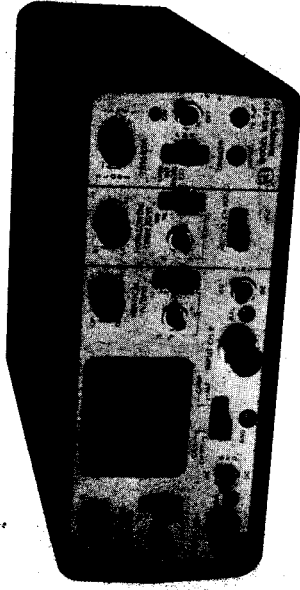


INSTRUCTION MANUAL

MINISCOPE



**NON-LINEAR SYSTEMS, INC.**  
DEL MAR, CALIFORNIA

7/79

LITHO IN USA

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SECTION I

INTRODUCTION AND DESCRIPTION

1-1. GENERAL.

1-2. The NLS MS-230 Miniscope you have purchased is a fine electronic instrument with a great deal of measuring capability and excellent accuracy. Its design is modern, utilizing the latest in low-powered integrated circuits, and it is packaged into the smallest practical size. The instrument fits into many briefcases and tool boxes with room to spare.

1-3. Operating characteristics have been chosen so that the MS-230 will make all of the measurements needed in servicing most electronic equipments. It is field-portable so its use is not restricted to the repair shop.

1-4. The Miniscope has a built-in ruggedness to withstand hard use. With only moderate care this fine, accurate electronic instrument will provide years and years of trouble-free service.

1-5. This manual is provided to acquaint you fully with your MS-230 Miniscope. You are urged to read the manual before you initially use your Miniscope. Two sections are most important. Reading the specifications is important because:

a. You should be aware of maximum input ratings to avoid damage to the instrument.

b. By understanding the performance characteristics you will save yourself immeasurable time learning to operate the Miniscope and best utilize all of its outstanding capabilities.

1-6. Secondly, you should study for a few minutes the section which describes the location of controls, indicators and connectors. Familiarize yourself with the location and function of each. You will save both time and frustration in becoming acquainted with the MS-230 and getting it to do all of the many amazing and interesting things it can do.

1-7. SPECIFICATIONS.

VERTICAL

Mode: CH1, CH2, CH1 & CH2 (Chopped) and CH1 & CH2 (Alternate)  
(The following specifications apply to each channel.)

Bandwidth: DC to 30 MHz (1 MHz above 10V/div),  $\pm 3$  db @ 3 div deflection\*  
Deflection Factor: 10 mV/div to 50V/div in 12 calibrated ranges. Accuracy is 3% of full scale with vernier in full clockwise position. Vernier provides continuously variable deflection factor between fixed ranges, uncalibrated.  
Input Impedance: 1 megohm in parallel with 50 pF.  
Maximum Input Voltage: 350V (DC + peak AC) provided DC component does not exceed 250V.

#### HORIZONTAL

Mode: Internal Time Base or External Horizontal, switch selectable. In the XY mode, vertical input is through CH1 and horizontal input through CH2.  
Time Base: 0.05  $\mu$ Sec/div to 0.2 Sec/div in 21 calibrated ranges. Accuracy is 3% of full scale with vernier in full clockwise position (10% of F. S. settings between fixed ranges, uncalibrated).

#### Amplifier

Bandwidth: DC to 200 kHz ( $\pm 3$  db).

Coupling: AC, DC or GND, switch selectable. Low frequency point on AC is 3 Hz.

Deflection Factor: 10 mV/div to 50V/div in 12 calibrated ranges. The ranges can be calibrated with the CH2 gain control.

Input Impedance: 1 M $\Omega$  in parallel with 50 pF.

Maximum Input Voltage: Same as vertical amplifier.

#### TRIGGER

Modes: Automatic (trigger is disabled, time base free runs), Internal (In the dual trace modes, the internal trigger source is CH1), External and Line (Line not functional when MS-230 operates on batteries). Input impedance is 1 megohm on External Trigger.

Slope: + or -, switch selectable.

Coupling: AC

\*Typical maximum frequency for full scale (4 div) deflection is 20 MHz.

Sensitivity: Less than 1 div for internal trigger and less than 1 volt for external trigger.

Level: Trigger Level control permits continuous adjustment of trigger point in all modes except AUTO.

#### CALIBRATOR

A square-wave signal of 1 volt p-p is provided. Voltage accuracy is  $\pm 5\%$ , frequency is approximately 1 kHz.

#### DISPLAY

Graticule: 4 x 5 div, each division is 0.25 inch.

CRT: Bluish-white phosphor, medium persistence. CRT uses low-power filament for low battery drain.

#### POWER SOURCES

Internal: Three sealed, rechargeable lead-acid cells. Operating time using fully charged cells is approximately one-half hour. Charging circuitry is integral and functions when MS-230 is connected to power line through plug-in transformer (supplied with each unit). Battery charge time with instrument non-operating is 16 hours.

External: Operates continuously from 115 vac source 50 - 60 Hz when connected via plug-in transformer. Alternate transformer for 230 vac is available. Power consumption from AC line is less than 40 watts.

#### ENVIRONMENT

Operating Temperature: 0° to +40°C.

Shock and Vibration: Will withstand normal shock and vibration encountered in commercial shipping and handling.

#### PHYSICAL MEASUREMENTS

Size: 2.9" H x 6.4" W x 8.6" D (74 mm x 163 mm x 217 mm).

Weight: 3.6 lbs (1.6 kg) with batteries. Weight of plug-in transformer is 1.8 lbs (0.82 kg).

SECTION II  
OPERATION

2-1. GENERAL.

2-2. This section provides location and identification of controls, indicators and connectors which are used to operate and monitor the measurement functions of the MS-230 (figure 2-1). Also provided are detailed instructions for operation of the controls.

2-3. OPERATING INSTRUCTIONS.

2-4. In the following instructions, the number in parenthesis following the name of a control, indicator or connector relates to the numerical callout of that control, indicator or connector shown in figure 2-1.

2-5. TURN-ON.

a. Decide the power source to be used. Choices are:

1. Internal batteries - be sure that the batteries have sufficient charge to operate the scope by checking to see if the power indicator LED (16) is illuminated.
2. For 115 vac operation, utilize a 115 vac charger/transformer unit.
3. For 230 vac operation, utilize a 230 vac charger/transformer unit.
  - b. After turning on the PWR switch (17), the warm-up time is less than five seconds. If the batteries are completely run down at turn-on, it will take approximately 60 minutes (PWR switch off) to charge them enough to operate the Miniscope.

2-6. BEAM LOCATION AND TRACE GENERATION.

a. Adjust the following:

1. INTENSITY control (31) to maximum.
2. Horizontal position (LEFT-RT) control (11) to center.
3. CH1 and CH2 vertical position (UP-DN) controls (4 & 8) to centers.
4. Select GND positions for input coupling switches (23 & 28).
5. Select mS or  $\mu$ S (21).

