GETTING INSTRUMENTS, INC.

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GETTING MICROELECTRODE AMPLIFIER

MODEL 5A
INSTRUCTION MANUAL
(SERIAL # 800 UP)

GETTING INSTRUMENTS, INC.
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I. WARRANTY

The **MODEL 5A** Microelectrode Amplifier is hereby warranted to the original purchaser only against defects in materials and workmanship for a period of one (1) year from the date of invoice.

Subject to the provisions of this Warranty, **GETTING INSTRUMENTS, INC**., shall repair or replace, at its option, all **MODEL 5A** Microelectrode Amplifiers which fail to operate properly due to defects in materials or workmanship during the terms of this Warranty at no cost to the purchaser. This Warranty applies only to those **MODEL 5A** Microelectrode Amplifiers which are not altered in any way and which are used in an ordinary and proper manner, as reasonably determined by **GETTING INSTRUMENTS, INC.**

In the event the **MODEL 5A** Microelectrode Amplifier should, within the period of this Warranty, fail to operate properly due to defect, the purchaser shall return the Amplifier, postage prepaid, to **GETTING INSTRUMENTS, INC**., with a note describing product failure. Failure to return the Amplifier within sixty (60) days of product failure shall constitute a waiver of all rights under this Warranty.

THIS WARRANTY IS IN LIEU OF ANY AND ALL OTHER EXPRESSED OR IMPLIED WARRANTIES OF GETTING INSTRUMENTS, INC., INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. GETTING INSTRUMENTS, INC. DOES NOT ASSUME, NOR DOES IT AUTHORIZE ANY PERSON TO ASSUME, ON ITS BEHALF, ANY OTHER OBLIGATION OR LIABILITY.

Dated: 11/00

II. INTRODUCTION

BEFORE USING THE **MODEL 5A** MICROELECTRODE AMPLIFIER, READ THIS INSTRUCTION MANUAL.

The **MODEL 5A** is made with high quality parts, but it is not indestructible. The input stage uses a FET operational amplifier. These units can be damaged by excess voltages or by static discharges. It is best not to touch the input wire of the probe; however, this may be necessary when installing or changing electrodes. **BEFORE INSTALLING AN ELECTRODE, BE SURE TO DISCHARGE ANY STATIC ELECTRICITY BY TOUCHING A GROUNDED METAL SURFACE.**

INITIAL INSTALLATION: The **MODEL 5A** Microelectorde Amplifier comes fully adjusted and ready to use. Mount the main chassis on a 19" equipment rack and connect the 7-pin probe plug to the matching socket on the main chassis. Two shielded input cables are provided. One end of the input cable has a gold connector that matches the input socket on the probe box. The other end of the cable is left free so that you may connect to an electrode holder of your design. The simplest way is to solder a silver-chlorided wire directly to the input cable.

> **CAUTION: IF YOU CHOOSE TO SHORTEN THE INPUT CABLE, BE SURE THE SHIELD IS NOT CONNECTED TO GROUND AND THAT THE SHIELD IS PROTECTED FROM CONTACT WITH OTHER WIRES OR ELECTROLYTES. THE SHIELD IS DRIVEN AND PROVIDES PART OF THE CAPACITANCE COMPENSATION NETWORK.**

GROUND CONNECTIONS: The bath or recording chamber ground should be connected to the black connector on the probe. Sometimes when more than one amplifier is used in the same bath, noise will be introduced by ground loops. This problem can usually be solved by trying various combinations of ground locations (e.g., connect both probe grounds together and then to the bath or connect the bath ground to only one of the amplifiers). In addition, the circuit ground (green binding post on chassis) and the chassis ground (black binding post) can be connected together. Experience has shown that there are no fixed rules for eliminating 60-cycle noise with multiple amplifiers. You will have to discover what works best for your particular needs.

OUTPUT and INPUT CONNECTIONS: Connect the **OUTPUT** and **CURRENT MONITOR** to an oscilloscope or other voltage-measuring device. When using BNC or shielded output cables, some care should be exercised to keep the length of the cables short. Long cables produce capacitive loading of the amplifier which can cause excess noise, and in extreme cases, oscillations. If you want to inject currents, connect one or more of the **STIMULUS INPUTS** to a pulse generator.

