If Broken, Calibration Void

INSTRUCTION MANUAL

MODEL AC-110

ABSOLUTE AC CALIBRATION SOURCE

OPTIMATION
Division of Julie Research Laboratories, Inc.
211 West 61st Street
New York, N.Y. 10023
(Phone: 212-245-2727)
(TWX: 710-581-5138)

ERRATA SHEET

MODEL ~~RCD~~-110 ABSOLUTE AC VOLTAGE CALIBRATOR

SERIAL NO._______

Please make the following corrections to the Model AC-110 Instruction Manual:

1. Paragraph 6-13, Step 4, change to read:

   4. Check +49.5 volts.

      a. DC voltmeter reads between +47.0 and +52.0 volts on the +49.5 volts test point.

2. Paragraph 6-17, Steps 4 and 5, change to read:

   4. Check sampling pulse width.

      a. The pulse width should be 40 microseconds, ±4 microseconds.

   5. Calibrate pulse width.

      a. If not, adjust A4R83 for a pulse width of exactly 40 microseconds.

3. Change identification of the +53.8 volt test point to +49.5 volts.

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SECTION I
GENERAL INFORMATION

1-1. SCOPE.

1-2. This publication covers all versions of the Optimation, Inc. Model AC-110 Absolute AC Voltage Calibrator, with the exception of option X, 1KV Power Amplifier, which is covered by a separate instruction manual.

1-3. GENERAL INFORMATION.

1-4. AC-110 GENERAL DESCRIPTION. The Model AC-110 is an Absolute AC Voltage Calibration system. Measurement error of the instrument under test is conveniently displayed, in percent, by front panel operating controls making it ideally suited for testing and calibrating AC Voltmeters, Digital Voltmeters, and other AC measuring instruments. The basic AC-110 system consists of two separate instruments, a Calibrator and a 100V Power Amplifier. Some of the more significant operating features are:

1. An absolute dial-in voltage accuracy of ±(0.02% + 10 microvolts) over the midband frequency range of 50 Hertz to 20 kilohertz.

2. Output voltages of up to 121 volts rms over the wide frequency range of 10 Hertz to 110 kilohertz (to 1MHz with option W).

3. Short term frequency drift of less than ±100ppm of setting.

4. Short term amplitude drift of less than 20ppm of setting for 24 hours.

5. Remote programming of the frequency, voltage and error determination ranges.

1-5. CALIBRATOR DESCRIPTION. The Calibrator unit contains the oscillator circuits, front panel operating controls, 10 volt power amplifier and output terminals. Output frequency and amplitude are dialed-in on direct reading switches over the frequency range of 10 Hertz to 110 kilohertz (1MHz with option W) and voltage range of 0 to 121.1110 volts rms. Accuracy of the frequency setting is better than ±1.0% (±0.1% with option B). A vernier control increases the resolution to better than 0.005% (50ppm) of the selected frequency range. Output voltage setting accuracy over the midband frequency range of 50Hz to 20kHz is ±(0.02% + 10 microvolts) with 6 digit resolution plus overranging. The voltage and frequency ranges can also be remotely programmed as well as the range of the error measurement being made. Should power to the AC-110 system be interrupted, an automatic standby operating mode shorts the output terminals when power is restored protecting operating personnel and preventing damage to the instrument being calibrated from unexpected overvoltage conditions. The Calibrator is self-contained and can be operated without the 100V Power Amplifier on the 10mV, 100mV, 1V or 10V output voltage ranges.

1-6. 100V POWER AMPLIFIER DESCRIPTION. The 100V Power Amplifier contains the power amplifier circuit for the 100 volts operating range of the Model AC-110. Relay and switching logic in the Calibrator connects the output of the 100V Power Amplifier to the Calibrator front panel output terminals when the 100V range is selected. The 100V Power Amplifier contains its own regulated DC power supplies.

1-7. SPECIFICATIONS.

1-8. The Model AC-110 is designed for continuous operation in a normal laboratory environment over the ambient temperature range of 0°C to 55°C. Within this range, the instrument will operate with the performance and accuracy specified in table 1-1. Warm up time for the given performance is 90 minutes.

1-9. OPTIONAL FEATURES.

1-10. The Model AC-110 may contain one or more optional features which are described below. A serial number label affixed to the rear panel of the Calibrator identifies the option(s), if any, which are contained in the system. For example, the Model AC-110BY includes options B and Y.

1. Option B, ACCURATE FREQUENCY. Accuracy of the output frequency is better than ±0.1% of setting for frequencies of between 10Hz and 10kHz. For frequencies of up to 100kHz the accuracy is better than ±0.3% of setting. A vernier frequency control is provided with a resolution of better than 0.0005% (5ppm) of the selected frequency range. Temperature coefficient is 100ppm/°C from 10kHz to 100kHz when option B is included.

2. Option W, 1MHZ FREQUENCY RANGE. Provides an extended output frequency range from 10Hz to 1MHz. Accuracy of the setting is ±1.0% with 3 digit setability.

3. Option Y, REMOTE PROGRAMMING. Remote programming of the frequency range, three digits of frequency setting (4 digits when option B is included), voltage range, six digits of voltage and the error measurement range. All programming is accomplished with 8-4-2-1 BCD logic levels.

1-11. PREPARATION FOR RESHIPMENTS.

1-12. Electronic calibration instruments must be packed with special care. The shipping cartons in which the AC-110 system was originally packed are designed to provide maximum protection from adverse environments and from shock and vibration incurred in shipment. They should be preserved and utilized for reshipment or subsequent storage whenever possible. When preparing the Model AC-110 for shipment, disassemble the system and pack each instrument in individual shipping containers. Stow all of the accessories in the carton which contains the mounting cabinet (if supplied). Ensure that each shipping container is well sealed with strong tape or metal bands.

* NOTE *

Remove all tubes from the 100V Power Amplifier, PA-110, and pack separately when shipping. Optimation, Inc. will not be responsible for replacing these tubes at no cost when left mounted in the instrument and damaged during transit.

Table 1-1. Specifications.

FREQUENCY

Range	10 Hertz to 110 kilohertz in 4 decade ranges.
Accuracy	±1.0% of setting.
Stability	±0.01%/hour at a constant temperature.
Temperature Coefficient	±0.02%/°C maximum.
Resolution	3 digits and vernier. 0.005% of setting.

AMPLITUDE

Stability, Short Term (24 hours)	20ppm maximum.
Stability, Long Term (6 months)	100ppm maximum.
Absolute Accuracy	See table 1-2.
Distortion	See table 1-2.
Temperature Coefficient	See table 1-2.
Hum and Noise, 100V range 10V and 1V ranges 100mV and 10mV ranges	3 millivolts. 30 microvolts. 10 microvolts.

OUTPUT

Voltage	10 microvolts to 121.1110 volts in 5 decade ranges.
Resolution	6 digits plus overrange above 10mV.
Overload Protection	Automatic reset to 10V, manual reset on 100V range.
Loading	See table 1-3.
Load Regulation	Rated accuracies are maintained for specified resistive load conditions on the 1V 10V and 100V ranges. Typical load regulation is ±0.002% from 50 to 20,000 Hertz on the 1V and 10V ranges and ±0.01% on the 100V range.
Remote Sensing	Provided on the 1V, 10V and 100V ranges.
Capacitive Loading	Must not exceed output current rating or 5,000pF. Typically 2,000pF at 1kHz and 150pF at 1MHz on 100V range.
Inductive Loading	Inductive loads (i.e., Ratio Transformers) require an external series capacitor.
Quadrature Phase Output	90°, ±0.1° to 10kHz at 2.5V rms with respect to the OSC REF OUT signal.

Table 1-1. Continued.

ERROR MEASUREMENT

Ranges	0%, ±0.3% and ±3.0%.
Accuracy	±0.3% of the selected range.
Resolution	Precision 3-turn potentiometer. 0.002% on the 0.3% error range.

EXTERNAL PROGRAMMING

Functions	Remote selection of the frequency, output amplitude and error measurement ranges.
Programming	Contact opening or logic levels plus an enable pulse.

POWER REQUIREMENTS

Voltage	115 volts or 230 volts AC, ±10%.
Frequency	50 to 400 Hertz.
Consumption, Calibrator 100V Power Amplifier	50 watts maximum. 170 watts maximum.

MECHANICAL

Dimensions	12½"H, 19"W, 18½"D, less cabinet.
Weight, Net Shipping	55 pounds. 75 pounds.

Table 1-2. Voltage Accuracy.

OUTPUT FREQUENCY	ABSOLUTE VOLTAGE ACCURACY[1]	DISTORTION[2]	TEMPERATURE COEFFICIENT
10Hz to 20Hz	±(0.1% + 10uV)	0.05%	±10ppm/°C
20Hz to 50Hz	±(0.05% + 10uV)	0.02%	
50Hz to 20kHz	±(0.02% + 10uV)		
20kHz to 100kHz	±(0.05% + 10uV)	0.05%	
0.1MHz to 1MHz[3]	±(0.5% + 10uV)	0.50%	±100ppm/°C

NOTES: 1. 10% to 110% of selected voltage range.
2. With up to a 50 milliamp load.
3. With option W only.

Table 1-3. Loading.

VOLTAGE RANGE	LOAD RATING
0 to 12.11110mV 10.0 to 121.1110mV	Internal impedance of output amplifier is less than 1 ohm. Typical load regulation for a 10 kilohm load is 0.01%.
0.1 to 1.211110V	40 ohms minimum.
1.0 to 12.11110V	1 to 2 volts: Linearly 25 to 50mA. 2 to 12 volts: Linearly 50 to 100mA.
10.0 to 121.1110V	10 to 20 volts: Linearly 25 to 50mA.[1] 20 to 121 volts: Linearly 50 to 200mA.[1]

NOTES: 1. For frequencies of over 50 Hertz.

SECTION II
INSTALLATION

2-1. UNPACKING AND HANDLING.

2-2. The Model AC-110 is shipped in separate packing containers to provide maximum protection during transit. All of the accessories supplied with the system are packed in the carton which contains the mounting cabinet, when supplied. Handle each unit carefully when removing them from the shipping containers using caution not to damage front or rear panel controls and connectors.

2-3. POWER REQUIREMENTS.

2-4. The Model AC-110 is designed to operate from 110 volts, ±10%, or 230 volts, ±10%, single-phase AC, at a line frequency of 50 to 400 Hertz. The AC LINE selector switches located on the rear panel of the Calibrator and 100V Power Amplifier converts each instrument from one operating voltage to the other. To convert the instruments from 115 volts to 230 volts, move both slide switches with the tip of a screwdriver to the 230 volts position and change the AC line fuses as follows:

1. Change the Calibrator fuse F1 (OUTLETS PWR) to 1 amp, slo-blo, and F2 (AC-110 PWR) to 1 amp, slo-blo.

2. Change the 100V Power Amplifier fuse F1 to 1 amp, slo-blo.

2-5. INSPECTION.

2-6. VISUAL INSPECTION. Inspect each of the instruments after unpacking for damage which may have occurred in transit. Check that there are no loose or broken knobs, bent or broken connectors, and dents or scratches on the cabinet and panel surfaces. Specifically the Calibrator and 100V Power Amplifier should be visually inspected for the following items before placing the system into operation.

2-7. 100V POWER AMPLIFIER INSPECTION. Inspect the 100V Power

Amplifier for the following items:

1. Remove the 8 pan head screws from the top cover and 2 pan head screws from the bottom of the rear panel. Lift the cover from the instrument.

2. Install vacuum tubes V1-V2-V3 (packed separately) into the proper sockets and connect the plate leads to V1-V2.

NOTE

Each tube is labeled with a "V" number which identifies the location of these tubes when the PA-110 was calibrated at the factory. Each tube should be installed in accordance with these labels.

3. Check relays K1 and K2 for proper seating and that the spring keepers are locked-in position.

4. Check all transistors which are mounted in sockets for proper seating.

5. Replace the covers and 10 pan head screws.

6. Check that the rear panel AC LINE selector switch is set for 115 volts unless the Model AC-110 is to be operated from 230 volts.

2-8. CALIBRATOR INSPECTION. Inspect the Calibrator for the following items.

1. Check that the front panel frequency and voltage selector switches can be rotated freely without binding and for smooth operation.

2. Remove the top cover by removing the 11 pan head screws.

3. Check that all socket mounted transistors and integrated circuits are properly seated.

4. Check that lamps A4DS1 and A4DS2 are not broken and are properly seated.

5. Check socket mounted potentiometers for proper seating.

6. Replace the top cover and 11 pan head screws.

7. Remove the bottom cover by removing the 11 pan head screws.

8. Check that lamps A2DS1 and A2DS2 are not broken or damaged.

9. Check that all potentiometers which are mounted in sockets

are properly seated.

10. Replace the bottom cover and 11 pan head screws.

11. Check that the rear panel AC LINE switch is set to 115 volts unless the AC-110 is to be operated from 230 volts.

NOTE

If the system was damaged during shipment it must be reported immediately to the responsible carrier. A complete report of the damage must be submitted to the carrier's claim agent with a copy forwarded to Optimation, Inc. Unless this damage claim is properly filed, Optimation cannot be held responsible for any subsequent repair or replacement charges.

2-9. INSTALLATION REQUIREMENTS.

2-10. MOUNTING. The Model AC-110 can be mounted in the cabinet supplied, Optimation P/N 200008 (optional) or in a standard EIA 19 inch rack cabinet that has 12¼ inches of panel mounting space available. Rack mounting screws for both instruments are supplied.

2-11. INSTALLATION IN CABINET SUPPLIED. When the Model AC-110 is to be installed in the cabinet supplied, use the following procedure:

1. Lay the cabinet down with the front facing up to facilitate mounting the instruments.

2. Place the Calibrator at the bottom of the cabinet by lowering it into position. Mount the Calibrator using 4 black panel mounting screws provided.

NOTE

A larger cabinet may have been supplied if Option X, 1KV Power Amplifier, is included in the system. The 1KV amplifier must be mounted below the Calibrator as described in the PA-1182 instruction manual.

3. Mount the 100V Power Amplifier directly above the Calibrator in the same manner using 4 black panel mounting screws provided.

2-12. INSTALLATION IN RACK CABINET. The AC-110 can be installed in any EIA standard 19 inch wide cabinet that has 12¼ inches of panel mounting space available. The procedure outlined above should be followed. Care must be taken to allow a minimum of 6 inches of clear space behind the instruments and at least 3 inches at the sides to permit proper circulation of air. The AC-110 is cooled by normal convection and does not require any additional cooling when operated within the temperature range of 0°C to 55°C.

2-13. CABLE ASSEMBLIES.

2-14. All cables that are required to interconnect the Model AC-110 are supplied with the system. Interconnect the two units using the following procedure:

1. A three-conductor power cord is supplied for the 100V Power Amplifier. Connect it between the AC INPUT receptacle on the rear panel and the AC OUTLET located on the rear panel of the Calibrator labeled PA-110.

NOTE

The 3 prong power receptacle on the 100V Power Amplifier (located directly below the fuse) is not used.

2. Connect the cable assembly terminated at both ends with a BNC connector between the 100V Power Amplifier rear panel INPUT connector and the Calibrator rear panel connector labeled PA-110 INPUT.

3. Connect a red cable assembly terminated at both ends with a pin jack between the 100V Power Amplifier OUTPUT HI (red) receptacle and the Calibrator PA-110 HI OUTPUT (red) receptacle.

4. Connect a black pin jack cable assembly between the 100V Power Amplifier OUTPUT LO (black) receptacle and the Calibrator PA-110 LOW OUTPUT (black) receptacle.

5. Connect a red pin jack cable assembly between the 100V Power Amplifier SENSING HI (red) receptacle and the Calibrator PA-110 HI SENSE (red) receptacle.

6. Connect a black pin jack cable assembly between the 100V Power Amplifier SENSING LO (black) and the remaining black receptacle on the Calibrator identified PA-110 LOW SENSE.

7. Install the copper grounding strap between the 100V Power Amplifier and Calibrator using 2 pan head screws as shown in Figure 2-1.

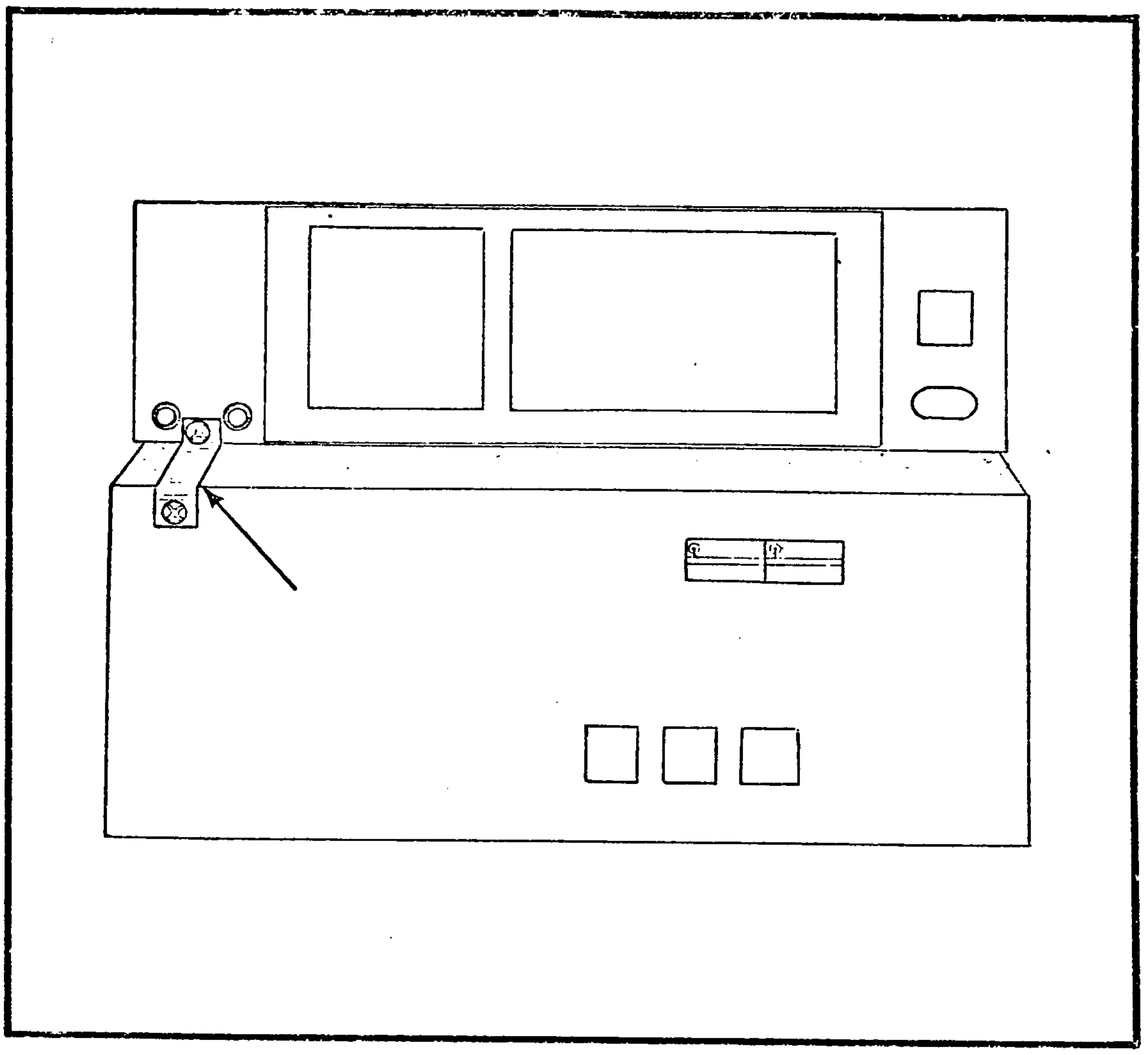

Figure 2-1. Grounding Strap Location.

NOTE

If option X, 1KV Power Amplifier, has been supplied with the system interconnect the 1KV amplifier before proceeding with step 8. Refer to the Model PA-1182 instruction manual for installation instructions.

8. Connect the AC-110 system AC line cord (grey) from a suitable power source to the Calibrator receptacle identified as AC INPUT. For the protection of operating personnel the 100V Power Amplifier and Calibrator front panels and exterior covers are connected to the ground pin of the AC LINE receptacles. If the system is connected to a 2 pin non-polarized electrical outlet a 2 prong adapter must be used with the pigtail wire of the adapter connected to an adequate electrical ground.

2-15. INITIAL TURN ON AND CALIBRATION.

2-16. INITIAL TURN ON. Connect the Calibrator AC line cord to the power source. Depress the Calibrator POWER switch. The POWER, STANDBY, 0% and 1KHZ lighted pushbuttons will illuminate indicating the operating modes which the system automatically assumes when power is initially applied. Also a frequency decimal point will light. After a short warm up period of approximately 50 seconds the 100V Power Amplifier READY lamp will light indicating that the amplifier is ready for operation. Refer to section 3 for detailed operating instructions.

2-17. INITIAL CALIBRATION. All internal adjustments have been set at the factory and the Model AC-110 is calibrated to laboratory standards which are traceable to the National Bureau of Standards. The Absolute AC Calibrator is ready for use when received.

SECTION III
OPERATION

3-1. GENERAL.

3-2. The Model AC-110 is an Absolute AC Voltage Calibrator which can be used for a wide range of applications. To make the most effective use of the system, the operation of all controls and the performance capabilities must be known. This section describes the operation of the controls and connectors, and contains general operating information for the Model AC-110.

3-3. OPERATING TEMPERATURE.

3-4. The Model AC-110 can be operated where the ambient air temperature is between 0°C and 55°C. It can be stored in ambient air temperatures that are between -40°C and 75°C. After storage at temperatures that are beyond the normal operating limits, allow the chassis to reach the operating temperature limits before applying power to the system to prevent moisture condensation.

3-5. OPERATING CONTROLS AND CONNECTORS.

3-6. GENERAL. A brief description of the function and operation for the operating controls and connectors of the standard AC-110 system is given in the following paragraphs. Optional features that affect the operation of these controls may also be included in the AC-110 and these differences are described in paragraph 3-11. A detailed operating description of the system is given in paragraph 3-15.

3-7. 100V POWER AMPLIFIER FRONT PANEL.

1. AMPLIFIER READY.- Lamp which indicates that the 100V Power Amplifier is ready for operation. Time delay is approximately 50 seconds after power is initially applied to the system.

2. OVERLOAD.- Lighted pushbutton which indicates the output is overloaded or shorted when the 100V range is selected on the

Calibrator. Must be pushed and held for approximately 2 seconds to reset the overload circuit after the short or overload has been removed from the Calibrator OUTPUT terminals.

3-8. 100V POWER AMPLIFIER REAR PANEL.

1. INPUT.- Connector for the 100V Power Amplifier input from the Calibrator.

2. Ip TEST.- Test button and test jacks for measuring the plate current of the output tubes.

CAUTION

The +225 volts plate supply voltage for the output tubes is across the Ip TEST terminals.

3. DC BAL ADJ.- Adjustment potentiometer for setting the DC offset level of the 100V Power Amplifier.

4. OUTPUT.- Output connectors for the 100V Power Amplifier output signal to the Calibrator.

5. SENSING.- Connectors for the remote sensing leads to the Calibrator.

6. AC INPUT.- 100V Power Amplifier AC power connector.

3-9. CALIBRATOR FRONT PANEL.

1. FREQUENCY.- Selector switches which set the 3 most significant digits (left-hand) of the frequency. The digit indicators display the selected frequency with the least significant (right-hand) digit fixed at zero.

2. VERNIER.- Adjusts the frequency over a high resolution vernier range of approximately ±0.15% of the selected frequency range.

3. K and HZ.- Indicate the frequency setting is read in kilohertz (KHZ) or Hertz (HZ) when lit.

4. FREQUENCY RANGE.- Illuminated pushbuttons which select the decade frequency range. Automatically positions the floating decimal point and lights the HZ or KHZ indicators.

5. ON PUSH OFF.- Illuminated pushbutton which controls the AC power to the Calibrator and 100V Power Amplifier. Also controls the filament and low voltage supplies in the 1KV Power Amplifier. Indicates power on when lit.

6. OVERLOAD.- Lamp which indicates that the output is overloaded or shorted on the 10mV, 100mV, 1V or 10V ranges. Reset is automatic when the overload or short is removed from the OUTPUT

terminals.

7. STANDBY.- Lighted pushbutton which selects the STANDBY operating mode. When the STANDBY pushbutton is depressed any selected voltage range is cancelled, the 0% ERROR RANGE is selected and the OUTPUT terminals are internally shorted.

8. ERROR RANGE.- Lighted pushbuttons which select the ERROR DETERMINATION RANGE.

a. 0%.- Output amplitude is calibrated to the OUTPUT VOLTAGE setting.

b. 0.3%.- The ERROR DETERMINATION potentiometer will adjust the output amplitude over a range of 0 to ±0.3% from the front panel OUTPUT VOLTAGE setting.

c. 3%.- The ERROR DETERMINATION potentiometer will adjust the output amplitude over a range of 0 to ±3.0% from the front panel OUTPUT VOLTAGE setting.

NOTE

The output amplitude is calibrated to the front panel OUTPUT VOLTAGE setting only when the 0% error range is selected.

9. ERROR DETERMINATION % ERROR.- A direct reading three turn potentiometer which adjusts the output amplitude over the calibrated range as selected by the % ERROR RANGE lighted pushbuttons. Setting is read directly in percent.

10. INDICATED ERROR.- Selects either a positive (+) or negative (-) adjustment range for the ERROR DETERMINATION potentiometer.

11. M and V.- Indicates that the voltage setting is read in millivolts (MV) or volts (V) when lit.

12. VOLTAGE RANGE.- Lighted pushbuttons which select the decade voltage range. Automatically positions the floating decimal point and illuminates the MV or V indicator.

13. OUTPUT.- Output terminals for the 10mV, 100mV, 1V, 10V and 100V ranges.

14. SENSING.- Terminals for the remote voltage sensing leads when the 1V, 10V or 100V ranges are selected.

NOTE

When the 10mV or 100mV ranges are selected the shorting links between the OUTPUT and SENSING terminals must be connected.

15. OUTPUT.- A recessed screwdriver actuated slide switch to select either a floating or grounded output configuration.

3-10. CALIBRATOR REAR PANEL.

1. PA-110.- Connectors for interconnecting the Calibrator and 100V Power Amplifier units.

a. HI OUTPUT.- Input connector for the 100V Power Amplifier high output signal.

b. LOW OUTPUT.- Input connector for the 100V Power Amplifier low output signal (circuit ground).

c. INPUT.- Output connector for the Calibrator output signal to the 100V Power Amplifier.

d. SENSING.- Output connectors for the 100V range remote sensing leads to the 100V Power Amplifier.

2. PA-1182 INPUT.- Output connector for the Calibrator output signal to the 1KV Power Amplifier (option X).

3. PA-1182.- AC line connectors for the 1KV Power Amplifier.

a. AC OUTLET NOT FUSED 1.- Connected directly to the AC INPUT connector and AC line is not switched or fused.

b. AC OUTLET 2.- Connected to the switched side of the Calibrator AC line and is not fused.

4. PA-110.- AC line connector for the 100V Power Amplifier connected to the switched side of the Calibrator AC line and is fused with F2.

5. OUTLETS PWR F1.- AC line fuse for the PA-110 AC outlet.

6. AC-110 PWR F2.- AC line fuse for the Calibrator.

7. AC INPUT.- AC-110 system AC power connector.

8. REMOTE PROGRAMMING DATA INPUT.- Input connector for the remote programming logic lines when remotely selecting the frequency, voltage and error measurement ranges.