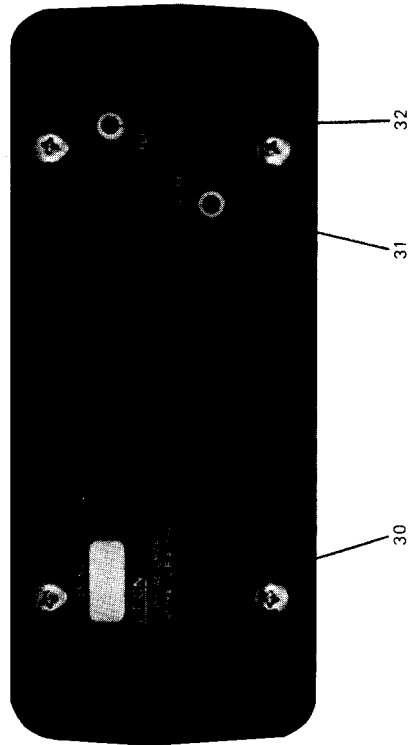
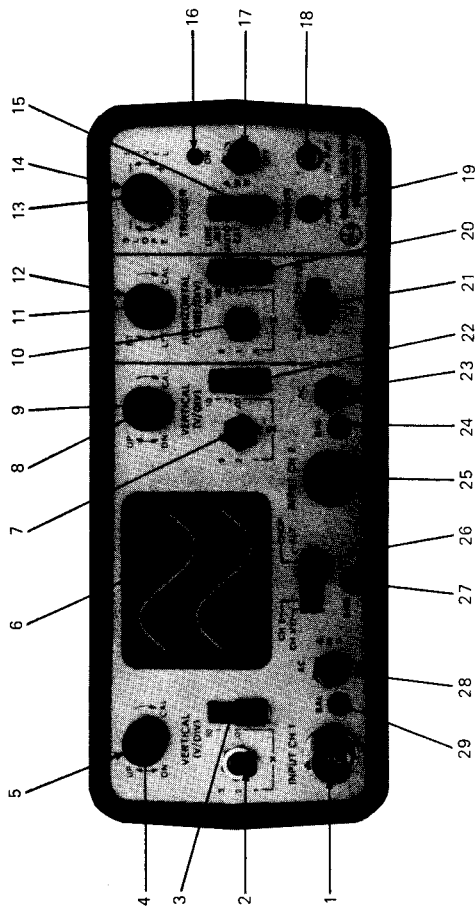


Figure 2-1. Controls, Indicators and Connectors (Sheet 1 of 2)

LEGEND

- |   |  |
|---|--|
| 1. CH1 Vertical Input Connector         | 18. Calibrator Output Jack                   |
| 2. CH1 Vertical V/Div Multiplier Select | 19. External Trigger Input Jack              |
| 3. CH1 Vertical V/Div Range Select      | 20. Time Base Range Select                   |
| 4. CH1 Vertical Position Control        | 21. Time Base Units Select                   |
| 5. CH1 Vertical V/Div Vernier Control   | 22. CH2 Vertical V/Div Range Select          |
| 6. Viewing Screen                       | 23. CH2 Vertical AC, GND, DC Coupling Select |
| 7. CH2 Vertical V/Div Multiplier Select | 24. CH2 Vertical Balance Control             |
| 8. CH2 Vertical Position Control        | 25. CH2 Vertical Input Connector             |
| 9. CH2 Vertical V/Div Vernier Control   | 26. Vertical Display Mode Select             |
| 10. Time Base Multiplier Select         | 27. Ground Jack                              |
| 11. Horizontal Position Control         | 28. CH1 Vertical AC, GND, DC Coupling Select |
| 12. Time Base Vernier Control           | 29. CH1 Vertical Balance Control             |
| 13. Trigger Slope Select                | 30. Charger Input Jack                       |
| 14. Trigger Level Control               | 31. Intensity Control                        |
| 15. Trigger Select                      | 32. Focus Control                            |
| 16. Power Indicator                     |  |
| 17. Power Switch                        |  |

Figure 2-1. Controls, Indicators and Connectors (Sheet 2 of 2)

6. Select AUTO trigger (15).

7. Select CHOP or ALT (26) vertical display mode.

b. Rotate the horizontal and vertical position controls to locate the traces and position them to the desired locations on the graticule (6).

c. Adjust the INTENSITY (31) and FOCUS (32) controls to give the sharpest and clearest traces possible.

2-7. SINGLE TRACE SIGNAL DISPLAY. After setting up the Miniscope to display the two traces as set forth in paragraph 2-6, connect an input signal to the CH1 input connector (1) using either a 1:1 cable or a 10:1 probe. Then proceed as follows:

a. Set the CH1 input coupling switch (28) to AC.

b. Set the vertical mode selector switch (26) to CH1.

c. Set the CH1 vertical V/DIV switches (2 & 3) to 5 x 10 (minimum sensitivity).

- d. Observe height of the display.
- e. Increase the sensitivity of the scope by changing the settings of the vertical V/DIV switches until the height of the display is one to three divisions.
- f. Change the trigger selector switch (15) from AUTO to INT and adjust the trigger level control (14) so that the trace reappears.
- g. Adjust the horizontal TIME/DIV switches (10, 20 & 21) to obtain a display of one to three periods of the waveform.
- h. Readjust the vertical, horizontal and trigger controls, if desired, to expand or compress the waveform or to start it at a different point in its cycle.

NOTE

A single trace display may also be obtained using the CH2 input and controls in a similar fashion.

2-8. DUAL TRACE OPERATION. Two harmonically related signals can be simultaneously displayed by the MS-230. Examples are the input and output waveforms of filters, attenuators, amplifiers, flip-flops, counters, shift registers, etc. The signal to be used as the internal trigger source must be connected to CH1. If an external trigger source is used then channel selection is immaterial. The same procedure for selecting the vertical and horizontal control settings as outlined in the single trace section apply here except that both CH1 and CH2 must be adjusted, and the CHOP or ALT modes must be selected. To obtain the clearest display, it is usually best to select the ALT mode for frequencies above 20 kHz and the CHOP mode for lower frequencies. Remember that the trigger source (time reference) for each trace is always the same for both modes so that time or phase comparisons between traces can always be made.

2-9. TRIGGERING.

2-10. The SLOPE (13) and LEVEL (14) controls are used to set the point on a waveform at which the Miniscope is triggered and the trace is started. Four trigger modes are provided, giving the capability to view and make measurements on a wide variety of waveforms. Time base controls, multiplier, 5-2-1 (10), range, .1-1-10-100 (20), vernier, CAL (12) and units, mS- $\mu$ S (21) allow sweep times to be varied over an extremely wide range of values. TRIGGER mode is chosen using the trigger select switch, LINE-AUTO-INT-EXT (15).

