacitive variations is maintained even with increased carrier frequency, making it possible to build a model having a frequency response up to 10 kHz.

For resistive balancing, too, it is no longer necessary to manipulate the R and C balance controls alternately. In the DPM-601A, 602A and 603A, initial balancing is achieved with an R balance control alone. The DPM-611A, 612A and 613A, on the other hand, have an entirely electronic auto balance system with which initial balancing is completed almost instantaneously by simply pressing a pushbutton switch. These auto balance models also have a self-test function which enables them to check automatically whether they are in order or not.

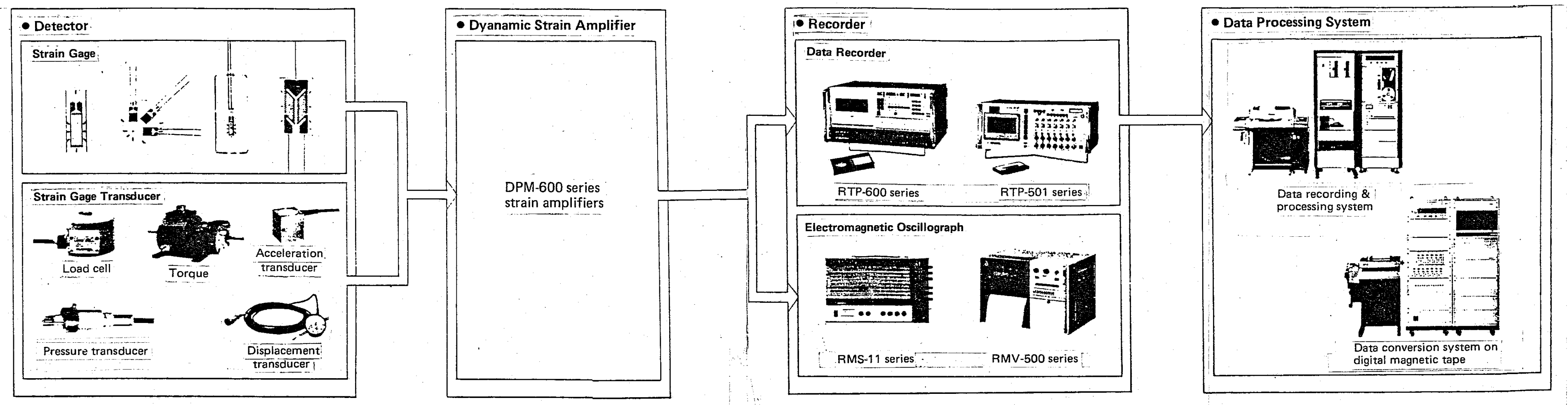
In addition, all models are provided with a 4-digit digital calibration function which allows arbitrary setting in the range of 1 to 9999 x 10^{-6} strain, as well as a dual output function which permits recording of phenomena on a data recorder or electromagnetic oscillograph while monitoring them on a CRT oscillograph.

CHAPTER 1 OPERATION

(Refer to Parts Identification on pages 10 ~ 11).

1.1 Measurement block diagram

Though various measuring methods can be designed for measurement of dynamic strain, we will introduce here the block diagram of a typical measuring system. For instructions on how to operate each unit, refer to the operation manual included with it.



1.2 Operating precautions

(1) Check the power voltage.
 (a) Your AC Mains
 (b) DC 12V .... 10.5 ~ 15V

(2) Avoid water splatters, oil, salt, and so on.

(3) Do not apply voltage or current from the output side.

(4) Always use the measuring instrument in the specified operating temperature range (−10° ~ 50°C) and humidity range (below 85% RH; there is no condensation, however).

1.3 Preparation for measurement

(1) References for connecting a detector:

(a) The connecting method differs with the type of detector used. For instructions on how to operate each detector, refer to the operation manual included with it.

(b) When using a strain gage, refer to "Kyowa Strain Gage Operation Manual".

(c) When using a Bridge Box, refer to paragraph 1.8, "Measurement Using a Bridge Box".

(2) When measuring, bring the measuring instrument as close to the measuring point as possible.

Note: The bridge box can be extended by an extension cable, but this is not recommended because it may cause increased measurement errors (see paragraph 2.5 on page 20), external induction or other measuring troubles.

(3) The amplifiers have a 2V/0.5V bridge voltage selector switch. As measurement is normally made at 2V, the switch has been set at 2V in the factory, but it can also be set at 0.5V in the following cases:

(a) Measurement of plastic models in which the heating up of the gage due to the bridge excitation current may cause a problem, or measurement using a gage with a short gage length.

(b) Measurement of very large strain

To change the bridge voltage, remove the side plate and switch the toggle switch located in the upper part of the printed circuit board (rear panel side). It is set at 0.5V if pointing toward the front panel, and 2V if pointing toward the rear panel.

Note 1: With the bridge voltage set at 0.5V, the maximum sensitivity is 10×10^{-6} strain input and the output is 0.05V (5 kΩ or more load).

Note 2: With the bridge voltage set at 0.5V (VERN minimum), measurement is possible up to $300{,}000 \times 10^{-6}$ strain.

(4) Insert the plug of the bridge box or strain gage transducer into the input connector labelled "INPUT" at the back of the instrument.

Note: See Fig. 1-1.

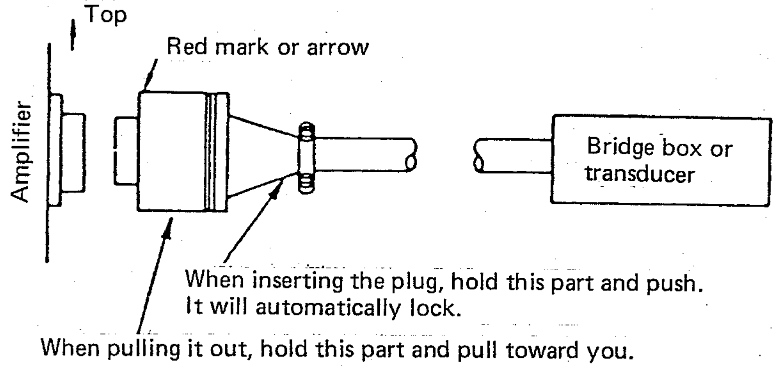


Fig. 1-1 Connection of the Bridge Box

(5) Connect the plug of the accessory power cord to the power connector, and the other end to AC Mains or DC 12V.

Note 1: For AC Mains . . . . . The power cable supplied is a 2-core cable with a 20P connector at one end and an AC plug at the other end.

Note 2: For DC 12V . . . . . As the cable is not provided with a 20-pin connector plug for a DC power supply, purchase an S-1620A-C connector plug (Hirose Denki K.K.).

Solder a lead wire of 0.3 mm^2 or more to the connector plug of the cable.

Correspondence of the connector plug pin No. and power source polarity:

Pin No. 1 . . . . (+) Polarity

Pin No. 4 . . . . (—) Polarity

If the voltage is within 10.5 ~ 15V, the instrument will operate properly.

(6) Set the sensitivity adjuster "RANGE" to "OFF".

(7) Set the low-pass filter selector switch "CUT OFF FREQ" at an arbitrary position.

(8) Switch the oscillator selector switch to "INT".

Note: Refer to paragraph 1.9, precautions (2) and (3).

1.4 Initial adjustment

(1) Press the "POWER" switch.

The power is on and this instrument is now in working condition. As soon as the "POWER" switch is pressed, the instrument starts up, readying itself for measurement; but it is usually recommended to warm it up for about 10 ~ 15 minutes. Especially in the case of measuring minute strain or long-term measurement, warming up of about 30 ~ 60 minutes is necessary.

(2) After it is sufficiently warmed up, perform initial balance adjustment.

(a) DPM-601A, DPM-602A and DPM-603A

Switch the sensitivity adjuster "RANGE" from "OFF" to the desired position. The unbalance component of the gage bridge will be indicated on the monitor meter. Adjust the initial balance adjuster "BAL" so that the monitor meter indicates "0".

If the monitor meter deflects to the (+) side, turn "BAL" adjuster counterclockwise; if it deflects to the (—) side, turn the knob clockwise.

(b) DPM-611A, DPM-612A and DPM-613A

Press the check/initial balance adjustment pushbutton labelled "CHECK/BAL" twice quickly (within 1 sec.). Whether "RANGE" is set to "OFF" or any other position, initial balance adjustment is automatically completed in about a second at maximum sensitivity.

Note 1: The "CHECK/BAL" switch serves for both checking and initial balance adjustment. If you want to check the instrument itself, press this push-button switch. The instrument is operating properly if the monitor meter needle moves inside the blue area while the switch is pressed. Initial balance adjustment is effected by pressing the switch twice within a second.

Note 2: If the monitor meter does not indicate "0" after initial balance adjustment, or if it indicates "0" but the excessive input indicator lamp blinks, it means there is an unbalanced capacity over 2,000 PF. In this case, refer to Chapter 3, "Troubles in measurement & troubleshooting".

(3) Set the low-pass filter selector switch "CUT OFF FREQ".
Good results can be obtained by setting the cutoff frequency at 10 Hz in the measurement of static strain, and at a point 5 to 10 times greater than the frequency of the expected wave in the measurement of an impulse wave.

1.5 Measurement of static strain

(1) Set the sensitivity adjuster "RANGE" and the calibration value setter "CAL" depending on the expected magnitude of strain.

(2) Switching the calibration switch to either "+" or "–" causes the monitor meter to swing. Adjust the fine sensitivity adjustment knob "VERN" so that the pointer indicates a scale value which is easy to read.
Note: For setting the calibration value, refer to Table 1-1.

(3) If strain occurs at the measuring point, the monitor meter swings. Read the value, compare it with the calibration value and determine the amount of strain at the measuring point by proportional calculation.
Note: The accuracy of the monitor meter is ±2.5%.

(4) If it is necessary to measure with higher accuracy, insert the accessory output cable to "OUTPUT V" or "OUTPUT I" and connect the other end to a digital voltmeter, DC ammeter, etc. The amount of strain at the measuring point can be determined by proportional calculation from the calibration value.

Example: CAL value being set .... 200×10^{-6} strain
Output voltage with CAL applied 4.000V
Output voltage with strain occurring
at the measuring point 3.500V
Amount of strain at the measuring point =

$$\frac{3.500\ (V)}{4.000\ (V)} \times 200 \times 10^{-6}\ \text{strain} = 175 \times 10^{-6}\ \text{strain}$$

(5) The output cable has a configuration as shown in Fig. 1-2. Connect its plug to "OUTPUT", and the other end to the input terminal of the recorder.