9. MASTER AMPLITUDE ADJ.- Recessed screwdriver adjustments for calibrating the Calibrator output amplitude.

a. 10Hz to 100KHz.- Calibrates the output amplitude below 100 kilohertz.

b. 100KHz to 999KHz.- Not used (see paragraph 3-14).

CAUTION

These adjustments affect the output voltage calibration of the AC-110 system. Adjustment must not be attempted except when following the calibration procedure given in section 6 of this manual.

10. OSC REF OUT.- Output connector providing an approximate 5 volts rms oscillator circuit test signal.

11. OSC QUAD OUTPUT.- Output connector providing an approximate 2.5 volts rms quadrature phase signal output. Phase angle is 90° (lagging), ±0.1° to 10kHz and ±1.0° at 100kHz, with respect to the oscillator reference output signal.

12. DC REF.- Test points for monitoring the internal DC reference diode voltage.

3-11. OPTIONAL OPERATING CONTROLS.

3-12. GENERAL. The Model AC-110 may contain one or more of the optional features described in paragraph 1-10. If an optional feature affects the operation of a standard operating control it is noted in the following descriptions.

3-13. CALIBRATOR FRONT PANEL.

1. FREQUENCY (option B).- An additional selector switch permits selection of the 4 most significant digits (left-hand) of output frequency. (selector switch for additional digit is concentric with the VERNIER control.)

2. FREQUENCY RANGE (option W).- An additional lighted pushbutton (1MHZ) selects the extended frequency range of 100 to 1,000 kilohertz

3. VOLTAGE RANGE (option X).- An additional lighted pushbutton (1KV) selects the extended output voltage range of 100 to 1,200 volts rms.

NOTE

Option X requires an external 1KV Power Amplifier. Operation of the Model PA-1182 is covered by a separate instruction manual.

3-14. CALIBRATOR REAR PANEL.

1. 100KHZ to 999KHZ (option W).- Recessed screwdriver adjustment for calibrating the output amplitude for the 100 to 1,000 kilohertz frequency range.

3-15. PRELIMINARY OPERATION.

3-16. GENERAL. The Model AC-110 does not require any special preliminary operational procedures. The following paragraphs are intended only as a guide and it is not necessary to follow any particular sequence when setting the front panel operating controls.

3-17. INITIAL TURN ON.- The following steps outline the procedure which should be followed when initially applying power to the Model AC-110.

1. Check that the 100V Power Amplifier and Calibrator rear panel AC LINE selector switches are set to the correct position (110 or 230 volts) for the power source that will be used.

2. Depress the Calibrator POWER switch to on. The STANDBY, 0% and 1KHZ pushbuttons will light indicating the initial operating modes selected when power is first applied.

3. After a time delay of approximately 50 seconds the 100V Power Amplifier READY lamp will light indicating that the 100V Power Amplifier is ready for operation.

4. The Model AC-110 is now ready for operation. To meet the specifications listed in table 1-1, a 1½ hour warm up period must be allowed after power is initially applied. If operation is attempted without sufficient warm up, the output amplitude and frequency will slowly drift and may exceed the given accuracy specifications.

3-18. OPERATION. The steps below demonstrate the correct procedure to be followed when setting the front panel operating controls for typical applications. Paragraph 3-19 gives detailed operating instructions for each of the front panel operating controls.

1. Select the desired FREQUENCY RANGE pushbutton.

2. Set the desired output frequency on the FREQUENCY selector switches. Frequency is read directly on the digit indicators with the KHZ or HZ indicator properly lit and the decimal point automatically positioned.

3. If the application requires an output frequency accuracy of better than ±2.5% calibrate the VERNIER frequency control as described in paragraph 3-26.

4. Set the OUTPUT slide switch for either a floating or grounded output configuration.

5. Connect the load or meter to be tested across the OUTPUT terminals.

NOTE

For inductive loads (e.g., ratio transformers) an external capacitor must be connected in series with the load.

6. If remote sensing is desired, remove the shorting links between the OUTPUT and SENSING terminals. Connect the remote sensing leads between the SENSING terminals and the load as described in paragraph 3-37.

NOTE

When the 10mV or 100mV ranges are selected the shorting links between the OUTPUT and SENSING terminals must be connected for local sensing.

7. Set the OUTPUT VOLTAGE switches for the desired output voltage setting. The most significant figure of the desired voltage must be set in the left-hand digit for the greatest accuracy and resolution except when setting voltages of less than 1 millivolt.

8. Select the VOLTAGE RANGE for the desired output amplitude.

CAUTION

If the Calibrator or 100V Power Amplifier OVERLOAD lamp lights depress the STANDBY pushbutton immediately to reduce the output to zero. Check the output and sensing leads for proper connection and shorts. Also make sure that the load impedance/output voltage combination does not exceed the AC-110 output current specification.

9. Set the ERROR DETERMINATION potentiometer to zero (fully counterclockwise). Note the reading on the meter being tested. If it is low set the INDICATED ERROR switch to minus, if it is high set the INDICATED ERROR switch to plus.

10. Select the 0.3% or 3%, %ERROR RANGE.

11. Adjust the ERROR DETERMINATION potentiometer until the meter under test reads the exact voltage set on the OUTPUT VOLTAGE

switches.

12. Read the error (in percent) of the meter directly from the ERROR DETERMINATION potentiometer.

3-19. GENERAL OPERATION.

3-20. OUTPUT FREQUENCY. The AC-110 output frequency can be accurately set using front panel operating controls which eliminates the need for external frequency monitoring instruments for most applications. The three most significant digits (four on AC-110B) of frequency are set on the FREQUENCY selector switches and the decade range is set by the FREQUENCY RANGE lighted pushbuttons. The VERNIER control varies the output frequency over a narrow high resolution range for setting the frequency with an accuracy greater than can be obtained by the frequency selector switches. These controls and the accuracy of the Model AC-110 are described in the following paragraphs.

3-21. OUTPUT FREQUENCY ACCURACY. The frequency accuracy of the AC-110 is ±1.0% of the setting over the wide range of 10 to 100,000 Hertz when the VERNIER control has been calibrated as described in paragraph 3-26. If the VERNIER control is not calibrated, the frequency accuracy will be better than ±2.5% of the setting. For applications which require an accuracy better than ±1.0% the exact frequency can be set with the VERNIER control while monitoring the output on an external frequency counter.

3-22. FREQUENCY ACCURACY WITH OPTION B. When option B is included (designated AC-110B) an additional FREQUENCY selector switch is provided and the four most significant digits can be directly dialed in. This permits setting the frequency with an accuracy of better than ±0.1%, when the VERNIER control has been calibrated, over the wide range of 10 to 10,000 Hertz. At 100,000 Hertz the accuracy is within ±1.0% of the front panel setting.

3-23. DECADE FREQUENCY RANGES. Four decade ranges (five with option W) are provided to cover the frequency range of 10 Hertz to 100 kilohertz (to 1 megahertz with option W). The FREQUENCY RANGE lighted pushbuttons select the decade range, light the KHZ or HZ indicator and positions the corresponding decimal lamp. To achieve the greatest accuracy and resolution, the lowest decade range where the desired frequency setting can be obtained should always be used. Table 3-1 shows the range of frequency settings for the decade frequency ranges.

TABLE 3-1. DECADE FREQUENCY F

FREQUENCY RANGES	SETTING R/
100Hz	10.00 to 99.90Hz
1kHz	100.0 to 999.0Hz a..
10kHz	1000. to 9990.Hz and (10)..
100kHz	10.00 to 99.90kHz and (10)0.00k..
1MHz*	100.0 to 999.0kHz and (10)00.0kHz

*With option W only.

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24. DISCRETE FREQUENCY SETTING. The discrete frequency setting is made by the front panel FREQUENCY selector switches which set the three most significant digits of frequency. This provides three digit resolution over the range of 10 to 100,000 Hertz. The least significant digit (right-hand) is fixed at zero and the decimal point is automatically positioned so that the displayed frequency setting is always read directly in Hertz or kilohertz and does not require interpolation by the operator. The most significant digit (left-hand) cannot be set below 1 (internal mechanical stop) and frequency selection is always made with the most significant figure of the desired frequency set in this digit. Setting the output frequency in this manner provides the maximum amplitude stability, lowest signal distortion and greatest resolution. This digit also has a tenth position for overranging convenience.

3-25. SETTING FREQUENCY WITH OPTION B. When option B is included (designated AC-110B) a fourth FREQUENCY selector switch, concentric with the VERNIER control, is provided. This permits setting the four most significant digits which increases the resolution over the entire frequency range. The least significant digit is not fixed at zero with option B.

3-26. VERNIER FREQUENCY CONTROL. The VERNIER frequency control adjusts the output frequency over a narrow high resolution range of approximately ±0.15% (±0.015% with option B) of the range selected. For most calibration and testing applications where an output frequency accuracy of ±2.5% (±0.25% with option B) is adequate the VERNIER control does not need to be calibrated and frequency can be set using the FREQUENCY and FREQUENCY RANGE controls only. However, since at the low end of the frequency ranges the vernier adjustment has a range equal to ±1.5% of setting (±0.15%, option B) for applications where a setting accuracy of better than ±2.5% (±0.25%, option B) the vernier control should be occasionally calibrated at 1 kilohertz. The frequency setting accuracy will be within ±1.0% over the entire frequency range (±0.1% between 10 and 10,000 Hertz, option B) when the vernier control is calibrated at 1 kilohertz. It will also be optimized for the best tracking over the decade ranges. For critical applications the vernier control can also be used to set the exact frequency using an external frequency counter. Resolution of the vernier control is approximately 0.005% (50ppm) of the range selected. The procedure for calibrating the VERNIER control is as follows:

1. Connect a Digital Reciprocal Counter or other accurate frequency measuring instrument to the Calibrator OUTPUT terminals. The counter should have at least six digit resolution and a crystal controlled time base.

2. Set the FREQUENCY and FREQUENCY RANGE controls to the desired frequency setting. When calibrating for a nominal ±1.0% (±0.1% with option B) frequency accuracy set the frequency selector switches to 1000 and depress the 10KHZ FREQUENCY RANGE pushbutton.

3. While monitoring the output frequency on the Reciprocal Counter, set the VERNIER control to the exact frequency desired or 1 kilohertz.

4. Disconnect the Digital Reciprocal Counter.

NOTE

Due to the poor input impedance linearity of most Digital Frequency Counters the counter must be disconnected after the vernier frequency adjustment is made or the AC-110 output may be excessively distorted.

3-27. OUTPUT AMPLITUDE. The Model AC-110 is an absolute AC voltage source with amplitude directly set by front panel operating controls. This eliminates the need for external monitoring instruments, such as a Thermal Transfer Standard, when testing or calibrating instruments. The six most significant digits (plus overrange) of voltage are set on the OUTPUT VOLTAGE selector switches and the range is set on the VOLTAGE RANGE lighted pushbuttons. The following paragraphs describe the operation of these amplitude controls and the accuracy of the Model AC-110.

3-28. OUTPUT AMPLITUDE ACCURACY. The accuracy of the output amplitude for the Model AC-110 is ±[(0.02% of setting) + 10 microvolts] over the broad midband frequency range of 50 to 20,000 Hertz. At 20 Hertz and 100 kilohertz its ±[(0.05% of setting) + 10 microvolts]. These accuracy specifications include the effects of short term instability, cycle-cycle instabilities, calibration uncertainties as specified by NBS, noise and distortion when calibrating average or rms responding instruments at 25°C, ±2°C. Table 3-2 lists the amplitude accuracy with respect to the frequency setting.

TABLE 3-2. OUTPUT AMPLITUDE ACCURACY.

FREQUENCY	AMPLITUDE ACCURACY
10Hz to 20Hz	±[(0.1% of setting) + 10uV]
20Hz to 50Hz	±[(0.05% of setting) + 10uV]
50Hz to 20kHz	±[(0.02% of setting) + 10uV]
20kHz to 110kHz	±[(0.05% of setting) + 10uV]
110kHz to 1MHz*	±[(0.5% of setting) + 10uV]

*with option W only.

3-29. OUTPUT VOLTAGE RANGES. Five decade ranges are provided which cover the output amplitude range of 10 microvolts to 121.1110 volts rms and are selected by the VOLTAGE RANGE lighted pushbuttons. The selected range automatically positions the floating decimal point and lights the MV or V indicator. The lowest decade range where the desired output voltage setting can be obtained should always be used to achieve the greatest accuracy and resolution for the setting. Table 3-3 shows the voltage settings for the decade ranges.

TABLE 3-3. DECADE VOLTAGE RANGES.

RANGE	VOLTAGE SETTING RANGE
10mV	10uV to (12).11110mV
100mV	10.0000 to (12)1.1110mV
1V	.100000 to (1.2)11110V
10V	1.00000 to (12).11110V
100V	10.0000 to (12)1.1110V
1KV EXT*	100.000 to (12)11.110V

*with option X only.

3-30. DISCRETE AMPLITUDE SETTINGS.
uation (plus overrange) can be di
VOLTAGE ladder attenuator swit
ically positioned and the volta
in volts or millivolts without a
switch is an 11 position (0 throu
most significant digit which has 1
additional tenth and eleventh posit
range since a large number of measur
meters are at the full scale points.
of the digits a one must be added to th
left. For example, the following settin
4th digit: 1.36(10)72 and is read as 1.3
must always be made with the most signific
output voltage set in the extreme left-hand
setting of less than 1 millivolt is desired.
in this manner will provide the maximum ampli
est output current and best resolution. The ou
to zero by dialing in all zeroes or by selecting
ating mode.

calibrated to
selects the
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in a positive
selected the
in a nega-
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3-31. ERROR DETERMINATION CONTROLS. The error of t
ment being tested can be rapidly determined by using
termination operating controls. The following paragra
the use and operation of these controls

3-32. % ERROR RANGE. Three % ERROR RANGE lighted pushbutt
lect the error range of 0%, 0.3% or 3.0%. This sets the ran
which the output amplitude can be varied from the front panel
ting with the ERROR DETERMINATION potentiometer. When testing
calibrating meters, the 0% range should be selected first and t
output voltage set to the amplitude at which the meter is to be tested. Since the output amplitude is calibrated on the 0% range, the approximate reading error of the meter can be empirically determined. If the approximate error is less than 0.3% then select the 0.3% ERROR RANGE and if it is greater than 0.3% select the 3% ERROR RANGE. Then the output amplitude can be adjusted over the range selected (0.3% or 3%). The 0% ERROR RANGE will automatically be selected when power is initially applied or the STANDBY operating mode is selected.

CAUTION

The AC-110 output amplitude will be calibrated to the OUTPUT VOLTAGE switches setting only when the 0% ERROR RANGE is selected.

3-33. ERROR RANGE ADJUSTMENT. A three turn potentiometer and polarity selector switch are used to adjust the output amplitude over the range selected on the % ERROR RANGE lighted pushbuttons. When the 0% error range is selected the ERROR DETERMINATION controls are inoperative and the output amplitude will always be calibrated to the output voltage setting.

1. INDICATED ERROR. The INDICATED ERROR switch selects the polarity of the error range adjustment. When minus is selected the % ERROR potentiometer will vary the output amplitude in a positive direction from the output voltage setting. If plus is selected the % ERROR potentiometer will adjust the output amplitude in a negative direction from the output voltage setting. Thus, if on the 0% range (i.e., output voltage calibrated) the meter tested reads low, by setting the INDICATED ERROR switch to minus the % ERROR potentiometer can be used to increase the AC-110 output amplitude until the meter reads the same as the output voltage setting by selecting one of the error ranges. When reading the error, the setting of the INDICATED ERROR switch is taken into consideration. For example, if the measured error is 0.25% and the INDICATED ERROR switch is set to minus, the error reading is -0.25%.

2. % ERROR. The % ERROR control is a direct reading three turn potentiometer which adjusts the output amplitude over a narrow range as selected on the ERROR RANGE lighted pushbuttons. When the 0% error range is selected the % ERROR potentiometer is inoperative and the output amplitude will always be calibrated to the output voltage setting. Deviation error is read directly from the potentiometer with a resolution of 0.001% for the 0.3% range and 0.01% for the 3% error range. The potentiometer makes three complete revolutions and the error percentage is read on the turns counter and dial. For example, on the 3.0% error range the % ERROR control will vary the output amplitude over the range of 0% to ±3.0% from the voltage setting and at 2½ turns the error percentage is read as 2.5%.

3-33. ERROR MEASUREMENT PROCEDURE. The following steps demonstrate a simple technique which can be used to rapidly determine the error of a meter. The procedure is not discussed in detail since each situation must be adapted to the individual instrument or meter being tested. These steps can however, be used as a general guide to develop testing and calibrating techniques for specific applications.

1. Depress the STANDBY pushbutton to reduce the output voltage to zero and prevent possible damage to the meter being calibrated.

2. Connect the meter to the OUTPUT terminals.

3. If remote sensing is to be used, connect the sense leads between the SENSING terminals and the meter or use the four wire output cable supplied (P/N 901363).

4. Set the OUTPUT switch for a floating or grounded output.

5. Set the FREQUENCY and FREQUENCY RANGE controls to the desired output frequency.

6. Set the OUTPUT VOLTAGE switches to the desired output amplitude setting.

7. Depress the VOLTAGE RANGE lighted pushbutton for the amplitude desired.

8. Note the reading on the meter being tested. If the meter reads low set the INDICATED ERROR switch to minus. If it reads high set the INDICATED ERROR switch to plus.

9. Note the approximate percentage of reading error on the meter and depress the 0.3% or 3% ERROR RANGE pushbutton.

10. Adjust the % ERROR potentiometer until the meter reads the same voltage as set on the OUTPUT VOLTAGE switches.

11. Read the error directly on the % ERROR potentiometer, in percent.

3-34. OUTPUT LEADS. A set of OUTPUT terminals are provided for the 10mV, 100mV, 1V, 10V and 100V ranges on the Calibrator front panel. If option X, 1KV EXT, is included an output cable assembly is provided on the 1KV Power Amplifier for the 1KV range. Since the AC-110 is capable of operating over a broad range of voltages and frequencies certain precautions must be observed when connecting load cables to the system. For output voltages of between 1 and 100 volts rms and up to 100 kilohertz, the type of leads used is not critical. The leads should be shielded for lower level outputs (below 1V rms) to minimize noise pickup. At frequencies of over 100 kilohertz (option W only) and up to 10 volts a loosely twisted pair of number 12 wire with teflon insulation is recommended for best performance. When the 100 volt range is being used, 300 ohm twin-lead heavy dute TV antenna lead (#18 or larger) has been found to offer a satisfactory solution to capacitive loading effects encountered at high amplitude and frequency settings.

3-35. OUTPUT CABLE ASSEMBLIES SUPPLIED. Two output cable assemblies are supplied with the standard AC-110 calibration system. The four wire cable assembly (P/N 901363) is for general applications and should be used on the 1V, 10V or 100V ranges at frequencies of up to 100 kilohertz. On the 10mV and 100mV ranges where remote sensing is not used the two wire cable assembly (P/N 008016) should be used with the Calibrator output terminals connected for local sensing. If option W is included an additional two wire output cable assembly (P/N 901369) is supplied. This cable assembly must be used for frequencies of between 100 kilohertz and 1 megahertz with the Calibrator output terminals connected for local sensing.

CAUTION

The load leads must always be connected to the OUTPUT terminals and never to the SENSING terminals, even though the shorting straps are in place for local sensing.

3-36. OUTPUT CONNECTIONS. Either a floating or grounded output configuration can be selected on the Calibrator front panel depending on the application and type of load. In general, when the AC-110 is used with an instrument that has a grounded input, such as some digital voltmeters, the output should be set for FLOATING. When driving an instrument or meter that has a floating input, such as a battery operated voltmeter, the output should be set for a grounded output. The configuration is selected by the OUTPUT slide switch. In the floating position the output terminals are isolated from the exterior covers and AC line ground. In the grounded position the LOW SENSING terminal (black) is grounded to the exterior covers and AC line ground.

3-37. REMOTE SENSING. Provisions for sensing the output amplitude at a remote point (i.e., load) and feeding back an error signal have been made on the AC-110 for the 1V, 10V and 100V ranges. This compensates for the voltage drop in the external load leads. For most applications such as calibrating high input impedance digital voltmeters the output should be connected for local sensing. However if a larger burden is applied or the impedance of the load changes as a function of the input voltage, such as a Thermal Transfer Standard or laboratory type of meter movement, remote sensing should be used to maintain the accuracy of the AC-110 at the load. An exception to this is when operating at frequencies of over 100 kilohertz remote sensing should not be used. At higher frequencies inductive loading characteristics of the output and sensing leads tend to increase the output amplitude when remote sensing is used. This is caused by a slight phase shift of the error signal being fed back to the output amplifier.

NOTE

The AC-110 is protected against accidental opening or shorting of the remote sensing leads with internal resistors connected between the OUTPUT and SENSING terminals. However, the output voltage and load regulation will not be within specification if the SENSING terminals are not properly terminated for either local or remote sensing.

3-38. Local or remote sensing is determined by the position of the two shorting straps on the OUTPUT and SENSING terminals. To connect the Calibrator for remote sensing use the following procedure:

1. Remove the two shorting straps between the OUTPUT and SENSING terminals.

2. Connect the load leads to the OUTPUT terminals.

3. Connect a pair of loosely twisted 22 gauge (or larger) wires between the SENSING terminals and the point where it is desired to maintain the load regulation. Or use the four wire output

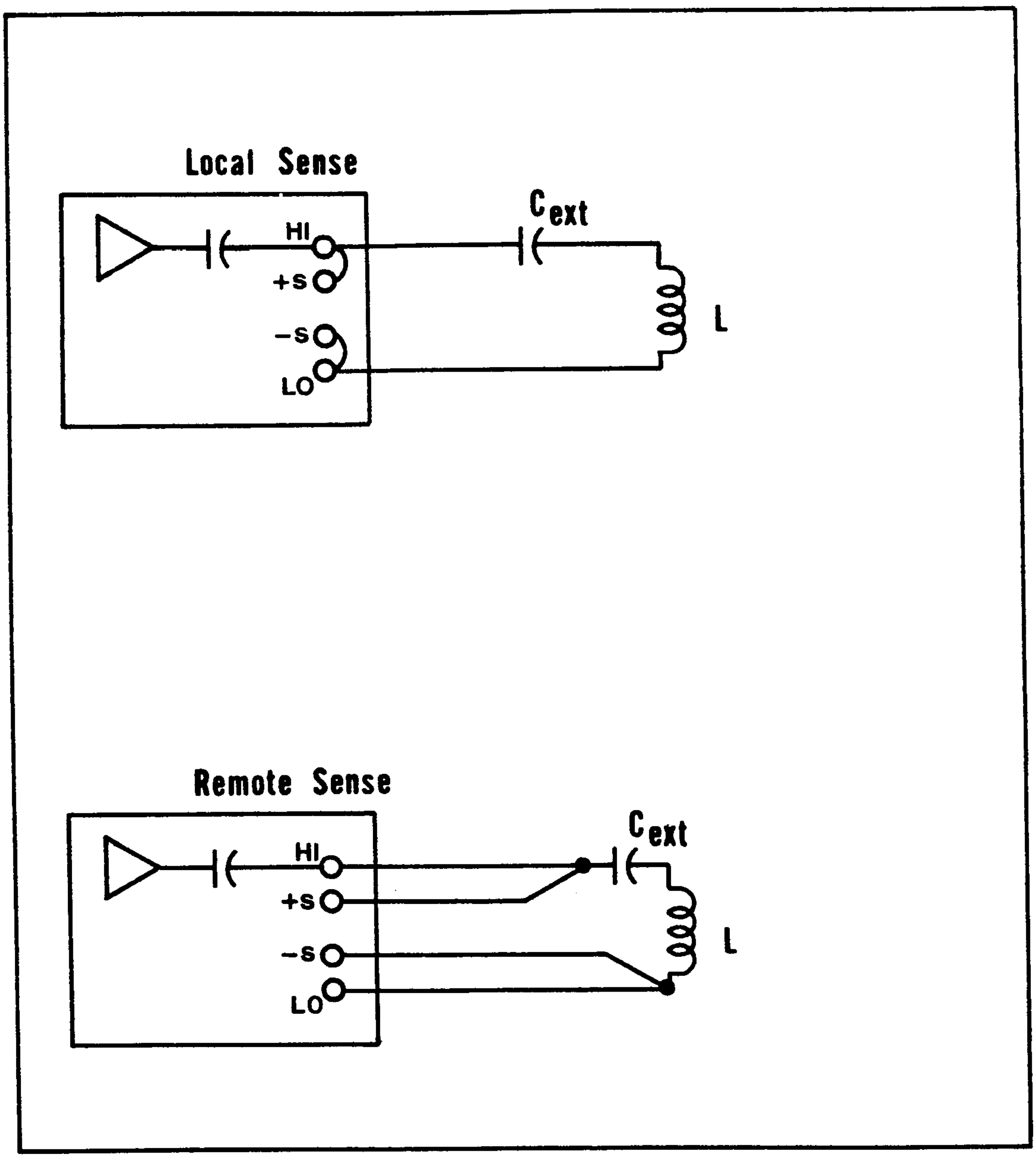


Figure 3-1. Inductive Load Connection.

cable assembly (P/N 901363) supplied. Use caution and observe the polarity when connecting the remote sensing leads.

NOTE

The load and sense leads must be loosely twisted (i.e., one turn every 2 or 3 inches) or excessive capacitive loading will result. For best results the high output and high sense leads can be loosely twisted together and the low output and low sense leads loosely twisted together.

3-39. OUTPUT CONNECTIONS FOR INDUCTIVE LOADS. When inductive loads such as a ratio transformer are to be driven by the AC-110 an external series capacitor must be used. This is necessary since the output of the Calibrator is AC coupled and when an external inductance is connected across the output terminals a series tuned circuit is formed and could cause the output amplifier to oscillate. The series capacitor must be connected external to the point where the remote sensing leads are terminated as shown in figure 3-1. Since inductive loads limit the operating frequency range a 100mfd capacitor can be used for most applications over a midband frequency range of 400 to 20,000 Hertz.

3-40. OVERLOAD PROTECTION. Overload protection is provided for all operating conditions of the Model AC-110. On the 10mV, 100mV, 1V and 10V ranges overload protection is provided in the Calibrator. If the output terminals are accidently shorted or overloaded, the OVERLOAD indicator on the front panel will light. Reset of the overload circuit on these ranges is automatic when the short or excessive load is removed. When the 100V range is selected overload protection is provided in the 100V Power Amplifier and the OVERLOAD indicator on that unit will light if the output is shorted or overloaded. To reset the 100V overload circuit remove the excessive load or short and press the OVERLOAD pushbutton on the 100V Power Amplifier holding it in for several seconds.

3-41. REMOTE PROGRAMMING. Each of the voltage, frequency and percent error ranges of the AC-110 can be programmed from a remote location through the rear panel REMOTE PROGRAMMING DATA INPUT connector. A momentary action switch is recommended for remote programming, however other methods can be used such as integrated circuit logic or transistor drivers. Each remote programming logic line must be shorted to ground (LOW state if logic is used) when the AC-110 is being operated locally. When a range is to be programmed externally, the proper program line is opened (HI state for logic) and the remote enable line is momentarily opened (pulsed if logic is used) while the selected line is held open. After the enable line has been programmed and once again grounded (LOW state for logic) the range program line is shorted to ground (LOW state for logic) and programming is complete. Internal storage circuits

TABLE 3-4. REMOTE PROGRAMMING CONNECTOR.