2-11. Triggered Modes. When a repetitive waveform is connected to VERT CH1 (1) with the triggered mode selected, the vertical controls permit the trace to be

started at any vertical point on the trace. Vertical coupling, AC-GND-DC (28) is selected to be either AC or DC. Ground coupling and auto sync is a convenient way to locate the ground reference for DC measurements. The vertical multiplier, 5-2-1 (2), range, .01-1-1-10 (3) and vernier, CAL (5) controls are used to adjust the height of the trace. One division minimum is required for operation in the triggered mode. Maximum vertical input voltage is 350 volts peak. Input impedance is one megohm shunted by 50 pF.

2-12. The SLOPE (13) control is used to choose whether the trace will start on the positive- or negative-going side of the waveform. Using the sync LEVEL (14) control, the trace can then be started at any point on the side which has been chosen.

2-13. Automatic Triggering. In the auto trigger mode, the sweep free runs at the rate selected by the time base switches. This provides an uninterrupted trace for non-repetitive waveforms. It is utilized for DC voltage measurements. In the absence of a vertical input, the trace represents zero amplitude. In the auto mode, synchronizing is usually not possible for repetitive waveforms as it is in the triggered modes.

2-14. Line Synchronization. In the LINE triggered mode, the line frequency is used to trigger the sweep. The LINE mode provides very positive synchronization for input waveforms which are derived from and consequently synchronized to the line frequency.

2-15. External Triggering. Trigger waveforms from any external source of one volt or more may be connected to the Miniscope by means of the TRIG INPUT jack (19).

2-16. Using an external trigger, an input waveform can be synchronized to itself. Consequently, it provides very positive synchronizing and for non-repetitive or transient waveforms, it is especially useful and provides better results than the other trigger modes in this regard. In clocked equipment, with the clock used as an external trigger, both AC and DC amplitude measurements can be made rapidly with a minimum of control adjustments.

2-17. MEASUREMENTS.

2-18. When the vernier controls for time (12) and vertical amplitude (5 & 9) are rotated fully clockwise to the CAL position, measurement of voltage, time, frequency and phase can be made with an accuracy of 3%.

2-19. With the vertical verniers in the CAL position, the V/DIV set in on the

If not fully charged, plug the charger into the rear of the MS-230 and into an active power outlet. Leave the power switch off until you are ready to use the instrument. The batteries will reach their maximum charge in 16 hours. Leaving the batteries on charge for a longer period of time will not harm them. The scope's charging circuitry will automatically cut off when the batteries reach full charge and will keep them at full charge.

c. At full charge, the batteries will provide over one-half hour of continuous operation. Take advantage of the instrument's short warm-up time and save the batteries - shut it off when you are not actually looking at it.

d. When the batteries have run down, the power indicator LED will go out. When this occurs, shut off the power and put the scope back on charge as soon as possible. It is better to give them a full charge before using the instrument again; this will help to preserve their capacity.



Do not leave PWR switch on when power indicator LED goes out. Do not leave the instrument with the PWR switch on as complete discharge of the batteries may take place. If this occurs, the batteries may be damaged and may not be rechargeable.

2-25. OPERATIONAL TROUBLESHOOTING.

- a. No trace.
  - 1. Intensity control turned down.
  - 2. X or Y position controls not centered.
  - 3. Batteries not charged.
  - 4. No input signal in triggered mode.
  - 5. Insufficient amplitude signal to trigger on.
  - 6. Trigger level control not adjusted properly.
- b. Beam spot only.
  - 1. Trigger level control set too low.
  - 2. No trigger present in external trigger mode.

multiplier and range controls are accurately calibrated vertically on the graticule for AC and DC voltage amplitudes.

2-20. With the horizontal vernier set at CAL, the time base settings on the horizontal multiplier, range and units controls are accurately calibrated horizontally on the graticule. Time and period (1/freq) can be read directly. Phase measurements can be accomplished by using an external trigger, dual trace or XY modes of operation.

2-21. XY Operation. When it is desired to control the horizontal deflection of the display from a source other than the internal linear time base of the MS-230, then the XY mode of operation must be used. This mode is selected by placing the vertical mode switch in the CH1 (Y) position, the horizontal mode switch in the CH2 (X) position and the trigger level control clockwise. This provides vertical control of the trace by the CH1 circuitry and horizontal control by the CH2 circuitry. In this manner Lissajous patterns can be displayed for simultaneous phase and gain measurements, signal synchronization, etc.

2-22. The XY mode transfers all horizontal controls to the CH2 circuits. The normal horizontal controls are disabled as are the trigger circuits. Also the CAL position of the CH2 variable gain control will not provide a truly calibrated deflection. If calibrated horizontal measurements are necessary, apply the 1V p-p calibrated signal to the CH2 input. Set the CH2 switch to .5V/DIV and adjust the variable gain control so that two horizontal divisions are displayed. This procedure will calibrate all switch settings in the XY mode, but remember to reset the CH2 variable gain control to CAL when returning to the triggered sweep mode.

2-23. CARE OF BATTERIES.

2-24. With proper care, the batteries within the Miniscope will give years of service with little degradation of capacity. To preserve the capacity of the batteries (the ability to retain a full charge), follow the instructions set forth below:

- a. When operating from line voltage, keep the charger plugged into the MS-230 and into an active power outlet at all times. The batteries will reach their maximum charge overnight when the power switch is off. Keeping the batteries as near to full charge as possible will help preserve their operating life. If the instrument is run from line voltage continuously, the batteries will level out at approximately one-half full charge.
- b. When it is desired to operate the scope from the batteries alone, first be sure that they are fully charged so that maximum operating life can be obtained.



SECTION III  
THEORY OF OPERATION

3-1. INTRODUCTION.

3-2. The MS-280 is a small, portable, dual trace oscilloscope, operating from an AC line or rechargeable batteries. Circuitry is mainly integrated circuits of the C-MOS or low-powered Schottky types. A low filament power CRT is used to reduce drain on the batteries. Four vertical deflection modes are included:

- a. CH1
- b. CH2
- c. CH1 & CH2, chopped
- d. CH1 & CH2, alternately

3-3. The source for internal triggering of the horizontal sweep during the four vertical modes is:

- a. CH1
- b. CH2
- c. CH1
- d. CH1

3-4. Besides internal triggering, the scope can also be triggered from an external signal, the power line, or the horizontal sweep will free run if there is no triggering sources available. In following the various internal circuit descriptions below, refer to figure 3-1 see also figures 4-1 and 4-2 for component location.

3-5. VERTICAL AMPLIFIER.