POWER CORD CONNECTIONS: Connect the power cord to an AC power line (110 VAC or 220 VAC). Unless specified otherwise, all units are shipped for use with 110 VAC power lines. Instructions for changing the power requirements to 220 VAC are given below. The amplifier can now be turned ON and the red pilot light should glow. Before proceeding, be sure to read the section on **CONTROLS and THEIR USE.**

SPECIFICATIONS

Input impedance	10^{11} ohms (min.) // 2 pfd
Voltage gain	x10 (fixed), single-ended output
Frequency response	Output frequency bandwidth has three selectable ranges: DC - 100Hz, DC – 1 kHz, and DC – 10kHz.
Rise-time (10-90%)	40-50 microseconds (10 Megohm source resistance and cap. comp. adjusted for no overshoot)
Input voltage range	± 1 volt (can tolerate ± 15 volts without permanent damage)
Noise	40 microvolts RMS (200 microvolts peak-to-peak) with 10 Megohm source
Leakage current	Adjustable to zero
Current injection	Mode A: Built-in adjustable source ± 0-10 nA Mode B: Externally applied voltages are converted to current Max. current = 6 volts / electrode res. or 120 nA, whichever occurs first. (See graph on Page 11 for current limits)
Current monitor	Built-in current monitor measures the current injected through the electrode. Sensitivity 100 mV/nA
Stimulus inputs	Two external stimulus inputs are provided. Input resistance = 100 kΩ Maximum input voltage = ± 12 volts. Voltage to current conversion = 1 nA/100 mV
Stimulus cancel	Built-in bridge circuit can compensate for the IR drop across the electrode during current injection. Standard bridge for use with electrodes up to 200 MegΩ. (Can be modified to handle electrodes up to 500 MegΩ.)
Power requirements:	110 VAC, 0.1 amps. Built-in regulated ± 15 VDC power supply. (Unit can be modified to operate on 220 VAC.)
Ground	Circuit and chassis grounds isolated. Maybe connected together on front panel.

III. CONTROLS AND THEIR USE

The **MODEL 5A** controls are conveniently located so that the recording controls are located to the left of the chassis mid-line while those used primarily for current injection are located to the right. The controls are described in order proceeding from the left to the right of the chassis panel.

- **BUZZ:** When penetrating some cell types, it can be helpful to oscillate the amplifier for a brief moment. Depressing the "BUZZ" button will oscillate the amplifier for as long as the button is depressed. The frequency of oscillation is largely independent of the CAP. COMP. setting.

- **CAP. COMP.:** This knob provides for negative capacitance compensation to cancel stray electrode and cable capacitance. It should be adjusted to give minimal (fastest) rise-time with no overshoot on a square voltage pulse applied to the input through the recording electrode. The adjustment depends upon the electrode resistance. Oscillation will occur if the CAP. COMP. is adjusted too high.

- **EL. CK. (ELECTRODE CHECK):** This button is used to measure electrode resistance. When depressed, one nA of current is injected through the electrode The change in output voltage is used to determine electrode resistance. Be sure to depress the button fully.

    - **CALIBRATION:** 1 MegΩ per 10 mV shift at the output.

- **POSITION:** This knob varies the DC level of the output voltage. It is a ten-turn potentiometer which allows easy adjustment even at high amplification. Turning the knob clockwise makes the output more positive.

- **STIM. CANCEL (STIMULUS CANCEL - BRIDGE BALANCE):** This knob controls an internal bridge circuit which allows the IR voltage drop across the electrode during current injection to be subtracted from the output voltage. It cancels for currents generated by both the internal current source and from external sources (STIM. INPUTS), but not for the current passed by the EL. CK. button. The bridge in the standard **MODEL 5A** amplifier can handle electrodes up to 200 MegΩ resistance. (The bridge circuit can be modified for use with electrodes up to 500 MegΩ -- see section entitled "MODIFICATIONS: BRIDGE BALANCE RANGE").

- **INTERNAL CURRENT SOURCE:** The **MODEL 5A** has an internal current source with switchable polarity and variable level. With the "HYP-OFF-DEP" switch in the "HYP" position, hyperpolarizing current of a magnitude selected by the "CURRENT LEVEL" control is injected continuously through the electrode. In the "DEP" position, depolarizing current is injected. In the "OFF" position, the internal current source is disabled but the external stimulus inputs are still operative. When not in use, the internal current source should be in the "OFF" position to prevent excessive leakage current. The standard range of the internal current source is 0 - 10 nA. (This range can be increased or decreased as discussed in the section entitled "MODIFICATIONS: RANGE OF INTERNAL CURRENT SOURCE").

