POTENTIOSTAT / GALVANOSTAT

WITH WAVEFORM GENERATOR

N600-HAB151

Manual of Operations

IMPORTANT!

Read the following before using this equipment:

Carefully Follow all instructions and observe all precautions given in this book

CAUTION!

- Never disassemble or attempt to repair the unit by yourself, such an attempt may damage the unit or cause you injury.
- Avoid installation of the unit where too much dust or corrosive gas exists.
- Do not install the unit on carpet to avoid interference of static electricity.
- Avoid installation of the unit where excessive vibration or electromagnetic fields exist.
- Do not place the unit in direct sunshine, and keep away from fog or rain.
- Do not install the unit in such a manner that blocks the rear panel or the bottom chassis because such installation may cause overheating and damage to the unit.
- Avoid installation of the unit where a heavy substance may drop on it.
- We recommend to ground the unit as to reduce noise and stabilize measurement. To ground the unit, connect the grounding terminal on the rear of the unit to a ground. (structural steel of building or power supply grounding conductor) through the wire supplied with the unit.
- Do not connect the TO-CELL-OUT cable (the output of this unit) to any other power source, to avoid damage the unit.

BEFORE YOU BEGIN

- Before connecting or disconnecting the power cable, be sure the power switch is off.
- Before turning on the unit, make sure that the FUNCTION switch is set to ZERO ADJ to avoid unstable initial conditions.

Connect the TO-CELL-OUT cable clips as follows:

Red (GE)	: Counter electrode
Green (RE)	: Reference electrode
Black (WF2)	: Working electrode
Black (WE1)	: Working etectrode

- The WE2 electrode grounds the RE terminal which detects electric potential. In order to minimize the error from voltage drop due to the lead wire and large current, place the WE2 electrode as close as possible to working electrode.
- Do not extend the TO-CELL-OUT cable clip using a PVC wire or a simillar conductor because such extension of the cable may cause oscillation or noise due to excessive floating capacity.

REPAIR

Do not force the unit to operate when any fault is found, Whenever a problem is encountered, switch off the power supply, pull out the plug, and contact NADA Scientific for a service and repair quote at support@nadascientific.com, or call us at 1-800-799-6232.

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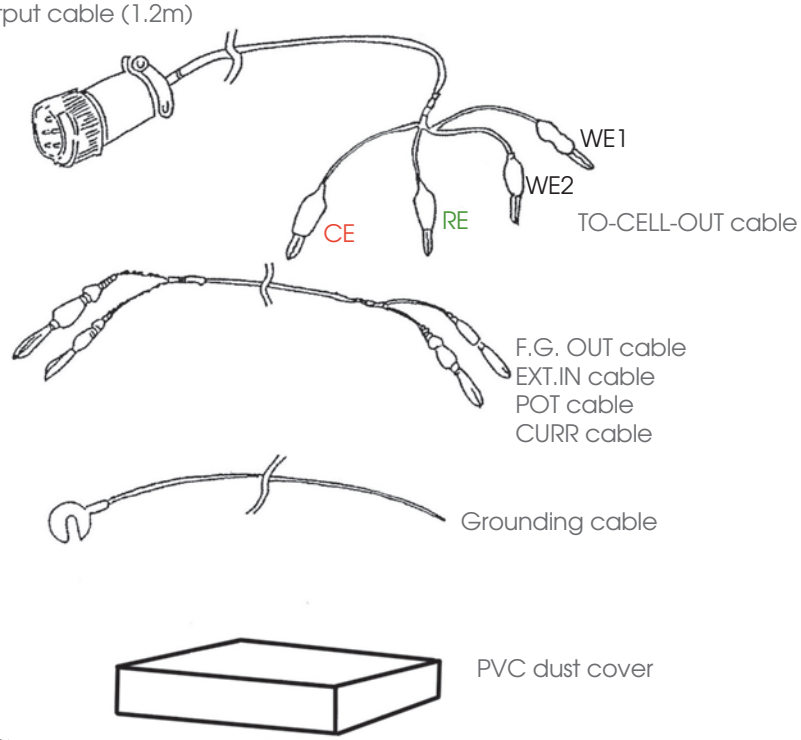
1. ADVICE BEFORE USE OF HAB-151

UNPACKING CHECK

Upon receipt of the HAB-151, please confirm that the panels and the enclosure have not been scarred or damaged. Confirm that the following componets are contained in the package and if any damage or shortage is discoverd contact the agent from whom you purchased the HAB-151 or one of the Hokto offices.

- HAB-151 unit
- TO-CELL OUT cable (1.2m)
- F.G. OUT waveform output cable (1.2m)
- EXT.IN external signal input cable (1.2m)
- POT voltage recorder output cable (1.2m)
- CURR current recorder output cable (1.2m)
- Grounding cable (3m)
- PVC dust cover
- Operation Manual



POWER SUPPLY

Be sure to use power supply of 220VAC (±10%), 50 Hz or 60Hz.

CAUTION: Supplying voltage lower than 198V AC may cause error in control, measurment or operation. Supplying voltage exceeding 242V AC may damage the unit.

CAUTION: When disconnecting the power cable from the power source, be sure to turn off the power swtich to the unit first, while holding the plug with your hand, pull out the cable. Do not pull out the cable by holding the cable itself, because this may decrease or break the electric continuity of the cable.