3-6. There are three amplifiers in cascade which make up the CH1 vertical amplifier. The first amplifier is a FET cascode follower (Q1). The input to this amplifier is either direct, AC coupled or grounded depending on the position of the front-panel toggle switch. Also a 10:1, 100:1 or 1000:1 attenuator is inserted between the input signal and the amplifier in the 1, 10 or 100 positions, respectively, of the front-panel (vertical V/DIV) slide switch. The output of the first amplifier connects to an attenuator with divisions of 1:1, 2:1 or 5:1 depending on the position of the front-panel (V/DIV) toggle switch. The front-panel variable gain control is also connected in series with this attenuator. The output of the second attenuator is connected to the second amplifier (U1). The front-panel vertical position control is also connected to U1. The second amplifier is a differential input/differential output monolithic, bipolar amplifier with a gain of about 100:1. The outputs of this amplifier are connected to the inputs of the vertical deflection amplifier through C-MOS solid-state analog transmission gates (1/2 U9). The vertical deflection amplifier consists of a differential bipolar pair (Q1) of the

- 3. External horizontal input (CH2 (X)) selected with no horizontal input.
- 4. External horizontal input (CH2 (X)) selected with CH1 and CH2 inputs at GND.
- 5. External horizontal input (CH2 (X)) selected with CH1 and CH2 V/DIV settings too high.

c. No vertical deflection.

1. Vertical input coupling switch in GND position.

2. No vertical input signal; check leads.

3. Vertical V/DIV settings too high.

d. Inaccurate measurements of voltage or time.

1. Vernier not set at CAL position.

e. Trace will not synchronize.

1. Incorrect trigger mode, generally.

2. Non-repetitive or unstable input frequency.

3. Automatic trigger mode selected.

4. Input signal not derived from the line in the LINE mode.

5. Vertical input signal not derived from the same source as the trigger input, in the external trigger mode.

41-193 assemblies). The bases are driven by emitter followers (Q4, Q5) connected to the output of the transmission gates (U9). The emitters are supplied by constant-current sources (Q8, Q9), and the collectors drive complimentary symmetry cascode-connected followers (Q2 - Q5 of the 41-193 assemblies). The output of the followers is connected to the vertical deflection plates of the CRT (pins 9 and 11).

3-7. The CH2 vertical amplifier is the same as the CH1 amplifier except that the circuit symbols are different.

### 3-8. HORIZONTAL AMPLIFIER.

3-9. The horizontal deflection amplifier (Q10, Q11, Q12, Q13) is the same as the vertical deflection amplifier except that it has a smaller bandwidth and the horizontal deflection plates are connected to its output. In the XY operation mode, the inputs to the horizontal deflection amplifier come from the outputs of the second amplifier of the CH2 vertical amplifier. In the triggered sweep operating mode, the inputs to the horizontal deflection amplifier come from the horizontal position control and the output of an N-channel junction FET source follower (Q2) which is connected to the time base generator. The connections to the horizontal deflection amplifier inputs are made by C-MOS solid-state analog transmission gates (U8).

### 3-10. TIME BASE GENERATOR.

3-11. The time base generator is composed of five sections: a front-panel controllable constant-current source (Q14, Q15, Q16), the capacitive load on the constant-current source (C21, C23), an astable multivibrator (1/2 U5), a flip-flop (1/2 U3), and a solid-state switch (U6). In the initial state, the capacitor is grounded through the solid-state switch. A pulse from the trigger circuit flips the flip-flop. The switch lets the capacitor charge positively in a linear ramp at a rate determined by the constant-current and the value of the capacitor. When the ramp reaches a level determined by the threshold of the astable multivibrator, the multivibrator generates a pulse which flips the flip-flop back to its initial state. This causes the capacitor to be discharged rapidly by the solid-state switch. The length of the multivibrator pulse is long enough to permit the complete discharge of the capacitor. The flip-flop is prevented from being triggered before the capacitor is discharged by a gate (1/4 U3) between the flip-flop and the time base trigger.

### 3-12. TIME BASE TRIGGER.

3-13. The time base trigger is composed of a Schmitt trigger (1/2 U4), an in-

verter (1/4 U4) and an input buffer (Q17). The input buffer is an N-channel junction FET connected as a source follower. Its input can be connected to the output of the second vertical amplifier for synchronization of the time base to the vertical input signal (internal trigger). It can be connected to an external source for synchronization of the time base to some other signal (external trigger). It can be disconnected when there is no signal to synchronize on so that the time base will free run (auto trigger). It can also be connected to a line frequency signal derived from the output of the charger/transformer (line trigger). These four sources are selectable with the front-panel trigger slide switch. The output of the buffer (Q17) is connected to the input of the Schmitt trigger which is connected to an inverter. Either the Schmitt trigger output or its inverse is connected to the time base generator depending upon the setting of the front-panel trigger slope switch.