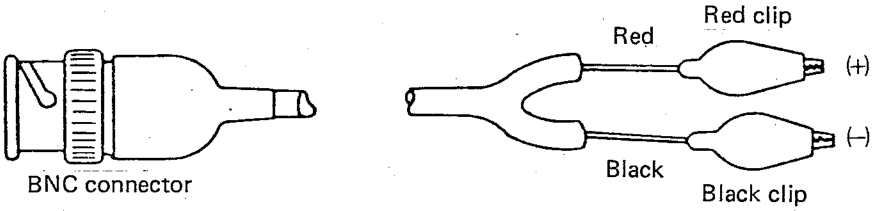


Fig. 1-2 Output Cord

(a) Connect "OUTPUT V" to a voltage input type recorder.
"OUTPUT I" is used for connecting a current-driven recorder such as an electromagnetic oscillograph and ammeter. Like "OUTPUT V", it can also be used to connect a voltage input type recorder.

(b) Even if instruments are connected to both "OUTPUT V" and "OUTPUT I" for simultaneous operation, the two outputs are not affected by each other.

(6) If a Kyowa DS type switch box is used, fix the 10-turn potentiometer for C balance at the 5-turn position in the center. (C balance adjustment is unnecessary.)

(7) Relationships between the positions of "RANGE" and "VERN" and the measurable range of strain are shown in Table 1-1.

Table 1-1 Relationships between the positions of "RANGE" and "VERN" and the measurable range of strain

RANGE" (x100 $\mu\epsilon$)	"VERN"	Setting of "CAL" and measurable range of strain			
		Bridge voltage 2V		Bridge voltage 0.5V	
		Range (x10⁻⁶ strain)	"CAL"	Range (x10⁻⁶ strain)	"CAL"
1	MAX	1 ~ 250	10 ~ 250	4 ~ 1000	10 ~ 1000
	MIN	app. 3 ~ 750	10 ~ 750	app. 12 ~ 3000	20 ~ 3000
2	MAX	2 ~ 500	10 ~ 500	8 ~ 2000	10 ~ 2000
	MIN	app. 6 ~ 1500	10 ~ 1500	app. 24 ~ 6000	30 ~ 6000
5	MAX	5 ~ 1250	10 ~ 1250	20 ~ 5000	20 ~ 5000
	MIN	app. 15 ~ 3750	20 ~ 3750	app. 60 ~ 15000	60 ~ 9990
10	MAX	10 ~ 2500	10 ~ 2500	40 ~ 10000	40 ~ 9990
	MIN	app. 30 ~ 7500	30 ~ 7500	app. 120 ~ 30000	120 ~ 9990
20	MAX	20 ~ 5000	20 ~ 5000	80 ~ 20000	80 ~ 9990
	MIN	app. 60 ~ 15000	60 ~ 9990	app. 240 ~ 60000	240 ~ 9990
50	MAX	50 ~ 12500	50 ~ 9990	200 ~ 50000	200 ~ 9990
	MIN	app. 150 ~ 37500	150 ~ 9990	app. 600 ~ 150000	600 ~ 9990
100	MAX	100 ~ 25000	100 ~ 9990	400 ~ 100000	400 ~ 9990
	MIN	app. 300 ~ 75000	300 ~ 9990	app. 1200 ~ 300000	1200 ~ 9990

Note: The calibration values in Table 1-1 are standard values. Any calibration value can be used if it is within the measurable range.
In case a calibration value not within the measurable range is entered, the excessive input indicator lamp will blink. Set "RANGE" or "CAL" once again.

1.6 Measurement of dynamic strain

(1) For measurement of dynamic strain, it is necessary to use this instrument and a recorder in combination to determine the form, size and time relationship of phenomena waves. Make sure that this instrument and the recorder are properly connected.

Note 1: Always connect a current input type recorder such as an electromagnetic oscillograph to "OUTPUT I".

Note 2: When a high sensitivity galvanometer (MS-400D, M-500F, etc.) is used, turn the current output sensitivity adjuster "OUTPUT I SPAN" fully counterclockwise.
"OUTPUT I SPAN" is adjustable from 1 to approx. 1/100 for "OUTPUT I" outputs only.

(2) Table 1-2 shows the general characteristics when Kyowa electromagnetic oscillographs are connected to "OUTPUT I". Because the output impedance of "OUTPUT I" is 10Ω, Kyowa electromagnetic oscillographs can be directly connected without considering the troublesome damping resistance.

Table 1-2

Electromagnetic oscillograph	Galvanometer	Deflection on chart paper		Frequency range of uniform sensitivity (Hz)	Remarks
		Sensitivity mm/10x10^{-6} strain	Non-linearity Amplitude (mm) within ±1%		
Model RMV-500	M-500F	520	±60	0 ~ 300	*
	M-1KF (H)	64	±60	0 ~ 600	*
	M-2KF (H)	26	±60	0 ~ 1000	
	M-4KF (H)	4.8	±36	0 ~ 2000	
Model RMS-11	MS-400D	180	±25	0 ~ 300	*
	MS-500D	52	±15	0 ~ 300	*
	MS-1.3KD	20	±20	0 ~ 700	
	MS-2KD	7.6	±20	0 ~ 1000	

Note 1: The sensitivity values shown in the table represent those when "RANGE" is set at "1", "VERN" at "MAX", and "OUTPUT I SPAN" turned fully clockwise.
When using a galvanometer marked with an * in the "Remarks" column, turn "OUTPUT I SPAN" fully counterclockwise.

(3) Set "RANGE" and "CAL" depending on the expected magnitude of strain. (Refer to Table 1-1 on page 7.)

(4) Adjust "VERN" so that the recorder meter swings properly when "CAL" is switched to "+" or "–".

Note: By adjusting "VERN", both outputs of "OUTPUT V" and "OUTPUT I" are adjusted. To adjust the output of "OUTPUT I" alone, use "OUTPUT I SPAN".

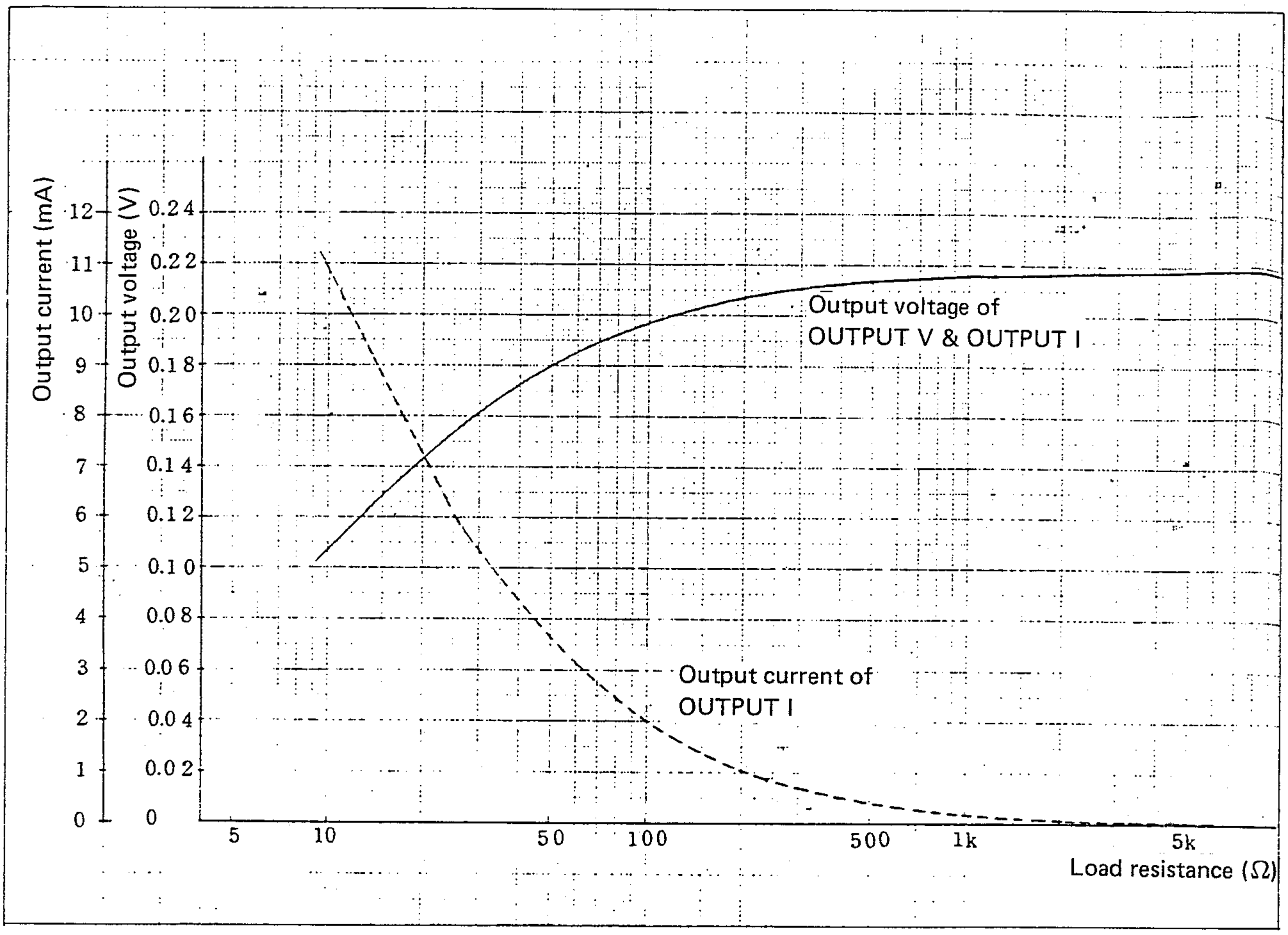


Fig. 1-3 Sensitivity characteristics (maximum output for 10 x 10^{-6} input strain)