Power supply must be sufficent for the following power consumption of this HAB-151:

- 20 VA at standby
- 100 VA under the maximum load (output short-circuited, in the G-STAT mode).

INSTALLATION

Install the unit where the weight of the unit can be safely supported (The unit and the accessories: 7.7kg)

CAUTION:
- Avoid installation of the unit where too much dust or corrosive gas exists.
- Do not install the unit on carpet to avoid interference of static electricity.
- Avoid installation of the unit where excessive vibration or electromagnetic field exists.
- Do not install the unit in direct sunshine, fog or rain.
- Do not install the unit in such a manner that blocks up the rear panel and the bottom chassis because such installation may disturb heat radiation, which may damage the unit.
- Avoid installation of the unit where a heavy substance may drop.

We recommend to ground the unit to reduce noice and stabalize measurement. For grounding the unit, connect the grounding terminal on the rear of the unit to the ground (structural steel of building or power of supply grounding conducto) through the grounding wire supplied together with the unit.

PRECAUTIONS

Following the precautions mentioned below:

- Before connecting or disconnecting the power cable, be sure to turn off the power switch of the unit.
- Before turning on the power switch of the unit make sure to avoid unstable initial conditions, that the FUNCTION switch is set to ZERO ADJ.

CAUTION: Do not connect the TO-CELL-OUT cable (the output of this unit) with any other power soucre. Connecting this cable with another power source may damage the unit.

- Connect the TO-CELL-OUT cable clips as follows:

Red (CE)	:	counter electrode
Green (RE)	:	reference electrode
Black (WE2)	:	working electrode
Black (WE1)	:	working electrode

The WE2 electrode grounds the RE terminal which detects electric potential. In order to minimize the error from voltage drop due to the lead wire and large current, place the WE2 electrode as close as possible to the working electrode

- Do not extend the TO-CELL-OUT cable clip using a PVC wire or a similar conductor because such extension of the cable may cause oscillation or noise due to excessive floating capacity

REPAIR

Do not force the unit to operate when any fault is found. Whenever a trouble is encountered, switch off the power supply, pull out the plug, and contact the agent from whom you purchased the unit or an office in Hokuto Denko.

CAUTION: Never disassemble or attempt to repait the unit by yourself. Such attempt may damage the unit or electrically shock you.

2. GENERAL INFORMATION ON HAB-151

FUNCTION

The HAB-151 is a compact standing-alone electrolyzing unit, intergrating a petentiostat, a galvanostat and a function (waveform) generator, which are indispensable for electrochemical measurement. This unit, easy to handle and reasonable in price, suits field use and training of operators.

The potentiostat /galvanostat part, provided with a capacity of 15V 1A and a current detecting range covering a minimum of 10A, has sufficient functions for normal electrolytic testing and corrosion testing. This part is equipped with three major functions:

high-input-impedance electrometer, potentiostat (constant-voltage control) and galvanostat (constant-current control). The potentiostat / galvanostat part is provided also with alarm functions for uncontrollableness and excess voltage as well as additional convenient functions, including external control input and current-monitor noise refection filter.

The waveform generating part employs an analog circuit system that assures smooth output. This part can generate lamp waves and triangular waves having a wide-range sweeping speed from 50V/sec to 10mV/mim, with set peak voltage of - 5V to +5V. Stop, hold and reverse can be performed easily during sweep.

CONFIGURATION

This unit consists of the electrometer, the potentiostat, the galvanostat, and the waveform generator. The panel is separated into the pctentiostat/galvanostat part and the function generator part and these parts are connected with the F.G.SET on/off switch.

SPECIFICATIONS

1) Potentiostat

a) Maximum output	±1A, ±15V
b) Current detection ranges	6 ranges of ±1A, ±100mA, ±10mA, ±1mA, ±100μA, and ±10μA
c) Maximum control Voltagre	±10v
d) Controltolerance	±3mV
e) Responsespeed	50μsec and less
f) Input resistance	10^{10} Ω and more

2) Galvanostat

a) Maximum output	±15V, ±1A
b) Set current ranges	6 ranges of ±IA, ±100mA, ±10mA, ±1mA, ±100μA and ±10μA
c) Current set-up accuracy	Not more than ±1% of the set current range fullscale
d) Response speed	50μsec and less

3) Electrometer

a) Input resistance	10^{10} Ω and more
b) Bias cunent	10^{10} Ω and more
c) Response speed	l0µsec and less
d) Conversion enor	Not more than 0.1% of the input voltage
e) Voltage display ranges	2 ranges of ±10V and.±2V (digital display)

4) Recording portion

a) Voltage record output	1:1
b) Cunent record output	Full scale of each current range is converted into 1V

5) Waveform generator

a) Output waveforms	Lamp wave Single triangular wave Singte two-stage triangular wave Continuous triangular wave
b) Output voltage Voltage set-up agcuracy	-5V to 0V to +5V Less than (±1% of set voltage) ±20mV
c) Sweepspeed	36 ranges of 0.1, 0.2, 0.5, 1, 2, 5, 10,20, 50, 100,200, 500mV/sec 1, 2, 5,10, 20, 50 V/sec 10, 20,50, 100,200, 500mV/min 1, 2, 5, 10, 20, 50, 100, 200, 500 v/min 1,2,5 kV/min
d) Setting accuracy	2% (at $x10^{-1}$ setting) 1% (at $x10^{9}$ to 10^{4} setting)

6) Current consumption — 20VA at standby
100VA under maximum load

7) External dimensions — 435 (w) x 360 (d) x 100 (h) mm

8) Weight — 7.7 kg

•Other requirements:

Temperature and humidity range:	Dew formation is not allowable in operation at 0-40°C, 10-90% relative humidity, and in custody at -10°C to +50°C, 10-80% relative humidity.