- **STIM. INPUTS (STIMULUS INPUTS):** Two inputs (BNC) are provided for externally applied current stimulation. Voltage waveforms applied to these inputs are converted to current injected through the electrode. For each 100 mV of voltage applied to either of these inputs, 1 nA of current will be injected through the electrode.

    CONVERSION: 1 nA / 100 mV

    THE MAXIMUM ALLOWABLE STIMULUS VOLTAGE APPLIED TO EITHER EXTERNAL INPUT IS $\pm$ 12 VOLTS. Damage to the current injection network may occur if the stimulus voltage exceeds $\pm$ 20 volts. There is no increase in injected current for stimulus voltages in excess of $\pm$ 12 volts. The current injected through the electrode is the sum of the currents from the two external inputs and the internal DC source. The total maximum stimulus current is limited to 120 nA or 6 volts/electrode resistance, whichever

limit occurs first. The graph on Page 11 is a plot of the maximum stimulus current as a function of electrode resistance. When using this graph, you should be aware that electrode resistance can go up dramatically as more current is passed.

- **CURRENT MONITOR:** This BNC connector provides the output for the current monitoring circuit which measures the total current passed through the electrode. The current-to-voltage conversion is 100 mV for each nA of injected current.

  CONVERSION: 100 mV / nA

  NOTE: The current monitor circuit measures the voltage across a current limiting resistor in the probe box. The current monitor output will therefore register current even if the microelectrode is not inserted into the bath. When the electrode is in the bath, the monitor circuit registers the current through the electrode.

- **FILTER (OUTPUT FREQUENCY FILTER):** This 3-position switch selects the output bandwidth. The selectable ranges are: DC - 100Hz, DC – 1 kHz, and DC – 10kHz. When using the **MODEL 5A** in either the 1 kHz or 100 Hz positions, the CAP. COMP. control will have little effect on the observed rise-time of the output.

- **OUTPUT:** A single x10 voltage output is provided. Output resistance < 100 Ω.

- **CIRCUIT AND CHASSIS GROUND:** The circuit ground (green binding post) is isolated by a 0.001 uF capacitor from the chassis ground (black binding post). For most uses, the circuit and chassis grounds can be shorted together by connecting a wire between the green and black binding post. Under some circumstances, however, a lower noise level can be obtained by keeping the circuit ground isolated from the chassis ground.

- **OTHER EXTERNAL CONTROLS:** Two access holes marked "Ig" and "Z" are located on the lower part of the front chassis. These adjustments control leakage current (Ig) and the zero level on the current injection circuit (Z). Under normal circumstances, these controls will not need adjustment; however, see MAINTENANCE section for periodic calibration and adjustment procedures.

IV. MAINTENANCE AND PERIODIC ADJUSTMENTS

Only two adjustments need to be made periodically. About every 100-200 hours of use; the current injection circuit and the leakage current should be checked and adjusted as outlined below. These two adjustments are made using the two trim potentiometers on the front panel labeled **"Z"** and **"Ig".** Disassembly of the amplifier is not necessary to make these two adjustments (see SECTIONS B and F below).

Due to component "aging", more extensive adjustments may be necessary. The entire calibration and adjustment procedure is summarized below. For these adjustments you will need:

1 - small screwdriver
1 - 100 Megohm resistor (a smaller value can be used, but the accuracy of the adjustment will be decreased
1 - pulse generator (0-1 volts) - the calibrator output on most oscilloscopes is good for this purpose
1 - differential input oscilloscope

The sequence of adjustments is critical and should be followed exactly. To make these adjustments, it will be necessary to remove the back cover.

CAUTION: UNPLUG THE AMPLIFIER FROM THE (AC) POWER SOURCE BEFORE PROCEEDING.

The back cover is removed by taking out the two screws located on the back cover. Carefully slide the aluminum back cover along the power cord to expose the circuit board.

WHILE THE BACK COVER IS REMOVED, DO NOT PLACE THE AMPLIFIER ON A CONDUCTING SURFACE OF ANY KIND. DO NOT TOUCH ANY OF THE WIRES OR COMPONENTS IN THE POWER SUPPLY SECTION. SOME OF THE COMPONENTS CARRY 110 VAC (220 VAC FOR MODIFIED UNITS).