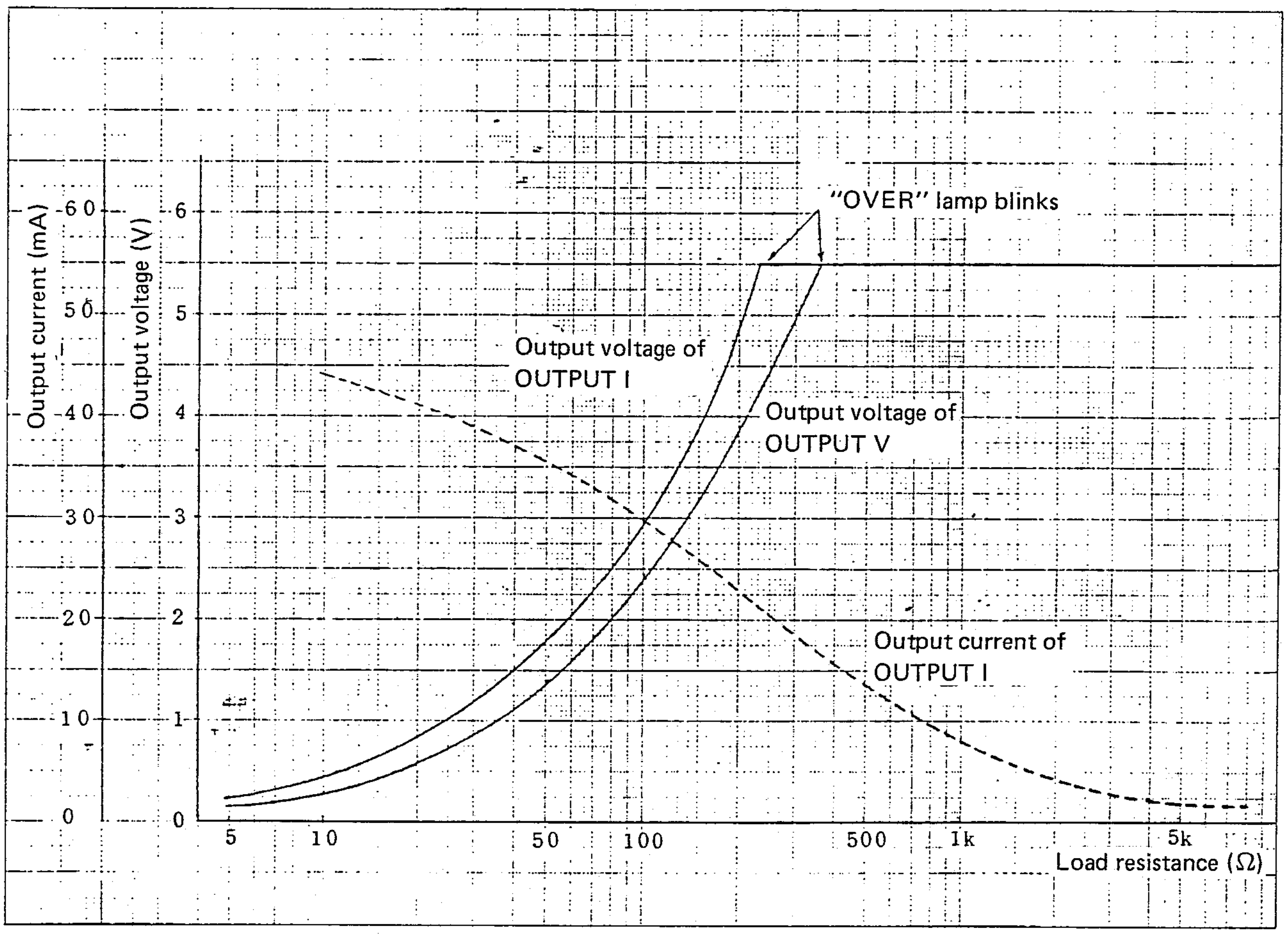


Fig. 1-4 Output characteristics (maximum output for non-linearity up to ±0.1%)

1.7 Parts identification

(1) Description of parts on the front panel

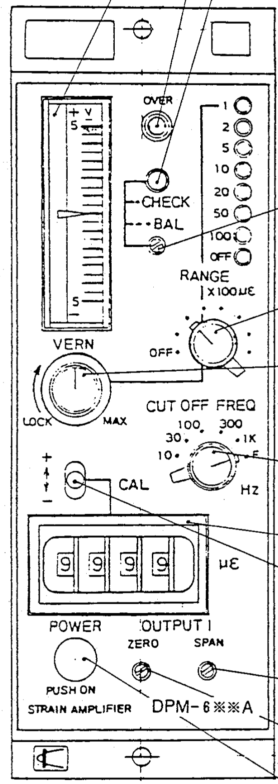


Fig. 1-5

The "CHECK/BAL" switch (3) of DP DPM-601A, 602A and 603A is a lockable manual switch and has no check function.

(1) Monitor meter
Meter for monitoring the bridge's initial balance adjustment and phenomenon.

(2) Excessive input indicator lamp "OVER"
Blinks in red if an excessive amount of strain is inputted. In this case, "RANGE" should be lowered by 1 step or the sensitivity should be lowered with "VERN".

(3) Check/initial balance adjustment pushbutton switch "CHECK/BAL"
Serves for both check and initial balance adjustment. Press this switch once for CHECK, and press it twice quickly (within 1 sec.) for BAL.

"CHECK" . . . . . Checks if the operation of this instrument itself is normal, independent of its inputs and outputs. The operation is normal if the meter pointer moves to the blue area when this switch is pressed once.

"BAL" . . . . . For initial balance adjustment of resistance of strain gage bridge. The balancing operation is automatically completed in about a second when this switch is pressed twice quickly.
Balancing is achieved at maximum sensitivity regardless of where the "RANGE" switch is set.

(4) Fine resistance adjuster "BAL"
12-turn potentiometer used for shifting zero point after auto balance is completed. Turn it clockwise for "+" output, and counterclockwise for "–" output.

(5) Sensitivity adjuster "RANGE"
Sensitivity selector that can be set from 100 to 10000 $\mu\epsilon$ in seven steps on the magnitude of the input strain. LED lights up on RANGE being set.

(6) Fine sensitivity adjustment knob "VERN"
With a constant strain, the output voltage and current can be adjusted continuously from 1 to 1/2.5 or more. Both outputs of OUTPUT V and OUTPUT I can be adjusted at the same time. The "VERN" knob is fixed by turning the outer "LOCK" knob clockwise.

(7) Low-pass filter selector switch "CUT OFF FREQ"
Built-in low-pass filter that can be set at six positions: 10, 30, 100, 300 Hz, 1 kHz and F.

(8) Calibration value setter "CAL"
The calibration strain can be set from 1 to 9999 $\mu\epsilon$ in steps of 1-$\mu\epsilon$.

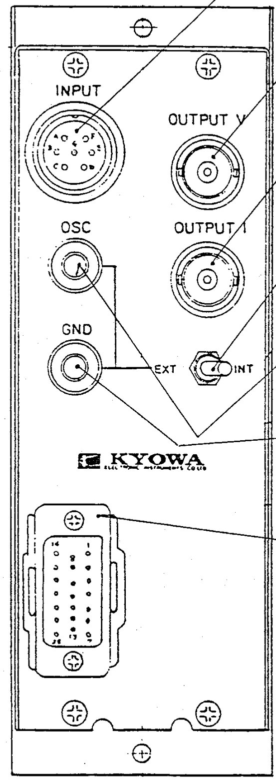
(9) Calibration switch "CAL"
The calibration value set by the "CAL" setter is entered by switching the "CAL" switch to "+" or "–".

(10) Current output sensitivity adjuster "OUTPUT I SPAN"
The output of "OUTPUT I" alone can be adjusted from 1 to about 1/100.

(11) Current output zero adjuster "OUTPUT I ZERO"
The zero point can be adjusted by about ±30 mV for output of OUTPUT I alone.

(12) "POWER" switch
Power ON/OFF switch for all circuits of this instrument. Press it once to turn the instrument on, and again to turn it off.

(2) Description of parts on the rear panel



(a) Input connector "INPUT"
Connector for connecting the bridge box and transducer.
A (red), C (black) . . . . . .Bridge voltage
B (white), D (green) . . . .Amplifier input
E (shield). . . . . .COM

(b) Connector for voltage output "OUTPUT V"
The output voltage is ±5V. To this connector is connected a voltage input type recorder or indicator such as a data recorder, oscillograph with amplifier, digital voltmeter and Braun tube oscillograph.

(c) Connector for current output "OUTPUT I"
The output current and voltage are ±30 mA and ±5V respectively. To this connector is connected an electromagnetic oscillograph, ammeter, etc., but a voltage input type recorder or indicator can also be connected.

(d) Oscillator selector switch
Switch for synchronizing carrier wave frequency when a number of the same DPM-600 series units are arranged and used at the same time. The switch of one unit is set at "INT", while those of all other units are at "EXT".

(e) Terminal for carrier wave frequency synchronization "OSC"
Terminal for carrier frequency synchronization which is used with the oscillator selector switch (d) when a number of the same DPM-600 series units are arranged and used at the same time. Respective terminals (OSC terminals (e) or GND terminals (f)) are connected. This terminal connection is not required when a dedicated enclosure is used.

(f) Ground terminal "GND"
Terminal for grounding the enclosure. If there is considerable noise or induction depending on the ambient conditions, this terminal should be connected to ground. It also serves as a terminal on the ground side for carrier frequency synchronization.

(g) Power connector

1 ······	+12V	
14 ······	0V	
7 ······	) AC Mains	
20 ······		
5 ······	COM	
3 ······	Oscillator output	
2 ······	BAL ※	For function operation, connect the respective pin to 5 (COM). For BAL, connection should be made twice (within about a second).
8 ······	CHECK※	
17 ······	+CAL	
18 ······	−CAL	
15 ······	+) Output of OUTPUT V	
16 ······	−	

Note: The functions marked with an * are not provided on the DPM-601A, 602A and 603A.

1.8 Measurement using a bridge box

(1) Characters on the bridge box terminal board

The Model DB-120P bridge box has a terminal board as shown in Fig. 1-7. The characters in the upper row are the symbols for the terminals to which gages are to be connected. The gage(s) is connected to A1 in the one-gage method, to A1 and D1 in the two-gage method, and to all terminals in the upper row in the four-gage method.

The characters between the upper and lower rows show the positions at which the upper and lower terminals are shorted. In the one-gage method, the terminals having a numeral of 1, that is, all three sets of terminals are shorted for operation; in the two-gage method, two sets of terminals having a numeral of 2 are shorted; and in the four-gage method, no terminal is shorted. (See Fig. 1-8).

If the circuit needs grounding, ground the terminal having a ground symbol.