### 3-14. CATHODE-RAY TUBE.

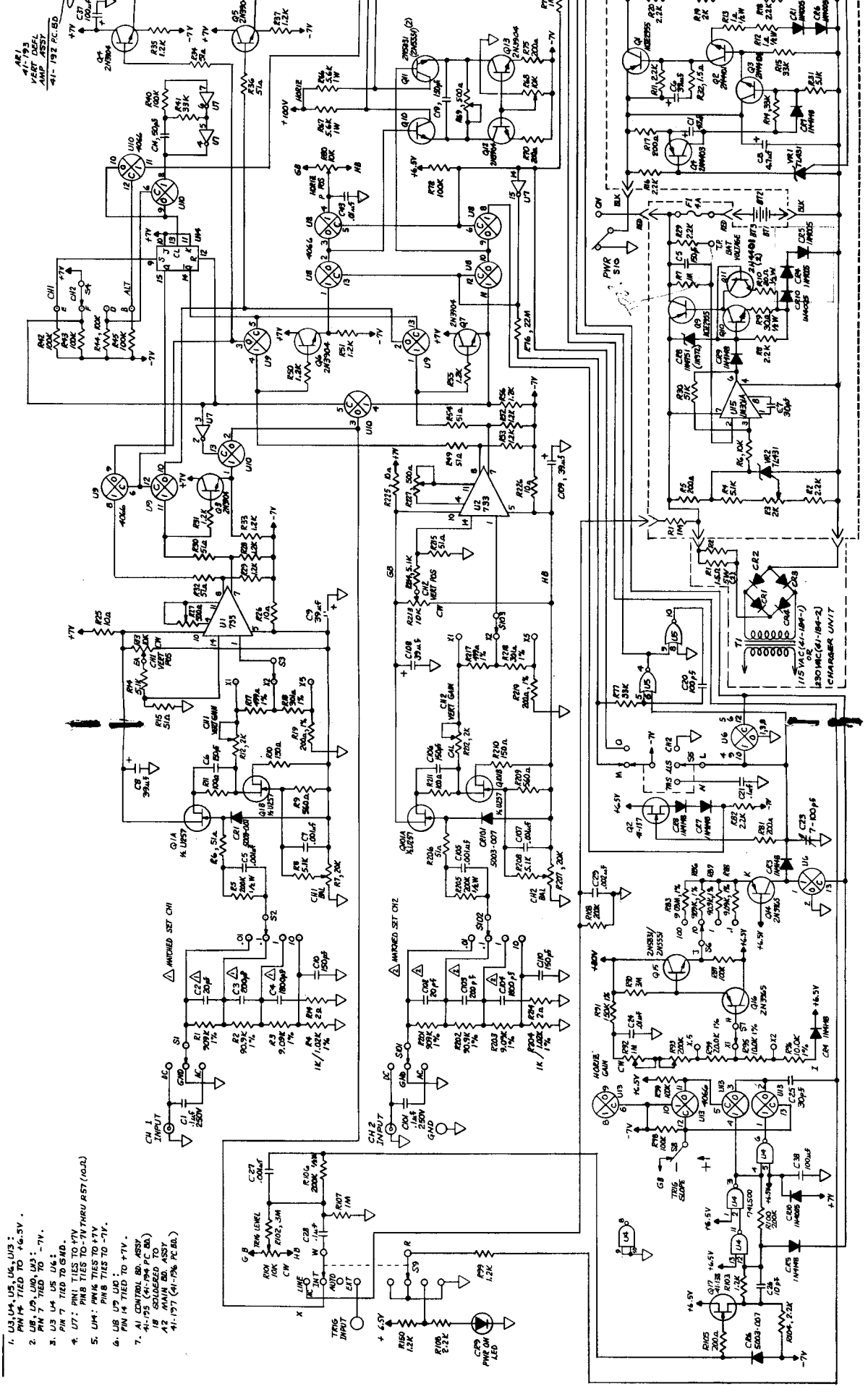
3-15. The deflection plates of the CRT are connected to the outputs of appropriate deflection amplifiers. At zero deflection the vertical plates are at approximately +45V with respect to ground and the horizontal plates are at approximately +55V. The astigmatism control element (pin 12) is connected to the wiper of a potentiometer between -7 VDC and +100 VDC. The wiper voltage for the best display can fall anywhere within those extremes, depending on the tube. The focus element of the CRT (pin 4) is tied to the wiper of a potentiometer which is one of a series of resistors from the cathode of the CRT to ground. The voltage at the wiper for display will be anywhere from 50 VDC to 200 VDC above the cathode of the CRT. The screen element of the CRT (pins 10 & 13) is connected to a fixed divider and is nominally 50 VDC above ground. The CRT has a directly heated cathode. The heater current is nominally 60 mA DC and is about 720 VDC below ground. The intensity control grid (Pin 3) is connected to the wiper of a potentiometer which is connected to a flip-flop (1/2 U11). The flip-flop is powered by a nominal 13 VDC supply referenced to the cathode of the CRT at -720 VDC. The flip-flop is capacitively coupled to the flip-flop (U3) in the time base generator and follows its state synchronously in the linear sweep mode. In one state of the flip-flop, the grid cuts off the beam current, thus preventing the retrace from appearing in the display. In the other state a beam current is obtained which depends on the setting of the intensity control. In the external horizontal input mode, the time base generator is disabled and a third capacitively-coupled connection to the blanking flip-flop turns the beam on continuously.

### 3-16. CALIBRATOR.

3-17. The 1V p-p calibrated output signal, available on the front panel, is de-

**NOTES: UNLESS OTHERWISE SPECIFIED.**

1. U3, U4, U5, U6, U13:
- PIN 14 TIED TO +6.5V.
2. U8, U9, U10, U13:
- PIN 7 TIED TO -7V.
3. U3, U4, U5, U6:
- PIN 7 TIED TO GND.
4. U7: PIN 8 TIES TO -7V THROUGH R57 (0.02).
5. U14: PIN 8 TIES TO +7V.
6. U8, U9, U10:
- PIN 14 TIED TO +7V.
7. AI CONTROL BD. ASSY:
- 41-195 (41-P44 PC BD.)
- 41-196 (41-P45 PC BD.)
- 41-197 (41-P46 PC BD.)





## SECTION IV CALIBRATION

rived from an internal frequency after being squared up by a flip-flop (1/2 U14). The signal is useful as a check on the calibration of the vertical amplifier, in setting the frequency compensation of high input impedance probes, or as a test signal source for external circuitry. The frequency is typically 1 kHz and the duty cycle is approximately 50%. It is a bipolar signal referenced to ground.

### 3-18. POWER SUPPLY.

3-19. All of the supply voltages required by the circuits in the MS-230 previously described in this section are generated by a DC/DC converter. The +80 VDC supply employs a full wave bridge. The -720 VDC, +7 VDC and -7 VDC supplies employ voltage doubler circuits. The remaining supplies use half-wave rectifiers. The primary of the DC/DC converter transformer is connected to two power transistors (Q5 & Q6). The transistors are driven from an oscillator (U12) by the low power transistors (Q7 & Q8). Since all of the loads on the secondaries are fairly constant, regulating the input voltage to the converter simultaneously regulates all the outputs. The input to the converter is provided by the +5 VDC regulator. The series pass transistor (Q1) is driven by an inverter (Q2) which is controlled by a 3-terminal shunt regulator (VR1) through a saturated transistor (Q4) and an emitter follower (Q3). VR1 has an internal reference of approximately +2.50 VDC. When the input to the +5 VDC regulator drops below +5 VDC, the regulator shuts down completely and the front-panel indicator goes out, indicating insufficient battery voltage to maintain proper operation of the scope. This unloads the batteries and protects them from excessive drain. As soon as it is noticed that the power indicator has gone out, the power switch should be turned off. The batteries should then be given a full recharge.

3-20. The batteries are charged from the line via a charger/transformer which plugs into the rear of the MS-230 through a two-contact plug. The output of the charger/transformer is full-wave rectified in the oscilloscope and charges the batteries through a series pass transistor (Q9). Q9 is controlled by the 3-terminal shunt-regulator (VR2) and an amplifier (U15). The charge regulator shuts off when the batteries reach +7.2 VDC ( $\pm 1$  VDC), thus protecting the batteries from overcharge.

### 4-1. INTRODUCTION.

4-2. The MS-230 must be functional in all modes before calibration. The calibration will be invalid if the instrument is partially inoperative.

### 4-3. EQUIPMENT REQUIRED.

- Digital Multimeter, NLS Model LM-3.5A, or equivalent.
- Oscilloscope, with vertical deflection calibrated to 1% or better.
- Waveform Generator - 1 Hz to 100 kHz, variable amplitude square and sine wave capability.
- Frequency Meter, NLS Model FM-7, or equivalent.
- DC Voltage Source, 6.3V @ 3 amperes.

### **WARNING**

Dangerous voltages are present at several locations in the MS-230. Since it is battery operated, with the PWR switch ON, such voltages will be present even when the instrument is disconnected from the AC power line. Exercise caution and use an all-plastic screwdriver for all adjustments.