PIN NO.	FUNCTION
1	Frequency Range Enable
2	1MHz Range*
3	100kHz Range
4	10kHz Range
5	1kHz Range
6	100Hz Range
7	Not used.
8	1KV Ext. Range**
9	100V Range
10	10V Range
11	1V Range
12	100mV Range
13	10mV Range
14	Voltage Range Enable
15	0% Error Range
16	0.3% Error Range
17	3% Error Range
18	Error Range Enable
19-22	Not used.
23	Logic Ground
24	Chassis Ground

*With option W only.
**With option X only.

hold the last range programmed until a new range is programmed and the proper enable line is opened (or pulsed for logic). The Calibrator front panel lighted pushbuttons will indicate the range which has been externally programmed. Table 3-4 shows the function for each pin of the remote programming connector and lists the corresponding pin numbers.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section of the manual contains preventive maintenance, maintenance and performance measurements information for the Model AC-110 Absolute AC Voltage Calibrator.

5-3. PREVENTIVE MAINTENANCE.

5-4. GENERAL. Preventive maintenance consists mainly of cleaning and inspecting the instruments and when performed on a regular basis may prevent failures and improve the reliability of the Calibration system. The most convenient time for performing preventive maintenance is prior to calibration of the system.

5-5. CLEANING. The Model AC-110 should be cleaned as often as the operating environment requires. The accumulation of dust and dirt can cause overheating and component breakdown. It can also provide an electrical conduction path between circuits. The best technique to use for cleaning the instrument is to blow off any accumulated dust with dry, low velocity air.

5-6. VISUAL INSPECTION. The Model AC-110 should be visually inspected for the following items prior to performing maintenance or calibration. Visual inspection should be conducted more frequently if the instrument is being operated in a high temperature environment or if it has been subjected to excessive physical shock.

1. Check for broken connections or damaged wires.

2. Check for burnt or bulging components that show evidence of overheating.

3. Check for damaged or broken capacitors.

4. Check that transistors and integrated circuits are properly seated into their sockets and heatsinks.

5. Check that the vacuum tubes in the 100V Power Amplifier are properly seated into the sockets.

6. Check that the socket mounted potentiometers are properly seated.

7. Check all lamps for damage and proper seating in the sockets.

8. Check that the relays are properly seated and that the spring keepers are correctly positioned.

NOTE

Overheated components usually indicate other defects in the instruments and it is important to correct the cause of over heating to prevent recurrence of the problem.

5-7. 100V POWER AMPLIFIER PREVENTIVE MAINTENANCE. The preventive maintenance procedure for the 100V Power Amplifier is as follows:

1. Disconnect the interconnecting cables to the Calibrator and the AC power cord.

2. Remove the 4 front panel rack mounting screws and lift the amplifier from the rack mounting cabinet.

3. Remove the 8 pan head screws from the top cover and 2 pan heads screws located at the bottom of the rear panel. Lift off the top cover and rear panel.

4. Clean the interior of the Amplifier as described in paragraph 5-5.

5. Visually inspect the Amplifier for the items listed in paragraph 5-6.

6. Replace the top cover and rear panel. Mount the Amplifier in the rack cabinet, reversing steps 1 through 3.

5-8. CALIBRATOR PREVENTIVE MAINTENANCE. The preventive maintenance procedure for the Calibrator is as follows:

1. Disconnect the interconnecting cables and the AC power cord from the rear panel.

2. Remove the 4 front panel rack mounting screws and lift the Calibrator from the rack mounting cabinet.

3. Remove the 11 top cover and 11 bottom cover pan head screws. Lift the covers from the instrument.

4. Clean the interior of the Calibrator as described in para-

graph 5-5.

5. Inspect the interior of the Calibrator for the items listed in paragraph 5-6.

6. Check each of the front panel FREQUENCY and OUTPUT VOLTAGE selector switches for proper mechanical operation and that they can be rotated freely through all of the detent positions.

7. Replace the top cover and bottom cover and mount the Calibrator by reversing steps 1 through 3.

5-9. CALIBRATION. In general, the Absolute AC Voltage Calibrator is extremely stable and will require infrequent adjustment. However, to assure accurate performance of the Model AC-110 the performance and calibration should be checked every 90 days of operation. A performance check procedure is given in this section and complete calibration instructions are given in section 6. It is recommended that before performing any of the calibration adjustments that the performance of the system be checked using the performance measurement procedure. This procedure will completely check the system to the specifications given in table 1-1. If the AC-110 meets all of the check steps then it will not be necessary to make any of the calibration adjustments.

5-10. PERFORMANCE TESTS.

5-11. GENERAL. The procedures listed below constitute the minimum performance measurements required to check the operation and performance of the Model AC-110. These checks are made without removing any covers or making internal adjustments. If the system does not meet one or more of the performance measurements then it will be necessary to trouble shoot the circuits or make calibration adjustments as described in section 6.

5-12. TEST EQUIPMENT REQUIRED. Test equipment required to complete the performance measurements are listed in table 5-1. The specifications given for each instrument are the minimum required and should alternate instruments be substituted they must meet or exceed these given specifications.

5-13. PERFORMANCE TEST PROCEDURE. In the following steps, control settings or test equipment connections should only be changed when the procedure specifically states a change. In this manner the performance procedure can be completed with the minimum number of control setting and test equipment changes.

5-14. CONTROL SETTINGS. Unless instructed otherwise, perform all

TABLE 5-1. REQUIRED TEST EQUIPMENT.

TEST EQUIPMENT	SPECIFICATIONS	MODEL NO.
DC VOLTMETER	Range: to 100 volts full scale; Resolution: 1mV; Must provide a high degree of AC isolation.	Universal Avometer Model 8
OSCILLOSCOPE	Frequency range: DC to 1MHz; Accuracy: 3%; Sensitivity: 1mV per centimeter.	Tektronix Model 561B w/10:1 Attenuation Probe.
DIGITAL RECIPROCAL COUNTER	Accuracy: 1 x 10^{-5}; 6 digits; Frequency range: 10Hz to 1Mhz.	General Radio Type 1159
DISTORTION ANALYZER	Frequency range: 10Hz to 500kHz; Voltage range: 0 to 100 volts rms; Accuracy: better than 0.02%.	Hewlett Packard Model 333A
PRECISION AC VOLTMETER	Short term stability: 50ppm/hr; Resolution: 0.002% of range; Voltage range: 0 to 100 volts rms.	Fluke Model 931AB
DC VOLTAGE STANDARD	Accuracy: ±0.002%; Voltage range: 1 to 100 volts.	Fluke Model 332B
THERMAL TRANSFER STANDARD	Frequency response: ±0.01% from 10Hz to 100kHz; DC reversal error: less than 0.025%; Voltage range: 0 to 100 volts rms.	Fluke Model 540B with Model A55 High Frequency Thermal Converter.
PRECISION 40 OHM LOAD	40 Ohms, ±1.0%, 1/2W.	
PRECISION 400 OHM LOAD	400 Ohms, ±1.0%, 2W.	
PRECISION 2,000 OHM LOAD	2,000 Ohms, ±1.0%, 10W.	

measurements with the Model AC-110 front panel controls set to the settings given in table 5-2.

TABLE 5-2. CONTROL SETTINGS.

CONTROL	SETTING
FREQUENCY RANGE	1KHZ
FREQUENCY	(10)00.0
% ERROR RANGE	0%
OUTPUT	FLOATING
OUTPUT VOLTAGE	All zeroes

5-15. TEST SETUP AND WARM UP. The following steps describe the initial setup to be made before proceeding with the performance tests.

1. Connect the interconnecting cables between the Calibrator and Power Amplifier as described in section 2.

2. Connect the Calibrator AC INPUT line cord to a suitable power source.

3. Set the front panel operating controls in accordance with table 5-3.

4. Depress the Calibrator POWER switch to on.

5. Allow the AC-110 to warm up for a period of 1½ hours prior to making any performance measurements.

5-16. <u>AC-110 PERFORMANCE MEASUREMENTS.</u>

1. Check Decimal Lamp Operation.

a. PROCEDURE.- Sequentially depress each of the FREQUENCY RANGE pushbuttons starting on the 100HZ range.

b. CHECK.- Each decimal lamp lights in sequence as the FREQUENCY RANGE buttons are depressed.

c. PROCEDURE.- Sequentially depress each VOLTAGE RANGE pushbutton starting on the 10MV range.

d. CHECK.- Each decimal lamp lights in sequence as the VOLTAGE RANGE buttons are depressed.

2. Check Voltage and Frequency Indicators.

a. PROCEDURE.- Sequentially depress each FREQUENCY RANGE pushbutton starting with the 100HZ range.

b. CHECK.- The HZ indicator lights when the 100HZ, 1KHZ and 10KHZ ranges are selected and the KHZ indicator lights when the 100KHZ range is selected.

c. CHECK.- When option W is included, check that the KHZ indicator lights when the 1MHZ range is selected.

d. PROCEDURE.- Sequentially depress the VOLTAGE RANGE pushbuttons starting with the 10MV range.

e. CHECK.- The MV indicator lights when the 10MV or 100MV ranges are selected and the V indicator lights when the 1V, 10V or 100V ranges are selected.

f. CHECK.- When option X is included check that the V indicator lights when the 1KV EXT range is selected.

g. Depress the STANDBY and 1KHZ FREQUENCY RANGE pushbuttons.

3. Check STANDBY Operating Mode.

a. PROCEDURE.- Depress the 10MV VOLTAGE RANGE and 0.3% ERROR RANGE pushbuttons.

b. CHECK.- Depress the STANDBY pushbutton. The 0% ERROR RANGE is selected and none of the VOLTAGE RANGE pushbuttons are lit when the STANDBY mode is selected.

c. CHECK.- Connect an Ohmmeter across the OUTPUT terminals and check that the resistance is zero ohms (terminals shorted).

d. Disconnect the Ohmmeter.

4. Check Calibrator Overload Circuit.

a. PROCEDURE.- Set the OUTPUT VOLTAGE switches to (10)00000. Depress the 10V VOLTAGE RANGE pushbutton (output set to 10 volts).

b. CHECK.- Short the OUTPUT terminals and check that the OVERLOAD indicator lights. Remove the short and check that the OVERLOAD indicator goes off.

c. Depress the STANDBY pushbutton.

5. Check 100V Power Amplifier Overload Circuit.

a. PROCEDURE.- Set the OUTPUT VOLTAGE switches to 100000. Depress the 100V VOLTAGE RANGE pushbutton (output set to 10 volts).

b. CHECK.- Short the OUTPUT terminals and check that the 100V Power Amplifier OVERLOAD indicator lights. Remove the short and depress the OVERLOAD pushbutton and check that the overload circuit resets.

c. Depress the STANDBY pushbutton and return the OUTPUT VOLTAGE switches to all zeroes.

6. Check the 100V Power Amplifier Output Tubes Plate Current.

a. PROCEDURE.- Connect the DC Ammeter to the Ip TEST terminals on the rear panel. Use caution as the +225V plate supply is across the Ip TEST terminals. Press the Ip TEST button.

b. CHECK.- The DC Ammeter reads between 50 and 60 milliamps.

c. Disconnect the DC Ammeter.

7. Check 100V Power Amplifier DC Balance.

a. PROCEDURE.- Connect the DC Voltmeter between the DC BAL terminals on the rear panel.

b. CHECK.- The DC Voltmeter reads less than ±10 millivolts.

c. Disconnect the DC Voltmeter.

8. Check Oscillator Circuit DC Balance.

a. PROCEDURE.- Connect the DC Voltmeter to the Calibrator rear panel OSC REF OUT connector.

b. CHECK.- The DC Voltmeter reads less than ±10 millivolts.

c. Disconnect the DC Voltmeter.

NOTE

The Oscillator circuit DC balance can also be checked at the OSC DC BAL test points accessible through the bottom cover when the instrument is not rack mounted.

9. Check Output Waveforms.

a. PROCEDURE.- Connect the Oscilloscope across the OUTPUT terminals. Set the OUTPUT VOLTAGE switches to 100000. Sequentially depress each VOLTAGE RANGE pushbutton (with the exception of the 1KV EXT if option X is included) while observing the waveforms on the Oscilloscope.

b. CHECK.- An undistorted sine wave is present for each decade voltage range.

c. PROCEDURE.- Depress the 10V VOLTAGE RANGE pushbutton (output set to 1V). Sequentially depress the FREQUENCY RANGE pushbuttons while observing the wave form on the Oscilloscope.

d. CHECK.- An undistorted sine wave is present for each of the decade frequency ranges.

e. Depress the STANDBY pushbutton and return the OUTPUT VOLTAGE switches to all zeroes.

f. Disconnect the Oscilloscope.

10. Check VERNIER Frequency Control Range.

a. PROCEDURE.- Set the FREQUENCY selector switches to 1000. Connect the Digital Reciprocal Counter to the rear panel OSC REF OUT connector. Depress the 10KHZ FREQUENCY RANGE pushbutton.

b. CHECK.- The frequency varies more than ±10 Hertz (±1.0 Hertz with option B) when the VERNIER frequency control is adjusted through its range.

c. Adjust the VERNIER control so that the Digital Frequency Counter reads exactly 1,000.0 Hertz.

NOTE

For the following frequency accuracy measurements the VERNIER control must be left at the calibrated setting made in step 10c.

11. Check Output Frequency Tracking.

a. PROCEDURE.- Set the FREQUENCY switches to (10)000. Depress each of the FREQUENCY RANGE pushbuttons sequentially while monitoring the frequency on the Digital Reciprocal Counter.

b. CHECK.- The Digital Reciprocal Counter reads within ±1.0% (±0.1% with option B) of the front panel frequency setting for each decade range.

12. Check Frequency Digit Tracking.

a. PROCEDURE.- Set the FREQUENCY selector switches and FRE-

TABLE 5-3. FREQUENCY DIGIT TRACKING SETTINGS.

FREQUENCY RANGE	FREQUENCY SETTING
100HZ	10.00 20.00 50.00 (10)0.00
1KHZ	100.0 200.0 500.0 (10)00.0
10KHZ	1000. 1110. 2220. 3330. 4440. 5550. 6660. 7770. 8880. 9990. (10)000.
100KHZ	10.00 20.00 50.00 (10)0.00
1MHZ*	100.0 200.0 500.0 (10)00.0

*with option W only.

QUENCY RANGE pushbuttons to the settings given in table 5-3.

b. CHECK.- The frequency for each setting is within ±1.0% (±0.1% to 10 kilohertz with option B).

c. Depress the STANDBY pushbutton.

d. Disconnect the Digital Reciprocal Counter.

13. Check Output Distortion.

a. PROCEDURE.- Connect the Distortion Analyzer to the OUTPUT terminals. Depress the 100HZ FREQUENCY RANGE pushbutton. Set the OUTPUT VOLTAGE switches to (10)00000. Depress the 10V VOLTAGE RANGE pushbutton (output set to 10 volts).

b. CHECK.- Set the FREQUENCY selector switches to 1000. The output distortion should be less than 0.05%.

c. CHECK.- Set the FREQUENCY selector switches to 2000. The output distortion should be less than 0.02%.

d. CHECK.- Depress the 10KHZ FREQUENCY RANGE pushbutton and set the FREQUENCY selector switches to 1000. The output distortion should be less than 0.02%.

e. CHECK.- Depress the 100KHZ FREQUENCY RANGE pushbutton and set the FREQUENCY selector switches to 2000. Output distortion should be less than 0.02%.

f. CHECK.- Set the FREQUENCY selector switches to (10)000. The output distortion should be less than 0.05%.

g. PROCEDURE.- If option W is included set the FREQUENCY selector switches to 5000 and depress the 1MHZ FREQUENCY RANGE pushbutton.

h. CHECK.- Output distortion should be less than 0.5%.

i. Depress the 100V VOLTAGE RANGE pushbutton and repeat steps a through h checking the distortion at 100 volts.

j. Depress the STANDBY and 1KHZ FREQUENCY RANGE pushbuttons. Return the FREQUENCY selector switches to (10)000. Disconnect the Distortion Analyzer.

13. Error Measurement Accuracy Test.

a. SETUP.- Connect the Precision AC Voltmeter to the OUTPUT terminals. Set the VOLTAGE selector switches to (10)00000 and depress the 10V VOLTAGE RANGE pushbutton.

b. PROCEDURE.- Measure the output voltage using the Precision

AC Voltmeter and record the reading. If the output voltage is less than 10.0 volts rms set the INDICATED ERROR switch to minus, if it reads higher set the INDICATED ERROR switch to plus. Depress the 0.3% ERROR RANGE pushbutton.

c. CHECK.- Adjust the % ERROR potentiometer until the Precision AC Voltmeter reads the exact voltage recorded in step b. The % ERROR potentiometer should read less than 0.001%.

d. PROCEDURE.- Depress the STANDBY pushbutton. Set the OUTPUT VOLTAGE switches to 9.97000. Set the INDICATED ERROR switch to minus and the % ERROR potentiometer to 0.30% (fully clockwise).

e. CHECK.- Depress the 10V VOLTAGE RANGE and 0.3% ERROR RANGE pushbuttons. The Precision AC Voltmeter should read within ±9 millivolts of the reading recorded in step b.

f. PROCEDURE.- Set the OUTPUT VOLTAGE selector switches to (10).03000V. Set the INDICATED ERROR switch to plus.

g. CHECK.- The Precision AC Voltmeter should read within ±9 millivolts of the reading recorded in step b.

h. PROCEDURE.- Set the OUTPUT VOLTAGE selector switches to (10).00000. Record the reading on the Precision AC Voltmeter. If the output voltage is less than 10.0 volts rms set the INDICATED ERROR switch to minus, if it reads higher set the INDICATED ERROR switch to plus. Depress the 3% ERROR RANGE pushbutton.

i. CHECK.- Adjust the % ERROR potentiometer until the Precision AC Voltmeter reads the exact voltage recorded in step h. The % ERROR potentiometer should read less than 0.01%.

j. PROCEDURE.- Set the OUTPUT VOLTAGE selector switches to 9.70000V. Set the INDICATED ERROR switch to minus. Ser the % ERROR potentiometer to 3.0% (fully clockwise).

k. CHECK.- The Precision AC Voltmeter should read within ±90 millivolts of the reading recorded in step h.

l. PROCEDURE.- Set the OUTPUT VOLTAGE selector switches to (10).30000V. Set the INDICATED ERROR switch to plus.

m. CHECK.- The Precision AC Voltmeter should read within ±90 millivolts of the reading recorded in step h.

n. Depress the STANDBY pushbutton and set the % ERROR potentiometer to 0.

14. Check 10V Amplifier Load Regulation.

a. SETUP.- Depress the 1KHZ FREQUENCY RANGE pushbutton. Set the VOLTAGE selector switches to 200000. Depress the 10V VOLTAGE RANGE pushbutton.

b. PROCEDURE.- Set the Precision AC Voltmeter to read the output voltage. Record the reading. Connect a 40 Ohm Precision Load resistor across the OUTPUT terminals with the Calibrator connected for local sensing.

c. CHECK.- The output voltage reading should change less than ±0.002% from the reading recorded in step b.

d. Depress the STANDBY pushbutton. Remove the 40 Ohm load resistor.

15. Check 100V Amplifier Load Regulation.

a. SETUP.- Depress the 1KHZ FREQUENCY RANGE pushbutton. Set the OUTPUT VOLTAGE switches to 200000. Depress the 100V VOLTAGE RANGE pushbutton.

b. PROCEDURE.- Set the Precision AC Voltmeter to read the output voltage. Record the reading. Connect a 400 Ohm Precision Load resistor across the OUTPUT terminals with the Calibrator connected for local sensing.

c. CHECK.- The output voltage reading should change less than ±0.002% from the reading recorded in step b.

d. PROCEDURE.- Depress the STANDBY pushbutton and disconnect the 400 Ohm load resistor. Set the OUTPUT VOLTAGE switches to (10)00000. Depress the 100V VOLTAGE RANGE pushbutton. Record the output voltage reading. Connect a 2,000 Ohm Precision Load resistor across the OUTPUT terminals with the Calibrator connected for local sensing.

e. CHECK.- The output voltage reading should change less than ±0.002% from the reading recorded in step d.

f. Depress the STANDBY pushbutton and remove the 2,000 Ohm load resistor. Disconnect the Precision AC Voltmeter.

NOTE

The following performance measurements require lengthy AC/DC transfer measurements to be made at a large number of voltage and frequency settings. This is necessary to verify the absolute accuracy and frequency response using a Thermal Transfer Standard. However, an alternate method which checks the absolute accuracy and frequency response on the 10V range and then compares the other ranges with the 10V range using the Precision AC Voltmeter can be used. This is possible since the identical output voltage settings can be obtained on two adjacent voltage ranges and compared. For example, 100000 on the 10V range and (10)00000 on the 1 volt range sets the AC-110 output to 1 volt. To perform this alternate procedure proceed as follows:

(1) Check the absolute accuracy and frequency response on the 10V range following step 16 below.
(2) Null the Precision AC Voltmeter at the 1V setting on the 10V range.
(3) Set the OUTPUT VOLTAGE switches to (10)00000 and depress the 1V VOLTAGE RANGE pushbutton.
(4) The 1V range error can now be determined by nulling the Precision AC Voltmeter using the ERROR DETERMINATION controls. Error percentage is read directly on the % ERROR potentiometer.
(5) The 1V range can then be compared to the 100MV range and the 100MV range compared to the 10MV range. The 100V range can be compared to the 10V range.
(6) The above steps can then be repeated at each of the frequency settings given in table 5-4 to complete the frequency response test.

16. Check 10V Range Accuracy.

a. SETUP.- Connect the DC Voltage Standard to the Thermal Transfer Standard. Connect the Thermal Transfer Standard to the Calibrator OUTPUT terminals and connect the AC-110 for remote sensing.

CAUTION

Because of the high degree of accuracy required for the following measurements interconnection of the test instruments is critical. Use remote sensing between the DC Voltage Standard and Thermal Transfer Standard as well as between the AC-110 and the Thermal Transfer Standard. Significant error could be introduced by the IR drop of the load leads. If the Precision DC Voltmeter is used to monitor the DC Standard Voltage, measurements must be made at the point where the DC Standard remote sense leads are connected to the load leads.

b. Make several DC reversal error measurements on the Thermal Transfer Standard (refer to the Thermal Transfer Standard handbook for the procedure). Divide the measured error by 2 and record the result for use as the corrected zero (null) in the following steps.

c. Set the DC Voltage Standard for a 10 volt output. Depress the Calibrator 10KHZ FREQUENCY RANGE pushbutton. Set the OUTPUT VOLTAGE switches to (10)00000 and press the 10V VOLTAGE RANGE pushbutton. Select the 0.3% ERROR RANGE.

d. PROCEDURE.- With the Transfer Standard set to the DC TRANSFER MODE, null the galvanometer to the corrected zero point determined above. Switch the Transfer Standard to the AC TRANSFER MODE and adjust the Calibrator INDICATED ERROR switch and % ERROR potentiometer for a true zero (null) reading on the galvanometer (do not adjust the Transfer Standard reference controls while in the AC mode). Record the setting of the % ERROR potentiometer. Switch the Transfer Standard back to the DC TRANSFER MODE and check to see if the DC Standard Voltage has drifted from the corrected null setting. If it has, it will be necessary to repeat the above transfer measurements until a reasonable degree of repeatability is achieved. Normally this will be when three close readings (within 0.01%) are made out of four attempts. Compute the average of the % ERROR potentiometer settings.

e. CHECK.- After three near identical transfers have been obtained the average of these three % ERROR readings should be less than ±0.02%.

f. Depress the STANDBY pushbutton.

g. PROCEDURE.- Repeat the procedure given in step d at the 10V setting for the frequency settings given in table 5-4. Use the ERROR DETERMINATION controls to obtain a null of the Thermal Transfer Standard in the AC TRANSFER MODE.

CAUTION

Depress the STANDBY pushbutton before changing the Calibrator frequency settings. After a new setting has been made depress the VOLTAGE RANGE pushbutton and 0.3% ERROR RANGE pushbutton to restore the output voltage.

h. CHECK.- For each of the frequency settings, the error percentage indicated on the ERROR DETERMINATION controls should be less than shown in table 5-4.

TABLE 5-4. FREQUENCY SETTINGS FOR VOLTAGE ACCURACY TESTS.

FREQUENCY	FREQUENCY RANGE	ERROR READING
1000	100HZ	-0.1% to +0.1%
2000	100HZ	-0.05% to +0.05%
5000	100HZ	-0.02% to +0.02%
1000	100KHZ	-0.02% to +0.02%
2000	100KHZ	-0.02% to +0.02%
5000	100KHZ	-0.05% to +0.05%
(10)000	100KHZ	-0.05% to +0.05%
(10)000	1MHZ*	-0.50% to +0.50%

*with option W only. **use 3% ERROR RANGE.

i. Depress the STANDBY pushbutton.

NOTE

The accuracy specifications of the AC-110 closely approximate that of the most accurate transer standards currently available. To improve the accuracy of these transfer measurements a test report and calibration record of the transfer standard can be obtained from the manufacturer. These correction figures given in the test report can then be subtracted from the error measured for the AC-110. For example, if the manufacturer's test report shows a -0.01% error at 1kHz and the measured AC-110 error was -0.023%, the corrected error is -0.13%.

17. Check 1V Range Accuracy.

a. PROCEDURE.- Set the DC Voltage Standard for a 1 volt output. Repeat the procedure given in steps 16c through 16f except using the 1V VOLTAGE RANGE on the Calibrator.

18. Check 100V Range Accuracy (to 50kHz).

a. PROCEDURE.- Set the DC Voltage Standard for a 100 volts output. Repeat the procedure given in steps 16c through 16i except using the 100V VOLTAGE RANGE on the Calibrator. Use table 5-4 with the exception of the 100kHz and 1MHz frequency settings.

NOTE

The accuracy of the Thermal Transfer Standard is not adequate for frequencies of over 50kHz at the 100V setting.

19. Check 100kHz Accuracy at 50V.

a. PROCEDURE.- Set the DC Voltage Standard for a 50 volt output. Set the Calibrator OUTPUT VOLTAGE switches to 50.0000. Set the FREQUENCY selector switches to (10)000 and depress the 100kHz FREQUENCY RANGE pushbutton. Select the 0.3% ERROR RANGE. Repeat the procedure given in step 16d.

b. CHECK.- After three near identical transfers have been obtained the average of these three % ERROR readings should be less than ±0.05%.

c. Depress the STANDBY pushbutton.

20. Check 1MHz Accuracy at 50V (with option W only).

a. SETUP.- Connect the High Frequency Thermal Converter to the Transfer Standard for the following measurements.

b. PROCEDURE.- Set the DC Voltage Standard for a 50 volt output. Depress the 1MHZ FREQUENCY RANGE pushbutton with the frequency selector switches set to (10)000. Set the OUTPUT VOLTAGE switches to 50.0000. Select the 3% ERROR RANGE. Repeat the procedure given in step 16d.

c. CHECK.- After three near identical transfers have been completed the average of these three % ERROR readings should be less than ±0.5%.

d. Depress the STANDBY pushbutton. Disconnect the DC Voltage Standard and Thermal Transfer Standard.

5-17. This completes the Performance Measurements for the Model AC-110. If the Absolute AC Voltage Calibrator met all of the CHECK steps it is in calibration and meets the accuracy specifications given in table 1-1.

SECTION VI
CALIBRATION

6-1. GENERAL.

6-2. Complete calibration instructions for the Model AC-110 are given in this section of the manual. The following procedures will calibrate the Absolute AC Voltage Calibrator to the performance specifications given in table 1-1. It is suggested that the AC-110 only be calibrated when after completing the Performance measurements procedure given in section 5 it is determined that calibration adjustments are necessary.

6-3. CALIBRATION FREQUENCY.

6-4. The Model AC-110 should be checked to the performance measurements given in section 5 and calibrated when necessary, every 90 days of operation to insure proper performance when the Absolute AC Voltage Calibrator is being used as a standard for calibrating and testing AC measuring instruments.