3. ACCESSORIES

OUTPUT CABLE

This 1.2 meter cable connects the HAB-151 unit with the electrodes in the load electrolytic cells. The five-pin metal connector is located on the rear panel of the HAB-151. Insert he connector pins into the TO-CELL-OUT terminal, refening to the notch on the terminal, then lock the connector. Connect the terminal clips with the electrodes as follows:

Red (CE) → with counter electrode
Green (RE) → with reference electrode
Black (WE2) → with working electrode
Black (WE1) → with working electrode

Since the unit has been tuned with the supplied output cable, do not replae the cable with other cable or extend the cable. If a longer cable is needed, please contact Hokuto.

EXTERNAL SIGNAL CABLE

This 1.2 meter shielded cable is provided with banana plugs at both ends. Use this cable for inputting control signals from an external source into the EXT.IN on the rear panel.

RECORDER OUTPUT CABLE

These 1.2 meter shielded cables also have banana plugs at both ends. Connect the cable with the CURR terminal for current record output. Connect the cable with the POT terminal for voltage record output.

WAVEFORM OUTPUT CABLE

This 1.2 meter shielded cable has banana plugs at both ends. Use this cable for supplying the waveforms from the built-in waveform generator to an external unit.

NOTE: The external signal cable, the recorder output cables and the waveform output cable use common cables and parts. Therefore these cables may be interchanged.

GROUNDING CABLE

This 3 meter PVC solid wire is designed to withstand large current. Connect this wire with the grounding terminal on the rear panel and with a grounding conductor of the laboratory where this unit is installed.

PVC COVER

When startng the unit, protect the unit with this cover against dust

4. PANEL OVERVIEWS

FRONT PANEL

① Power switch

This on/off switch connects commercial AC power supply.

②-1 Display switch

This switch changes over the digital meter ⑤ to voltage, or current. For voltage, sensitivity of the digital meter ⑤ can be either 10V F.S. (at upper setting) or 2V F.S. (at lower setting). For current, set this switch to the neutral position. The sensitivity of the digital meter depends on the CURR RANGE selector switch ②-2

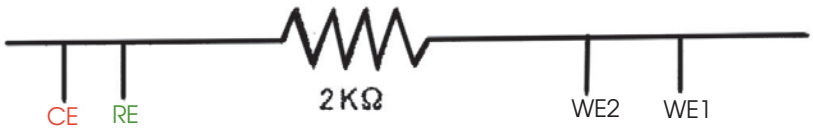
②-2 CURR range switch

The CURR output terminal for a recording instrument outputs 1V when full scale cunent in the set range flows. This switch is used as a current setting switch for the galvanostat mode.

③ FUNCTION selecting switch

CHECK:

The output of the unit {RE and CE) is separated from the electrolytic cell and connected with a built-in 2kΩ resistance



ZERO ADJ:

Zero adjustment position. Turn the zero adjustment potentiometer with a minus driver so that the digital meter ⑤ shows zero

REST POT:

Set to this position for measurement of rest potential (in the electrometer mode).

OPERATION:

Set to this position for changing over to potentiostat or to galvanostat. Setect a mode using the P-STAT/G-STAT selecting switch.

④ P-STAT/G-STAT selecting switch

With this switch select either potentiostat or galvanostat when the FUNCTION switch ③ is set to OPERATION

⑤ Digital meter

Digital meter displays both voltage and amperage, interlocked with the range switch ②-2 The metbr displays polarity + 3-1/2 digits, and units of V,A, mA and µA are automatically selected.

⑥ Excess CE, POT and CURR indicating lamps

CE OVER is lit when the bath voltage (output voltage) exceeds 15V, POT OVER is lit when the control or detection voltage exceeds 10V, and CURR OVER is lit when the current exceeds the range. Even when these lamps indicate abnormal conditions during measurement, the unit is protected by built-in protective circuit against damage.

⑦ EXT.SET ONIOFF - external signalonloff switch

When this switch is set to ON, signals led to the EXT.IN terminal on the rear panel are added to the control system.

⑧ F.G. SET ONIOFF - function generator signal on/off switch.

Set this switch to ON when sending the signals set at the waveform generator to the control part.

⑨ WAVEFORM setting switch

This switch selects lamp wave, single triangular wave, single two-stage triangular wave or continuous triangular wave.

⑩ SCAN SPEED selecting switches

UNIT SELECTION:

One of two units can be selected - 100mV/min or mV/sec.

MULTIPLIER SELECTION:

One of three figures can be selected - 1, 2 and 5.

EXPONET SELECTION:

One of the following can be selected - $x10^{-1}$, x1, x10, $x10^{2}$, $x10^{3}$ and $x10^{4}$.

EXAMPLE: For setting 500 mV/min, set 5 x1 100V/min

⑪ STOP/START pushbutton and lamps

Pushing this button starts or stops waveform generation. When STOP lamp is lit, the output voltage of the waveform generator is "initial" potential.

Therefore the initial potential serves as the internal DC setting for the potentiost/galvanostat.