ADJUSTMENTS:

- **SECTION A: ZERO INPUT AMPLIFIER (A-1).** Ground the input on the probe and connect test point 1 (TP-l) (see DRAWING 1) to an oscilloscope. Plug in the amplifier to the power line and turn the unit on. Allow at least five minutes for the unit to warm up. Adjust the trim potentiometer (P1) in the probe box until the voltage at TP-1 is at ground (within $\pm$ 1 mV of ground is adequate). To gain access to the trim pot P1, you will have to take out the four screws on the probe box and remove the cover. Reassemble the probe cover when this adjustment is completed.

- **SECTION B: ZERO THE CURRENT INJECTION AMPLIFIER (A-5).** This adjustment may be necessary periodically. If the output level of the amplifier shifts more than 10 mV when the STIM. CANCEL control is rotated through its entire range and no current is being injected, then this adjustment is necessary. Ground the input to the probe. Be sure the current polarity switch is in the "OFF" position and all inputs are removed from the STIM. INPUTS. Rotate the STIM. CANCEL control fully counterclockwise. Connect the x10 amplifier OUTPUT to the oscilloscope and turn the gain to 10 mV/div. Center the trace using the POSITION control. Slowly turn the STIM. CANCEL control clockwise while observing the output voltage. If the output voltage shifts more than 10 mV, adjust the trim potentiometer labeled "Z" (P5) to return the trace to its original position. The "Z" adjustment potentiometer is accessible on the front panel just to the left of the current monitor output (CUR. MON.). Adjust "Z" for minimal shift between fully counterclockwise and clockwise positions of the STIM. CANCEL. When this adjustment is completed, return the STIM. CANCEL knob to its counterclockwise position. Whenever this adjustment is performed, the leakage current adjustment (SECTION

F) must also be done.

- **SECTION C: GAIN ADJUSTMENT.** Connect a pulse generator (or oscilloscope calibrator) to the probe input and apply a known voltage pulse of less than 1 volt. Connect the x10 amplifier output to the oscilloscope. Adjust the gain trim potentiometer (P2) for exactly x10 gain. P2 is located on the back of the chassis circuit board (refer to DRAWING 1 for the location of P2).

- **SECTION D: INPUT IMPEDANCE ADJUSTMENT.** Connect the pulse generator to the probe input as in SECTION C. In addition, connect the pulse generator to the minus (-) input of a differential input oscilloscope. Connect the plus (+) input of the scope to test point 2 (TP-2) on the chassis circuit board (see DRAWING 1 for the location of TP-2). Adjust the trim pot P3 for a null response; that is no voltage shift during the voltage pulses. Turn the gain on the oscilloscope so that a one percent (1%) difference in potential can be detected (e.g., if the input pulse is 100 mV, the gain on the scope should be set at 1 mV/div.).

- **SECTION E: CURRENT MONITOR COMMON MODE REJECTION.** Apply a known voltage pulse (less than 1 volt) to the probe input. Connect the current monitor output (CUR. MON.) to an oscilloscope and turn the gain to 1-5 mV/div. Adjust trim pot P6 on the chassis circuit board for a null response. Disconnect the pulse generator and ground the probe input.

- **SECTION F: LEAKAGE CURRENT (Ig).** Be sure the internal current source is in the "OFF" position and the STIM. INPUTS are disconnected from any external devices. Connect a 100 MegΩ resistor between the probe input and ground (a smaller value resistor can be used, but the accuracy of this adjustment will be diminished). Using a short wire with clips on either end, short the 100 Megohm resistor (connect the wire across the resistor). Connect the x10 OUTPUT to the scope and turn the gain to 10 mV/div. Center the trace with the POSITION control. Alternately ground and un-ground the input side of the 100 Megohm resistor by removing the shorting wire. Any shift in the DC level of the output voltage is due to leakage current. Adjust the trim potentiometer (P4) located on the left side of the front panel for minimal DC shift. This adjustment is labeled "Ig". A voltage shift of less than 10 mV means a leakage current of less than 10 picoamps (0.01 nanoamps). Remove the 100 MegΩ resistor and ground the probe input.

- **SECTION G: CURRENT MONITOR ZERO LEVEL.** Ground the input to the probe, turn the internal current source to "OFF", and disconnect any external devices from the STIM. INPUTS. Connect the current monitor output (CUR. MON.) to the oscilloscope (gain 1-5 mV/div.). Adjust trim pot P7 on the chassis circuit board so that the current monitor output voltage is at zero (ground).