### 4-4. INITIAL PREPARATION.

- Set PWR switch to OFF position. Remove screw from bottom of case.
- Gently slide instrument out of case.
- Connect charger/transformer to instrument and then connect charger/transformer to appropriate power source.
- Set PWR switch to ON position.

### NOTE

If the batteries are fully charged, allow 30 seconds for instrument warmup; if batteries are completely run down, turn the scope off and allow approximately 60 minutes of charging time before turning scope back on.

#### 4-5. PROCEDURE.

#### 4-6. CHARGING CIRCUIT.

a. Disconnect charger/transformer from instrument and place PWR switch in OFF position.

b. Remove fuse (F1 - figure 4-1).

c. Connect a 2 k $\Omega$ , 1/2W resistor and a 300  $\mu$ F, 10V capacitor in parallel (values of capacitor may be higher) from the right-hand terminal of fuse (as you face the fuse looking from front panel) to ground. Negative terminal of capacitor must be connected to ground.

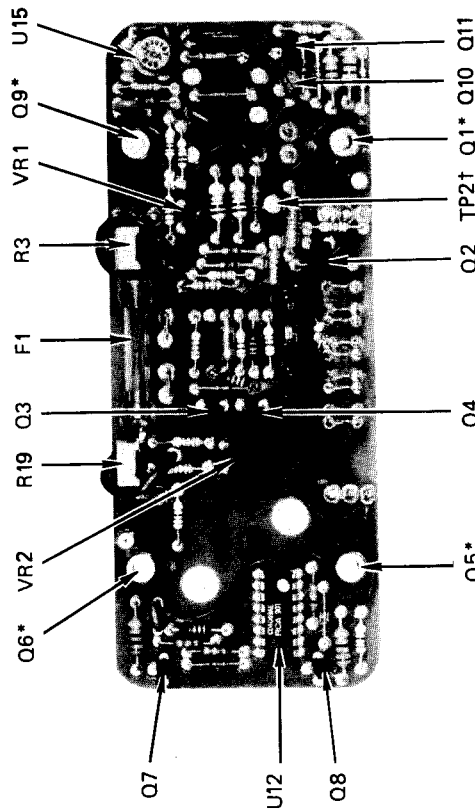
d. Connect charger/transformer to instrument and to an active line voltage outlet.

e. Measure the voltage across the resistor and capacitor; it should be +7.2 VDC ( $\pm 0.1$  VDC). If it is not, adjust R3 (figure 4-1) until it is.

f. Disconnect charger/transformer and remove resistor and capacitor.

#### 4-7. +5.00 VDC REGULATOR AND BATTERY DISCHARGE CUTOFF.

a. With charger/transformer disconnected and fuse removed, connect a



\* Rear side.

† TP2 is accessible from opening near charger input at rear of instrument.

Figure 4-1. Component Location - Outer Rear Board

source of +6.3 VDC to right-hand fuse terminal.

b. Place PWR switch in ON position.

c. Check to see that red power indicator LED on front panel is illuminated. If it is not, adjust R19 (figure 4-1) CW until it is. Turn PWR switch off and then on again.

d. Connect an LM-3.5A DMM between TP2 (figure 4-1) and ground.

e. Adjust R19 (figure 4-1) until multimeter reads +5.00 VDC.

f. Reduce DC voltage source to +5.00 VDC; front-panel LED will go out.  
g. Reading at TP2 should be 0 volts.

#### 4-8. POWER SUPPLY VOLTAGE CHECKS.

a. Perform tests with batteries charged, fuse in place and charger/transformer connected.

b. Connect an LM-3.5A as set forth in table 4-1 and read voltages listed.

#### 4-9. ASTIGMATISM.

a. Using triggered mode and AC input coupling, connect waveform generator output to vertical input. With generator set to 10 kHz, sine wave, set vertical and time base controls to display two complete sine waves two divisions high.

b. Adjust INTENSITY (rear panel) control to obtain a bright trace.

c. Adjust FOCUS (rear panel) control to obtain the clearest and sharpest trace possible. Readjust intensity if needed.

d. Adjust astigmatism potentiometer (R60 - figure 4-2) so trace has uniform brightness and width in both vertical and horizontal directions.

e. Repeat steps c and d until no further improvement can be made.

#### 4-10. VERTICAL AMPLIFIER BIAS.

a. Using front-panel controls, obtain a horizontal trace on CRT.

b. Rotate vertical position control fully clockwise and then fully counterclockwise.

c. Adjust R46 (figure 4-2) until trace just barely disappears from view at top and bottom of screen.

Table 4-1. Power Supply Voltages

VOLTAGES	WHERE MEASURED	CONDITIONS
1. +11 VDC (±1 VDC)	Output of 115 VAC charger	115 VAC, 60 Hz input - no load
2. +11 VDC (±1 VDC)	Output of 230 VAC charger	230 VAC, 50 Hz input - no load
3. +5.2 VDC to +7.3 VDC	Fuse to ground	Any operating or non-operating mode
4. +5.00 VDC (±0.05 VDC)	TP2 to ground (figure 4-1)	Any operating mode with batteries charged
POWER SUPPLY CONNECTIONS*		
5. -700 VDC to -750 VDC	Pin 18 to ground	Same as 4
6. +0.50 VDC to +0.65 VDC	Pin 17 to pin 18	Same as 4
7. -11.5 VDC to -13.5 VDC	Pin 16 to pin 18	Same as 4 with intensity control at minimum
8. +75 VDC to +85 VDC	Pin 7 to ground	Same as 4
9. +95 VDC to +105 VDC	Pin 6 to ground	Same as 4
10. +7.5 VDC to +8.0 VDC	Pin 4 to ground	Same as 4
11. -7.5 VDC to -8.0 VDC	Pin 5 to ground	Same as 4

\*Power supply connection pins are located on the inner rear vertical board and are accessible from the underside of the instrument.