When STOP lamp blinks, proper conditions of initial potential, high potential and low potential are not satisfled. In such a case, reset proper conditions.

Proper conditions for potential set-up:
Low potential +50mV < initial potential < high potential-50mV

This means that the high potential must be higher than the initial potential by 50mV and more, and the low potential rnust be lower than the initial potential by 50mV and more.

Start lamp (green) is turned on when waveforms are generated.

⑫ HOLD lamp and Pushbutton switch

press this button to terminate output scanning, and also to release holding. This lamp blinks during holding. This analog holding is not suitable for long time holding.

⑬ UP/DOWN lamps and REVERSE pushbutton

The Up lamp blinks when the electric potential increases, where as the DOWN lamp blinks when the electric potential decreases. Pressing the REVERSE button switch reverses UP to DOWN or DOWN to UP.

⑭ LOW potential set-up switches

The lower limit voltage of the triangular wave output is set up with these switches - polarity switch, 1V step switch, and 0-1V dial-within a variable range of -5.00V to +5,00V,

⑮ INITIAL potential set-up switches

The initial voltage of triangular wave output is set up with these switches - polarity switch, 1V step switch, and 0-1V dial -within a variable range of - 5.00V to +5.00V.

⑯ High potential set-up switches

The upper limit voltage of the triangular wave output is set up with these switches - polarity switch, 1V step switch, and 0-1V dial - within a variable
range of -5.00V to +5.00V.

REAR PANEL

⑰ F.G. OUT- waveform generator terminal
The waveform voltage from the waveform generator built in this unit is put out at 1:1 ratio.

⑱ EXT.IN - external signal input terminal
Constant-voltage control with the potentiostat and constant-current control with the galvanostat may depend on an external signal generating Source. In such cases, external signals are put in through this terrninal.

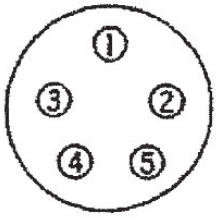
⑲ POT - voltage record terninal
Voltage record output terminal. Output impedance: 50Ω and less.

⑳ CURR curent record terminal
Current record output terminal. Output impedance: 50Ω and less.

㉑ FILTER HIGH/LOW - filter switch
This switch decreases hum noise (50Hz or 60Hz) or other AC noise included in the output form the current record terminal ⑳. Attenuation and response speed are as follows inespective of the current range:

Range	Current detection response speed	Attenuation at 50Hz	Attenuation at 60Hz
LOW	40msec	-16dB (0.15)	-17.5dB (0.13)
HIGH	20msec	-22dB (0.079)	-23.5dB (0.066)

㉒ TO CELL OUTPUT - load cell connecting terminal
Five-pin metal connector for connecting the TO-CELL-OUT output cable, which is connected with the electrolytic cell. Pay attention to the orientation of the Pins.
Pin 1 : counter electrode (CE) red wire
Pin 2 : RE shield (RE) green wire
Pin 3 : reference electrode
Pin 4': working electrode sensor (WE2)white wire
Pin 5 : workIng electrode common (WE1) black wire



㉓ GND - grounding plug

Connected with the enclosure. We recommend grounding be made for preventing electric shock and decreasing noise.

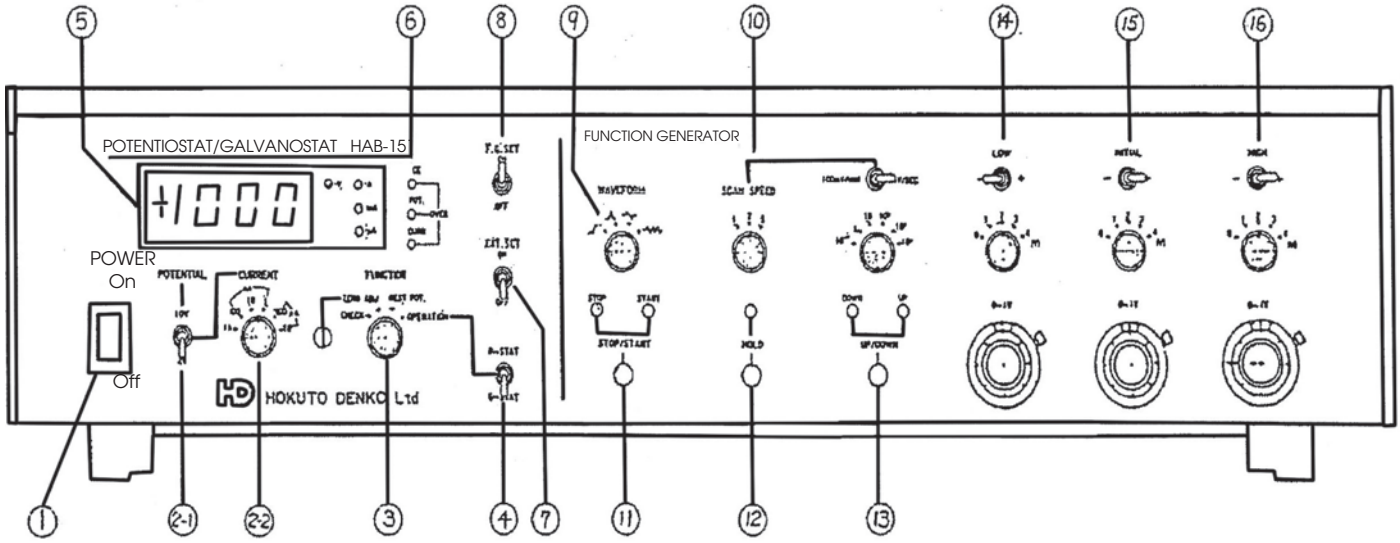
㉔ Fuse holde

A 1A fuse in a glass tube is contained. Replace, if necessary, with a fuse of the same standard capacity.