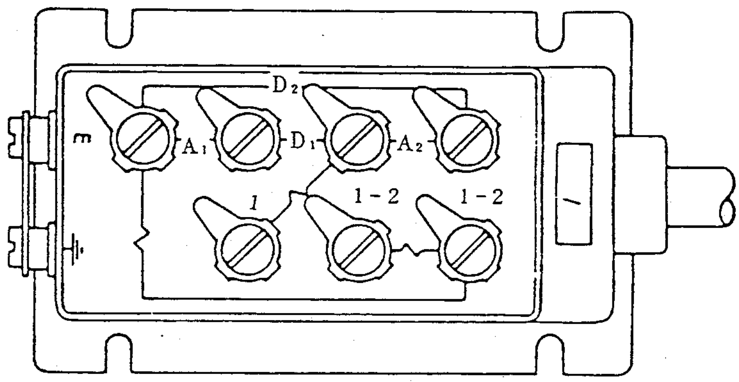
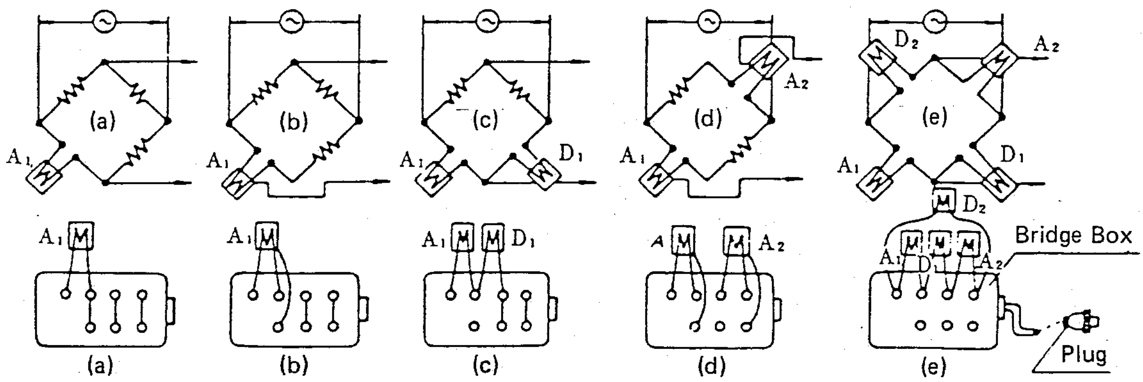


Fig. 1-7 Bridge Box Terminals



(a) One-gage method (two-wire system)
(b) One-gage method (three-wire system)
(c) Two-gage method (two-wire system)
(d) Active-active method (three-wire system)
(e) Four-gage method (two-wire system)

Fig. 1-8 Connection of the Bridge Box according to the Number of Strain Gages

(2) Connection of strain gage

For connecting or shorting the strain gage lead wire, use soldering.

For shorting, use a naked copper wire or tin-plated copper wire of about 0.1 mm in diameter. To avoid external induction, use a single-core or two-core shielded wire for the lead wire between the strain gage and bridge box whenever possible. If there is considerable induction, stranding the shielded wires for A gage and D gage will be effective in eliminating it. Be sure to connect the sheath of the shielded wire to the ground terminal. Although it is preferable to ground the ground terminal, it is not always good to ground the measuring instrument if the object being measured has a DC or AC potential. In that event, good results are often obtained by connecting the ground terminal to the object being measured. Bring the bridge box as close to the strain gage (measuring point) as possible to reduce the length of the lead wire. If the lead wire is longer than 10 m, the use of a four-core shielded wire is recommended, but if a two-core or single-core shielded wire is used, make the wire lengths to the A gage and D gage as equal as possible and strand the wires. All this will help in obtaining good measurement results. For gage bonding, refer to "Kyowa Strain Gage Operation Manual".

For D gage connection, refer to the instructions on the setting of temperature-compensating gages in the above-mentioned manual (see also the circuit diagram).

1.9 Measuring precautions

(1) All DPM-600 series models have a built-in DC amplifier circuit. Because "OUTPUT I" delivers a high output (±30 mA with 30 Ω load), take proper care to avoid burning of the galvanometer when using a high-sensitivity galvanometer (observe its safe current).

(2) When two or more units of the same model are used, "beats" may occur due to a difference in their carrier frequencies. In that event, connect the respective carrier frequency synchronization terminals and ground terminals "GND" for all these units, and set the oscillator selector switch of one unit at "INT" and those of all other units at "EXT". It is possible to synchronize about 100 units with only one unit.

If units are housed in the specified enclosures, there is no need to connect the respective carrier frequency synchronization terminals and ground terminals "GND" because connection is made inside the enclosure. Set the oscillator selector switch of one unit at "INT", and those of all other units at "EXT", then operate.

(3) Operation in combination with different models

(a) In the case of combining models in the same group of (A), (B) or (C) below, it is possible to synchronize them by setting only one unit of either model at "INT" and all others at "EXT".

(A) group models ..... DPM-601A, DPM-611A, DPM-1H, DPM-1K, DPM-1N, DPM-100A, DPM-110A, DPM-110B, DPM-301A, DPM-305A, DPM-305B, DPM-310A, DPM-310B.

(B) group models ..... DPM-602A, DPM-612A, DPM-306A, DPM-307A, DPM-311A.

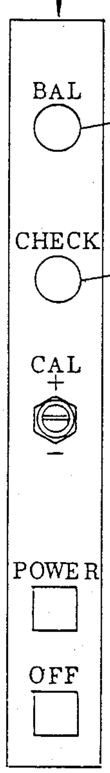
(C) group models ..... DPM-603A, DPM-613A.

(b) In the case of combining models of different groups, however, it is necessary to synchronize for each of the above three groups. There is almost no problem in measurement even with different carriers if the transducer and amplifier are connected with a four-core shielded cable. For extension connection from the bridge box to the gage, mutual interference can be avoided by using a two-core or three-core shielded cable.

(4) Because all models are provided with an excessive input indication function, the indicator lamp blinks in red if an excessive input is applied during measurement. If the measurement is continued in this condition, the large-level portion of the recorded data becomes unreliable. In this case, reduce "RANGE" by one step or turn "VERN" toward "MIN" (minimum), enter the calibration value again and measure. Though the excessive input indicator lamp may light up for an instant when "RANGE" is switched, it does not mean that anything is wrong.

(5) As the enclosure for the DPM-600 series, use the Model YA-50*A housing case – the same as that for the DPM-300 series. Observe the following precautions when using it:

YA-50*A operating panel



For BALANCE, press twice (within a second).
If pressed only once, CHECK operation is effected while it is kept pressed.

Avoid pressing this switch again within a second after "BAL" is pressed (misoperation may result).

"BAL" and "CHECK" are not provided on DPM-601A, 602A and 603A.

CHAPTER 2 CALCULATION OF STRAIN AND STRESS

2.1 Calculation method for measurement with strain gages

Suppose that an oscillograph of a recorded waveform as shown in Fig. 2-1 has been obtained.

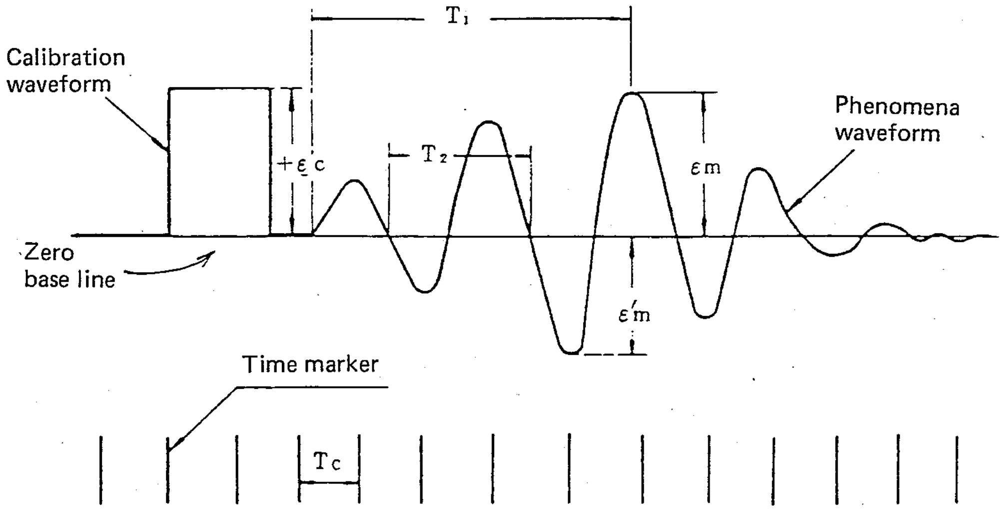


Fig. 2-1 Recording Example of Waveform

We will try to determine various values from Fig. 2-1. If the calibration value setter "CAL" is set properly according to the expected magnitude of the phenomenon and the calibration switch "CAL" is switched to either side for an appropriate time, a calibration waveform as shown in Fig. 2-1 is recorded. The size of this calibration waveform represents the calibration value, and the magnitude of strain can be determined from this.

The size of the time axis of the phenomenon can be calculated from the width T_C on the time marker.

(1) Calculation of maximum strain ϵm and maximum stress σm

The heights (from the zero base line) of the points representing the calibration value and maximum strain are measured with a scale.

If ϵc = hc (mm) and ϵm = hm (mm), the maximum strain ϵm is:

$$\epsilon m = \epsilon c \times \frac{hm}{hc}$$

Because ϵm has the same direction as $+\epsilon c$, it is positive, that is, it is an elongation. If the strain ϵ is known, the stress σ at this point is determined by the following formula (as a uniaxial stress system):

$$\sigma m = E \cdot \epsilon$$

where E is Young's modulus at this measuring point and the gage axis corresponds to the direction of the main stress axis.

Therefore, the maximum stress σm is:

$$\sigma m = E \cdot \epsilon m$$

(2) Calculation of strain $\epsilon'm$ and stress $\sigma'm$

The strain $\epsilon'n$ us ub the opposite direction to $+\epsilon c$, that is, it is a contraction. If the height of $\epsilon'm$ is h'm (mm), the magnitude of strain is determined as follows:

$$\epsilon'm = -\epsilon c \cdot \frac{h'm}{hc}$$

The stress $\sigma'm$ is (as a uniaxial stress system):

$$\sigma'm = E \cdot \epsilon'm$$

(3) Time from the beginning of the phenomenon to the maximum strain

A time marker is used for determining the time T_1 from the beginning of phenomenon to the maximum strain. About 10 lengths are actually measured and the length t_C (mm) corresponding to the time T_C is determined from their average. If the measured length of T_1 is t_1 (mm), the time T_1 is determined as follows:

$$T_1 = \frac{t_1}{t_C} \times T_C \text{ (sec)}$$

(4) Period of the phenomenon

If the vibration of the phenomenon is periodic, the period can be calculated. To determine the period of T_2 for one cycle, the lengths of about ten cycles are actually measured and the average t_2 (mm) is determined. By comparing with t_C on the time marker, T_2 is calculated as follows:

$$T_2 = \frac{t_2}{t_C} \times T_C \text{ (sec)}$$

The frequency f is:

$$f = \frac{1}{T_2} \text{ (Hz)}$$

(5) Analysis of the phenomenon

If the phenomenon is so simple that it needs only one-point measurement, all necessary information is obtained by simply calculating the relationship between the amount of strain and the time from the recorded waveform.

As the phenomenon becomes complicated, it is necessary to measure and record many points at the same time or separately. The relationship between the amount of strain and the time for each of these measuring points can be determined in the procedure described above. With this method alone, however, it is impossible to obtain a full understanding of the phenomenon.