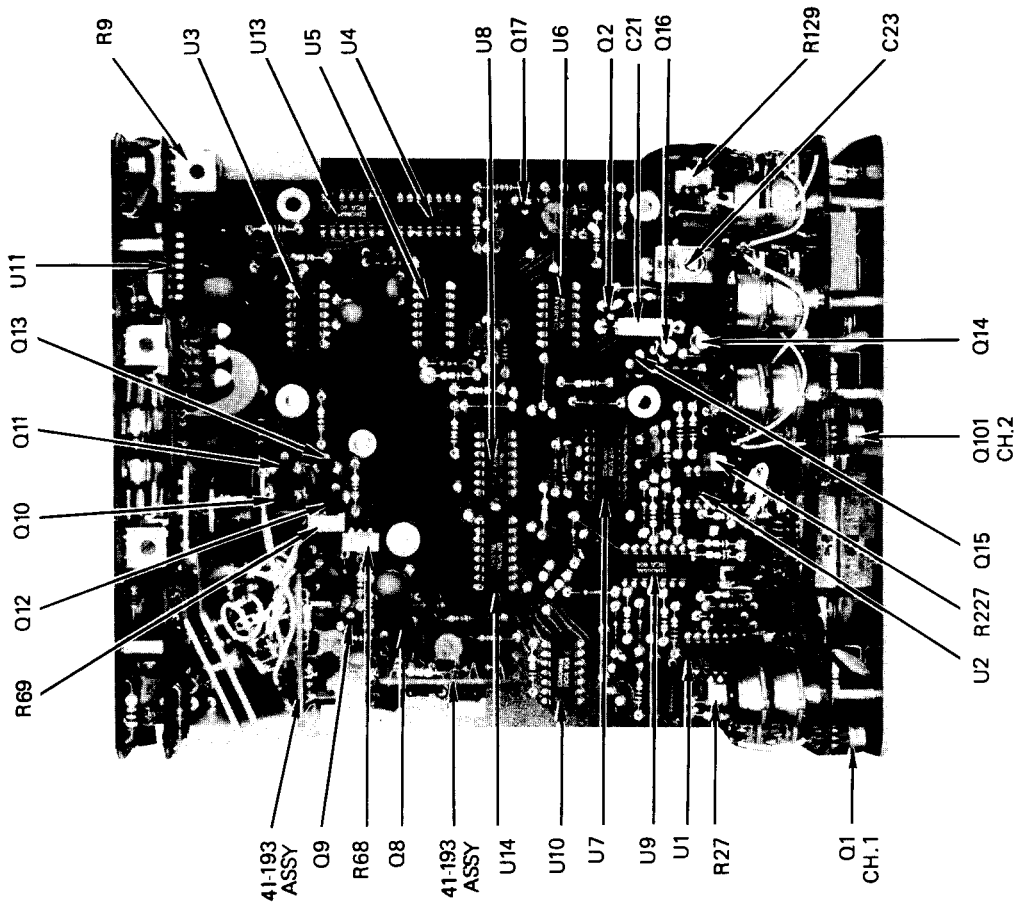


Figure 4-2. Component Location - Main Board

#### 4-11. HORIZONTAL AMPLIFIER BIAS.

- a. Using front-panel controls, place instrument in XY mode of operation.
- b. Rotate CH2 vertical position control fully clockwise and then fully counterclockwise.
- c. Adjust R68 (figure 4-2) until spot just disappears from view at both left and right sides of screen.

#### 4-12. CALIBRATOR.

- a. Connect a calibrated oscilloscope from calibrator 1V p-p output to ground.
- b. Center trace on screen and adjust R129 (figure 4-2) until calibrator output is exactly 1V p-p.

#### 4-13. VERTICAL AMPLIFIER BALANCE.

- a. Set trigger mode switch to AUTO. Set CH1 input switch to GND. Set vertical V/DIV controls to 50 V/DIV. Set vernier to CAL (CW).
- b. Center trace vertically so it coincides with central horizontal line of screen using vertical position control.
- c. Change V/DIV controls to 0.1 V/DIV.
- d. Adjust CH1 vertical BAL control until trace coincides with central horizontal line of screen.

e. Change V/DIV controls to 50 V/DIV and repeat steps b thru d until trace does not move from central line at 50 V/DIV or .01 V/DIV. When this is completed, there will be less than 1/3 division shift in trace for other V/DIV settings.

- f. Repeat above steps for CH2 amplifier.

#### 4-14. VERTICAL AMPLIFIER LOW FREQUENCY GAIN.

- a. Using AC vertical input coupling and internal triggered mode, connect calibrator output to CH2 vertical input. Set vertical V/DIV controls to .5 V/DIV. Center trace vertically. Set vernier to CAL (CW).
- b. Adjust R227 (figure 4-2) until trace amplitude is exactly two graticule divisions high.

- c. Repeat step a using CH1.

- d. Repeat step b using R27 (figure 4-2).

#### 4-15. TIME BASE LOW FREQUENCY.

- a. Use internal trigger mode and AC vertical coupling. Set time/DIV to 5  $\mu$ S/DIV with time vernier in CAL (CW) position.
- b. Connect a 100 Hz square wave frequency, calibrated to 1% accuracy to vertical input. Center trace. An inexpensive square wave generator may be used if monitored by an NLS FM-7 Frequency Meter. Input voltage to the FM-7 should not exceed 0.7V peak-to-peak.
- c. Adjust R69 (figure 4-2) and horizontal position control until trace is approximately 1/32 inch longer than five divisions of graticule in horizontal direction.
- d. Adjust R93 (figure 4-2) and horizontal position control for best coincidence of vertical lines of square wave trace with vertical lines of graticule.

#### 4-16. TIME BASE HIGH FREQUENCY.

- a. Preparation is the same as in paragraph 4-15 except vertical input frequency is 100 kHz and time/DIV is 5  $\mu$ S/DIV.

b. Adjust C23 (figure 4-2) and horizontal position control for best coincidence of vertical lines of square wave trace with vertical lines of graticule.

#### 4-17. RETRACE BLANKING ADJUSTMENT.

- a. Using a positive triggered sweep and AC input coupling, connect a 100 kHz square wave vertical input. Set time/DIV controls to 5  $\mu$ S/DIV.

- b. Turn INTENSITY control to maximum.

c. Adjust R9, high voltage power supply potentiometer (figure 4-2), until retrace just appears at top and/or bottom of square wave. Note position of R9.

- d. Readjust R9 until trace disappears. Note position of R9.

e. Set R9 to a position halfway between positions noted in c and d above so that a complete bright trace is obtained with no retrace and no bright spot or vertical line at beginning.



SECTION V  
MAINTENANCE

5-1. CLEANING.

5-2. The outer surfaces of the MS-230 will require cleaning from time to time. Use a warm water and detergent solution with a cloth and/or brush. Be careful not to scratch the graticule. Since there are no ventilating holes in the case of the MS-230, the circuitry probably will not require cleaning. However, in a severely dusty environment blow off the dirt accumulated inside the case with filtered compressed air. If this is not available, use a brush and vacuum cleaner. Use care so as not to upset the settings of the calibration potentiometers. If the above methods are not sufficiently effective, use a Freon<sup>(R)</sup> base solvent with a brush. Do not use a vapor degreaser as it will damage the potentiometers.

5-3. VISUAL INSPECTION.

5-4. After every few months of use visually inspect the oscilloscope for loose or broken connections, loose screws, heat-damaged components or leaking batteries. If anything improper is noted, the appropriate corrective action should be taken. In the case of overheated components, it is likely that the problem is not with the part that is overheated. When replacing an overheated component make sure the associated circuitry is functioning properly. Otherwise another overheated component may result.

5-5. TROUBLESHOOTING PROCEDURE.

5-6. Before attempting to troubleshoot the MS-230 make sure that any apparent trouble is actually due to a malfunction within the instrument rather than improper control settings. Instructions for the operation of the oscilloscope are contained in the Operation section of this manual.