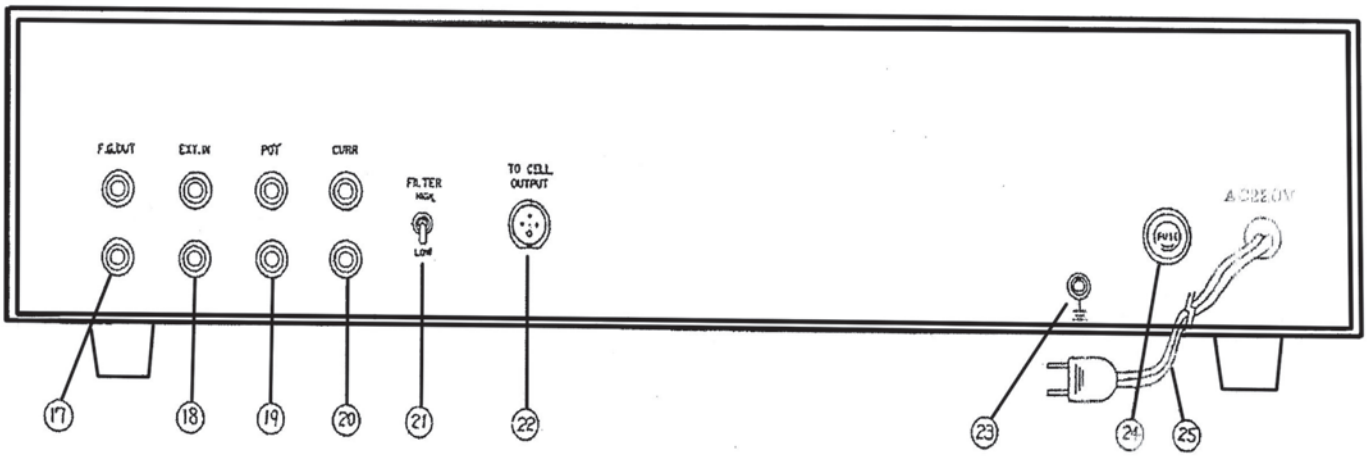
㉕ AC cable

The cable can be connected with a 100V AC (50/60Hz) receptacle. Current capacity of the power source must be 1A and more,

FRONT PANEL



REAR PANEL



5. OPERATION

GENERAL PRECAUTIONS BEFORE OPERATION

Connection of power supply:

Before turning on the pcruerswitch make sure that the FUNCTION switch is set to ZERO ADJ.
CAUTION: If the power supply is connected with the FUNCTION switch set to OPERATION, the specimen may receive excess voltage and if so may be darnaged.

Salt bridge:

In order to measure the potentiel of the working efectrode accurately, the Luggin prove must be as close as possible to the working electrode. The salt bridge connecting the Luggin probe and the reference electrode may be affected by noise because this bridge is of high impedance. Therefore we recommend to shield the whole electrolytic cell or, if it is difficult, shield only the salt bridged reference electrode.

Reference electrode circuit:

Make sure that the reference electrode is not leaking and the salt bridge contains salt.
CAUTION: If the P-STAT rnode is selected with the reference eletrode disconnected, the unit becomes out of control. This may damage the specimen or heat the electrolytic cell although this unit is protected with a built-in protective circuit against such phenomenon.

Connection with the electrolytic cell:

When the electrolylic cell is connected, the FUNCTION switch must be set to ZERO ADJ. position.
CAUTION: If the electrolytic cell is connected with the FUNCTION switch set to OPERATION mode, the cell may be exposed to high voltage. This may electrically shock you or may generaie a spark from poor electrical continuity.

ZERO ADJUSTMENT

Normally zero adjustment is unnecessary, Check zero adjustment when the room temperature fluctuates remarkably or the unit will be used for a long time.

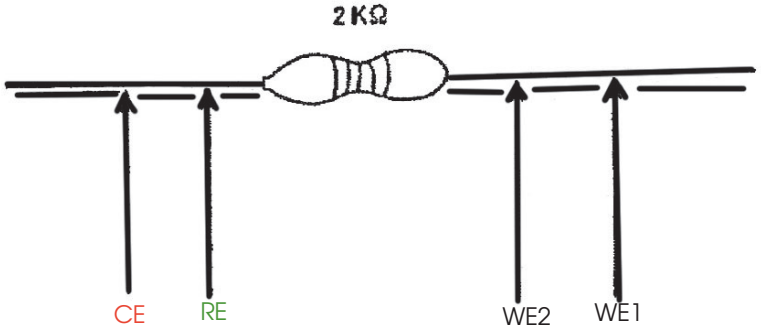
- Set the FUNCTION switch ③ to ZERO ADJ.
- Turn on the POWER switch ①
- Warm up the unit for 10-20 minutes.
- Set display selects ②-1 to 2V.
- Using a minus driver, adjust the ZERO ADJ hole ③ so that the digital meter ⑤ indicates ±0001 and less.