6-5. TEST EQUIPMENT REQUIRED.

6-6. The test instruments required to complete these procedures are listed in table 6-1. Specifications given for each instrument are the minimum required and should alternate instruments be substituted they must meet or exceed these specifications.

6-7. CALIBRATION PROCEDURE.

6-8. GENERAL. The calibration procedures are arranged in a sequence which allows the Model AC-110 to be calibrated with minimum interaction of adjustments. If the measured performance is within the limits defined in the CHECK step, it is recommended that no further adjustments be made. However, it if is necessary to obtain maximum overall performance of the Model AC-110 then each adjustment can be made to the exact setting, even though the measurement falls

TABLE 6-1. REQUIRED TEST EQUIPMENT.

TEST EQUIPMENT	SPECIFICATIONS	MODEL NO.
Variable Autotransformer	Range: 103 to 127 volts rms; Power: 230 watts maximum.	General Radio Type W10MT3W
DC Voltmeter	Range: to 100 volts full scale; Resolution: 1mV; Must provide a high degree of AC isolation.	Universal Avometer Model 8
Oscilloscope	Frequency range: DC to 1MHz; Accuracy: 3%; Sensitivity: 1mV per centimeter.	Tektronix Model 561B w/10:1 Attenuation Probe
Precision AC Voltmeter	Short term stability: 50ppm/hr; Resolution: 0.002% of range; Voltage range: 0 to 100 volts rms.	Fluke Model 931AB
Digital Reciprocal Counter	Accuracy: 1×10^{-5}; 6 digits; Frequency range: 10Hz to 1MHz.	General Radio Type 1159
Thermal Transfer Standard	Frequency response: ±0.01% from 10Hz to 100kHz; DC reversal error: less than 0.025%; Voltage range: 0 to 50 volts rms.	Fluke Model 540B
DC Voltage Standard	Accuracy: ±0.002%; Voltage range: 1 to 50 volts.	Fluke Model 332B
Precision DC Voltmeter	Accuracy: 25ppm of input + 1ppm of range; Range: to 50V; Resolution: 10ppm of range.	Fluke Model 887A
Precision 40 Ohm Load	40 Ohms, ±1.0%, 1/2W.	
Precision 200 Ohm Load	200 Ohms, ±1.0%, 1W.	
Precision 400 Ohm Load	400 Ohms, ±1.0%, 2W.	
Precision 2,000 Ohm Load	2,000 Ohms, ±1.0%, 10W.	

within the specification limits given in the CHECK step.

6-9. TEST SETUP AND WARM UP. The following steps describe the initial setup to be made before proceeding with the calibration procedures.

1. Remove the Calibrator unit from the rack mounting cabinet (if supplied) and disconnect all interconnecting cables to the 100V Power Amplifier.

2. Remove the top cover from the Calibrator by removing the 11 pan head screws.

3. Remove the bottom cover from the Calibrator by removing the 11 pan head screws.

4. Place the instrument on a convenient insulated working surface.

5. Connect the Autotransformer to a 115 volts AC power source and set the power switch to on. Set the Autotransformer to exactly 115 volts rms.

6. Connect the Calibrator AC line cord to the Autotransformer. Depress the Calibrator POWER switch to ON.

7. Connect the 100V Power Amplifier AC line cord to a suitable power source. (do not interconnect the 100V Power Amplifier and Calibrator at this time)

8. Allow the Model AC-110 to warm up for 1½ hours at 25°C, ±5°C, prior to making calibration adjustments or measurements.

6-10. <u>CALIBRATOR CALIBRATION PROCEDURE.</u>

6-11. +5 VOLTS POWER SUPPLY ADJUSTMENT. The following steps calibrate the Regulator Board (A5) +5 volts and checks the -6 volts. The adjustment location is shown in figure 6-1.

1. TEST EQUIPMENT.

   a. DC Voltmeter.

2. TEST SETUP.

   a. Connect the DC Voltmeter to the +5 volts test point, terminal 3 on the A5 board assembly, and ground, terminal 5.

3. CHECK +5 VOLTS.

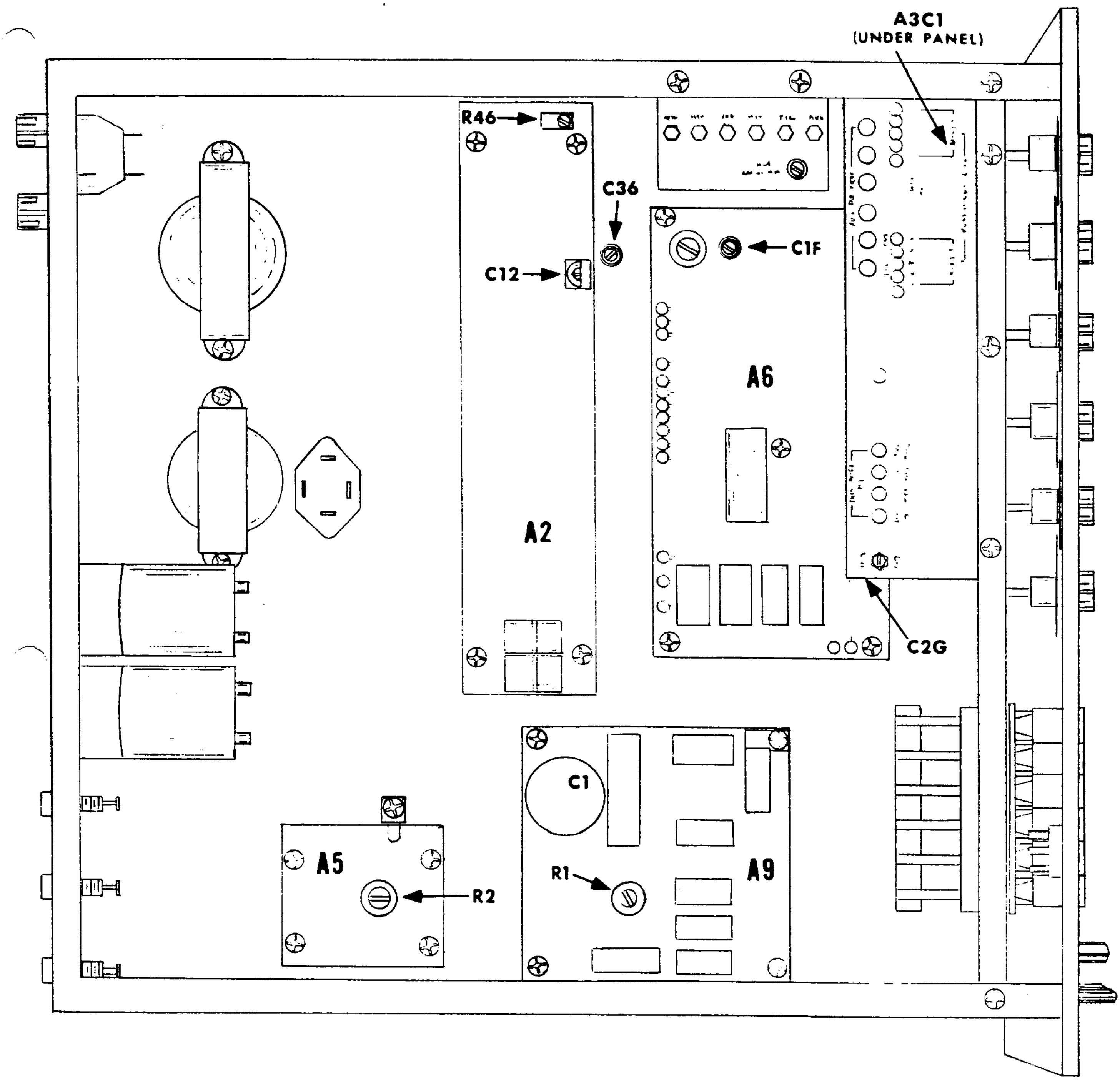


Figure 6-1. Adjustment Locations, Bottom View.

a. The voltage reading on the DC Voltmeter should be between +4.75 and +5.25 volts.

4. CALIBRATION.

a. If not, adjust A5R2 for exactly +5.00 volts.

5. TEST SETUP.

a. Connect the DC Voltmeter to the -6 volts test point (terminal 7 on the A5 board assembly) and ground (terminal 5).

6. CHECK -6 VOLTS.

a. The voltage reading on the DC Voltmeter should be between -5.4 and -7.2 volts.

NOTE

The -6 volts is not adjustable. If the voltage reading exceeds the CHECK step, it will be necessary to trouble shoot the power supply circuit (A5).

7. Disconnect the DC Voltmeter.

6-12. +12 VOLTS POWER SUPPLY ADJUSTMENT. The following steps calibrate the +12 volts power supply on the Oscillator Board (A4). Adjustment location is shown in figure 6-2. Test points are located on the plate under the bottom cover.

1. TEST EQUIPMENT.

a. DC Voltmeter.

2. TEST SETUP.

a. Connect the DC Voltmeter to the +12 volts test point and GND.

3. CHECK +12 VOLTS.

a. The voltage reading on the DC Voltmeter should be between +11.4 and +12.6 volts.

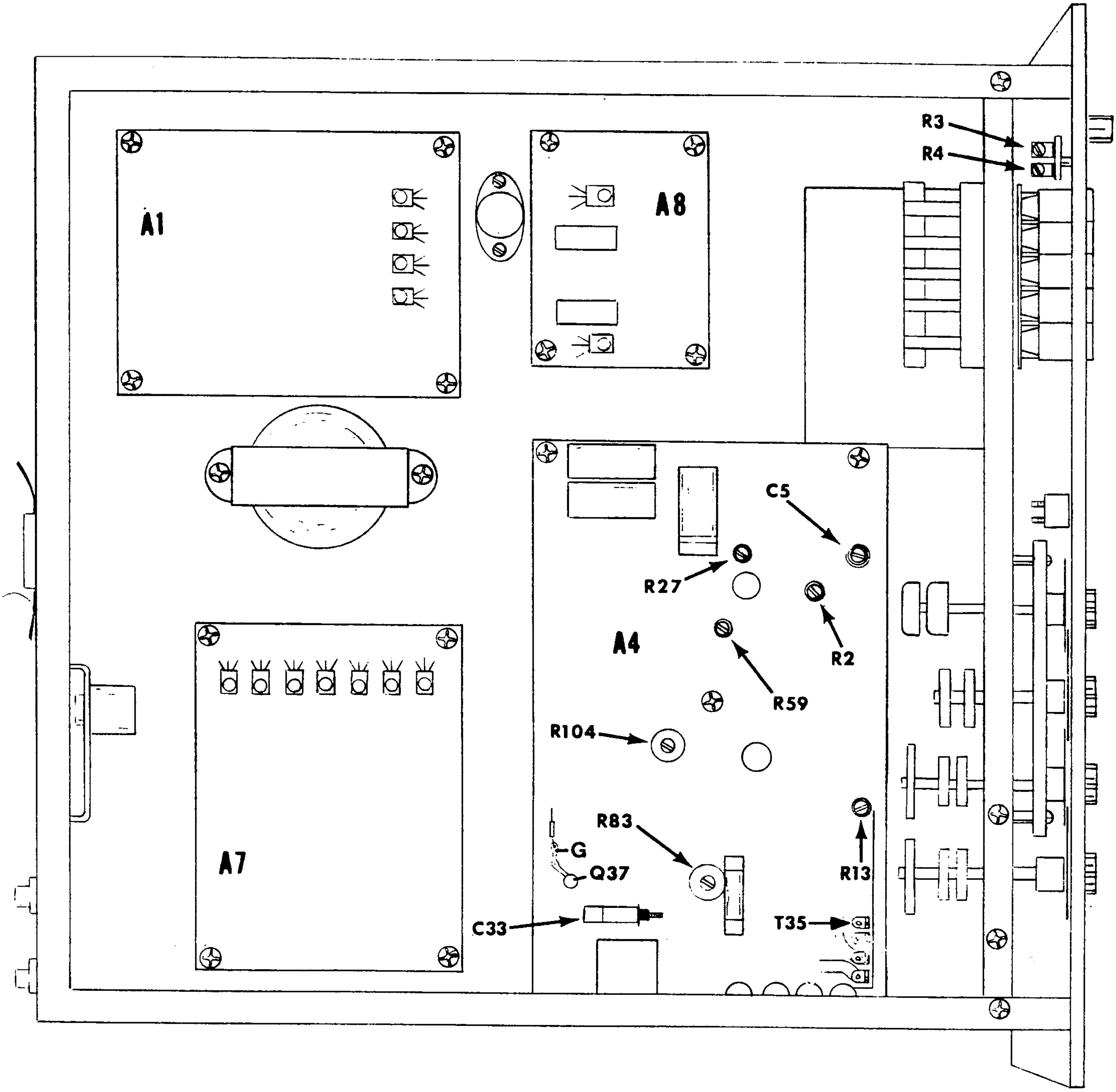


Figure 6-2 Adjustment Locations,
Top View.

4. CALIBRATION.

a. If not, adjust A4R59 for exactly +12.00 volts.

6-13. CHECK OSCILLATOR BOARD (A4) SUPPLY VOLTAGES. The following steps check the oscillator circuit regulated power supplies. These voltages are not adjustable and should the voltage readings exceed the check steps, it will be necessary to trouble shoot the power supply circuits. Test points are located on the plate under the bottom cover.

1. TEST EQUIPMENT.

a. DC Voltmeter.

2. TEST SETUP.

a. Connect the DC Voltmeter to the -12V and +53.8V test points.

3. CHECK -12 VOLTS.

a. DC Voltmeter reads between -11.4 and -12.6 volts on the -12V test point.

4. CHECK ~~+53.8~~ +49.5 VOLTS.

a. DC Voltmeter reads between ~~+51.0~~ +47.0 and ~~+56.5~~ +52.0 volts on the ~~+53.8V~~ +49.5V test point.

6-14. CHECK 10V AMPLIFIER (A2) POWER SUPPLIES. The following steps check the 10V Power Amplifier circuit DC supply voltages. These voltages are not adjustable and should the voltage reading exceed the check steps it will be necessary to trouble shoot the power supply circuits. The test points are located on the plate under the bottom cover.

1. TEST EQUIPMENT.

a. DC Voltmeter.

2. TEST SETUP.

a. Connect the DC Voltmeter to the +60V, +28V, -27V and -28V test points.

3. CHECK +60 VOLTS.

a. DC Voltmeter reads between 57 and 63 volts on the +60V test point.

4. CHECK +28 VOLTS.

a. DC Voltmeter reads between 22 and 30 volts on the +28V test point.

5. CHECK -27 VOLTS.

a. DC Voltmeter reads between -25 and -29 volts on the -27V test point.

6. CHECK -28 VOLTS.

a. DC Voltmeter reads between -22 and -30 volts on the -28V test point.

7. Disconnect the DC Voltmeter.

6-15. CALIBRATE OSCILLATOR CIRCUIT (A4) DC BALANCE. The following steps check the DC offset level of the oscillator circuit output. Test points and adjustment are located on plate under the bottom cover.

1. TEST EQUIPMENT.

a. DC Voltmeter.

2. TEST SETUP.

a. Connect the DC Voltmeter between the OSC DC BAL and GND test points.

3. CHECK DC LEVEL.

a. The DC voltage level should be less than ±10 millivolts.

4. CALIBRATION.

a. If not, adjust the OSC DC BAL ADJ (R80) for zero volt.

5. Disconnect the DC Voltmeter.

6-15A. QUADRATURE AMPLIFIER DC BALANCE. The following steps calibrate the DC level on the output of the quadrature amplifier and oscillator circuits when components have been replaced on the A4 board.

NOTE

The following calibration steps need only to be performed if a component(s) has been replaced on the A4 board or if R80 (paragraph 6-15) could not be adjusted for zero volt.

1. TEST EQUIPMENT.

   a. DC Voltmeter.

2. CHECK QUADRATURE AMPLIFIER DC BALANCE.

   a. Connect the DC Voltmeter to the rear panel OSC QUAD OUT connector.

   b. The DC level should be less than ±10 millivolts.

3. CALIBRATION.

   a. If not, adjust OSC DC BAL ADJ (R80) for zero volt.

4. CHECK OSCILLATOR CIRCUIT DC LEVEL.

   a. Connect the DC Voltmeter between the OSC DC BAL and GND test points.

   b. The DC level should be less than ±10 millivolts.

5. CALIBRATION.

   a. If not, adjust A4R27 for zero volt.

6. Repeat steps 2 through 5 until both DC balance adjustments are set for 0 volt.

7. Disconnect the DC Voltmeter.

6-16. CALIBRATE OSCILLATOR STAGE FEEDBACK. The following steps calibrate the positive feedback in the Oscillator stage. Refer to figure 6-2 for test point and adjustment locations.

1. TEST EQUIPMENT.

a. Oscilloscope.

b. 10:1 attenuation probe.

2. TEST SETUP.

a. Set the FREQUENCY switches to 1000 and depress the 100KHZ FREQUENCY RANGE pushbutton.

b. Connect the Oscilloscope using the 10:1 attenuation probe to terminal 35 of the A4 board (shown as T35 on figure 6-2).

3. CALIBRATION.

a. Adjust A4R13 for minimum signal level at terminal 35.

6-17. CALIBRATE SAMPLING PULSE WIDTH. The following steps check the amplitude and calibrate the width of the quadrature sampling pulse. Test point (G) and calibration location is shown in figure 6-2.

1. TEST EQUIPMENT.

a. Oscilloscope.

b. 10:1 attenuation probe.

2. TEST SETUP.

a. Connect the Oscilloscope using the 10:1 attenuation probe to the gate of A4Q37, identified as G on figure 6-2.

b. Set the FREQUENCY selector switches to 1000 and depress the 10KHZ FREQUENCY RANGE pushbutton.

3. CHECK SAMPLING PULSE AMPLITUDE.

a. The pulse amplitude should be greater than 6 volts P-P.

NOTE

No adjustment is provided for the pulse amplitude.

4. CHECK SAMPLING PULSE WIDTH.

a. The pulse width should be 20 microseconds, ±2 microseconds.

5. CALIBRATE PULSE WIDTH.

a. If not, adjust A4R83 for a pulse width of exactly 20 microseconds.

6. Disconnect the Oscilloscope.

6-18. CALIBRATE QUADRATURE SAMPLING PULSE POSITION. The following steps calibrate the position of the sampling pulse so that it is coincident with the negative peak of the Oscillator signal. Refer to figure 6-2 for location of the calibration adjustment.

1. TEST EQUIPMENT.

a. Precision AC Voltmeter.

b. Oscilloscope.

c. 10:1 Attenuation Probe.

2. TEST SETUP.

a. Connect the Precision AC Voltmeter to the OSC REF OUTPUT connector on the Calibrator rear panel.

b. Connect the Oscilloscope using the 10:1 Attenuation Probe to the SERVO OUT test point (located on plate under bottom cover).

c. Depress the 100kHz FREQUENCY RANGE pushbutton and set the FREQUENCY selector switches to 1000.

d. Adjust the Precision AC Voltmeter for a null reading.

3. CALIBRATE PULSE POSITION.

a. Adjust A4R104 for the lowest reading on the Precision AC Voltmeter (i.e., minimum AC output).

4. CALIBRATE PULSE COMPENSATION.

a. Adjust A4C33 for the correct waveshape as shown in figure 6-3.

5. RECALIBRATE PULSE POSITION.

a. Readjust A4R104 for the lowest reading on the Precision AC Voltmeter.

6. Disconnect the Precision AC Voltmeter and Oscilloscope.

6-19. CALIBRATE MODULATOR BIAS. The following steps calibrate the Servo Amplifier circuit bias. Refer to figure 6-2 for location of the calibration adjustment.

1. TEST EQUIPMENT.

a. DC Voltmeter..

2. TEST SETUP.

a. Connect the DC Voltmeter to the SERVO OUT test point (located on plate under bottom cover).

b. Set the FREQUENCY selector switches to 1000 and depress the 10KHZ FREQUENCY RANGE pushbutton.

3. CHECK.

a. The DC Voltmeter should read between 1.0 and 2.0 volts.

4. CALIBRATION.

a. If not, adjust A4R2 for 1.5 volts.

5. CHECK FREQUENCY FLATNESS.

a. Check that the DC Voltmeter reads between 1.0 and 2.0 volts when the 100KHZ, 1KHZ and 100Hz frequency ranges are selected. Adjustments are not provided for these ranges and should the servo voltage exceed the 1.0 to 2.0 volts range check the frequency determination capacitors A6C1 and A6C2 and the Servo Amplifier circuit.

6. Disconnect the DC Voltmeter.

6-20. OUTPUT FREQUENCY CALIBRATION. The following steps calibrate the output frequency on the standard Model AC-110 (3-digits). For four digit models, option B, use the procedure given in paragraph 6-20A.

1. TEST EQUIPMENT.

a. Digital Reciprocal Counter.

b. DC Voltmeter.

2. TEST SETUP.

a. Connect the Digital Reciprocal Counter to the OSC REF OUTPUT connector on the Calibrator rear panel.

b. Set the FREQUENCY selector switches to 1000 and depress the 10KHZ FREQUENCY RANGE pushbutton.

c. Adjust the VERNIER frequency control until the Digital Reciprocal Counter reads exactly 1,000 Hertz.

3. CHECK.

a. Depress the 100KHZ FREQUENCY RANGE pushbutton.

b. The Digital Reciprocal Counter should read between 9,900 and 10,100 Hertz.

4. CALIBRATION.

a. Connect the DC Voltmeter to the SERVO OUT test points.

b. Depress the 10KHZ FREQUENCY RANGE pushbutton and record the reading on the DC Voltmeter.

c. Depress the 100KHZ FREQUENCY RANGE pushbutton. While monitoring the Servo Amplifier bias voltage adjust A6C1F and A6C2G for exactly 10,000 Hertz.

NOTE

Variable capacitor adjustments C1F and C2G are interacting. Output frequency is determined by the product of the settings and the bias voltage is determined by the ratio of the settings. Therefore, 10KHz can be obtained at several settings. The correct calibrated setting is where the output frequency is within ±1.0% of 10kHz and the servo amplifier bias voltage is within ±0.25V of the voltage reading made at 1kHz.

5. CHECK 100KHZ.

a. Set the FREQUENCY selector switches to (10)000.

b. The Digital Reciprocal Counter should read between 99,000 and 101,000 Hertz.

6. CALIBRATION.

a. If not, adjust A4C5 for exactly 100,000 Hertz (shown in figure 6-2).

7. Repeat steps 2 through 4 and recalibrate the 10 kilohertz frequency setting if necessary.

8. Disconnect the Digital Reciprocal Counter and DC Voltmeter.

6-20A. OUTPUT FREQUENCY CALIBRATION (with option B). The following steps calibrate the output frequency when option B, accurate frequency, is included in the Model AC-110.

1. TEST EQUIPMENT.

a. Digital Reciprocal Counter.

2. TEST SETUP.

a. Connect the Digital Reciprocal Counter to the OSC REF OUTPUT connector on the Calibrator rear panel.

b. Depress the 10KHZ FREQUENCY RANGE pushbutton and set the FREQUENCY switches to 1000.

3. CHECK FREQUENCY CALIBRATION.

a. Set the VERNIER frequency control for a reading of exactly 1,000.0 Hertz on the Digital Reciprocal Counter.

b. Depress the FREQUENCY RANGE pushbuttons in sequence with the FREQUENCY switches set to (10)000 and record the reading for each range. See table 6-2.

TABLE 6-2. FREQUENCY TRACKING SETTINGS.

FREQUENCY SETTING	MEASUREMENT RANGE (HERTZ)	RECORDED READING
(10)0.00 Hz	99.900 to 100.100	
(10)00.0 Hz	999.00 to 1001.00	
(10)000. Hz	9990.0 to 10010.0	
(10)0.00 Hz	99700. to 100300.	

c. The 4 decade range readings should be within the measurement range in table 6-2.

d. If one or more of the readings exceeded the measurement range perform the frequency calibration procedure given in steps 4 through 7.

4. CALIBRATE 10KHZ RANGE.

a. Depress the 10KHZ RANGE pushbutton and set the FREQUENCY selector switches to (10)000.

b. The output frequency should be between 9,990 and 10,010 Hertz.

c. If not, adjust A1R90 (10KHZ on plate under bottom cover) for exactly 10,000 Hertz.

d. Set the FREQUENCY selector switches to 1000. Reset the VERNIER frequency control for 1,000.0 Hertz.

e. Step the frequency from 1kHz to 10kHz using the most significant FREQUENCY selector switch. The frequency reading for each setting should be within ±0.1% of the setting.

f. If not, adjust A1R90 at 10kHz and the VERNIER control at 1kHz until the most optimum tracking (i.e., linearity) is obtained.

5. CALIBRATE 100HZ RANGE.

a. Set the FREQUENCY selector switches to (10)000 and depress the 100HZ FREQUENCY RANGE pushbutton.

b. The output frequency should be between 99.9 and 100.1 Hertz.

c. If not, adjust A1R92 (100HZ on plate under bottom cover) for exactly 100.00 Hertz.

NOTE

If a Digital Frequency Counter is used in place of the Reciprocal Counter it must be used in the PERIOD mode for frequencies of less than 1 kilohertz to obtain better than 0.1% resolution without using time base settings longer than 10 seconds.

6. CALIBRATE 1KHZ RANGE.

a. Depress the 1KHZ FREQUENCY RANGE pushbutton.

b. The output frequency should be between 999.0 and 1001.0 Hertz.

c. If not, adjust A1R91 (1KHZ on plate under bottom cover) for exactly 1000.0 Hertz.

7. CALIBRATE 100KHZ RANGE.

a. Depress the 100KHZ FREQUENCY RANGE pushbutton.

b. The output frequency should be between 99,700 and 100,300 Hertz.

c. If not, adjust A1R89 (100KHZ on plate under bottom cover) for exactly 100,000 Hertz.

8. Disconnect the Digital Reciprocal Counter.

6-21. CHECK OSCILLATOR CIRCUIT FREQUENCY RESPONSE. The following steps check the frequency response and flatness of the oscillator circuit (A4). Adjustments are not provided for frequency response and should any of the CHECK steps exceed ±0.01% this indicates one of the frequency determination capacitor values has changed value. Also the sampling pulse position adjustment affects the 100KHZ range flatness and should only the 100KHZ range exceed ±0.01% readjusting A4R104 (see paragraph 6-18) may improve the frequency response for that range.

1. TEST EQUIPMENT.

a. Precision AC Voltmeter.

2. TEST SETUP.

a. Connect the Precision AC Voltmeter to the OSC REF OUTPUT connector on the rear panel.

b. Set the FREQUENCY selector switches to (10)000 and depress the 1KHZ FREQUENCY RANGE pushbutton.

c. Measure and record the amplitude reading. For convenience leave the Precision AC Voltmeter at the "null" setting.

3. CHECK 10KHZ RANGE.

a. Depress the 10KHZ FREQUENCY RANGE pushbutton and set the FREQUENCY selector switches to 1000.

b. The output amplitude should be within ±0.01% of the reading recorded in step 2c.

c. Set the FREQUENCY selector switches to (10)000.

d. Measure and record the output amplitude reading. For convenience leave the Precision AC Voltmeter at the "null" setting.

4. CHECK 100KHZ RANGE.

a. Depress the 100KHZ FREQUENCY RANGE pushbutton and set the FREQUENCY selector switches to 1000.

b. The output amplitude should be within ±0.01% of the reading recorded in step 3d.

5. CHECK 100HZ RANGE.

a. Depress the 1KHZ FREQUENCY RANGE pushbutton.

b. Measure and record the output amplitude reading. For convenience leave the Precision AC Voltmeter at the "null" setting.

c. Depress the 100HZ FREQUENCY RANGE pushbutton and set the FREQUENCY selector switches to (10)000.

d. The output amplitude should be within ±0.01% of the reading recorded in step 5b.