THIS COMPLETES THE ADJUSTMENT SECTION. CAUTION: BEFORE REASSEMBLING THE BACK COVER, TURN THE POWER OFF AND UNPLUG THE POWER CORD. CAREFULLY SLIDE THE BACK COVER ALONG THE POWER CORD AND INSTALL THE TWO (2) MOUNTING SCREWS.

FUSE:

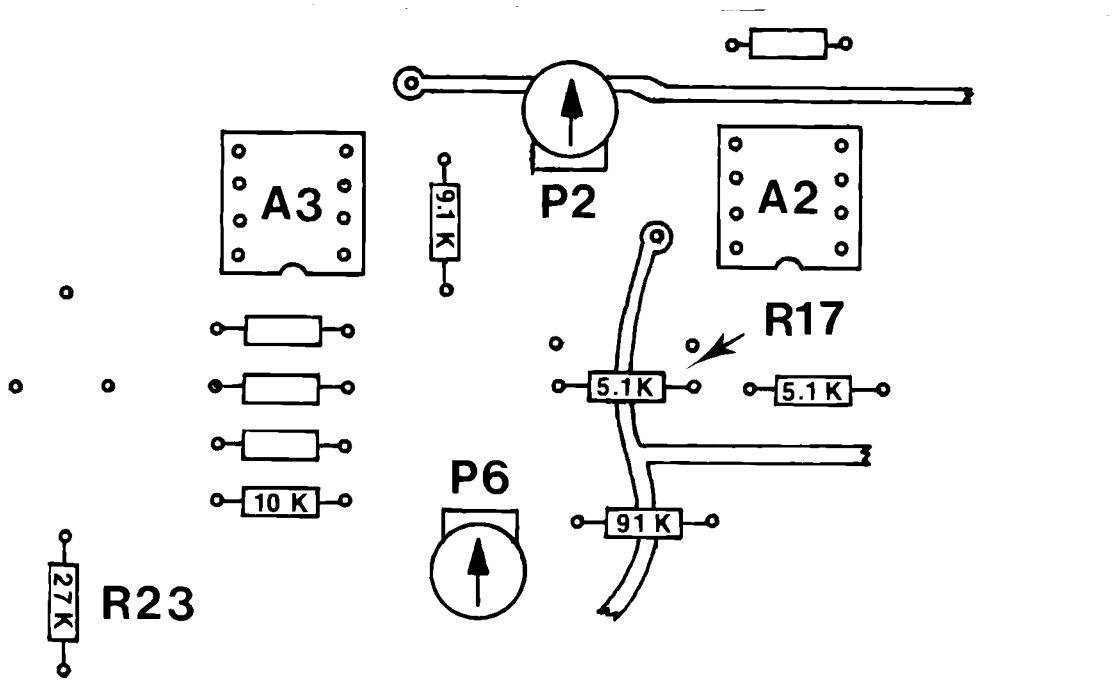
- If the pilot light does not glow when the unit is plugged in and the power switch is in the "ON" position, the fuse may be blown. **CAUTION: UNPLUG THE POWER CORD BEFORE REMOVING THE BACK COVER.**
- The fuse is located on the back side of the chassis circuit board in the power supply section. Before replacing the fuse, determine the cause for the failure and repair as necessary. The fuse should be replaced with a one-eighth (1/8) amp, 110 VAC fuse (Size 3AG). **CAUTION: REPLACE THE BACK COVER BEFORE PLUGGING THE UNIT INTO AN AC POWER LINE.**

V. MODIFICATIONS

The MODEL 5A amplifier can be modified to accommodate a variety of operating conditions. The three most common modifications are summarized below. For additional modifications, please consult Getting Instruments, Inc. directly. Each of the modifications requires removing the back cover box.

CAUTION: UNPLUG THE AC POWER CORD BEFORE REMOVING THE BACK COVER. REPLACE THE BACK COVER BEFORE PLUGGING THE UNIT INTO THE AC POWER.

Modification option one -- BRIDGE BALANCE RANGE. The standard **MODEL 5A** bridge circuit can handle electrodes up to 200 MegΩ The bridge circuit can be modified easily to accommodate electrodes up to 500 MegΩ. Use of the amplifier with electrodes above this range is not recommended due to degradation of its performance. To increase the bridge balance range, a 3.3 kΩ resistor must be added in parallel to the existing R17 (5.1 kΩ) on the main chassis circuit board (refer to the drawing below for the location of R17). The circuit board is predrilled to accommodate the new resistor. After the new resistor is installed, the current injection circuit will have to be re-zeroed (MAINTENANCE: SECTION B) and leakage current readjusted (MAINTENANCE: SECTION F).