Now you have completed zero adjustment.

FUNCTION CHECK

Make sure that the unit is in normal conditions before operation or after any trouble occurred during operation. Particularly when any trouble occurred (such as CURR OVER, POT OVER, OUT OF CONTROL) with the electrolytic cell connected, it is necessary to clarify whether the unit is abnormal or the cell connection is abnormal.

For checking the abnormality, set the FUNCTION selecting switch ③ to CHECK. When the swiich is set to CHECK, a built in 2kΩ resistance, as an electrolytic-cell simulating load, is connected with the output as follows:



When the FUITICTION switch is set to CHECK position, the unit operates in the potentiostat mode. If the INITIAL potential ⑮ from the waveform generator is set to a suitable value and the F.G SET ⑧ is turned on, a current value in accordance with the Ohm's law should be indicated. Check the norrnal conditions of the unit referring to the indication.

$$\text{Current} = \frac{\text{Internal set value (V)}}{2000\Omega}$$

Example: In case of the initial potential +1V, 500μA should be indicated.

If a current value in accordance with the Ohm's law is indicated when the waveform generator is started up, the unit is normal.

CONNECTION OF THE LOAD (HOW TO SHIEILD)

Connect the load cell with the special cable (TO-CELL-OUT cable) supplied with the unit. Connect slips WE1 and WEZ with the working electrode, RE with reference electrode, and CE with the counter electrode.

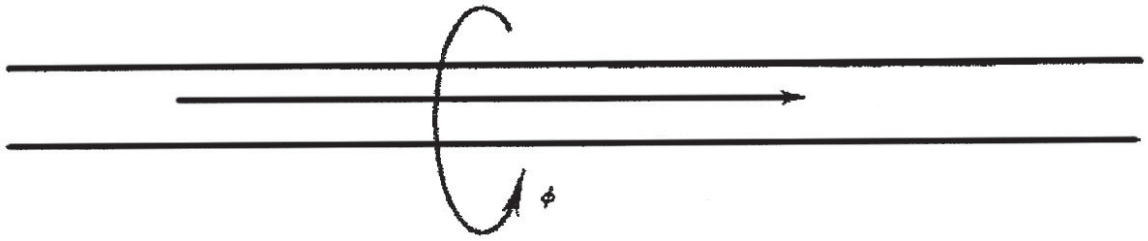
WE1 (black clip and black wire)	working electrode
WE2 (black clip and white wire)	working electrode (as close as possible to the specimen)
RE (green clip and green wire)	reference electrode
CE (red clip and red wire)	counter electrode

In connecting the WE1 and the WE2 with the working etectrode, pay attention to the following, Very little current flows I the WE2, which detects the potential of the working electrode. Current flows in the WE1, which receives electrolytic current from the counter electrode. Therefore, in order to avoid voltage drop from resistance of the specimen and the conductor or contact resistance of the WE1, install the WE2 clip as close as possible to the specimen. Do not allow the clips of WE1 and WE2 to contact each other.

(shielding of the electrolytic cell)

Current flow in a wire causes a magnetic field in accordance with Fleming's rule. The more the current changes (in frequency), the stronger the magnetic field.

It is said that various magnetic inducing noises having cammercial frequency (50Hz or 60Hz) from indoor and outdoor electric cables files inside non-shielded buildings.



For electrolytic experirnent using the potentiastat, the following two types of noise should be reduced:

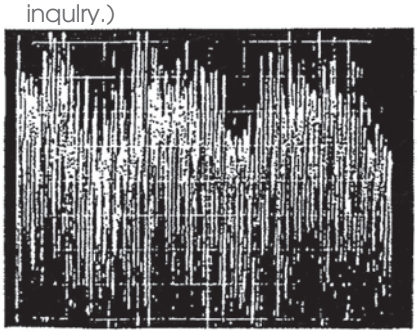
(1) Magnetic inducing noise having 50/60 Hz frequency
(2) Electrostatic noise produced by electric capacitance that exists in all substances

Electrostatic noise can be reduced by any of the following means:

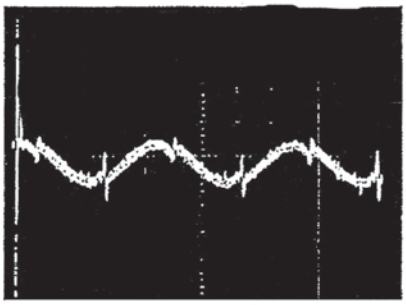
(A) Cover the electrolytic cell with a steel sheet for electrostatic shielding. Connect the shield case with the grounding terminal ㉓ of the enclosure.
(B) Cover the reference electrode with shield and connect the electrode to the enclosure grounding terminal ㉓
(c) Wrap the salt bridge of the reference electrode with metal, such as aluminum foil, and connect the bridge to the shielding cover.

Magnetic inducing noise can also be reduced in the same manner as mentioned above, it is effective for reducing magnetic inducing noise to use magnetic absorbing material (steel or permalloy is better than aluminum) for shielding.

(Hokuto Denko manufactures shield cases of general and railroad specifications. Hokuto Denko welcomes your inqulry.)