6. Disconnect the Precision AC Voltmeter.

6-22. CHECK DC REFERENCE VOLTAGE. This measurement checks the voltage of the reference zener diode.

1. TEST EQUIPMENT.

a. Precision DC Voltmeter.

2. TEST SETUP.

a. Connect the Precision DC Voltmeter to the DC REF test points on the Calibrator rear panel.

3. CHECK.

a. The DC voltage should be within ±(0.005% + Precision DC Voltmeter error) of the reading recorded on the rear panel decal.

4. Disconnect the Precision DC Voltmeter.

6-23. CALIBRATE ERROR DETERMINATION CONTROLS. The following steps check and calibrate if necessary the accuracy of the front panel ERROR DETERMINATION controls. Once the accuracy of these controls has been verified they can be used to make subsequent output amplitude calibration measurements.

1. TEST EQUIPMENT.

a. Precision AC Voltmeter.

2. TEST SETUP.

a. Connect the Precision AC Voltmeter to the front panel OUTPUT terminals.

b. Set the FREQUENCY selector switches to 1000 and depress the 10KHZ FREQUENCY RANGE pushbutton.

c. Set the VOLTAGE selector switches to (10)00000 and depress the 10V VOLTAGE RANGE pushbutton.

d. Depress the 0% ERROR RANGE pushbutton.

e. Measure and record the output amplitude using the Precision AC Voltmeter. For convenience leave the Precision AC Voltmeter at the "null" setting.

3. CHECK 0.3% RANGE.

9.97009V

a. Depress the STANDBY pushbutton and set the OUTPUT VOLTAGE switches to ~~9.97000V~~. Set the INDICATED ERROR switch to minus and the % ERROR potentiometer to 0.3% (fully clockwise).

b. Depress the 10V VOLTAGE RANGE and 0.3% ERROR RANGE pushbuttons. The Precision AC Voltmeter should read within ±9 millivolts of the reading recorded in step 2e.

4. CALIBRATION.

a. If not, adjust R4 until the Precision AC Voltmeter reads the exact voltage recorded in step 2e.

5. CHECK +0.3%.

(10).03009V

a. Depress the STANDBY pushbutton and set the OUTPUT VOLTAGE switches to ~~(10).03000V~~. Set the INDICATED ERROR switch to plus and the % ERROR potentiometer to 0.3% (fully clockwise).

b. Depress the 10V VOLTAGE RANGE and 0.3% ERROR RANGE pushbuttons. The Precision AC Voltmeter should read within ±9 millivolts of the reading recorded in step 2e.

c. If not, it will be necessary to repeat steps 3, 4 and 5 to optimize the calibration of R4 where the minus and plus polarities are both within ±9 millivolts of the reading recorded in step 2e, but are not necessarily exact.

d. Depress the STANDBY pushbutton.

6. CHECK +3.0%.

.30928V

a. Set the OUTPUT VOLTAGE switches to (10)~~.30000V~~. Set the INDICATED ERROR switch to plus and the % ERROR potentiometer to 3.0% (fully clockwise).

b. Depress the 10V VOLTAGE RANGE and 3.0% ERROR RANGE pushbuttons. The Precision AC Voltmeter should read within ±90 millivolts of the reading recorded in step 2e.

7. CALIBRATION.

a. If not, adjust R3 until the Precision AC Voltmeter reads the exact voltage recorded in step 2e.

8. CHECK -3.0% RANGE.

9.70374V a. Depress the STANDBY pushbutton and set the OUTPUT VOLTAGE switches to ~~9.70000V~~. Set the INDICATED ERROR switch to minus and the % ERROR potentiometer to 3.0% (fully clockwise).

b. Depress the 10V VOLTAGE RANGE and 3.0% ERROR RANGE pushbuttons. The Precision AC Voltmeter should read within ±90 millivolts of the reading recorded in step 2e.

c. If not, it will be necessary to repeat steps 6, 7 and 8 to optimize the calibration of R3 where the minus and plus polarities are both within ±90 millivolts of the reading recorded in step 2e, but are not necessarily exact.

d. Depress the STANDBY pushbutton and disconnect the Precision AC Voltmeter.

6-24. LOAD REGULATION ADJUSTMENT. The following steps calibrate the load regulation of the 10V output amplifier.

1. TEST EQUIPMENT.

a. Precision AC Voltmeter.

b. Precision 40 Ohm Load Resistor.

2. TEST SETUP.

a. Connect the Calibrator output terminals for local sensing.

b. Connect the Precision AC Voltmeter to the Calibrator OUTPUT terminals.

c. Set the FREQUENCY selector switches to (10)000 and press the 1KHZ FREQUENCY RANGE pushbutton.

d. Set the VOLTAGE selector switches to 200000. Depress the 10V VOLTAGE RANGE pushbutton.

3. CHECK.

a. Set the Precision AC Voltmeter for a null.

b. Connect the Precision Load Resistor across the OUTPUT terminals and record the change in amplitude.

c. The no load to full load amplitude change should be less than ±0.002%.

4. CALIBRATION.

a. If not, adjust LOAD REG ADJ until the amplitude change from no load to full load is less than ±0.002%.

6-25. CHECK MASTER AMPLITUDE CALIBRATION. The following steps verify the amplitude calibration of the AC-110 at the full scale output voltage setting of 10 volts rms using the Thermal Transfer Standard.

1. TEST EQUIPMENT.

a. Thermal Transfer Standard.

b. DC Voltage Standard.

2. TEST SETUP.

a. Connect the DC Voltage Standard to the Thermal Transfer Standard using remote sensing.

b. Connect the Thermal Transfer Standard to the Calibrator OUTPUT terminals and connect for remote sensing.

CAUTION

> Because of the high degree of accuracy required for the following measurements, interconnection of the test instruments is critical. Use remote sensing between the DC Voltage Standard and Thermal Transfer Standard as well as between the Calibrator and the Thermal Transfer Standard. Significant error can be introduced by the IR drop in the load leads. If the Precision DC Voltmeter is used to monitor the DC Standard voltage, measurements must be made at the point where the DC Standard remote sense leads are connected to the load leads.

c. Set the OUTPUT switch to FLOATING.

d. Set the FREQUENCY selector switches to (10)000 and depress the 1KHZ FREQUENCY RANGE pushbutton.

e. Make several DC reversal error measurements on the Thermal Transfer Standard (refer to the Transfer Standard handbook for the procedure). Divide the measured error by 2 and record the result to use as the corrected zero (null) setting in the following steps.

f. Set the DC Voltage Standard for a 10 volt output.

g. Depress the Calibrator 10V VOLTAGE RANGE and 0.3% ERROR RANGE pushbuttons.

3. CHECK.

a. With the Transfer Standard set to the DC TRANSFER MODE, null the galvanometer to the corrected zero point determined above. Switch the Transfer Standard to the AC TRANSFER MODE and adjust the Calibrator INDICATED ERROR switch and % ERROR potentiometer for a true zero (null) reading on the galvanometer (do not adjust the Transfer Standard reference controls while in the AC mode). Record the setting of the % ERROR potentiometer. Switch the Transfer Standard back to the DC TRANSFER MODE and check to see if the DC Standard voltage has drifted from the corrected zero setting. If it has, it will be necessary to repeat the above transfer measurement until a reasonable degree of repeatability is achieved. Normally this will be when three close readings (within 0.01%) are made out of four attempts. Compute the average of the % ERROR potentiometer settings. This average should be less than ±0.02%.

4. CALIBRATION.

a. If not, depress the 0% ERROR RANGE pushbutton and adjust the rear panel MASTER AMPLITUDE ADJUST (10HZ to 100KHZ) for exactly 10.0000 volts using the Thermal Transfer Standard.

6-26. CHECK LADDER ATTENUATOR LINEARITY. The following steps check the linearity of the 6 digit ladder attenuator network. Normally it should not be necessary to calibrate the attenuator due to the inherent stability of the components used.

1. TEST EQUIPMENT.

a. Thermal Transfer Standard.

b. DC Voltage Standard.

c. Precision AC Voltmeter.

2. TEST SETUP.

a. Connect the DC Voltage Standard and Thermal Transfer Standard as described in paragraph 6-25.

b. Connect the Precision AC Voltmeter to the Calibrator at the point where the remote sensing leads are connected to the load leads.

NOTE

The linearity calibration procedures below involve a large number of length transfer measurements. To simplify the measurements an alternate method using the Precision AC Voltmeter can be used. Set the AC-110 for a 10 volt output (accuracy was verified in paragraph 6-25). Using a Precision Ratio Transformer connected to the AC-110, the deviation of the Precision AC Voltmeter can be checked and recorded for voltages of down to 100 millivolts. The linearity measurements can then be performed with the Precision AC Voltmeter using the recorded deviation error to correct the reading for each measurement.

3. CHECK.

a. Depress the 10V VOLTAGE RANGE pushbutton.

b. The output amplitude should be within ±0.005% of the setting for the following OUTPUT VOLTAGE switch settings:

9.9999(10)
9.99999
8.88888
7.77777
6.66666
5.55555
4.44444
3.33333
2.22222
1.11111
1.00000

c. If the above voltage settings are not within ±0.005% it will be necessary to adjust the linearity of the ladder attenuator using the following calibration procedures. If the settings are within ±0.005% the ladder attenuator calibration steps given below in steps 4 through 9 will not be necessary.

4. CALIBRATION OF 1st DIGIT LINEARITY.

a. Set the OUTPUT VOLTAGE switches to the following settings. Measure and record the voltage using the Thermal Transfer Standard

8.00000
4.00000
2.00000
1.00000

b. The output amplitude for the above settings should be within 0.005%. If they are proceed with step 5.

c. If not, calibrate the 1st digit linearity as follows:

(1) Set the OUTPUT VOLTAGE switches to 8.00000V. Adjust the DECADE 1

"8" potentiometer for 8 volts, ±0.0004 volt, using the Thermal Transfer Standard.

(2) Set the OUTPUT VOLTAGE switches to 4.00000V. Adjust the DECADE 1 "4" potentiometer for 4 volts, ±0.0002 volt.

(3) Set the OUTPUT VOLTAGE switches to 2.00000V. Adjust the DECADE 1 "2" potentiometer for 2 volts, ±0.0001 volt.

(4) Set the OUTPUT VOLTAGE switches to 1.00000V. Adjust the DECADE 1 "1" potentiometer for 1 volt, ±0.00005 volt.

NOTE

The above calibration adjustments are interacting and steps (1) through (4) should be repeated until the 8-4-2-1 settings are all within ±0.005%.

5. CALIBRATE 2nd DIGIT RANGE.

a. Set the OUTPUT VOLTAGE switches to 1.00000. Depress the 10V VOLTAGE RANGE pushbutton. Set the Precision AC Voltmeter for a null.

b. Set the OUTPUT VOLTAGE switches to 0.(10)0000. The output amplitude should be within ±0.00005 volt of the reading in step 5a.

c. If not, adjust DECADE 2 "RANGE" until the readings in steps 5a and 5b are within ±0.00005 volt of each other.

6. CALIBRATE 2nd DIGIT LINEARITY.

a. Set the OUTPUT VOLTAGE switches to the following settings. Measure and record the output amplitude using the Thermal Transfer Standard.

0.80000
0.40000
0.20000
0.10000

b. The output amplitude for the above settings should be within ±0.005%. If they are proceed with step 7.

c. If not, calibrate 2nd digit linearity as follows:

(1) Set the OUTPUT VOLTAGE switches to 0.80000. Adjust the DECADE 2 "8" potentiometer for 0.8 volt, ±0.00004 volt using the Thermal Transfer Standard.

(2) Set the OUTPUT VOLTAGE switches to 0.40000. Adjust the DECADE 2 "4" potentiometer for 0.4 volt, ±0.00002 volt.

(3) Set the OUTPUT VOLTAGE switches to 0.20000. Adjust the DECADE 2 "2" potentiometer for a 0.2 volt, ±0.00001 volt output.

(4) Set the OUTPUT VOLTAGE switches to 0.10000. Adjust the DECADE 2 "1" potentiometer for a 0.1 volt, ±0,000005 volt output.

NOTE

The above calibration adjustments are interacting and steps (1) through (4) should be repeated until the 8-4-2-1 settings are within ±0.005%.

7. CALIBRATE 3rd DIGIT RANGE.

a. Set the OUTPUT VOLTAGE switches to 0.10000. Depress the 10V VOLTAGE RANGE pushbutton. Set the Precision AC Voltmeter for a null.

b. Set the OUTPUT VOLTAGE switches to 0.0(10)000. The output amplitude should be within ±0.000005 volt of the reading in step 7a.

c. If not, adjust DECADE 3 RANGE CAL until the readings in steps 7a and 7b are within ±0.000005 volt of each other.

8. CHECK 3rd DIGIT LINEARITY.

a. Set the OUTPUT VOLTAGE switches to the following settings. Measure and record the readings using the Thermal Transfer Standard.

0.19000
0.18000
0.17000
0.16000
0.15000
0.14000
0.13000
0.12000
0.11000
0.10(10)00

b. The output amplitude for the above settings should be within ±0.01%.

9. CHECK 4th DIGIT LINEARITY.

a. Set the OUTPUT VOLTAGE switches to the following settings. Measure and record the readings using the Thermal Transfer Standard.

0.10900
0.10800
0.10700
0.10600
0.10500
0.10400
0.10300
0.10200
0.10100

b. The output amplitude for the above settings should be within ±0.01%.

NOTE

Linearity adjustments are not provided for the 3rd and 4th digits. Should the measurements made in steps 8 and 9 exceed the ±0.01% linearity specification it will be necessary to return the AC-110 to the factory for calibration or select ladder attenuator components.

10. Disconnect the Precision AC Voltmeter and Thermal Transfer Standard. Depress the STANDBY pushbutton.

6-27. CHECK 1V RANGE ACCURACY. The following steps verify the amplitude calibration on the 1 volt range. Since the accuracy of the 10 volt range and ladder attenuator have been verified with the Thermal Transfer Standard the Precision AC Voltmeter is used for an accurate comparison.

1. TEST EQUIPMENT.

a. Precision AC Voltmeter.

2. TEST SETUP.

a. Connect the Precision AC Voltmeter to the Calibrator OUTPUT terminals. Connect for local sensing.

b. Set the FREQUENCY selector switches to (10)000 and depress the 1KHZ FREQUENCY RANGE pushbutton.

c. Set the OUTPUT VOLTAGE switches to 100000. Depress the 10V VOLTAGE RANGE pushbutton.

d. Measure and record the output amplitude using the Precision AC Voltmeter. For convenience leave at the null setting.

3. CHECK.

a. Set the OUTPUT VOLTAGE switches to (10)00000 and depress the 1V VOLTAGE RANGE pushbutton.

b. The output amplitude should be within ±0.02% of the reading recorded in step 2d.

4. CALIBRATION.

a. If not, adjust 1V RANGE CAL (located on plate under bottom cover) until the readings in step 2d and 3b are within ±0.02% of each other.

5. Depress the STANDBY pushbutton and disconnect the Precision AC Voltmeter.

6-28. CHECK 100MV RANGE ACCURACY. The following steps verify the amplitude calibration on the 100 millivolt range using the Precision AC Voltmeter as a comparison device.

1. TEST EQUIPMENT.

a. Precision Inductive Divider.

b. Precision AC Voltmeter.

2. TEST SETUP.

a. Connect the Precision Inductive Divider to the Calibrator OUTPUT terminals with a series capacitor (refer to paragraph 3-37).

b. Connect the Precision AC Voltmeter to the output of the Precision Inductive Divider.

c. Set the divider ratio to 0.0100000.

d. Depress the 10V VOLTAGE RANGE pushbutton.

e. Measure and record the amplitude using the Precision AC Voltmeter. For convenience leave at the null setting.

f. Depress the STANDBY pushbutton and disconnect the Precision Inductive Divider.

3. CHECK.

a. Connect the "nulled" Precision AC Voltmeter to the Calibrator OUTPUT terminals.

b. Depress the 100MV VOLTAGE RANGE pushbutton.

c. The output amplitude should be within ±0.02% of the reading recorded in step 2e.

4. CALIBRATION.

a. If not, adjust A9R1 until the readings in steps 2e and 3c are within ±0.02% of each other.

5. Depress the STANDBY pushbutton and disconnect the Precision Inductive Divider and Precision AC Voltmeter.

6-29. CHECK HIGH FREQUENCY RESPONSE. The following steps check the high frequency response of the Calibrator.

1. TEST EQUIPMENT.

a. Precision AC Voltmeter.

2. TEST SETUP.

a. Connect the Precision AC Voltmeter to the Calibrator OUTPUT terminals.

b. Set the FREQUENCY selector switches to (10)000 and depress the 100KHZ (1MHZ with option B) FREQUENCY RANGE pushbutton.

c. Set the OUTPUT VOLTAGE switches to 100000. Depress the 10V VOLTAGE RANGE pushbutton.

d. Measure and record the output amplitude reading using the Precision AC Voltmeter. For convenience leave at the null setting.

3. CHECK.

a. Set the OUTPUT VOLTAGE switches to (10)00000 and depress the 1V VOLTAGE RANGE pushbutton.

b. The output amplitude should be within ±0.05% (±0.5% with option B) of the reading recorded in step 2d.

4. CALIBRATION.

a. If not, adjust A3C1 until the readings in steps 2d and 3b are within ±0.05% (±0.5% with option B) of each other.

5. Depress the STANDBY pushbutton and disconnect the Precision AC Voltmeter.

6-30. 10V AMPLIFIER LOW FREQUENCY RESPONSE. The following steps calibrate the low frequency response (10 to 50 Hertz) of the 10V Output Amplifier.

1. TEST EQUIPMENT.

a. Thermal Transfer Standard.

b. DC Voltage Standard.

2. TEST SETUP.

a. Connect the DC Voltage Standard to the Thermal Transfer Standard using remote sensing.

b. Connect the Thermal Transfer Standard to the Calibrator OUTPUT terminals and connect for remote sensing.

c. Set the OUTPUT switch for FLOATING.

d. Set the FREQUENCY selector switches to 5000 and depress the 100HZ FREQUENCY RANGE pushbutton.

e. Set the DC Voltage Standard for a 10 volt output.

f. Depress the Calibrator 10V VOLTAGE RANGE pushbutton.

3. CHECK 50HZ ACCURACY.

a. Measure the output amplitude using the Thermal Transfer Standard.

b. The amplitude should be between 9.9980 and 10.0020 volts rms.

4. CALIBRATION.

a. If not, adjust A2R4 for exactly 10.0000 volts rms.

5. CHECK FREQUENCY RESPONSE.

a. Measure the output amplitude using the Thermal Transfer Standard at FREQUENCY switch settings of 2000, 3000 and 4000.

b. The amplitude should be between 9.9980 and 10.0020 volts rms at each setting.

c. Set the FREQUENCY selector switches to 1000. Measure the output amplitude with the Thermal Transfer Standard.

d. The amplitude should be between 9.9950 and 10.0050 volts rms.

6. CALIBRATION.

a. If steps 5b and 5d exceed the specification range it will be necessary to readjust A2R4 to an optimized setting where the 10 to 50 Hertz frequency settings are all within the specification range, but are not necessarily exa...

7. Depress the STANDBY pushbutton and disconnect the Thermal Transfer Standard.

6-31. OUTPUT AMPLIFIER STABILITY CALIBRATION. The following steps calibrate the 10V Output Amplifier stability for capacitive loading conditions on the standard 100kHz AC-110. For option W, 1MHz, use the procedure given in paragraph 6-31A.

1. TEST EQUIPMENT.

a. Variable Air Capacitor.

b. Oscilloscope.

c. Thermal Transfer Standard.

d. DC Voltage Standard.

2. TEST SETUP.

a. Connect the Variable Air Capacitor across the Calibrator OUTPUT terminals. Connect for local sensing.

b. Connect the Oscilloscope to the Calibrator OUTPUT terminals.

c. Set the FREQUENCY selector switches to (10)000 and depress the 1KHZ FREQUENCY RANGE pushbutton.

d. Set the OUTPUT VOLTAGE switches to (10)00000 and depress the 10V VOLTAGE RANGE pushbutton.

3. CHECK.

a. Adjust the Variable Air Capacitor between 0 and 5,000 picofarads while observing the output waveform on the Oscilloscope. The Calibrator should not oscillate for any capacitance setting.

4. CALIBRATION.

a. If it does, adjust A2C12 until the oscillation stops. For optimum performance A2C12 should be set for minimum capacitance while maintaining a stable output over the capacitive loading range of 0 to 5,000 picofarads.

5. Depress the STANDBY pushbutton. Disconnect the Oscilloscope and Variable Air Capacitor.

6. CHECK HIGH FREQUENCY ACCURACY.

a. Connect the DC Voltage Standard to the Thermal Transfer Standard using remote sensing.

b. Connect the Thermal Transfer Standard to the Calibrator OUTPUT terminals and connect for remote sensing.

c. Depress the 100KHZ FREQUENCY RANGE pushbutton.

d. Depress the 10V VOLTAGE RANGE pushbutton.

e. The output amplitude should be between 9.9950 and 10.050 volts rms.

7. CALIBRATION.

a. If not, it will be necessary to readjust A2C12 and optimize the setting for capacitive loading stability at 1 kilohertz and amplitude accuracy at 100 kilohertz.

8. Depress the STANDBY pushbutton and disconnect the Thermal Transfer Standard.

6-32. OUTPUT AMPLIFIER STABILITY CALIBRATION (option W). The following steps calibrate the 10V Output Amplifier stability for capacitive loading conditions on the AC-110 with option W, 1MHz.

1. TEST EQUIPMENT.

a. Variable Air Capacitor.

b. Oscilloscope.

c. Thermal Transfer Standard.

d. DC Voltage Standard.

e. High Frequency Thermal Converter.

2. TEST SETUP.

a. Connect the Variable Air Capacitor across the Calibrator OUTPUT terminals. Connect for local sensing.

b. Connect the Oscilloscope to the Calibrator OUTPUT terminals.

c. Set the FREQUENCY selector switches to (10)000 and depress the 1KHZ FREQUENCY RANGE pushbutton.

d. Set the OUTPUT VOLTAGE switches to (10)00000 and depress the 10V VOLTAGE RANGE pushbutton.

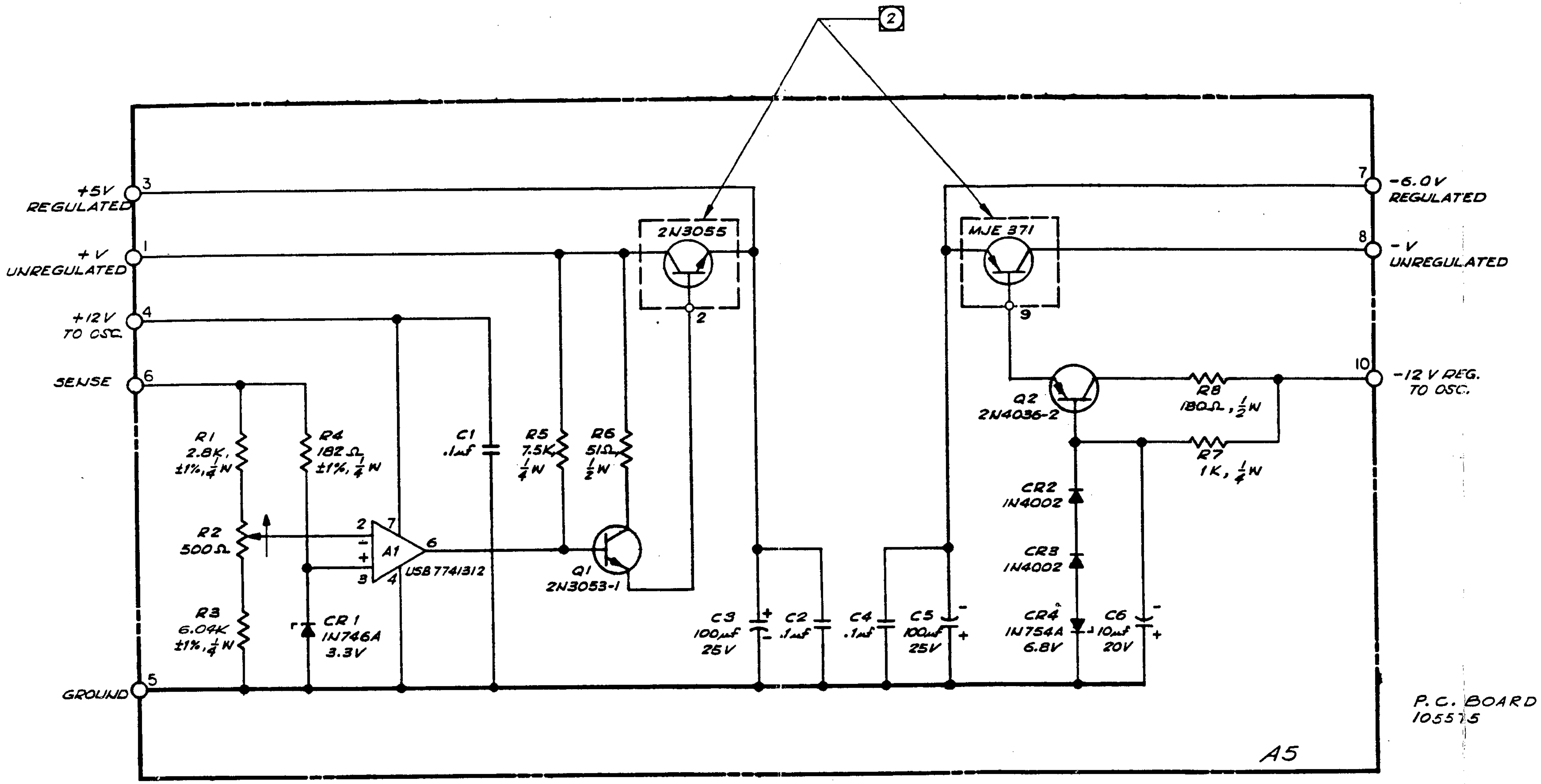
3. CHECK.

a. Adjust the Variable Air Capacitor between 0 and 5,000 picofarads while observing the output waveform on the Oscilloscope. The Calibrator should not oscillate for any capacitance setting.

4. CALIBRATION.

a. If it does, adjust A2C12 until the oscillation stops. For optimum performance A2C12 should be set for minimum capacitance while maintaining a stable output condition over the capacitive loading range of 0 to 5,000 picofarads.

REVISIONS			
SYM	DESCRIPTION	BY	DATE



2. SYMBOL [dashed box] ARE HEAT SINKED TO CHASSIS.

1. ALL RESISTORS ARE IN OHMS, ±5%.

NOTES: (UNLESS OTHERWISE SPECIFIED)

ITEM	QTY	DESCRIPTION	PART OR IDENTIFYING NO.	VENDOR	SPEC. / NO.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ±1/32 | DECIMALS XX ±.010, XXX ±.005 | ANGLES ±1°

MAKE FROM DRAWING NO.
MATERIAL
TREATMENT
FINISH

DRAWN	[signature]	4 Aug 69
CHECKED	[signature]	6/11/70
PROJECT DESIGNER		
PROJECT ENGINEER		
APPROVED	[signature]	7/7/70
CUSTOMER		
FIN. WT.		