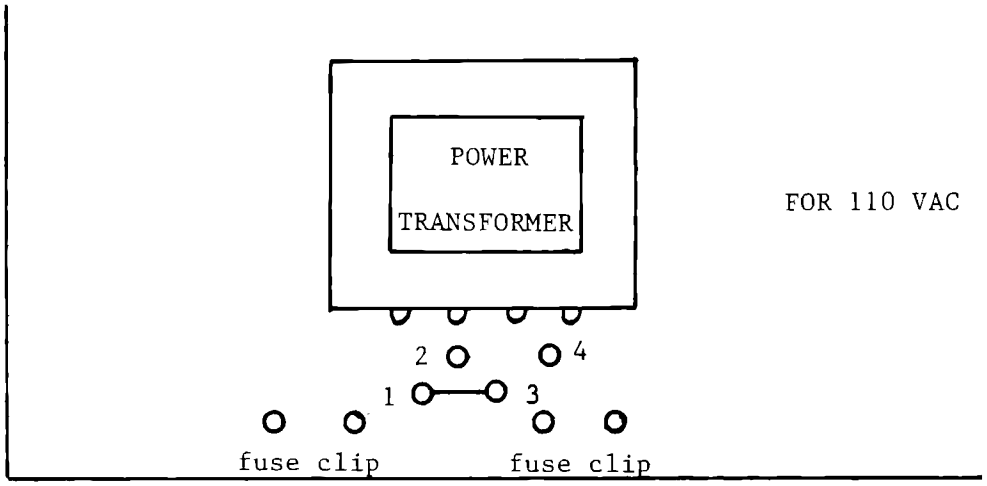
BACK VIEW OF CIRCUIT BOARD TOP

Modification option two -- RANGE OF INTERNAL CURRENT SOURCE. The range on the standard internal current source is 0-10 nA. This range may be increased or decreased by altering the value of resistor R23 on the main chassis circuit board (refer to above drawing for the location of R23). Replacing the existing 27 kΩ resistor with a 270 kΩ resistor decreases the range to approximately 0-1 nA. Likewise, decreasing the value to 1 kΩ increases the range to 0-100 nA.

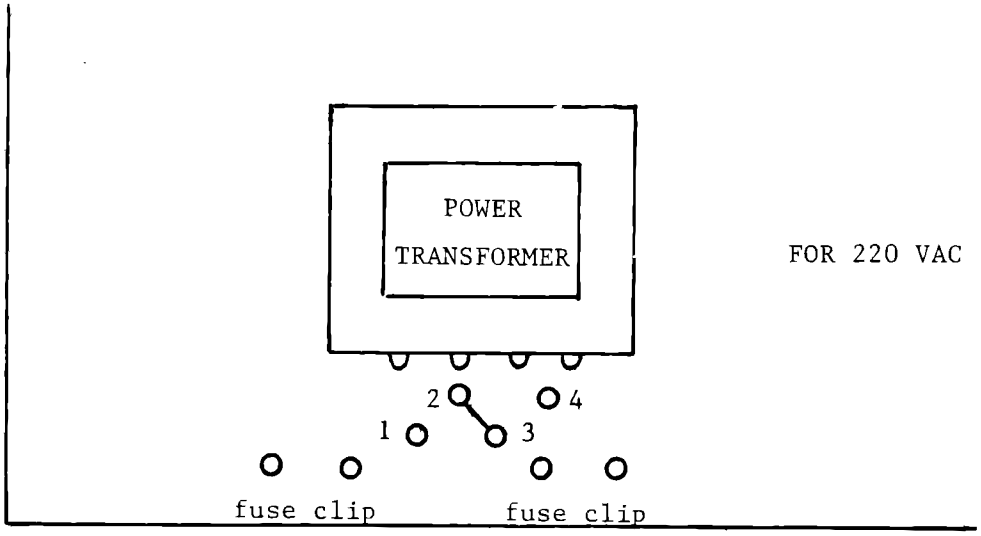
Modification option three -- POWER SOURCE CHANGE. The standard **MODEL** 5A comes equipped for use with 110 VAC, 60 cycle power. The unit may be used with 220 VAC, *50-60* cycle power by changing the location of jumper wires in the power supply section. Refer to the drawings below for the proper jumper configurations. To change the jumper wires, the fuse must be removed and then replaced.