Experiment with a non-shielded electrolytic cell - High-frequency noise (electrostatic noise) is added to 50Hz hum.
5mV/DIV,5ms/DIV



Shielded with aluminum sheet. Electrostatic noise is removed, and 50Hz magnetic hum noise remains.
5rnV/DIV, 5ms/DIV

Shielded with steel sheet.
5mV/DIV, 5ms/DIV

USE OF HAB-151 AS THE ELECTROMETER

Set the FUNCTION selecting switch ③ to REST POT. Set the range selecting switch ②-2 to a suitable sensitivity -10V, 1V or 0-1V. Then the digital meter ⑤ will indicate the rest potential. Also the potential record terminal ⑲ on the rear panel will output impedance-converted potential at 1:1 ratio. At this time, if the range selecting switch ②-1 is changed over, the digital meter ⑤ display changes its digit but the output of the potential record terminal ⑲ remains unchanged

USE OF HAB-151 AS THE POTENTIOSTAT

For using the HAB-151 as the potentiostat, take the steps as follows:

(a) Preparation
Set the FUNCTION switch ③ to OPERATION. Set the P-STAT/G-STAT selecting switch ④ to P-STAT. Adjust the INITIAL potential set-up switch ⑮ to rest or other desired initial potential. For reading voltage, set the display change-over switch ②-1 to a suitable range, such as 10V and 2V. For reading current, set the display change-over switch ②-1 to neutral. Select the CURR range switch ②-2 for a suitable range from 1A to 10μA

(b) For control with waveforms form the waveforrn generator. Set the WAVEFORM switch ⑨ to a desired waveform. LOW switch ⑭ is used for cyclic voltammetry. Set this switch to the lower limit potential. In case of polarization, set the INITIAL switch ⑮ to the initial potential or rest potential (Ecorr). Set the HIGH switch ⑯ to the polarization final voltage in case of anode or cathode polarization. Set the HIGH switch to the upper limit voltage in case of cyclic voltammetry. Turn on the F.G. SET switch ⑧ .

(c) For drawing polarization curve. Connect the potential record termina ⑲ with the X-axis of the X-Y recorder. Connect the current record terminal ⑳ with the Y-axis of the X-Y recorder. (For setting the current rage and reading current values, see below (f).) Press the STOP/START button ⑪ to scan waveforms.

(d) For introducing external signals. Connect an external signal source to the EXT.IN terminal ⑱ on the rear panel. Since the potential setup (INITIAL, HIGH, LOW of the waveform generator and the extemal input are overlapped, turn the F.G.SET switch ⑧ off in order to use the external signals only

(e) Set the current range to a little larger current value than expected. Since the current range selecting switch is of the make-before-break type, the circuit is not opened by current range switching-over during electrolysis.

(f) The current value can be read directly from the digital meter ⑤ display selecting switch ②-1 , and the CURR range switch ②-2 . Anode polarization is denoted by (+) while cathode polarization is denoted by (-). The voltage appearing at the CURR record terminal ⑳ can be converted into a current value proportionatly to the ratio of the current range set by the CURR range switch ②-2 versus 1V.

Example: When 0.2V (200mV) appears at the record terminal ⑳

$$\text{In 1A range} \quad : \quad \text{current value} = 1\text{A} \times \frac{0.2\text{V}}{1\text{V}} = 0.2\text{V}$$

$$\text{In 10mA range} \quad : \quad \text{current value} = 10\text{mA} \times \frac{0.2\text{V}}{1\text{V}} = 2\text{mA}$$

USE OF HAB-151 AS THE GALVANOSTAT

For using the HAB-151 as the galvanostat, take the following steps.

(a) Preparation
Set the FUNCTION switch ③ to OPERATION. Set the P/G STAT switch ④ to G-STAT. Adjust the INITIAL ⑮ of the waveform generator to zero or any other desired initial current value.

NOTE: When the total voltage of the waveform generator set voltage and the external input voltage equals 2V, the full scale current set at the CURR range selector switch ②-2 flows.

Example: Setting 250mA
CURR range switch ②-2 : 1A
INITIAL switch ⑮ : +500
Setting -2.56mA
CURR range switch ②-2 : 10mA
INITIAL switch ⑮ : -512

(b) Control with waveform from the waveform generator. Set the WAVEFORM switch ⑨ to a desired waveform. The LOW switch ⑭ is used for repeated sweeping of triangular wave. Set this switch to the lower limit current. Set the INITIAL switch ⑮ to zero or the initial current value. Set the HIGH switch ⑯ to the final current value in case of constant-current polarization, and to the upper limit current in case of cyclic sweeping. Turn the F.G.SET switch ⑧ on.

(c) For drawing polarization curve. Connect the potential record terminal ⑲ to the X-axis of the X-Y recorder. Connect the current record terminal ⑳ to the Y-axis of the X-Y recorder. Press the STOP/START button ⑪ to scan waveforms.

(d) For current setting with external input, connect the extemal signal source to the EXT IN input terminal ⑱ . Since external signals and the waveform generator set voltage are overlapped, make sure that: EXT.IN voltage + waveform generator set voltage does not exceed 2V.

(e) Potential appears at the POT record output terminal ⑲ also at the constant current mode. For reading the potential with the digital meter, set the switch ②-2 to either 'l0V 'or '2V'. When the switch ②-2 is set to CURRENT position, only the current value is indicated.

6. OVERLOAD DISPLAY

GENERAL PRECAUTIONS BEFORE OPERATION

If a current larger than the detecting current range set with the range switch ②-2 (current 1.1 times the range full scale) flows when the unit is in the potentiostat mode, the CURR OVER lamp at the overload display ⑥ is turned on.