In this case, the relationship between these measuring points should be analyzed by comparison, with regard to the amount of strain and the time axis, along with an analysis of each point. Since the method of analysis varies with the purpose of measurement, it is impossible to make one general statement about it. However, because the relationship between measuring points can in many cases be anticipated in the measurement of a phenomenon, it is possible to understand the overall phenomenon by separately analyzing the recorded waveforms at individual points and relating them to each other in studying the relationship between measuring points.

2.2 Correcting according to the number of strain gages

The above-mentioned calculation method applies when a single strain gage is connected as an active gage for measurement as shown in Fig. 2-2. If two or more strain gages are used to detect strain, however, the results of measurement should be corrected depending on the number of strain gages. There is no need for such correction if a strain gage transducer is used.

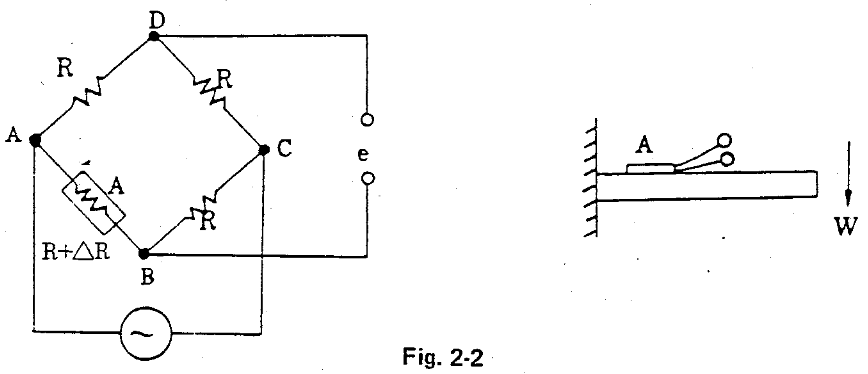


Fig. 2-2

(1) Both A and D gages are used for strain detection.

(1)−1 Two gages are used and arranged as shown in Fig. 2-3.
Multiply the measured value ϵ by 1/2.

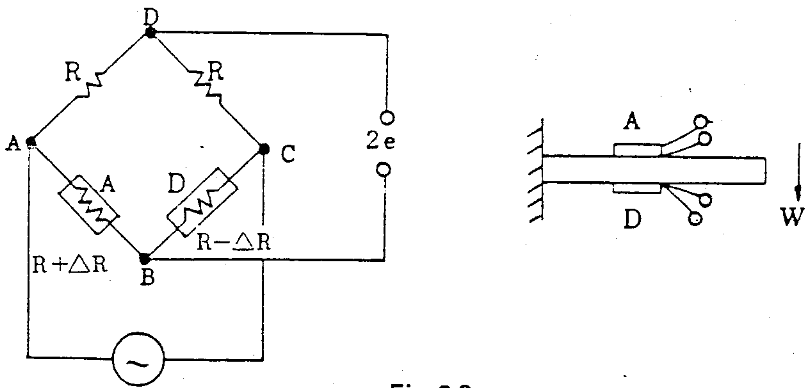


Fig. 2-3

$$\varepsilon_2 = \frac{\varepsilon}{2} \qquad \sigma_2 = \mathrm{E}\varepsilon_2 = \frac{\varepsilon}{2}\mathrm{E}$$

(1)−2 Four gages are used and arranged as shown in Fig. 2-4.
Multiply the measured value ϵ by 1/2.

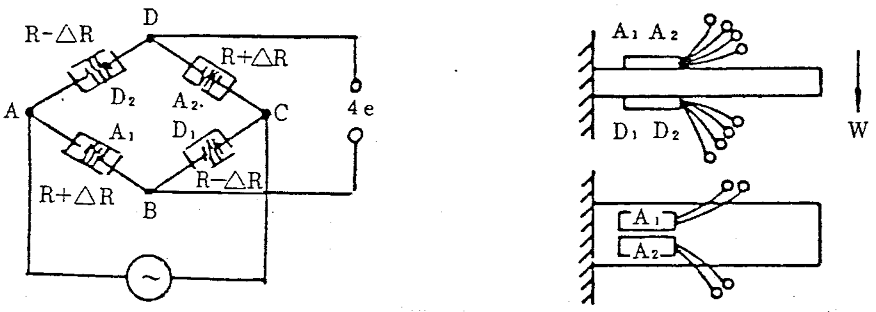


Fig. 2-4

$$\varepsilon_3 = \frac{\varepsilon}{4} \qquad \sigma_3 = \mathrm{E}\varepsilon_3 = \frac{\varepsilon}{4}\cdot\mathrm{E}$$

(2) A gage and D gage at a right angle

(2)—1 Two gages are used and arranged as shown in Fig. 2-5.
Multiply the measured value ϵ by $1/(1+\nu)$.

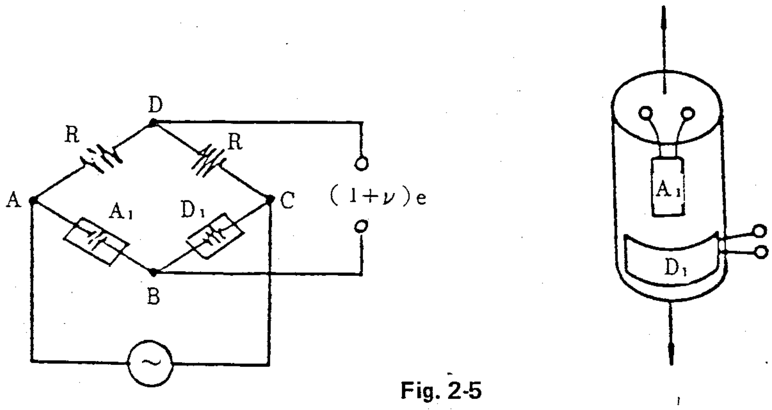


Fig. 2-5

$$\epsilon_4 = \frac{\epsilon}{1+\nu} \qquad \sigma_4 = E\epsilon_4 = \frac{\epsilon}{1+\nu} \cdot E$$ where ν = Poison's ratio

(2)—2 Four gages are used and arranged as shown in Fig. 2-6.
Multiply the measured value ϵ by $1/2\,(1+\nu)$.

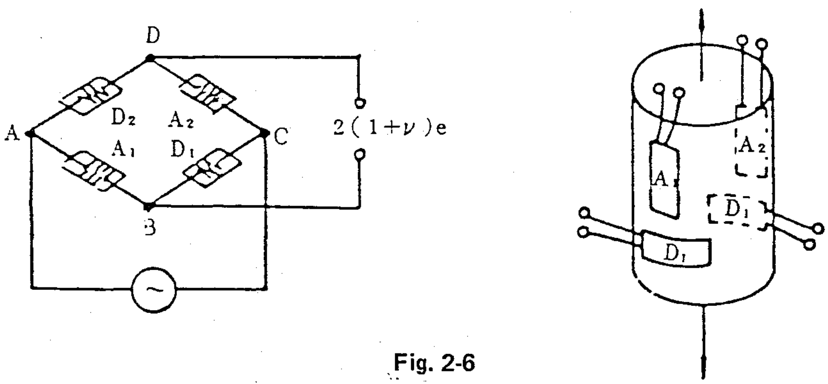


Fig. 2-6

$$\epsilon_5 = \frac{\epsilon}{2\,(1+\nu)} \qquad \sigma_5 = E\epsilon_5 = \frac{\epsilon}{2\,(1+\nu)} \cdot E$$

2.3 Using strain gages with gage factors other than 2.0

Calculations are made using the following formulas:

$$\epsilon_6 = \frac{2.00}{K_S}\,\epsilon, \qquad \sigma_6 = E \cdot \epsilon_6 = \frac{2.00}{K_S}\,\epsilon \cdot E$$

where K_S is the gage factor of the strain gage used.

2.4 Calculation method for measurement with strain gage transducers

Strain gage transducers measure such physical quantities as load, pressure, torque and acceleration by converting them into electric values via strain gage. Because the DPM-600 series strain amplifiers measure the amount of strain, it is necessary to calculate the physical value from the measured amount of strain and the calibration coefficient or rated output described on the inspection sheet of the transducer.

(1) Calculation of physical value with calibration coefficient

The desired physical value can be determined by multiplying the amount of strain obtained in paragraph 2.1 by the calibration coefficient described on the transducer inspection sheet.

Example: Load cell LC-2TG with 2tf capacity and a calibration coefficient of 0.0004997 tf/1.0×10^{-6}

Measured value of strain: 2900×10^{-6} strain

The load applied to the load cell is calculated as follows:

0.0004997 tf/$1.0 \times 10^{-6} \times 2900 \times 10^{-6} = 1.44913$ tf

(2) Determination of the physical value with the rated output value

The output value with rated load applied (rated output or output voltage sensitivity) is described on the inspection sheet of a strain gage transducer.

The physical quantity applied to the transducer can be obtained in almost direct-reading form by adjusting the calibration value and output of this instrument according to this rated output.

Example: Combination of this instrument and a PG-5KU pressure head (capacity: 5 kgf/cm^2, rated output: 3999×10^{-6} strain)

Adjust "RANGE" and "VERN" so that the output voltage is 5.000V when the calibration value of this instrument is set at 3999 $\mu\epsilon$ (rated output of transducer) and the calibration switch is set at "+". With pressure applied to the transducer, 5.000V corresponds to 5 kgf/cm^2.

Example: Combination of this instrument and an AS-20GA acceleration transducer (capacity: 20G, rated output: 850×10^{-6} strain)

Adjust so that the output voltage is 2.000V when the calibration value of this instrument is set at 850 $\mu\epsilon$ and the calibration switch is set at "+". 2.000V corresponds to 20G.

If a recorder is used, adjust so that the deflection width of the chart paper is 20 mm or 200 mm when a calibration value of 850 $\mu\epsilon$ is entered. 20 mm or 200 mm corresponds to 20G.

2.5 Correcting according to the extension cable used

Though there is practically no need for an extension cable in laboratory measurement, measuring instruments are sometimes installed at some distance from the measuring point in the field, thus requiring an extension cable.

In such cases, a bridge box is installed near the measuring point and an extension cable is used to connect it to the measuring point. However, the measured values in this case always involve some error resulting from the extension cable. The longer the cable, the larger the error.

To remove this error, the measured values must be corrected by multiplying them by a correction factor shown in Table 2-1.

Table 2-1

Cable length / Bridge resistance	5 m	25m	50m	75m	100m	200m
120Ω	1.000	1.016	1.032	1.049	1.066	1.132
350Ω	1.000	1.005	1.010	1.016	1.022	1.044

Table 2-1 shows the correction factors using Kyowa's extension cable (0.5 mm^2 four-core shielded tough-rubber cable).