OPTIMATION, INC.
SUN VALLEY, CALIF. 91352

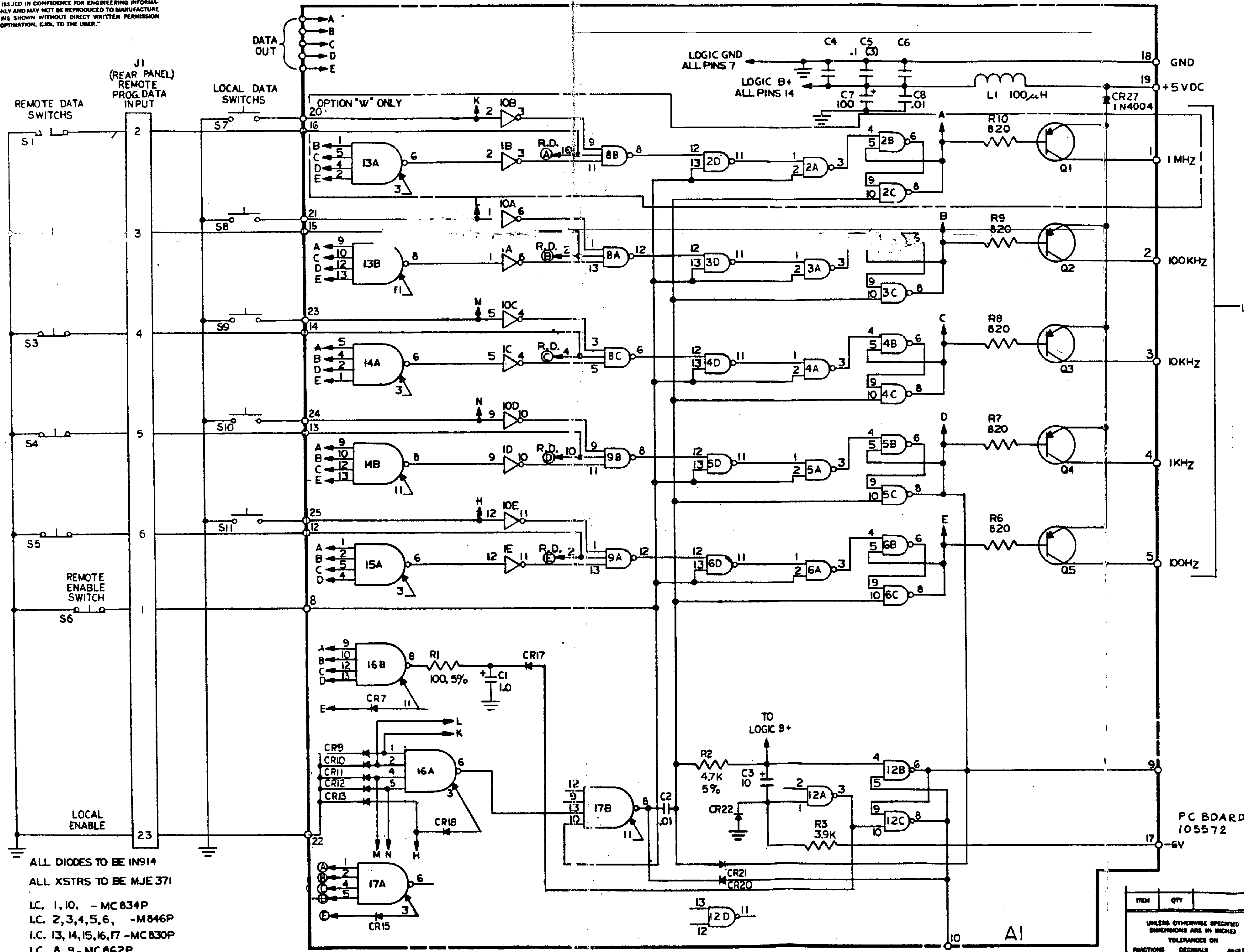
DRAWING NAME: SCHEMATIC, +5V & -6V (A5) POWER SUPPLY AND REGULATOR

MODEL: AC110 | DWG. SIZE: D | DRAWING NO.: 3265 | REV.:

NEXT ASSY: C908106 | SPEC. CONTROL NO.: | SCALE:

SHEET 1 OF 1

REVISIONS			
SYM	DESCRIPTION	BY	DATE
A	ADDED CR 24-28	DLM	12-30
B	PER ECO 291	TAG	2-21
C	REF. DESIG. NO. & TERM. NO. CHANGED	HAM	4-16



ALL DIODES TO BE IN914

ALL XSTRS TO BE MJE 371

I.C. 1, 10. - MC834P
I.C. 2,3,4,5,6, - MC846P
I.C. 13, 14, 15, 16, 17 - MC830P
I.C. 8, 9 - MC862P

HIGHEST REF DESIG.	REF. DESIG. NOT USED
R10	R4, R5
C8	
CR27	CR1, 2, 3, 4, 5, 6, 8, 14, 16, 19, 23, 24, 25, 26
Q5	Q6, Q7
M17	M7

1. ALL VALUES OF RESISTANCE IN OHMS, & CAPACITANCE IN MFD'S.

NOTES: (UNLESS OTHERWISE SPECIFIED)

ITEM	QTY	DESCRIPTION	PART OR IDENTIFYING NO.	VENDOR	SPEC.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/32, DECIMALS XX ± .010, XXX ± .005, ANGLES ± 1°

DRAWN 7/31/69 · CHECKED 7/30/69 · PROJECT DESIGNER · PROJECT ENGINEER 2/24/70 · APPROVED 7/1/70

MAKE FROM DRAWING NO. · MATERIAL · TREATMENT · FINISH · CUSTOMER

OPTIMATION, INC. SUN VALLEY, CALIF.

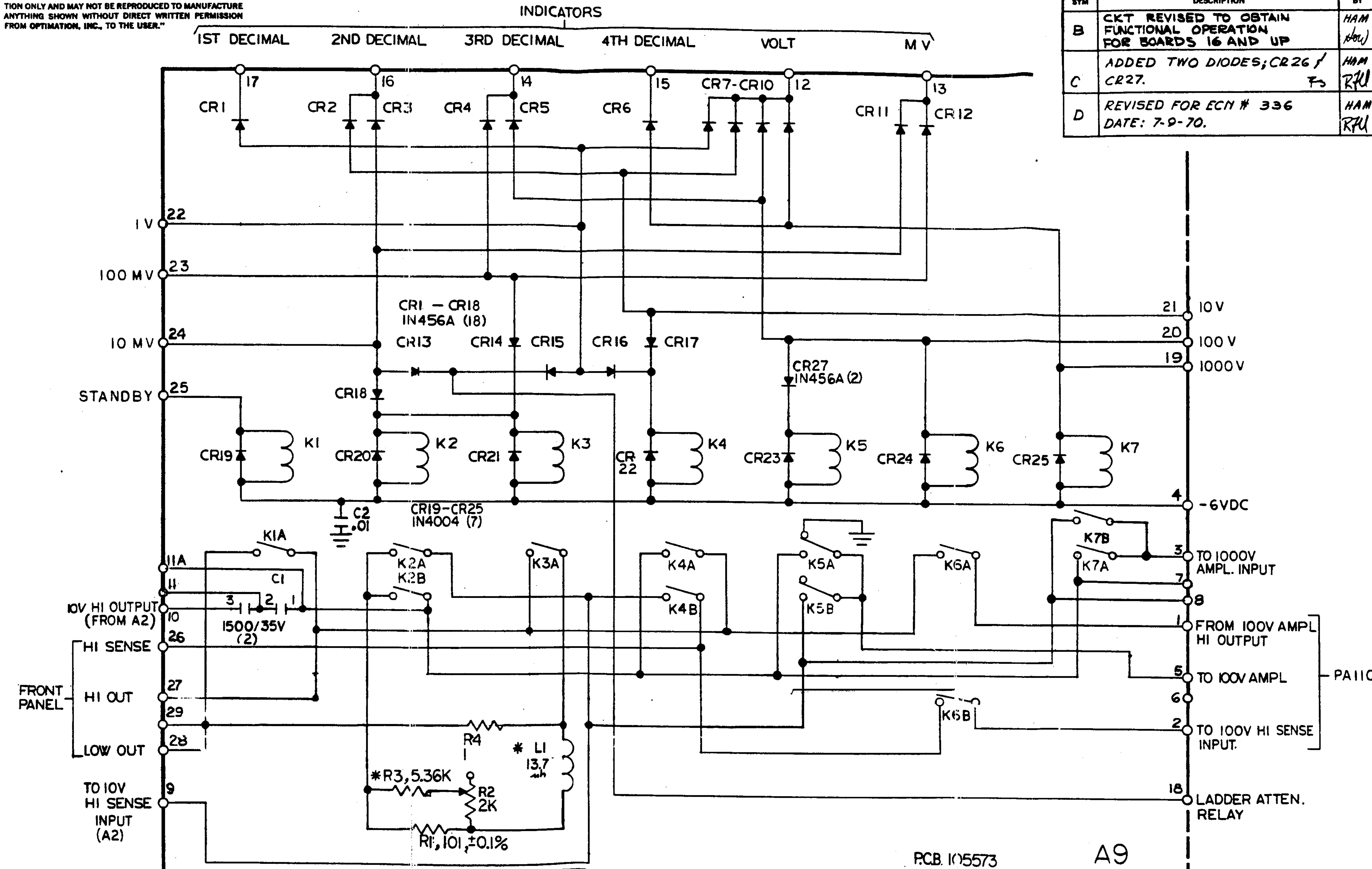
DRAWING NAME: SCHEMATIC DIAGRAM FREQ RANGE PROGRAMMING & INHIBIT LOGIC BOARD (A1)

MODEL: AC110 WITH "W" OPT. · SIZE D · DRAWING NO. 3261

NEXT ASSY 908101 · SCALE NONE · SHEET 1 OF 1

REVISIONS

SYM	DESCRIPTION	BY	DATE
B	CKT REVISED TO OBTAIN FUNCTIONAL OPERATION FOR BOARDS 16 AND UP	HAM	12-11-69
C	ADDED TWO DIODES; CR26 & CR27.	HAM RFU	4-28-70
D	REVISED FOR ECN # 336 DATE: 7-9-70.	HAM RFU	7-9-70 7/9/70



4. DENOTES COMMON ELECTRICAL GND ON INNER FLOATING CHASSIS.
3. (*) FACTORY SELECTED VALUE.
2. ALL RESISTORS ± 1%.
1. ALL VALUES OF RESISTANCE IN OHMS, AND CAPACITANCE IN MFDS.

NOTES: (UNLESS OTHERWISE SPECIFIED)

ITEM	QTY	DESCRIPTION	PART OR IDENTIFYING NO.	VENDOR	SPEC. / NO.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± 1/32 — DECIMALS XX ± .010, XXX ± .005 — ANGLES ± 1°

MAKE FROM DRAWING NO.
MATERIAL
TREATMENT
FINISH

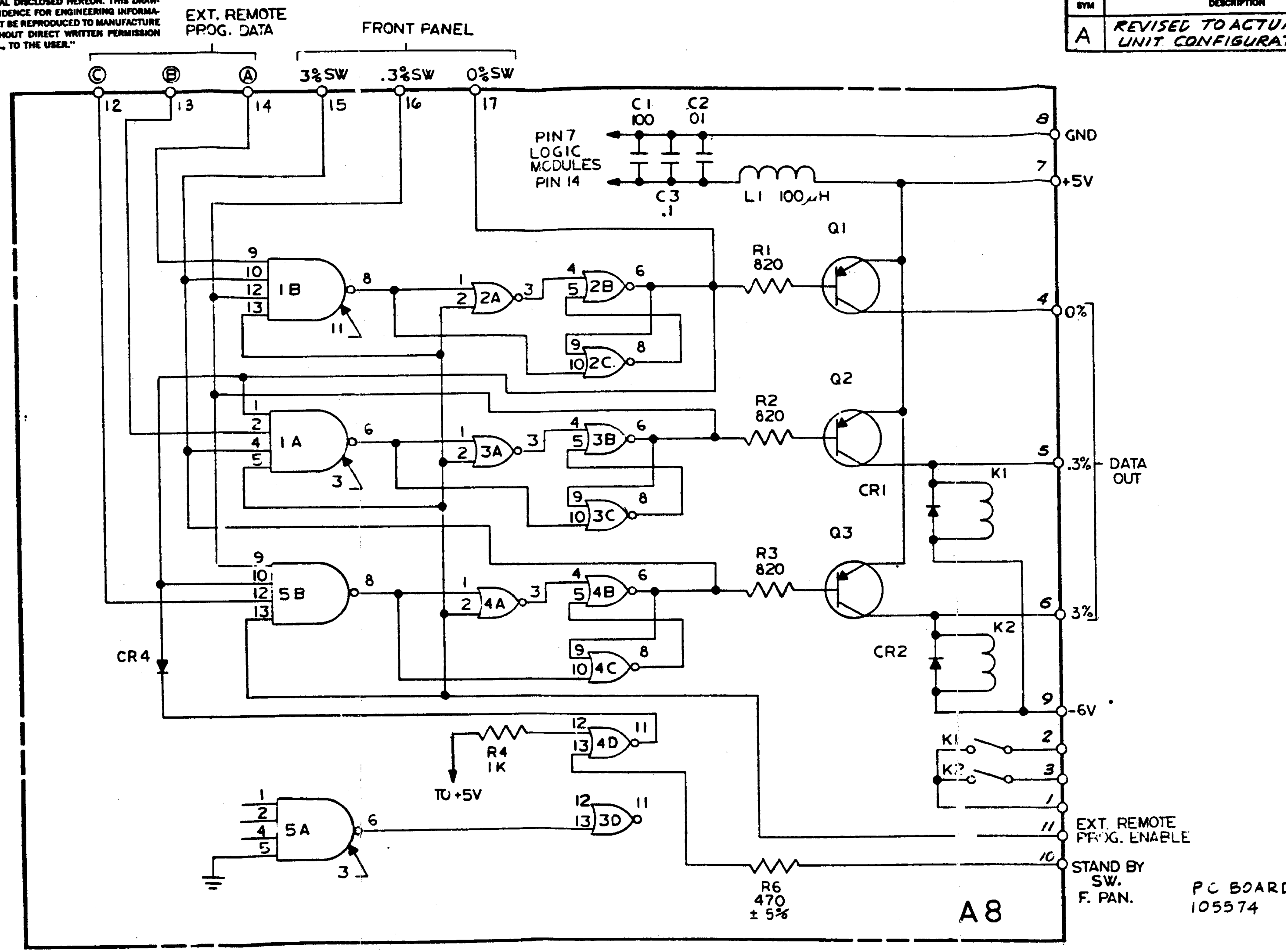
DRAWN: G. Arce 11-69
CHECKED: R.F. Ulmer 5/18/70
PROJECT DESIGNER
PROJECT ENGINEER
APPROVED: Haw 7/8/70
CUSTOMER
FIN. WT.
NEXT ASSY C908109

OPTIMATION, INC.
SUN VALLEY, CALIF. 91352

DRAWING NAME: SCHEMATIC DIAGRAM VOLTAGE RANGE SWITCHING BD. A9
MODEL: AC 110
DWG. SIZE: C
DRAWING NO.: 3264
REV.: D
SHEET 1 OF 1

"OPTIMATION, INC., CLAIMS PROPRIETARY AND/OR PATENT RIGHTS IN THE MATERIAL DISCLOSED HEREON. THIS DRAWING IS ISSUED IN CONFIDENCE FOR ENGINEERING INFORMATION ONLY AND MAY NOT BE REPRODUCED TO MANUFACTURE ANYTHING SHOWN WITHOUT DIRECT WRITTEN PERMISSION FROM OPTIMATION, INC., TO THE USER."

REVISIONS			
SYM	DESCRIPTION	BY	DATE
A	REVISED TO ACTUAL UNIT CONFIGURATION		3-17-70



I.C. 1,5 - MC 830P
I.C. 2, ,4 - MC 846P
ALL XSTR MJE 371
CR 1,2 - IN4004
CR 4, - IN914

1. ALL VALUES OF RESISTANCE IN OHMS & CAPACITANCE IN MFD'S.

NOTES: (UNLESS OTHERWISE SPECIFIED)

ITEM	QTY	DESCRIPTION	PART OR IDENTIFYING NO.	VENDOR	SPEC. / NO.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± 1/32 — DECIMALS XX ± .010, XXX ± .005 — ANGLES ± 1°

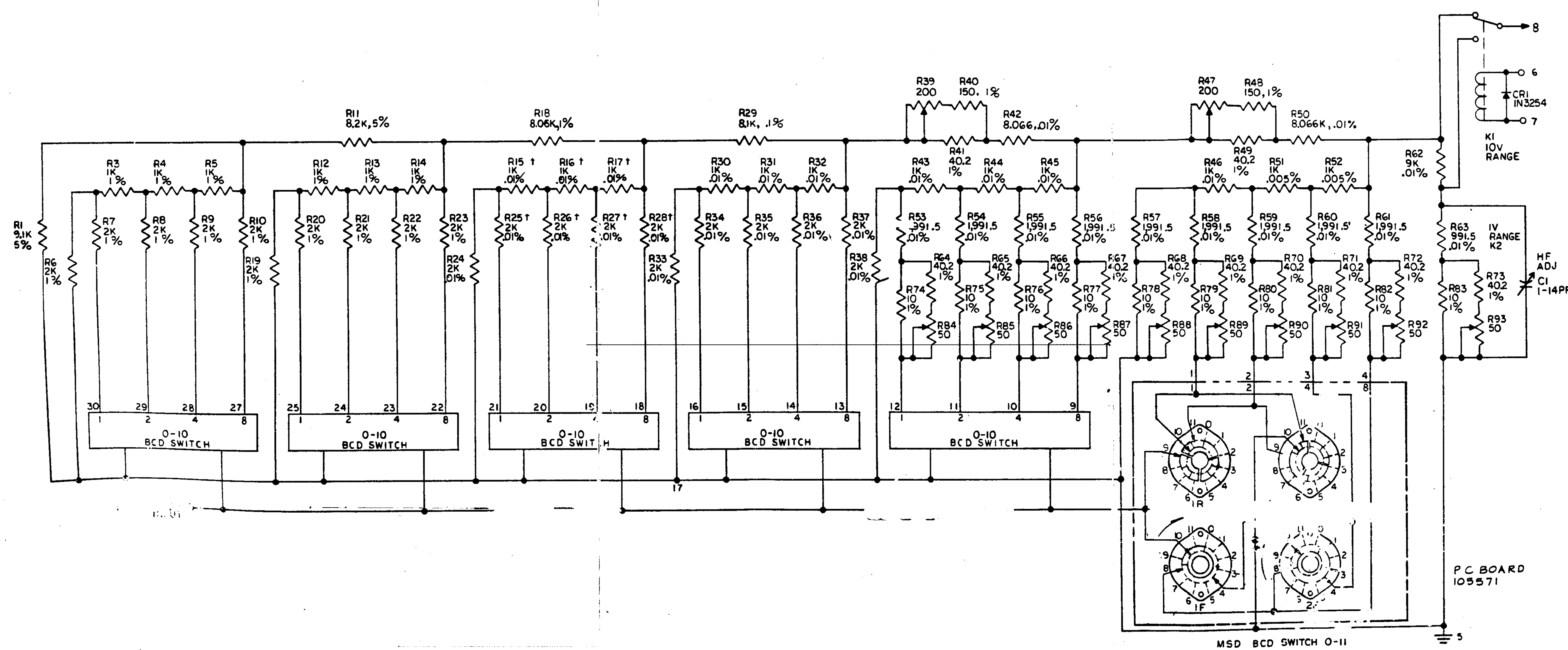
MAKE FROM DRAWING NO.
MATERIAL
TREATMENT
FINISH

DRAWN: Alice 7/24-69
CHECKED
PROJECT DESIGNER
PROJECT ENGINEER 7/24/69
APPROVED 7/29/69
CUSTOMER
FIN. WT.
NEXT ASSY C908108
SPEC. CONTROL NO.
SCALE

OPTIMATION, INC.
SUN VALLEY, CALIF. 91352

DRAWING NAME: SCHEMATIC DIAGRAM ERROR RANGE PROGRAMMING
MODEL: AC110
DWG. SIZE: C
DRAWING NO.: 3263
REV.: A
SHEET ___ OF ___

REVISIONS			
SYM	DESCRIPTION	BY	DATE



ITEM	QTY	DESCRIPTION	PART OR IDENTIFYING NO.	VENDOR	SPEC. / NO.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ±1/ DECIMALS XX ± .010 XXX ± .005 ANGLES ± 1°

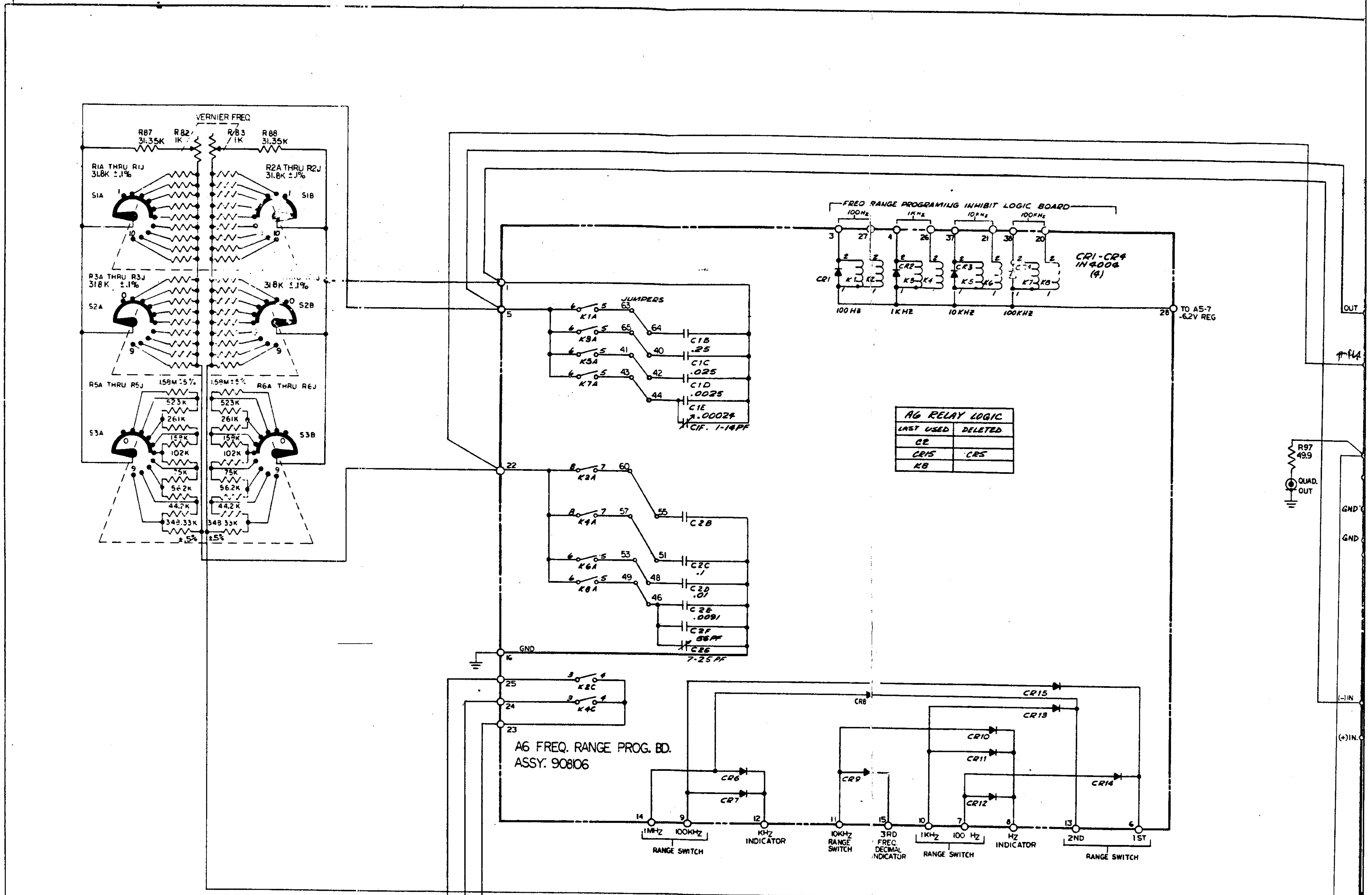
DRAWN · CHECKED · PROJECT DESIGNER · PROJECT ENGINEER · APPROVED · CUSTOMER

OPTIMATION, INC.

SCHEMATIC DIAG.
VOLTAGE ATTENUATOR (A8)

MODEL AC 110 — SIZE D — DRAWING NO. 3255

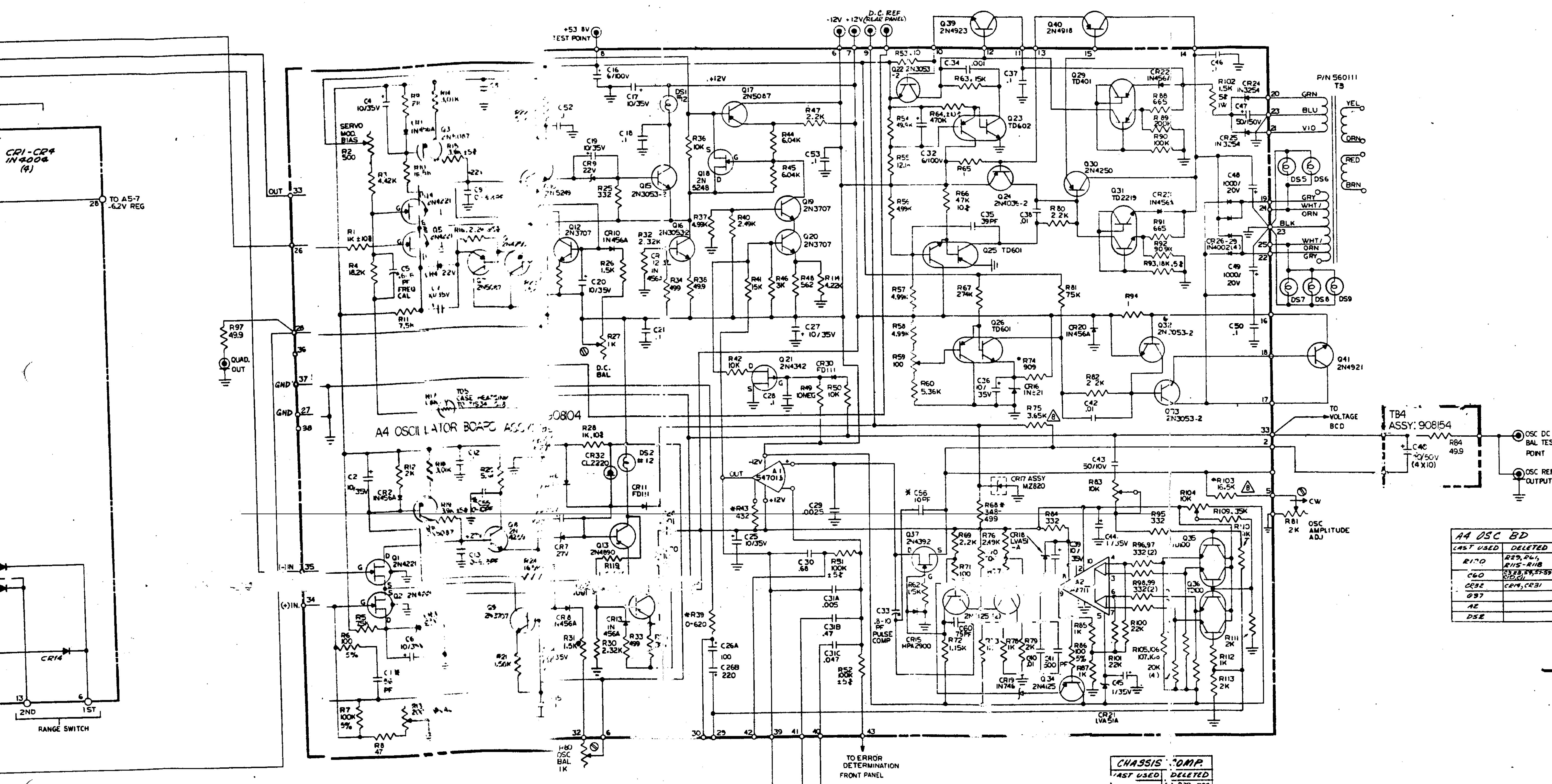
2 ‡ SELECT TO MATCH WITHIN 1% OF EACH OTHER
1 † SELECT TO MATCH WITHIN .1% OF EACH OTHER
NOTES: (UNLESS OTHERWISE SPECIFIED)



8. R75 & R103 TO BE TC MATCHED ±5 PPM.
7. DENOTES COMMON ELECTRICAL GND ON INNER FLOATING CHASSIS.
6. DENOTES OUTER CHASSIS AND PANEL GROUND.
5. SELECTED TOLERANCE.†
4. (*) FACTORY SELECTED VALUE, OR OPTIONAL PART.
3.
2. ALL RESISTANCE ±1%.
1. ALL VALUES OF RESISTANCE IN OHMS, AND CAPACITANCE IN MFD'S.