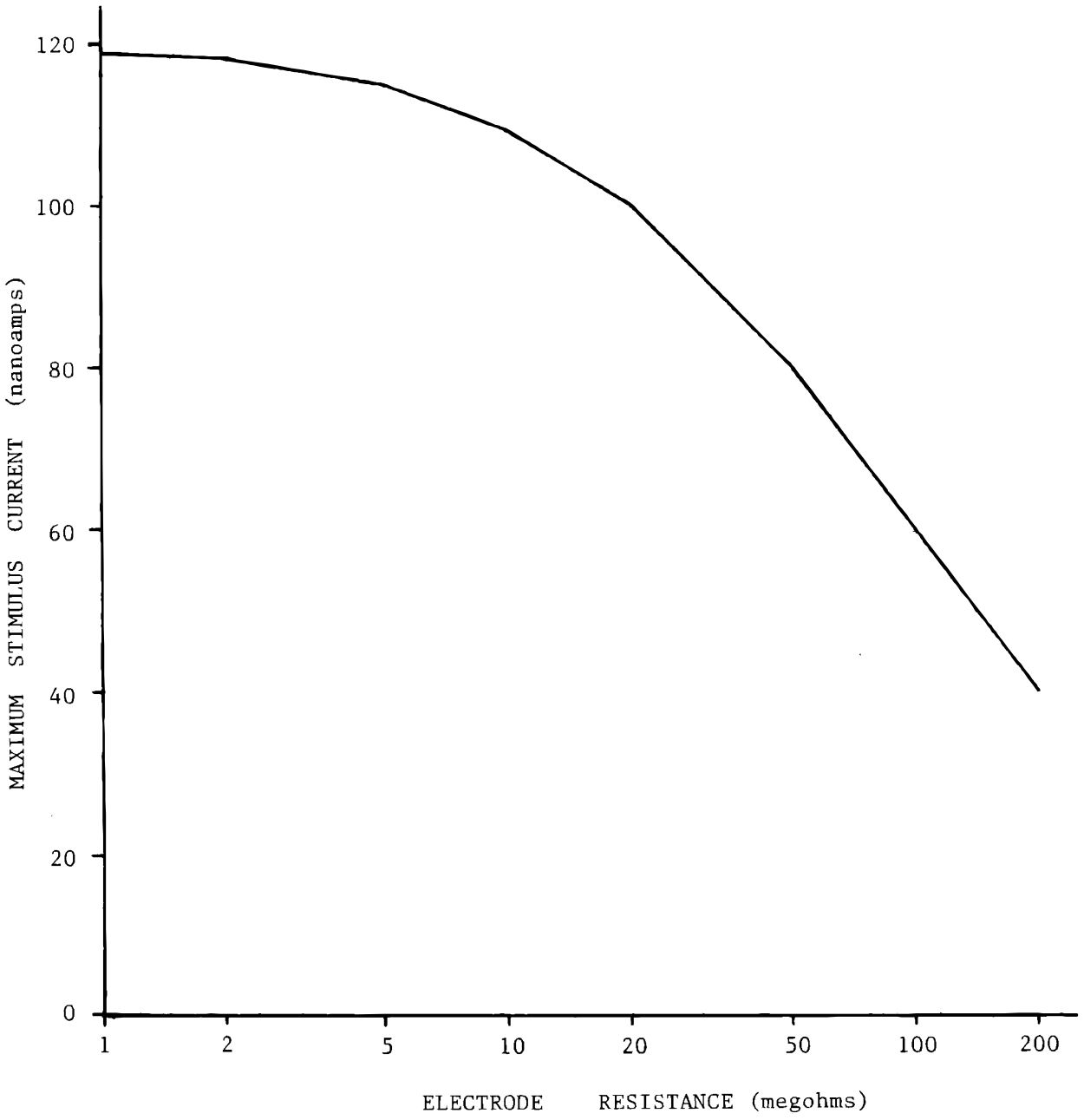
CAUTION: UNPLUG THE AMPLIFIER FROM THE (AC) POWER SOURCE BEFORE PROCEEDING.

- **For 110 VAC operation**, one jumper wire must be installed between holes 1 and 3 as in the drawing below.