This correction method involves some error depending on the type of extension cable and the ambient temperature.

CHAPTER 3 TROUBLES DURING MEASUREMENT AND TROUBLESHOOTING

3.1 Troubles during measurement (when the measuring instrument functions properly)

If the monitor meter does not swing fully or does not swing at all during initial balance adjustment, or if the excessive input indicator lamp blinks or some other trouble occurs during operation, perform an operation check by referring to the following troubleshooting guide.

With regard to the DPM-611A, 612A and 613A, the measuring instrument itself is functioning properly if the monitor meter pointer moves to the blue area when the CHECK pushbutton is pressed.

(1) Bridge balance is impossible

(a) Balancing of the bridge resistance is impossible

Replace the bridge box with another one. If balancing is possible, the cause may be that the strain gage or lead wire to that channel of the bridge box is shorted, broken or improperly connected, or the bridge box itself is defective.

Check the strain gage and its connection. If nothing is wrong, measure the resistance values between the bridge box terminals and the connector plug pins to see if these values correspond to those in Fig. 3-1. If they do, the cause may be a poor contact of the connector pin.

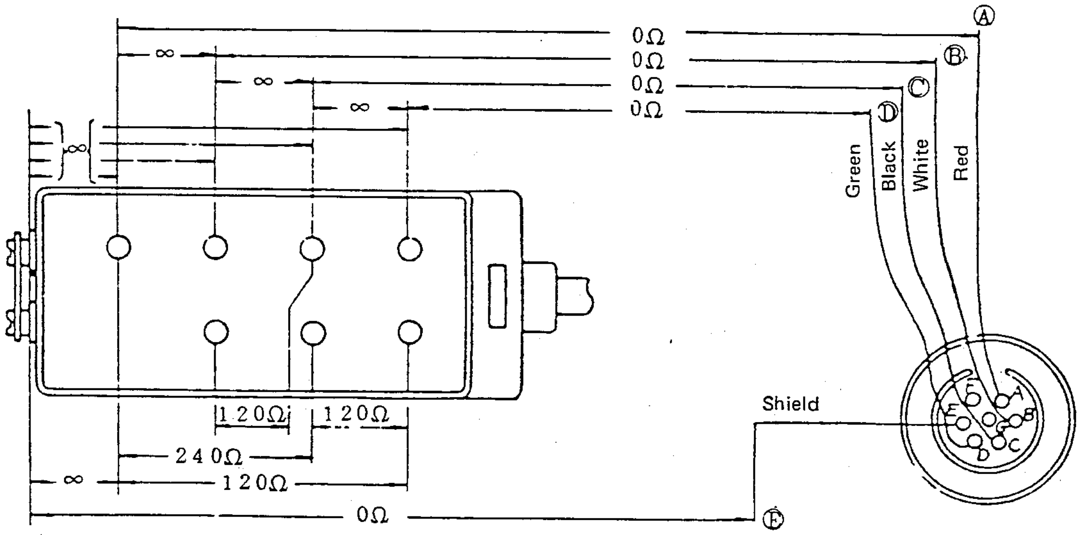


Fig. 3-1 Checking the Bridge Box

(b) Balancing of the bridge capacity is impossible

Balancing may be impossible if the wiring from the bridge box terminal to the strain gage is long and the capacity unbalance is large. The cause may be an excessively long lead wire in the one-gage method, or in the two-wire method, the cause may be that one gage is wired with a shielded wire and the other with a vinyl wire, or the line capacity is unbalanced due to unsatisfactory stranding of the cable core wires used for extending the bridge box.

If the capacity unbalance is large, use lead wires of the same type and length to eliminate the capacitive unbalance or change the combination of cable core wires in various ways so as to bring the monitor meter pointer as close to the zero scale as possible.

(2) During initial balance adjustment, with "RANGE" set at its maximum, as the "BAL" knob is turned, the monitor meter pointer comes near the zero scale, but does not come to "zero" (except for auto-balance models – DPM-611A, 612A and 613A).

(a) If the strain gage resistance deviation is large, initial balancing of the bridge is impossible. Use strain gages having the same resistance values.
Note: The deviation of Kyowa's 120 Ω strain gages is within ±1%.

(b) If the cause is the lead wire's capacity unbalance, balancing is impossible even if strain gages with the same resistance values are used. In this case, follow the instructions in paragraph 3-1 (1).

(3) After initial balance adjustment, the zero point shifts with time with no strain applied.

(a) When the insulation resistance of the strain gage or lead wire has decreased
Check the insulation resistance and moisture-proof it after drying or replace the gage with a new one.

(b) When the temperature compensation of the strain gage is insufficient
Check if the temperature has changed and if the zero point shifts due to that change. Also check if the linear expansion coefficients of the portions where gage A and gage D are bonded are the same.

(c) When the stability of the fixed bridge in the bridge box is low
If the fixed resistor in the bridge box deteriorates due to its moisture absorption or other causes, the resistance value may change with the ambient temperature or the heat generated by the resistor itself. In that event, replace the fixed resistor.

(d) When the zero point of the measuring instrument shifts
Excepting the above-mentioned three causes, a possible cause is the zero point shift of the measuring instrument. Although the measuring instrument is rigorously inspected in terms of its stability before shipment from the factory, a possibility of zero point shift cannot be excluded because the parts life is limited.
In that event, contact your local Kyowa representative or Kyowa Electronic Instruments in Tokyo for repairs.

(4) The zero point fluctuates during adjustment or measurement

(a) Faulty insulation of the strain gage
In the case of faulty strain gage insulation, check the insulation resistance and moisture-proof it after drying or rebond a new gage.

(b) Strain is applied
This is not likely to happen in laboratory measurements, but in a test measurement in a building or the like it is very difficult to obtain "no strain" conditions because small dynamic strain is most always applied. Since it is almost impossible to eliminate strain in such cases, it would be more important to examine how measurement and data processing can be done rather than to try to eliminate it. An appropriate method should be determined by experiment in each case.

(c) Disturbance by induction
Induction may be caused if there is a machine with large leakage of magnetic flux (e.g. large-size electric machine, ferro-resonance type constant-voltage source, etc.) in the neighborhood of the measuring instrument or if the measuring point is far away from the instrument.
To correct this:

1) Move the measuring instrument as far away as possible from the electric machine.

2) Use a 2-core flat braided cord or a 2-core shielded cord, if possible, for wiring to the strain gage and connect the shield to terminal E on the bridge box.

3) Completely ground the structure to be measured and ground the measuring instrument at the same grounding point.

(d) The structure to be measured is at a DC or AC potential
In this case, grounding of the measuring instrument is not always desirable. The problem may sometimes be solved by simply connecting the measuring instrument and the object measured to ground. If there is disturbance or potential, however, the problem can rarely be solved by a simple method. Try various methods in the field to find one which yields the best result.

(5) Low S/N ratio (large ripple)

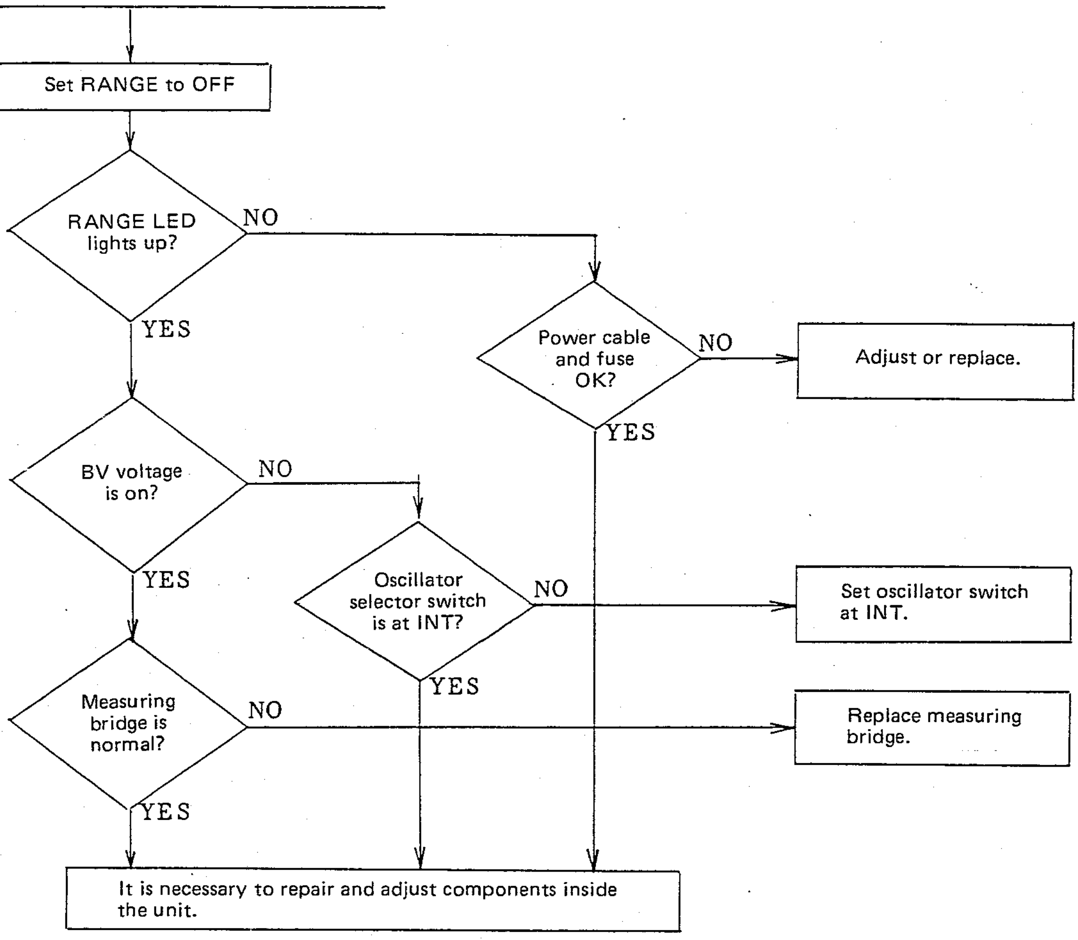
(a) Disturbance by induction
If this is the case, refer to paragraph 3-1, (4), (c) & (d).