NOTES: UNLESS OTHERWISE SPECIFIED

A	REVISED PER ECN 337



A4 OSC BD	
LAST USED	DELETED
R120	R29, R61, R115-R118
C60	C3, 23, 54, 57-59, C10, C11
CR32	CR14, CR31
Q37	
A2	
DS2	

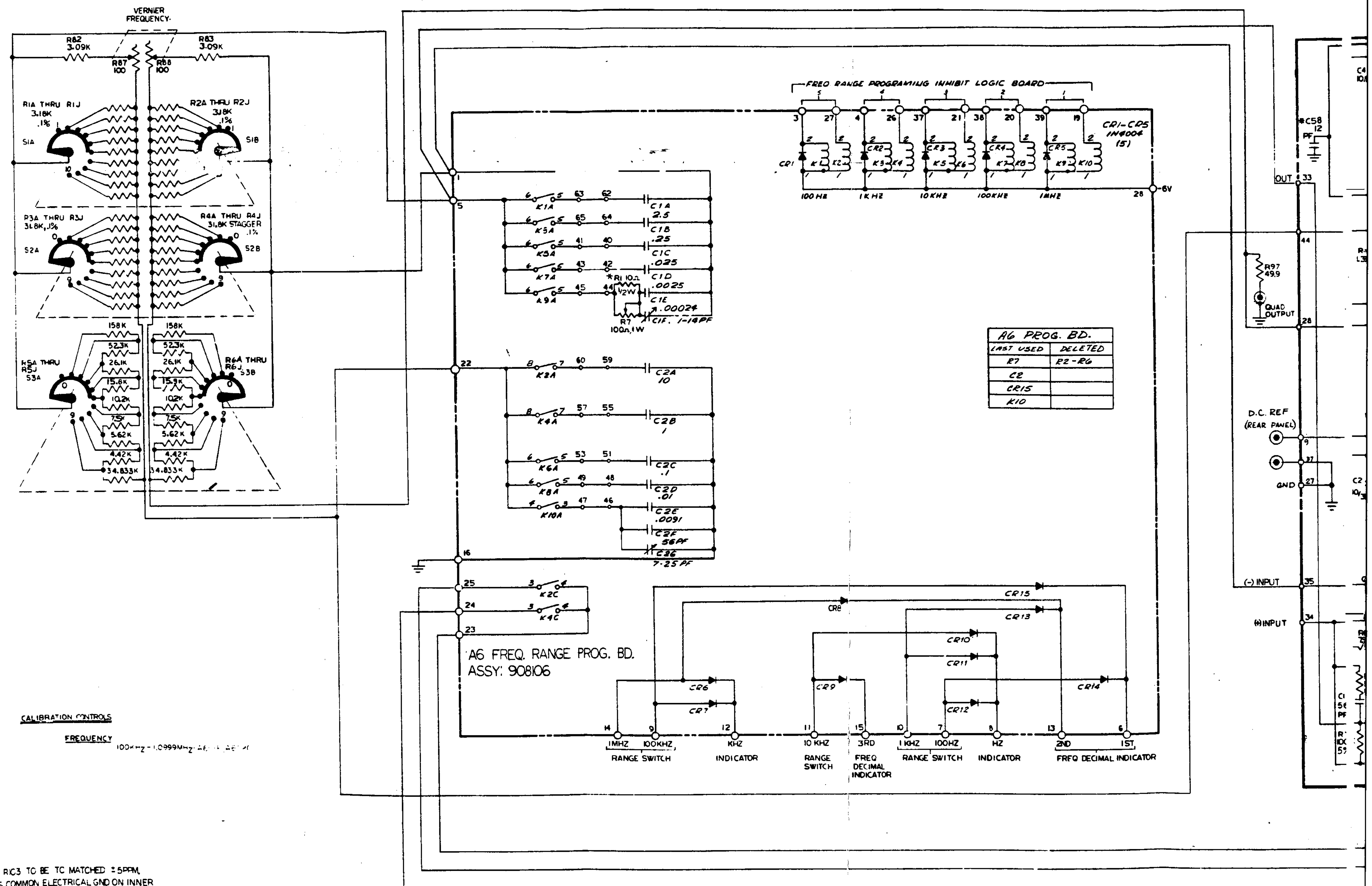
CHASSIS COMP.	
LAST USED	DELETED
R97	-R79, R84-R86, R89-R96
S3	
Q41	Q1-Q38
T3	T1, T2
DS9	DS1-DS4

OPTIMATION, INC.
SUN VALLEY, CALIF 91352

SCHEMATIC DIAGRAM
POWER OSCILLATOR

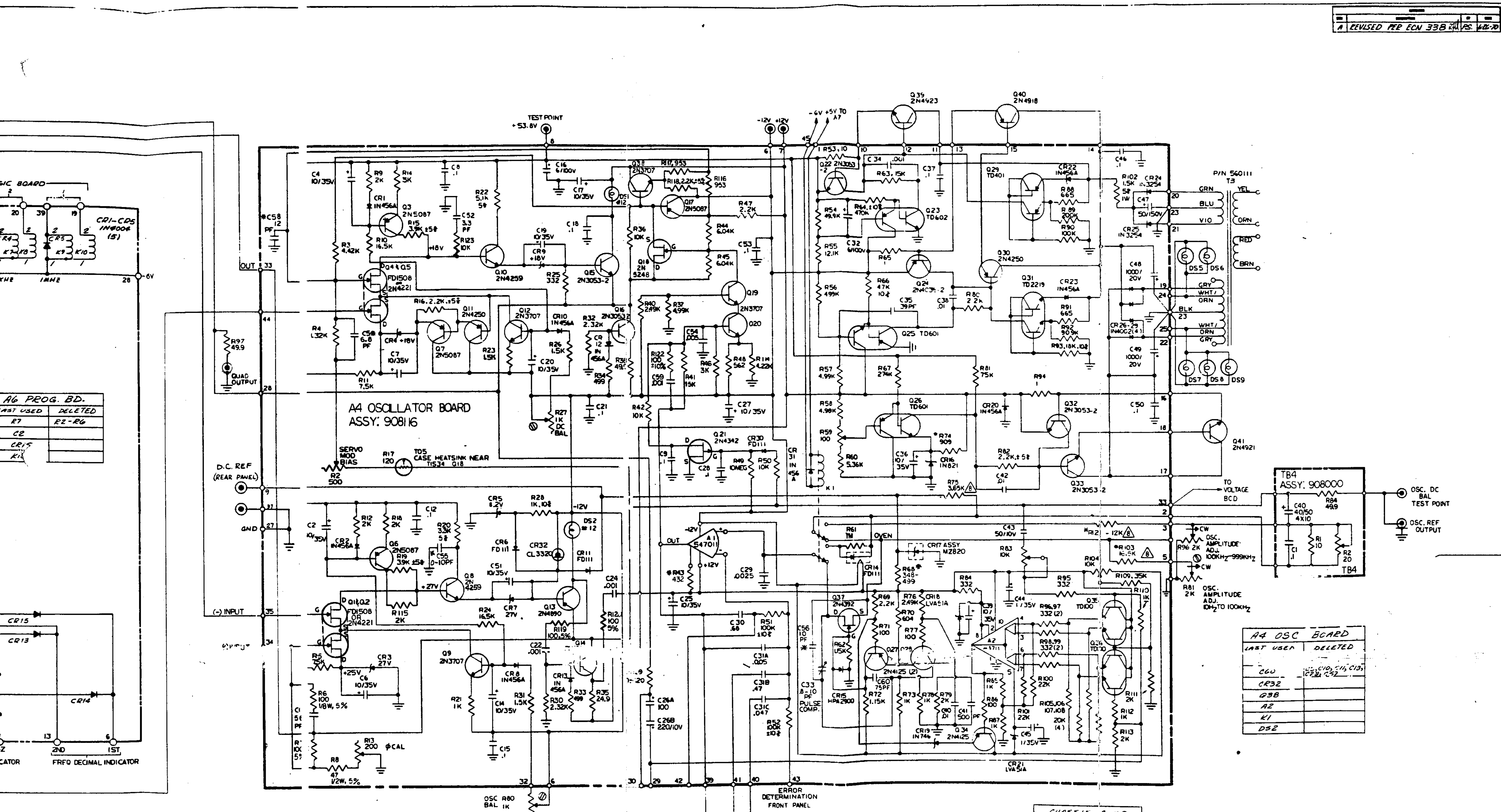
AC110
3 DIGIT 100KHz

B | 3279 | A



8. R121, R75, & R103 TO BE TC MATCHED ±5PPM.
7. ⏚ DENOTES COMMON ELECTRICAL GND ON INNER FLOATING CHASSIS.
6. DENOTES OUTER CHASSIS & PANEL GND.
5. SELECTED TOLERANCE.†
4. (*) FACTORY SELECTED VALUE OR OPTIONAL PART
3.
2. ALL RESISTORS ±1%.
1. ALL VALUES OF RESISTANCE IN OHMS, CAPACITANCE IN MFD.

NOTES: UNLESS OTHERWISE SPECIFIED



A6 PROG. BD.	
LAST USED	DELETED
R7	R2-R6
C2	
CR15	
K1	

A4 OSC BOARD	
LAST USED	DELETED
C60	C10, C11, C13, C27, C52
CR32	
Q38	
A2	
K1	
DS2	

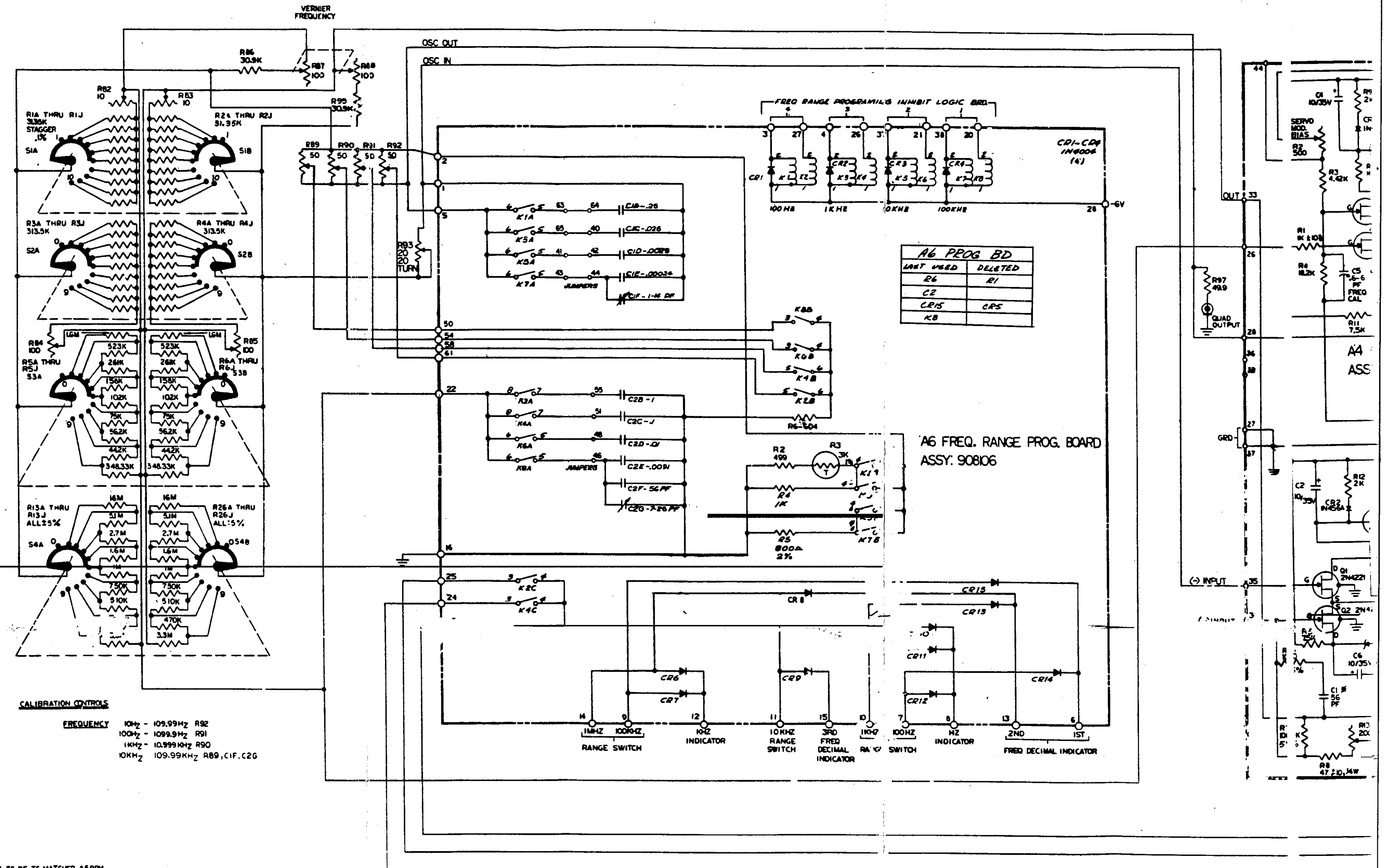
CHASSIS COMP.	
LAST USED	DELETED
R97	R7-R79, R84-R86, R89-R95
53	
Q41	Q1 Q38
T3	T1, T2
DS9	DS1-DS4

OPTIMATION, INC.

SCHEMATIC DIAGRAM
POWER OSCILLATOR

AC110 3DIGIT 1MHZ

H 3281 A

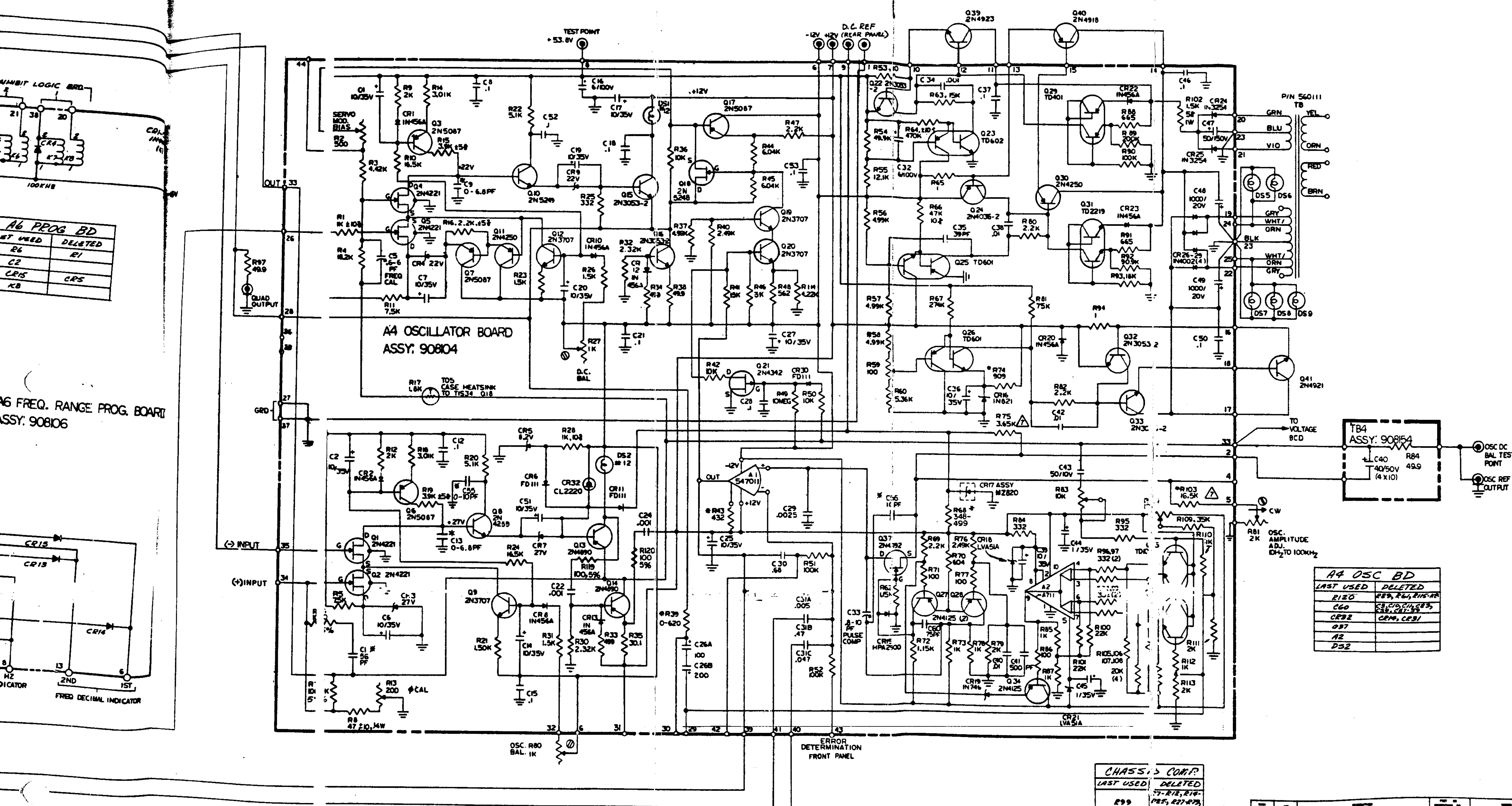


CALIBRATION CONTROLS

FREQUENCY 10Hz - 109.99Hz R92
100Hz - 1099.9Hz R91
1KHz - 10.999KHz R90
10KHz 109.99KHz R89, C1F, C2G

7 R75 & R103 TO BE TC MATCHED ±5PPM.
6. DENOTES COMMON ELECTRICAL GND ON INNER FLOATING CHASSIS.
5. DENOTES OUTER CHASSIS & PANEL GRD
4. (†) SELECTED TOLERANCE.
3. (*) FACTORY SELECTED VALUE OR OPTIONAL PART
2. ALL RESISTORS ±1%.
1. ALL VALUES OF RESISTANCE IN OHMS, CAPACITANCE IN MFD'S.
NOTES. UNLESS OTHERWISE SPECIFIED.

A	REVISED PER ECN 324	P.S. 4-26-70



A6 PROG BD	
LAST USED	DELETED
R6	R1
C2	
CR15	CR5
K8	

A4 OSC BD	
LAST USED	DELETED
R120	R89, R61, R115-R118
C60	C8, C10, C11, C23, C54, C57-59
CR32	CR14, CR31
Q37	
A2	
DS2	

CHASSIS COMP.	
LAST USED	DELETED
R99	R7-R12, R14-R25, R27-R73, R74-R96, R98
S4	
Q41	Q1-Q38
DS9	DS1-DS4
T3	T1, T2

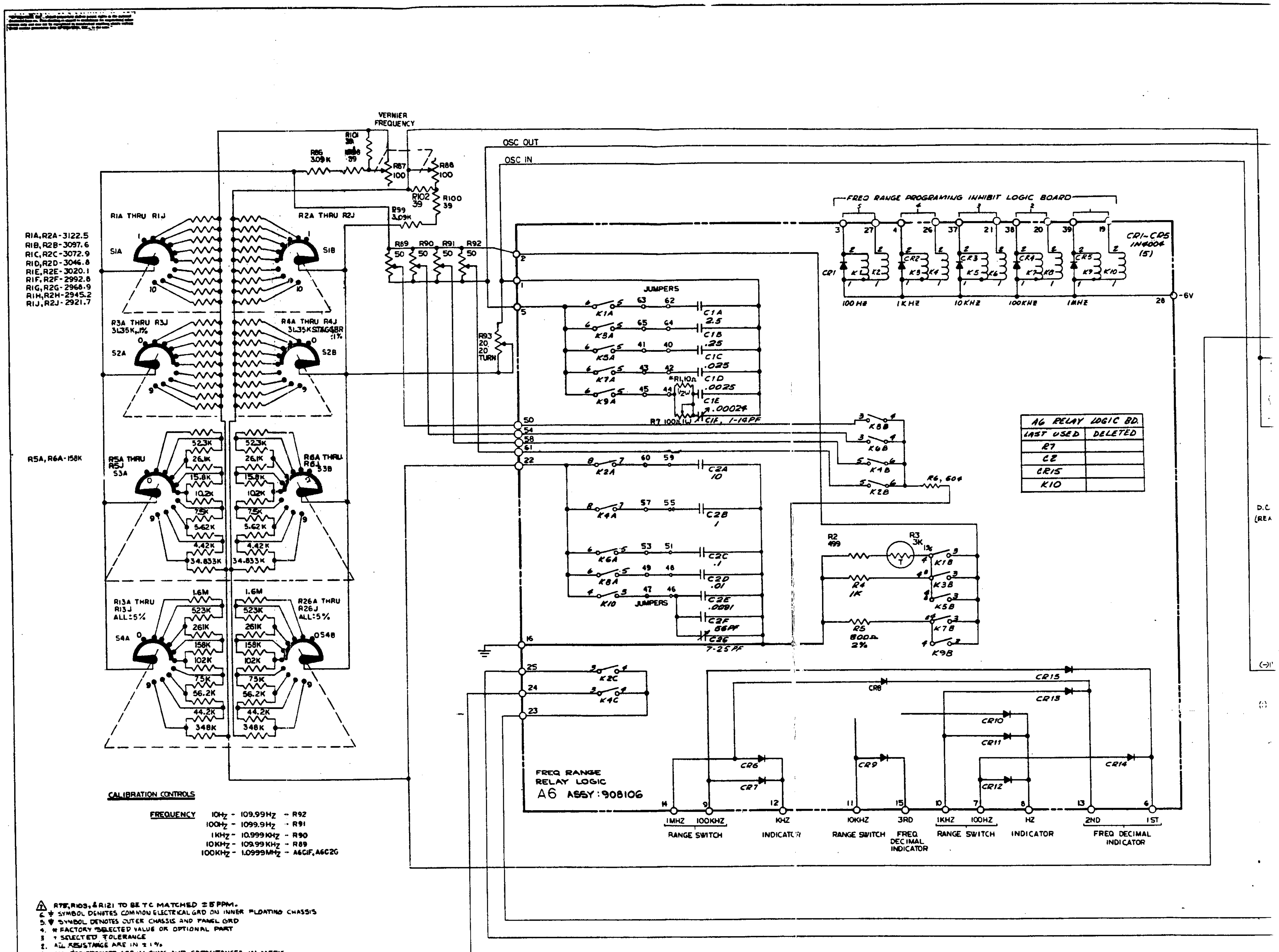
OPTIMATION, INC.
SUN VALLEY, CALIF.

SCHEMATIC DIAGRAM
POWER OSCILLATOR

AC 110
4 DIGIT 100KHz

H | 3280 | A

11-20-69
7/10/70
7/16/70



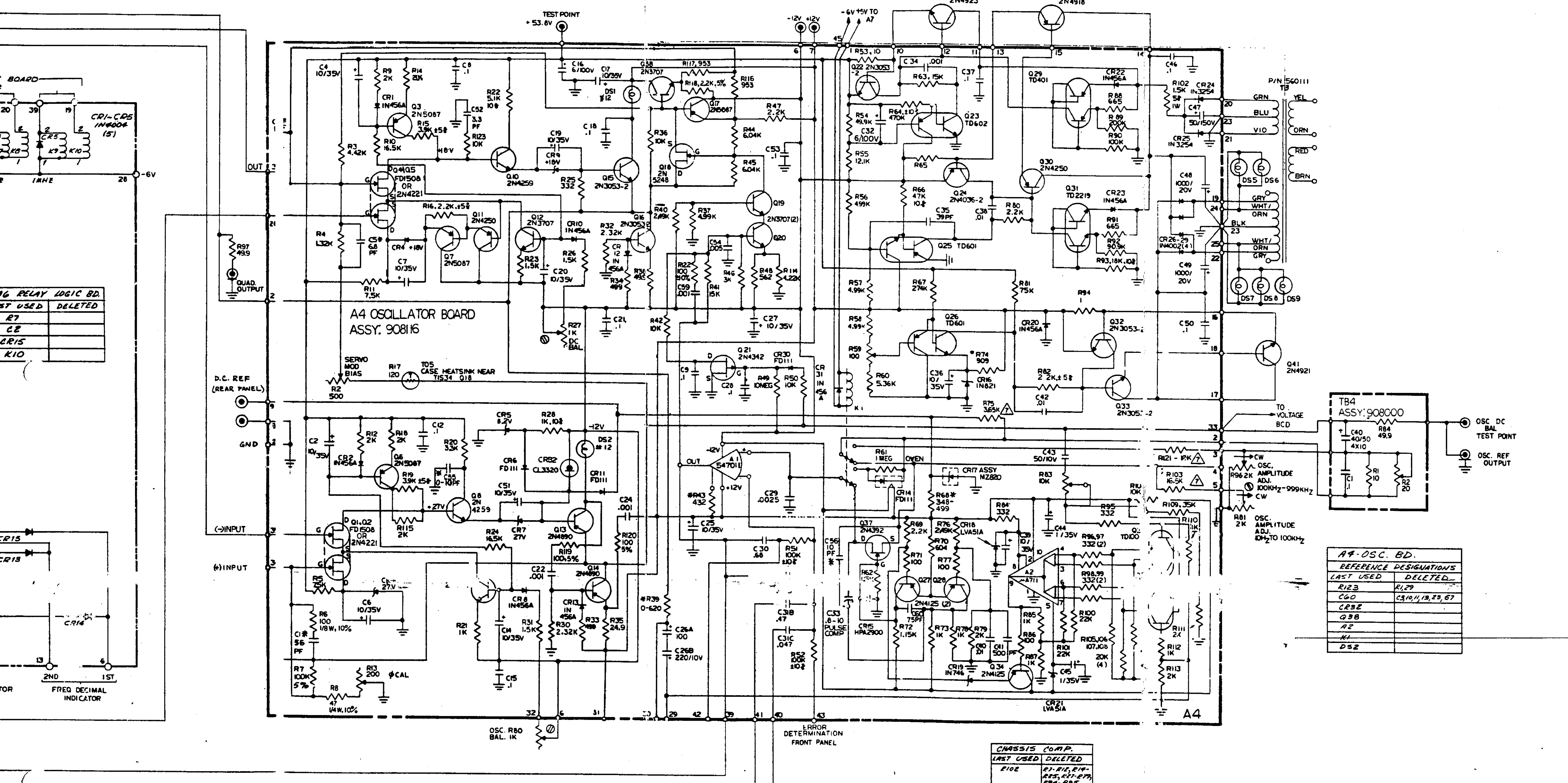
A6 RELAY LOGIC BD.	
LAST USED	DELETED
R7	
C2	
CR15	
K10	

CALIBRATION CONTROLS

FREQUENCY
10Hz - 109.99Hz - R92
100Hz - 1099.9Hz - R91
1KHz - 10.999KHz - R90
10KHz - 109.99KHz - R89
100KHz - 1.0999MHz - A6C1F, A6C2G

7. R75, R103, & R121 TO BE TC MATCHED ±5 PPM.
6. ⏚ SYMBOL DENOTES COMMON ELECTRICAL GRD ON INNER FLOATING CHASSIS
5. ▼ SYMBOL DENOTES OUTER CHASSIS AND PANEL GRD
4. * FACTORY SELECTED VALUE OR OPTIONAL PART
3. † SELECTED TOLERANCE
2. ALL RESISTANCE ARE IN ±1%
1. ALL RESISTANCES ARE IN OHMS AND CAPACITANCES IN MFD'S
NOTES: UNLESS OTHERWISE SPECIFIED

A	REVISED PER ECN 339



...G RELAY LOGIC BD.	
LAST USED	DELETED
R7	
C2	
CR15	
K10	

A4-OSC. BD. REFERENCE DESIGNATIONS	
LAST USED	DELETED
R123	R129
C60	C5,10,11,13,23,57
CR32	
Q38	
A2	
K1	
DS2	

CHASSIS COMP.	
LAST USED	DELETED
R102	R1-R12, R14-R25, R27-R77, R79-R95
S4	
Q41	Q1-Q38
T3	T1, T2
DS9	DS1-DS4

OPTIMATION, INC.
SUN VALLEY, CALIF.