- **For 220 VAC operation**, a single jumper wire should be installed between holes 2 and 3 (remove any other existing jumpers). See figure below.





GRAPH 1: MAXIMUM ALLOWABLE STIMULUS CURRENT

The graph below shows the maximum current which the **MODEL 5A** amplifier can pass through a microelectrode. To find the maximum current, locate the resistance of the microelectrode and go up the graph vertically. The line gives the maximum current for that electrode resistance. Be aware that electrode resistance commonly increases as more and more current is passed. This is particularly true of dye filled electrodes.

SEMICONDUCTORS:

AMPLIFIER	LOCATION	PART NUMBER	SUPPLIER
Al	Probe	MA-333	Analog Systems, Tucson, Arizona
A2	Chassis	MCl74ICP	Motorola
A3	Chassis	MCl74ICP	Motorola
A4	Chassis	MCl74lCP	Motorola
AS	Chassis	LF13741	National Semiconductor
A6	Chassis	MCl74ICP	Motorola
A7	Chassis	MCl74ICP	Motorola

The probe operational amplifier must have the following characteristics:

- low bias current (less than 10-50 pA)
- FET input stage
- stable at unity gain
- offset voltage adjust with a 10-20 kΩ pot. between pins 1 and 5

Other OP AMPS with the above characteristics can be used as the probe amplifier. These include:

LF13741	Motorola	inexpensive but not quite as quiet as fast as the MA333.
OPA-111	Burr Brown	Also slower but good replacement, moderately priced.

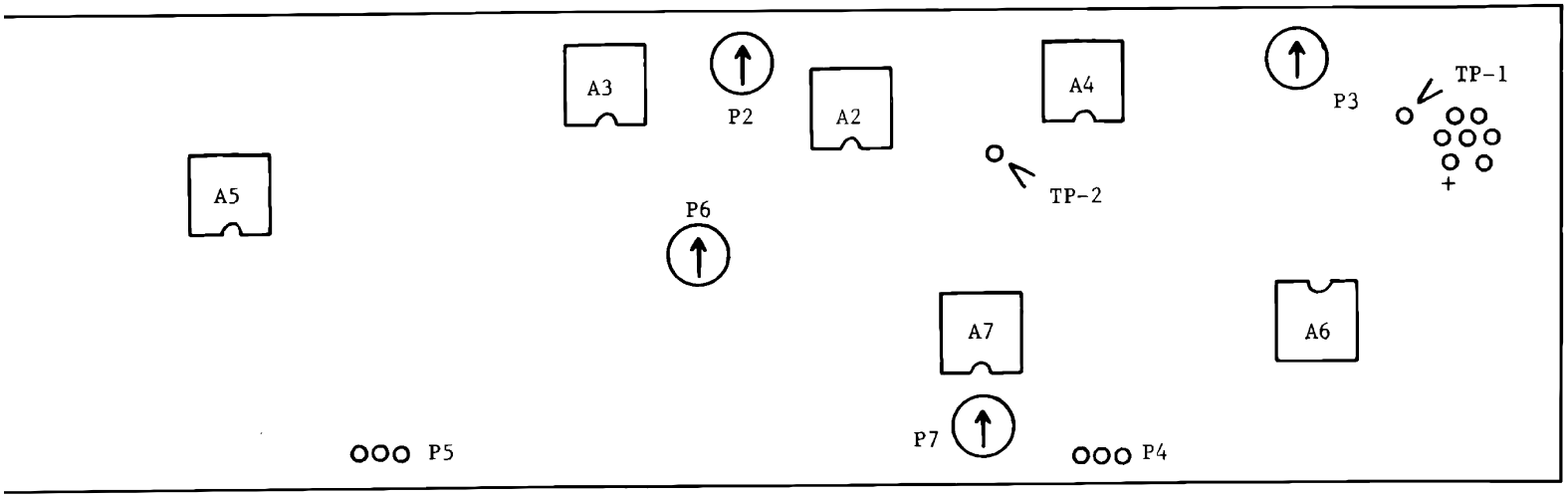
The amplifier is normally supplied with the offset voltage trim pot with center wiper connected to -15 VDC. The probe circuit board can be rewired to accommodate OP AMPS requiring +15 VDC to the offset trim.

POWER SUPPLY REGULATOR: MC1468G ±15VDC tracking regulator (Motorola).

DRAWING 1

MODEL 5A

REAR VIEW OF CHASSIS CIRCUIT BOARD



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