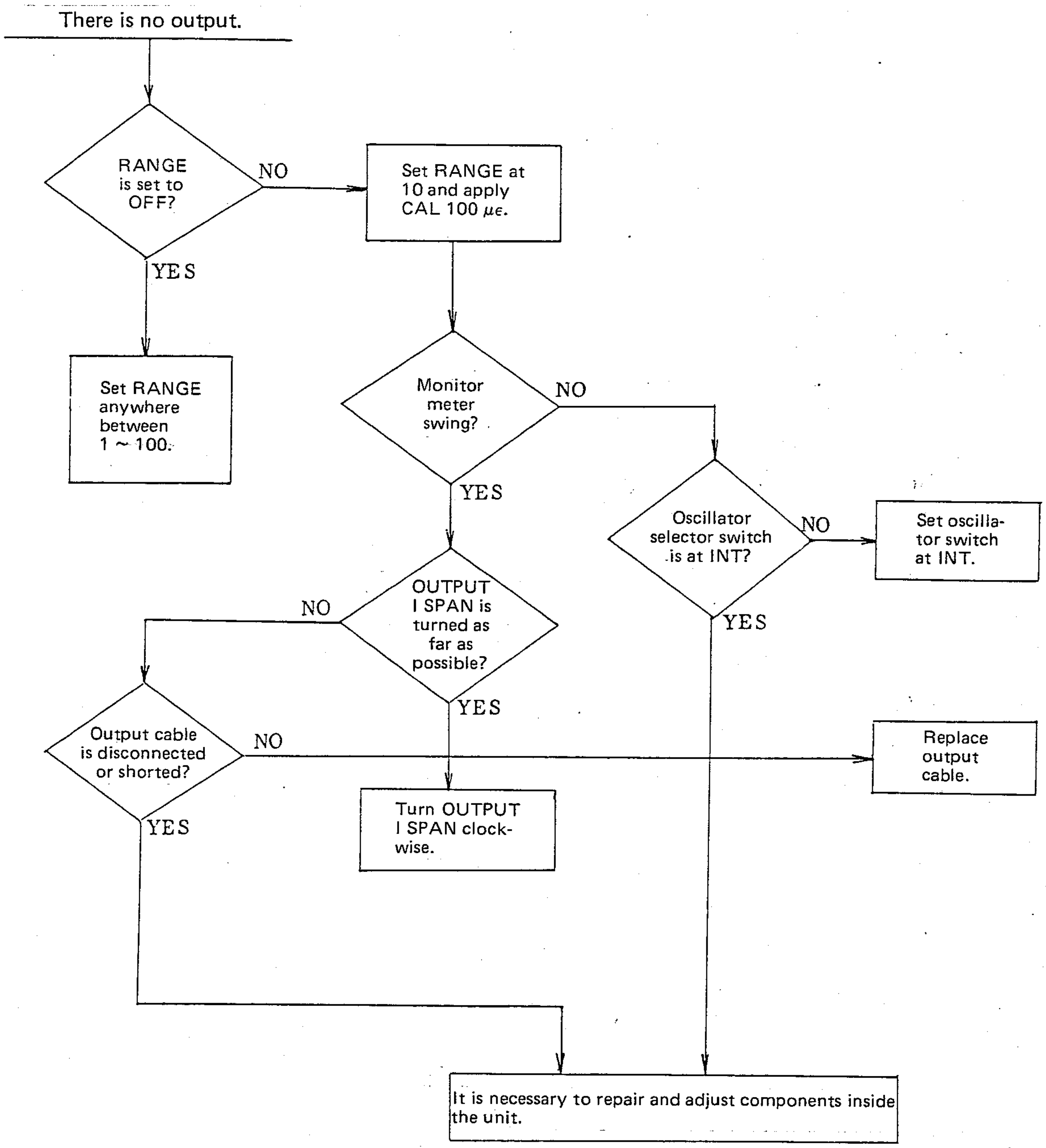
(b) Inappropriate combination of the amplifier sensitivity and recorder sensitivity
The S/N ratios of the measuring instruments are shown in Chapter 4, "Specifications". If the ratio is much lower than the value in "Specifications", which is likely to occur when a high sensitivity recorder is used, the cause may be an inappropriate combination of the amplifier sensitivity and recorder sensitivity. Refer to the operation manual of the recorder.

3.2 Measuring instrument troubles and their corrective measures

Kyowa instruments use specially selected parts and have been inspected rigorously before shipment from the factory to ensure their high reliability.
However, the component parts have their own lifetime and are not immune to failure if subjected to excessive temperature, humidity, dust, shocks and other adverse conditions over a long period.
For your reference, the following charts illustrate some checking items at the measuring site and the corrective measures for the cases "Initial balance adjustment is impossible" and "There is no output".
In case of trouble, do not try to repair the components inside the unit by yourself. Contact your Kyowa dealer or representative for repairs with a description of the trouble and conditions under which it is used. Repairs will be made in the factory.

Initial balance adjustment is impossible

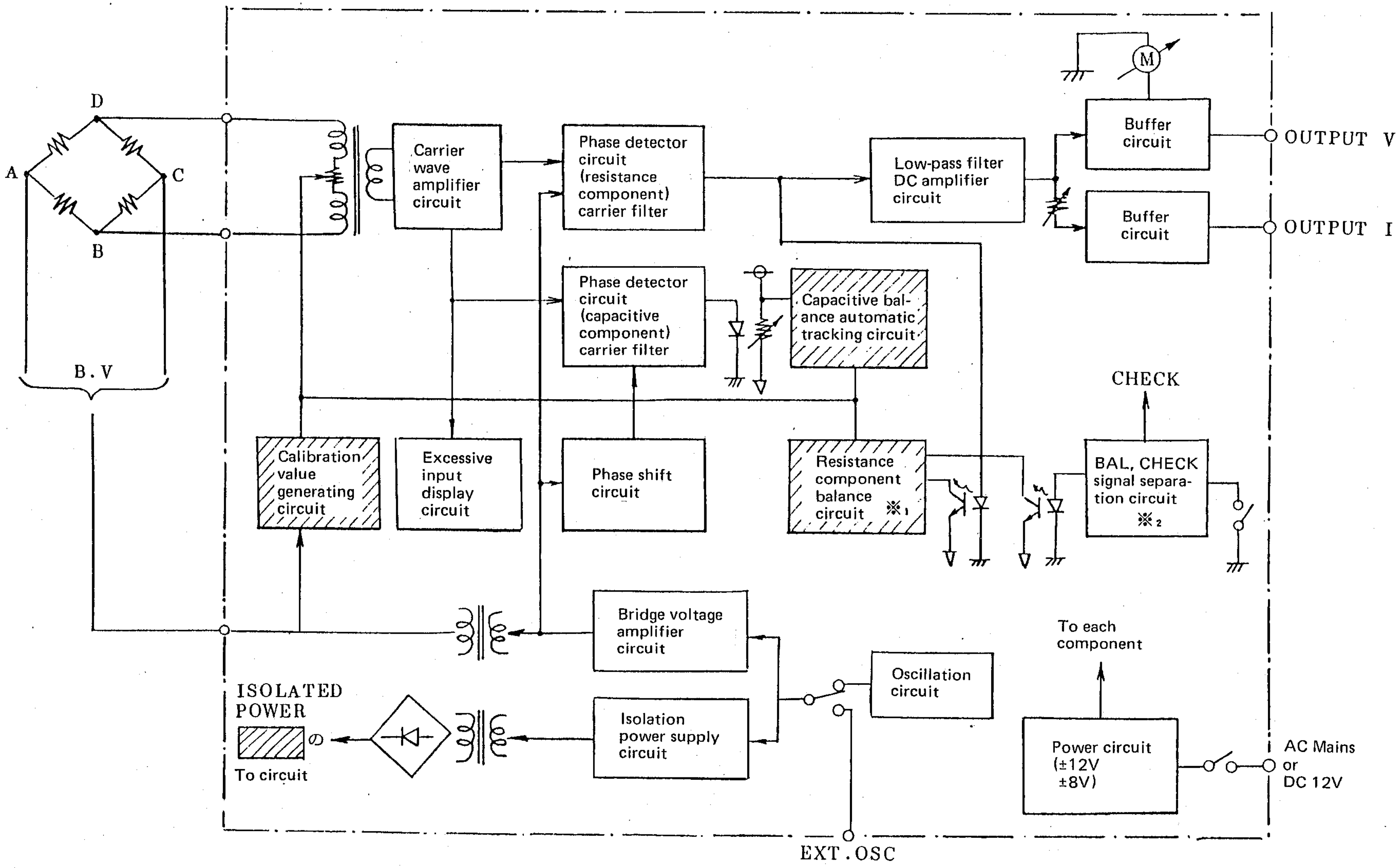



There is no output.
RANGE is set to OFF?
NO
Set RANGE at 10 and apply CAL 100 $\mu\epsilon$.
YES
Set RANGE anywhere between 1 ~ 100.
Monitor meter swing?
NO
YES
Oscillator selector switch is at INT?
NO
Set oscillator switch at INT.
YES
OUTPUT I SPAN is turned as far as possible?
NO
YES
Output cable is disconnected or shorted?
NO
Replace output cable.
YES
Turn OUTPUT I SPAN clockwise.
It is necessary to repair and adjust components inside the unit.