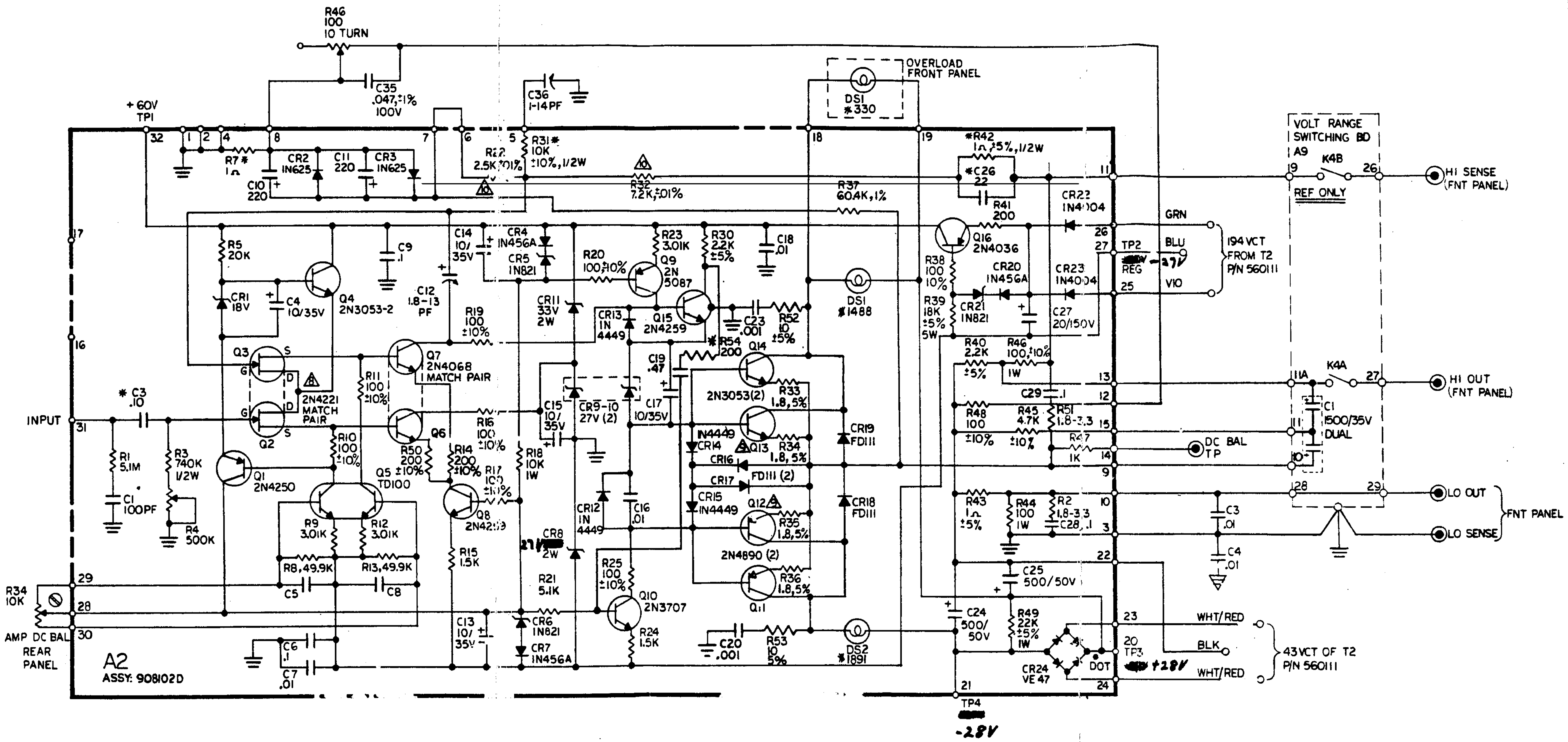
SCHEMATIC DIAGRAM
POWER OSCILLATOR

AC110 4DIGIT 1MHz

H 3275 A

REVISIONS

SYM	DESCRIPTION	BY	DATE
B	REDRAWN AND REVISED.	HAM	3.31.70
C	REVISED PER ECN 325	P.S	6-26-70



HIGHEST REF. DESIG.	REF. DESIGN. NOT USED
Q16	
R54	R6, 26-29
C29	C2,21,22
CR23	
DS2	

8. R22 / R32 TO BE MATCHED T.C.
9. Q13 / Q12 TO BE MOTOROLA TYPE MATCHED WITHIN 10% OF EACH OTHER.
10. TRANSISTOR FD 1508 MAY BE USED IN PLACE OF 2N4221 (Q2 & 3).
7. CR14 / Q13, CR15 / Q12 TO BE BONDED TOGETHER.
6. DENOTES COMMON ELECTRICAL GND. ON INNER FLOAT. CHASSIS.
5. DENOTES OUTER CHASSIS AND PANEL GND.
4. SELECTED TOLERANCE †.
3. FACTORY SELECTED VALUE OR OPTIONAL PART *.
2. ALL RESISTORS ±1%
1. ALL VALUES OF RES. IN OHMS, CAP. IN MFDS.

NOTES: UNLESS OTHERWISE SPECIFIED

ITEM	DESCRIPTION	PART OR IDENTIFYING NO.	VENDOR	SPEC./C.D.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/32, ANGLES ± 1°

DRAWN 3-31-70
CHECK 4-3-70
APPROVED 7-1-70

OPTIMATION, INC. SUN VALLEY, CALIF. 91352

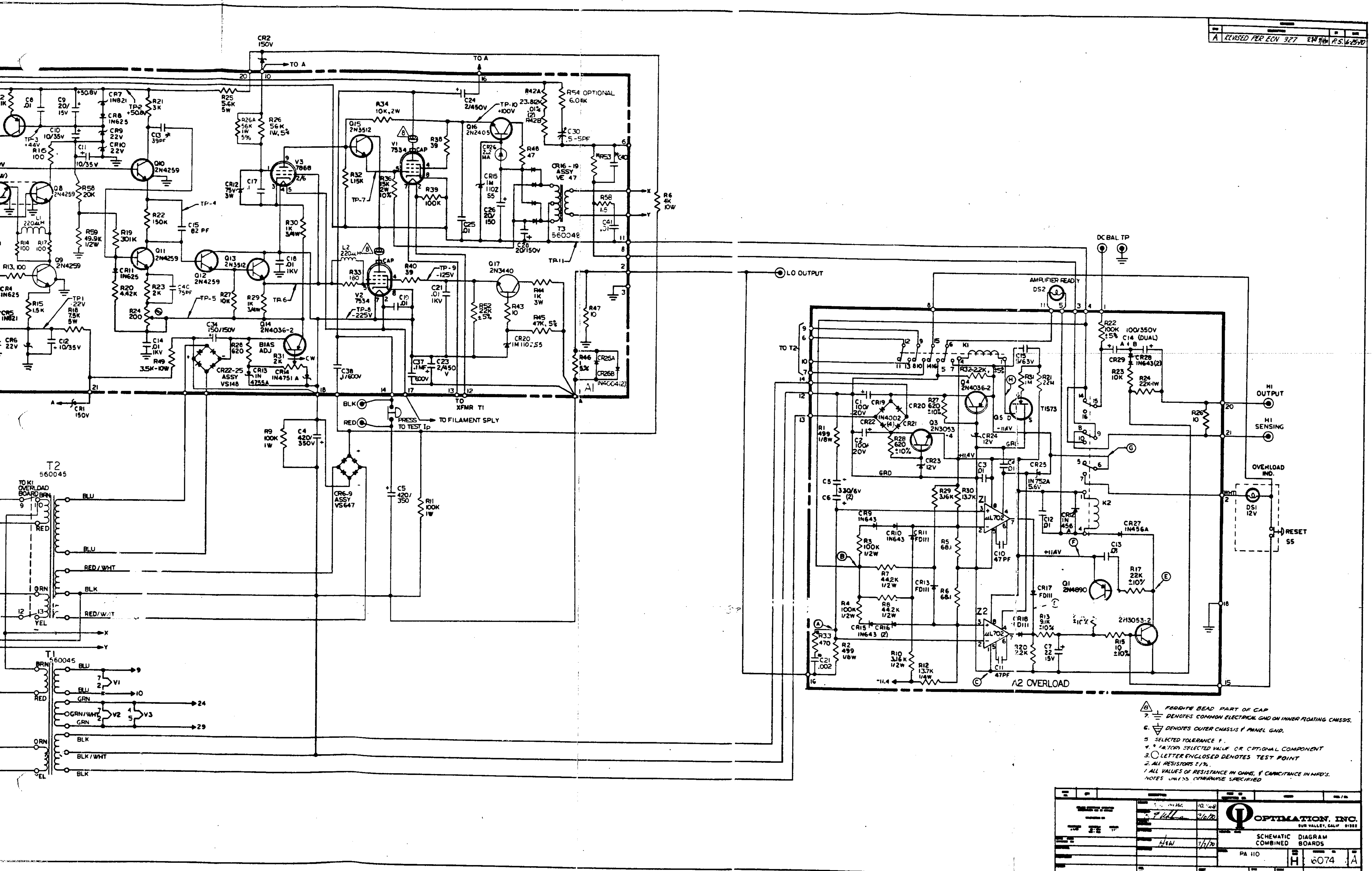
SCHEMATIC DIAGRAM 1 WATT AMPL BRD

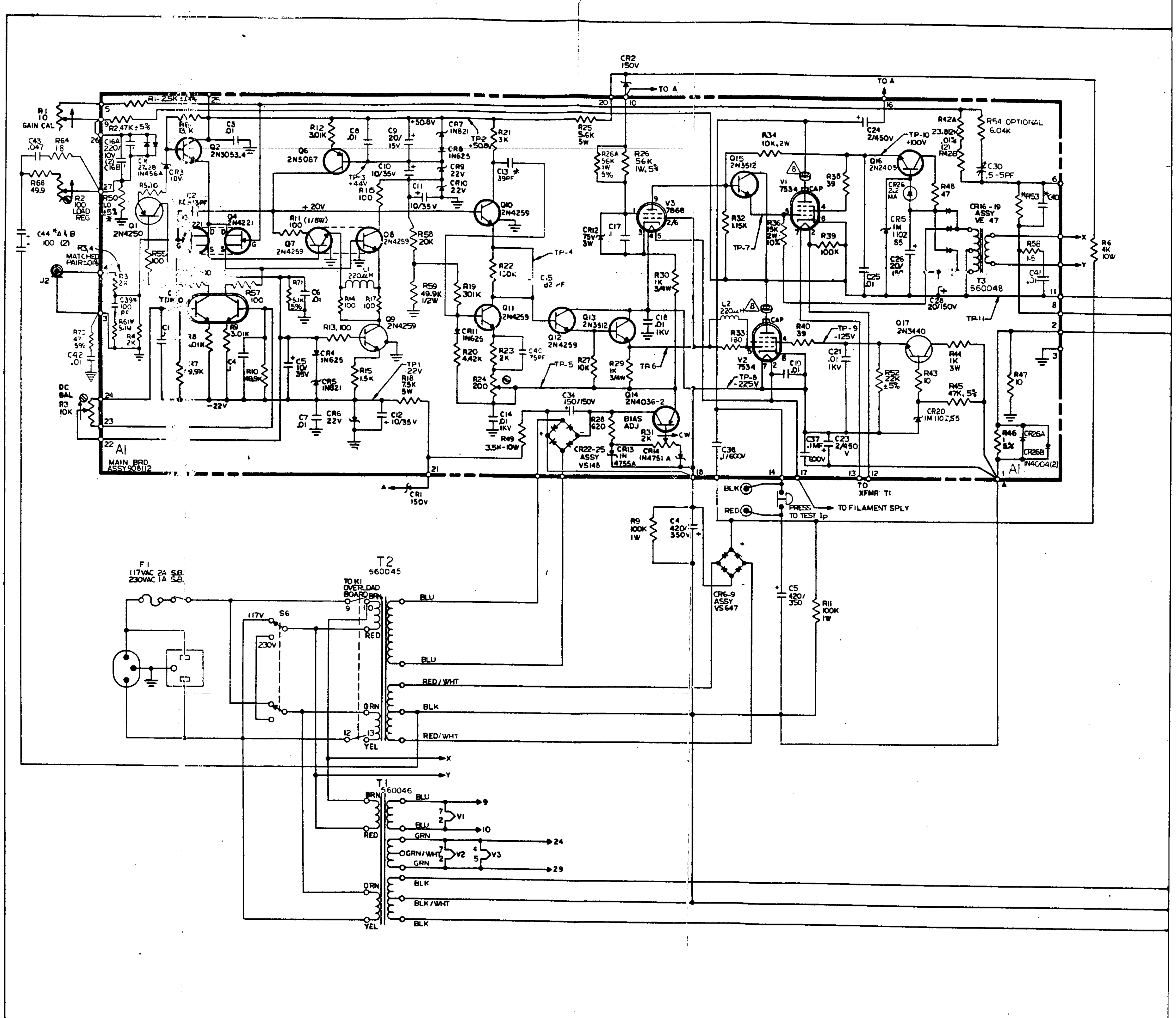
A2

AC 110

SIZE D | DRAWING NO. 6075

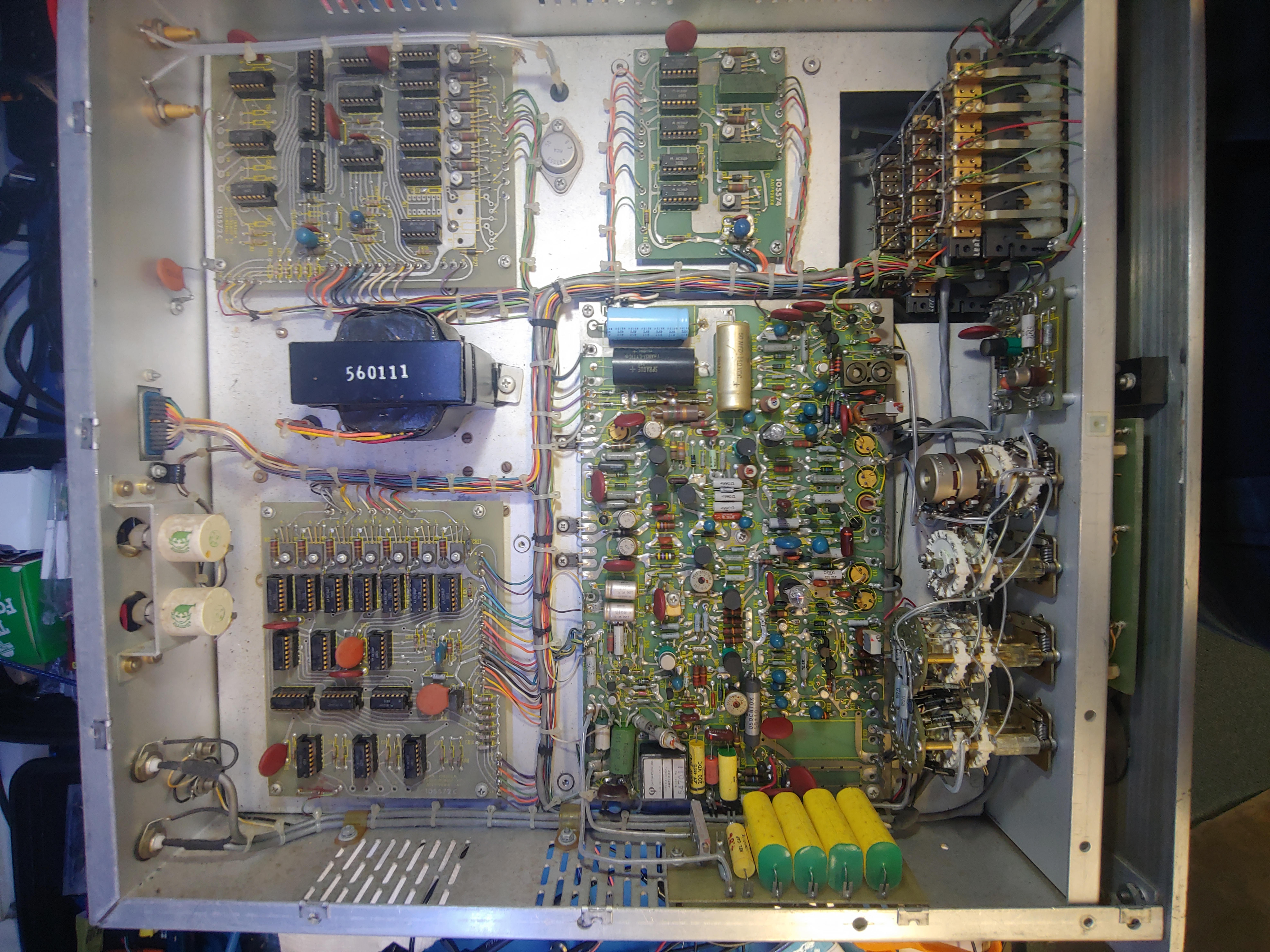
SHEET 1 OF 1


A REVISED PER ECN 327
LO OUTPUT
HI OUTPUT
HI SENSING
DC BAL TP
AMPLIFIER READY
OVERLOAD IND.
RESET S5
A2 OVERLOAD
A1
TO FILAMENT SPLY
PRESS TO TEST Ip
TO XFMR T1
T2 560045
T1 560045
8. FERRITE BEAD PART OF CAP
7. DENOTES COMMON ELECTRICAL GND ON INNER FLOATING CHASSIS.
6. DENOTES OUTER CHASSIS & PANEL GND.
5. SELECTED TOLERANCE ±.
4. * FACTORY SELECTED VALUE OR OPTIONAL COMPONENT
3. LETTER ENCLOSED DENOTES TEST POINT
2. ALL RESISTORS ±1%.
1. ALL VALUES OF RESISTANCE IN OHMS, & CAPACITANCE IN MFD'S.
NOTES UNLESS OTHERWISE SPECIFIED
OPTIMATION, INC.
SUN VALLEY, CALIF. 91352
SCHEMATIC DIAGRAM COMBINED BOARDS
PA 110
H 6074 A



CR2 150V
TO A
R1 10 GAIN CAL
R1- 2.5K ±1%
R2 47K ±5%
C43 .047
R64 18
R68 49.9
R2 100 LOAD REG
Q1 2N4250
Q2 2N3053
C3 .01
Q4 2N4221
R12 301K
Q6 2N5087
C8 .01
C9 20/15V
+50.8V
CR7 1N821
TP-2 +50.8V
CR8 1N625
CR9 22V
CR10 22V
TP-3 +44V
C10 10/35V
R16 100
C11 10/35V
C13 39PF
R21 3K
Q10 2N4259
R25 5.6K 5W
R26A 56K 1W 5%
R26 56K 1W, 5%
+ 20V
R11 100 (1/8W)
Q7 2N4259
Q8 2N4259
R58 20K
R59 49.9K 1/2W
L1 220µH
R14 100
R17 100
R13, 100
Q9 2N4259
R71 5.1K 5%
C6 .01
R57 100
C44 A & B 100 (2)
R3,4 MATCHED PAIR-.01%
J2
R73 47 5%
C42 .01
DC BAL R3 10K
R8 .01K
R9 3.01K
R7 9.9K
R10 49.9K
-22V
C5 10/35V
CR4 1N625
CR5 1N821
C7 .01
CR6 22V
C12 10/35V
R15 1.5K
TP1 -22V
R18 7.5K 5W
A1 MAIN BRD ASSY 908112
CR1 150V
R19 301K
R22 150K
TP-4
C-5 82 PF
Q11 2N4259
CR11 1N625
R20 4.42K
R23 2K
C4C 75PF
TP-5
R24 200
C14 .01 1KV
R49 3.5K-10W
Q12 2N4259
Q13 2N3512
R27 10K
R29 1K 3/4W
TP 6
C16 .01 1KV
C34 150/150V
R28 620
BIAS ADJ
R31 2K
Q14 2N4036-2
CR22-25 ASSY VS148
CR13 1N 4755A
CR14 1N4751 A
CR12 75V 3W
C17 .1
V3 7868
R30 1K 3/4W
L2 220µH
R33 180
V2 7534
TP-8 -225V
C19 .01
C38 .1/600V
R40 39
TP-9 -125V
C21 .01 1KV
C37 .1MF 600V
C23 2/450 V
R34 10K, 2W
Q15 2N3512
R32 1.15K
TP-7
V1 7534
R36 15K 2W 10%
R38 39
R39 100K
C24 2/450V
TP-10 +100V
Q16 2N2405
CR26 2.2 MA
CR15 1M 110Z 55
C26 20/150
C25 .01
R42A 23.8K .01% (2) R42B
R54 OPTIONAL 6.04K
C30 .5-5PF
R48 47
CR16-19 ASSY VE 47
R53
C40
R58 1.5
C41 .01
T3 560048
C28 20/150V
TP-11
R6 4K 10W
X
Y
Q17 2N3440
R44 1K 3W
R45 47K, 5%
R52 22K ±5%
R43 10
CR20 1M 110Z55
R47 10
R46 1 5%
CR26A
CR26B
1N4004(2)
A1
TO XFMR T1
BLK
RED
PRESS TO TEST Ip
TO FILAMENT SPLY
R9 100K 1W
C4 420/350V
CR6-9 ASSY VS647
C5 420/350
R11 100K 1W
F1 117VAC 2A S.B. 230VAC 1A S.B.
T2 560045
TO K1 OVERLOAD BOARD
117V
S6
230V
BRN
BLU
RED
RED/WHT
ORN
BLK
YEL
T1 560046
GRN
GRN/WHT
BLK/WHT
V1
V2
V3
24
29


Valhalla Scientific Inc.
MODEL 2701 PROGRAMMABLE PRECISION DC VOLTAGE CALIBRATOR
POWER
13W
12V
120V
1200V
OUTPUT
POWER AMPLIFIER
0-120V • 200 MA MAX
AMPLIFIER READY
OVER LOAD PUSH TO RESET
OPTIMATION, INC.
FREQUENCY
VERNIER
FREQUENCY RANGE
100 Hz
1K Hz
10K Hz
100K Hz
1M Hz
ERROR DETERMINATION
% ERROR
INCREASE
MODEL AC 110 CALIBRATOR
31W
ON PUSH OFF
STAND BY
% ERROR RANGE
0%
.3%
3%
INDICATED ERROR
OUTPUT VOLTAGE
VOLTAGE RANGE
10 MV
100 MV
1 V
10 V
100 V
INV EXT
HIGH
FLOATING
OUTPUT
OPTIMATION, INC.
FLUKE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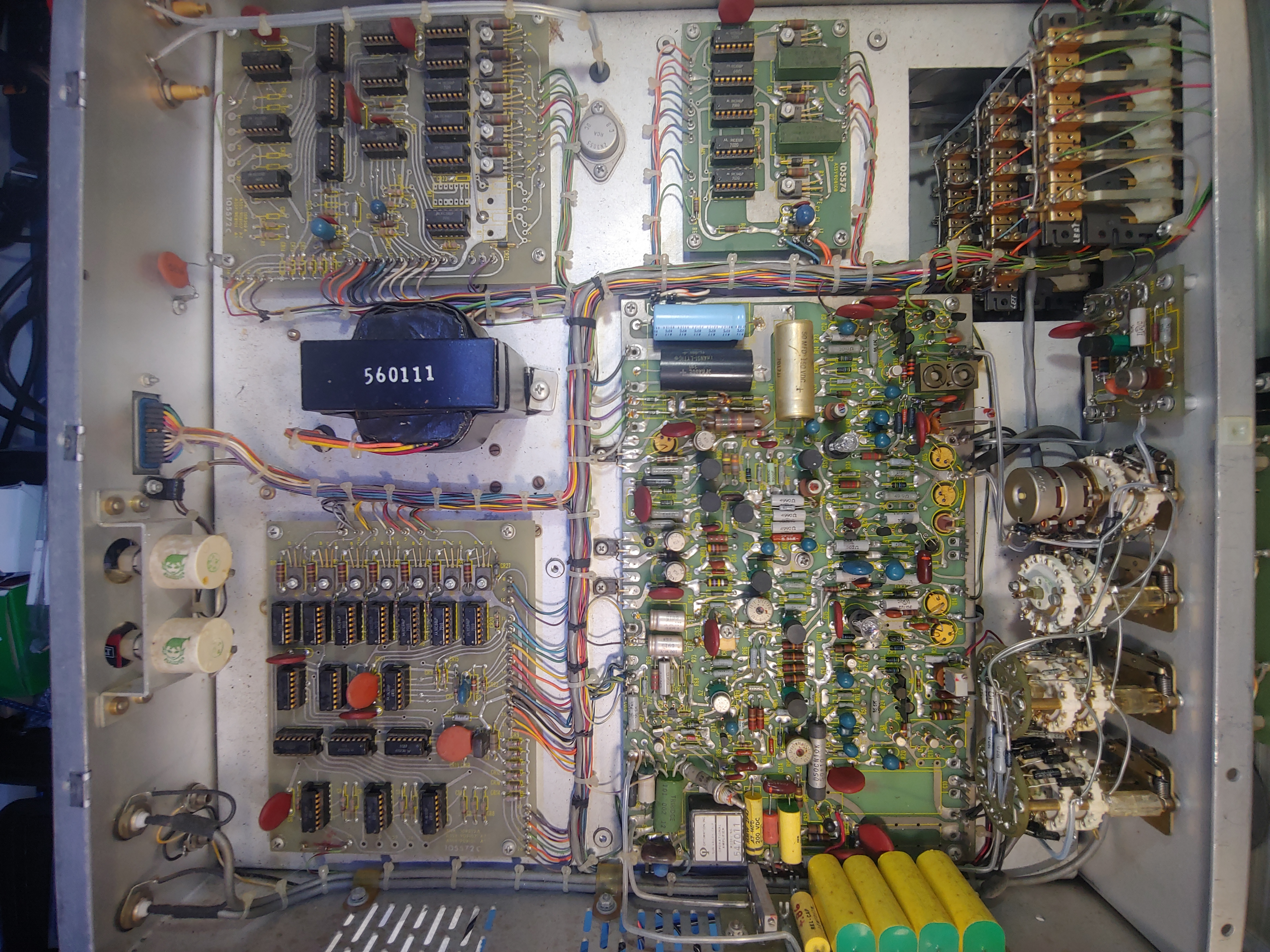
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AMPEREX
E 130 L
7534
7060
INPUT
DC BAL ADJ
91%