NOTE: The unit is protected against overload, and the protective current-limiting circuit recovers the constant-current mode.

If the total set voltage (waveform voltage+extemal voltage) exceeds 2V when the unit is in the galvanoslat mode, the CURR OVER lamp at the overload display ⑥ is turned on.

NOTE: The unit is protected against overload, and the protective circuit recovers the constant-voltage mode.

EXCESS VOLTAGE (POT OVER)

The control voltage of this unit is maximum ±10V. The POT OVER lamp at the overload display ⑥ is turned on when.

- the total of external signal voltage and waveform voltage exceeds 10V in the potentiostat mode, or
- the detected potential difference between the reference electrode and the working electrode exceeds 10V.

NOTE: The unit is protected with the protective circuit against overload.

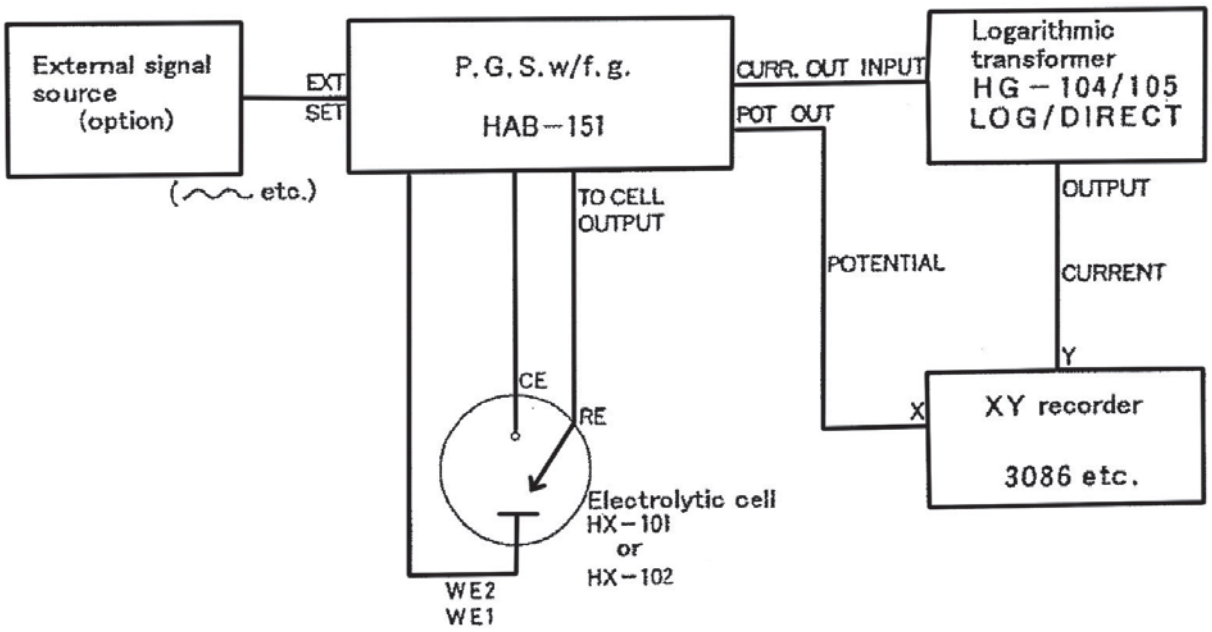
UNCONTROLLABLENESS (CE OVER)

The maximum output voltage (CE-WE bath voltage) of this unit equals ±15V. If the bath voltage exceeds 15V in potentiostat or galvanostat mode due to solution resistance, the CE OVER lamp at the overload display ⑥ is turned on.

NOTE: The protective circuit protects the unit against overload.

7. CONNECTION WITH PERIPHERAL EQUIPMENT

Current values increase exponentially general electrochemical measurement. Also current values are treated logarithmically in Tafel plotting for studying electrode reaction process. For these reasons, Hokuto Denko offers two models of logarithmic transformers: HG-104 and HG-105
The following diagram shows a general circuit connecting a logarithmic transformer and a X/Y recorder.



CONNECTION WITH LOGARITHMIC TRANSFORMER

For Tafel plotting to study the electrode reaction process, current values during potentiostat sweep must be logarithmically transformed. For logarithmic transformation, it is recommended to connect the cunent record output ⑳ to the X-Y recorder through a logarithmic transformer, such as HG-104 and HG-105.

In this case, connect the input cable banana plug attached to the logarithmic transformer to the record output terminal ⑳, and connect the logarithmic transformer output to the X-Y recorder.

Reading of current:

The current record terminal outputs the set-up current range full-scale converted into 1V. Consequently, in order to calculate the real current value from the logarithmic transformer output, it is necessary to reverse the logarithmic transformation referring to the formula mentioned in the logarithmic transformer manual, and further to convert the logarithmic transformer input voltage into current at 1V full scale.

Example: In case of curent range of 10mA and logarithmic transformer HG-104 output of 600mV HG-104 input (HAB-151 output current) equals 100mV and the true current equals 1mA.)

RECOMMENDATION OF MEASURED WAVEFORM MONITORING

In case very small current is detected, the signal/noise ratio may be extremely poor due to a high amplification ratio. X-Y recorder cannot detects 50/60 Hz noise because of slow response. In order to clarify the reliability of measured data, we recommend waveform monitoring using an oscilloscope connected to the CURRENT record terminal ⑳