CHAPTER 4 SPECIFICATION

Specifications \ Model	DPM-601A	DPM-602A	DPM-603A	DPM-611A	DPM-612A	DPM-613A
1. Number of measuring points	1 (provided for multi-channel use)					
2. Compatible bridge resistance	60 ~ 1000 Ω					
3. Bridge voltage	2V, 0.5V switchable					
4. Balance adjustment range	R: ±1% (±5000 x 10^{-6} strain) C: 2000 pF					
5. Balance adjustment method	R: manual (10-turn potentiometer) C: CST method			R: Completely electronic auto-balance Accuracy: ±1 x 10^{-6} strain Time: 1 sec. Memory storage: 24 hr. C: CST method		
6. Sensitivity (10 x 10^{-6} strain)	0.2V (RL 5 kΩ) 3 mA (RL 30 Ω)					
7. Output	OUTPUT V: ±5V, ±5 mA OUTPUT I: ±5V, ±30 mA					
8. Non-linearity	±0.1% FS					
9. Output impedance	10 Ω					
10. Gage factor	2.00 fixed					
11. Standard calibration strain	±1 ~ 9999 x 10^{-6} strain (4-digit digital switch) Accuracy: ±(0.5% + 0.5 x 10^{-6} strain)		±1 ~ 9999 x 10^{-6} strain (4-digit digital switch) Accuracy: ±(0.5% + 1 x 10^{-6} strain)	±1 ~ 9999 x 10^{-6} strain (4-digit digital switch) Accuracy: ±(0.5% + 0.5 x 10^{-6} strain)		±1 ~ 9999 x 10^{-6} strain (4-digit digital switch) Accuracy: ±(0.5% + 1 x 10^{-6} strain)
12. Sensitivity adjuster	8 steps: 1, 2, 5, 10, 20, 50, 100 x 100 $\mu\epsilon$, and OFF Accuracy ±0.5% and 1 ~ 1/2.5					
13. Dual output adjuster	Sensitivity: 1 ~ 1/100 Zero point approx. ±30 mV					
14. Frequency response	DC to 2.5 kHz, deviation ±10%	DC to 5 kHz, deviation ±10%	DC to 10 kHz, deviation ±10%	DC to 2.5 kHz, deviation ±10%	DC to 5 kHz, deviation ±10%	DC to 10 kHz, deviation ±10%
15. Low-pass filter	10, 30, 100, 300, 1 kHz, F Cutoff point: –3 dB ± 1 dB About –12 dB/oct					
16. SN ratio	100 $\mu\epsilon$ range: 46 dBp-p Other than 100 $\mu\epsilon$ range: 52 dBp-p		100 $\mu\epsilon$ range: 40 dBp-p Other than 100 $\mu\epsilon$ range: 46 dBp-p	100 $\mu\epsilon$ range: 46 dBp-p Other than 100 $\mu\epsilon$ range: 52 dBp-p		100 $\mu\epsilon$ range: 40 dBp-p Other than 100 $\mu\epsilon$ range: 46 dBp-p
17. Stability	Zero point shift ±0.1 x 10^{-6} strain/°C ±0.5 x 10^{-6} strain/24 hr. ±0.05% FS/±10% power voltage fluctuation Sensitivity variation ±0.05%/°C ±0.3%/24 hr. ±0.05%/±10% power voltage fluctuation					
18. Insulation resistance	Between measuring bridge and enclosure: AC 250V, 1 min. Between AC power source and enclosure: AC 1000V, 1 min.					
19. Operating temperature and humidity	–10° ~ 50° C, 85% RH or less (no condensation)					
20. Storage temperature	–30° ~ 70°C					
21. Excessive input display	"OVER" lamp blinks.					
22. Self-check	No provision for self-check.			"Good" displayed on meter when pushbutton is depressed.		
23. Remote function	Simultaneous "CAL" on all channels			Simultaneous "auto-balance" on all channels Simultaneous "CAL" on all channels Simultaneous "CHECK" on all channels		
24. Power source	AC Mains, 6 VA DC 10.5 ~ 15V, 0.35A			AC Mains, 7 VA DC 10.5 ~ 15V, 0.4A		
25. Dimensions & weight	49 W x 142 H x 264 D mm Approx. 1.5 kg			Approx. 1.6 kg		

Diagram 1 BLOCK DIAGRAM



*1 Potentiometer on DPM-601, 602 and 603 models
*2 Not provided on DPM-601, 602 and 603 models

Diagram 2 External View (DPM-601A, 602A and 603A)

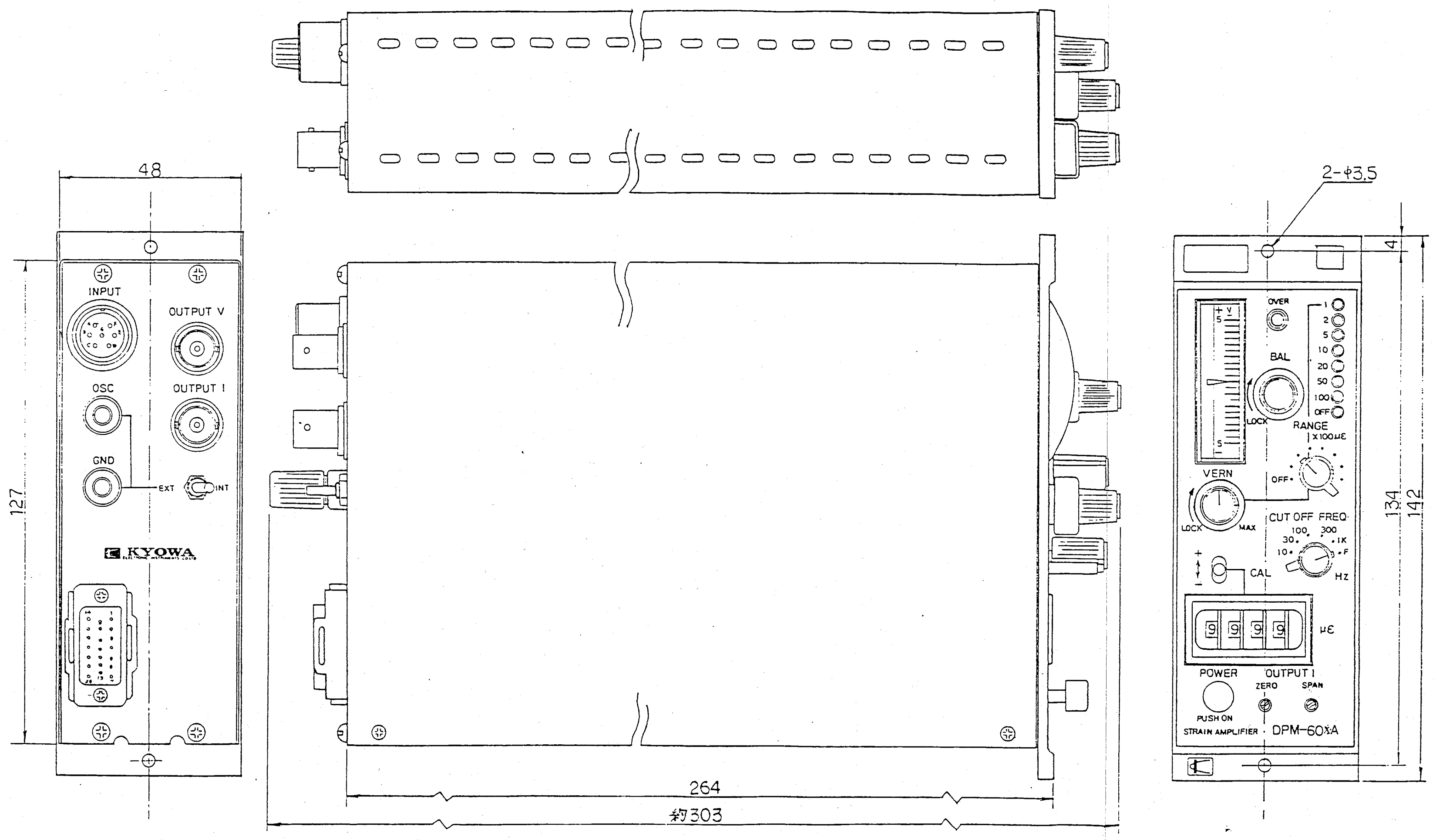
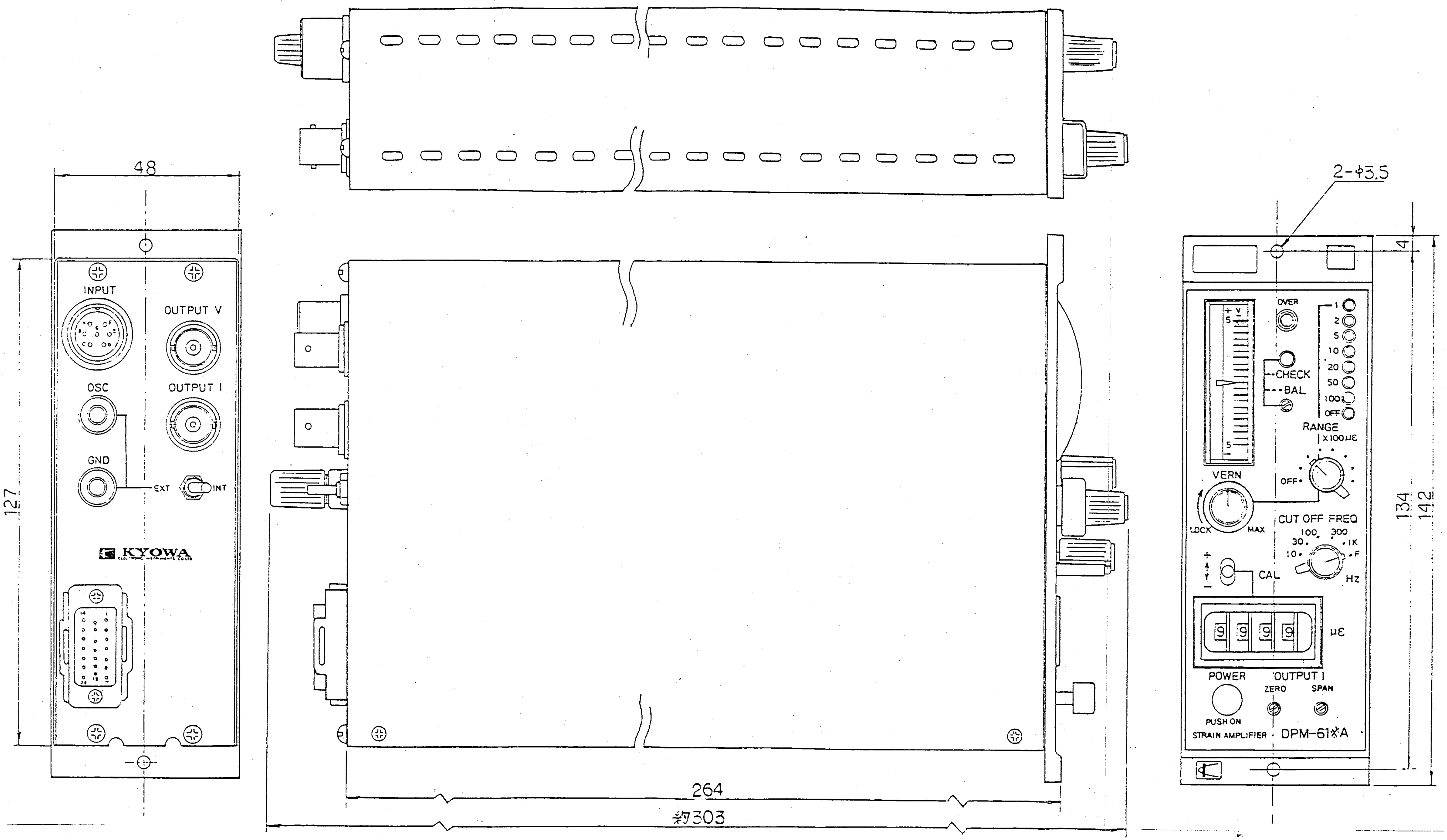


Diagram 3 External View (DPM-611A, 612A and 613A)



KYOWA

Manufacturer

KYOWA ELECTRONIC INSTRUMENTS CO., LTD.

Address: 3-8, Toranomon 2-chome, Minato-ku, Tokyo , Japan

Phone: Tokyo 03-502-3551 Cable: KYOWASTRAINGAGE TOKYO Telex: 222-3854 KYOWAT J

26

Printed in Japan