5-7. CIRCUIT TROUBLESHOOTING.

5-8. The MS-230 consists of seven main circuits. These are:

- a. Power Supply.
- b. Vertical Amplifier.
- c. Horizontal Amplifier.
- d. Time Base Trigger.

(R) Registered trademark of E. I. DuPont de Nemours & Co. (Inc.)

e. Time Base Generator.

f. Cathode-Ray Tube.

g. Calibrator.

5-8. The first circuit to check for any type of trouble is the Power Supply (See table 4-1). All the other circuits in the instrument are dependent upon the proper operation of the power supply circuitry. If all the power supply voltages are correct, then the nature of the symptom should direct you to the circuit which contains the trouble. For example, if the trace on the CRT appears normal in the horizontal direction but not in the vertical then the problem is most likely in the vertical amplifier.



Use extreme caution in performing the following tests as dangerously high voltages will be present.

#### 5-10. TROUBLESHOOTING THE POWER SUPPLY.

5-11. If the power indicator does not light and there is no trace when operating from batteries alone, but there is an erratic appearing trace when operating from the charger/transformer then the problem is very likely a blown fuse. The fuse (F1 - figure 4-1), if not defective, will measure less than 0.1 ohm. If after replacement the fuse blows again, then the problem may be in the +5.00 VDC regulator between the batteries and the DC/DC converter. The +5.00 VDC regulator should use less than 350 mA DC unloaded. The regulator can be unloaded by unplugging the 41-202 low voltage (rear) power supply board. Leave the two black and two red wires connected. If the regulator is functioning properly, then check the rectifiers and loads on the secondaries of the DC/DC converter. Also check the switching transistors and oscillator circuitry on the input of the DC/DC converter. If these tests do not uncover a fault, the DC/DC converter transformer is probably defective.

5-12. If the MS-230 will not operate on batteries alone for more than one-half hour after receiving a full charge (refer to Operation section of this manual), then either the batteries are weak, there is an excessive load on the batteries or the charging circuitry is at fault. First check the batteries. From the fuse to ground the battery voltage should measure between +5.2 VDC and 7.3 VDC regardless of whether the scope is operating from the batteries or not. Measure the battery voltage during each of these modes. If the voltage is outside the limits, then at

least one cell is faulty. Measure each cell. If any cell measures less than 1.7 VDC or greater than 2.4 VDC then that cell is faulty and should be replaced.

5-13. If the batteries are satisfactory then check the load current. With the charger/transformer unplugged and an ammeter in place of the fuse, measure the operating current drain on the batteries with the PWR switch on. It should be less than 2.5A. If not, then one of the secondary windings of the DC/DC converter is probably overloaded and one or more of its output voltages will measure low.

5-14. If all the above checks do not locate the problem then the charging circuitry is at fault. After giving the batteries a full charge (refer to Operation section of manual) measure the battery voltage from the fuse to ground. It should be +7.2 VDC ( $\pm 0.1$  VDC) before the scope is turned on. If it is not, then the charging circuitry is faulty. Too high a voltage will overcharge the batteries and reduce their life. Too low a voltage will not fully charge the batteries and the scope will operate only a short time from the batteries alone. The charge regulator may just need readjusting (refer to Calibration section) or there may be a faulty component.

5-15. If the scope will not run continuously from the charger/transformer, measure the line voltage. It should be within 105 VAC to 125 VAC with a 115 VAC charger/transformer and 210 VAC to 250 VAC with a 230 VAC charger/transformer. If the line voltage is satisfactory, go through the procedure listed for short operating time from batteries. Finally, with the battery voltage less than +6.4 VDC measured from the fuse to ground, measure the charge current by inserting an ammeter in place of the fuse and plugging in the charger/transformer with the scope off (if necessary, operate the meter from the batteries alone to achieve this voltage). The current should measure greater than 3 amperes DC.

#### NOTE

The charge current is related to the battery voltage, rising as the battery voltage drops. If the current is less than 3 amperes DC, the charging circuitry is faulty.

#### 5-16. TROUBLESHOOTING THE VERTICAL AMPLIFIER.

5-17. With the vertical input grounded, if the trace or spot is visible when the vertical deflection plates (pins 9 & 11) are shorted together and disappears when the short is removed, the vertical amplifier is in a state of DC imbalance. To determine where the problem is measure the differential voltage at the output of the second amplifier (pins 7 & 8 of U1 - figure 4-2). If it can be adjusted to  $\pm 2$

VDC with the front-panel vertical position control, then the problem is in the deflection amplifier output stage. If the voltage cannot be adjusted as specified, measure the voltage at the output of the first amplifier (wiper of vertical gain potentiometer, R12 - figure 4-2). If it is within 0.01 VDC of ground, then the problem is in the second amplifier. If it is not as specified, then the problem is in the first amplifier. If the problem is incorrect gain, use signal tracing techniques to locate the problem.

#### 5-18. TROUBLESHOOTING THE HORIZONTAL AMPLIFIER.

5-19. Use the same approach as is outlined for the vertical amplifier.

#### 5-20. TROUBLESHOOTING THE TIME BASE TRIGGER.

5-21. If a problem exists in one or more positions of the trigger mode switch but not all, then the switch itself or associated networks are at fault. If a problem exists in all positions, then the fault lies with either the source follower (Q2 - figure 4-2), the Schmitt Trigger (U4 - figure 4-2) or slope selector (U12). Check the output of the source follower. If it exhibits approximately unity gain, the problem is in the trigger or slope selector. If the source follower does not have unity gain then it is the problem.

#### 5-22. TROUBLESHOOTING THE TIME BASE GENERATOR.

5-23. If there is no horizontal sweep and the time base trigger is not at fault, then the time base generator is at fault. If the sweep works in some settings and not in others then the switching or the associated networks are at fault. If the sweep does not work at all, the constant-current source can be tested by disconnecting the output collector lead (Q14 - figure 4-2) and measuring the current to ground. The gates in the astable multivibrator (U5 - figure 4-2), transmission gate (U6 - figure 4-2) and the flip-flop (U3 - figure 4-2), can be checked by examining their input versus output relationships.

#### 5-24. TROUBLESHOOTING THE CATHODE-RAY TUBE.

### WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be present.

5-25. If there is no spot or trace on the CRT:

- a. Check all the power supply voltages. (Refer to table 4-1.)

- b. Short across the horizontal and vertical deflection plates (pins 6 & 7).
- c. Connect a 1 k $\Omega$  resistor between pins 1 & 3 of the CRT.
- d. Turn the INTENSITY control to mid-range.

5-26. If there is no spot, then the CRT is defective. If there is a spot, check the horizontal and vertical amplifiers for balance. If no problem is found, then the problem is in the blanking circuitry.

#### 5-27. TROUBLESHOOTING THE CALIBRATOR.

5-28. If there is no 1V p-p calibrator output use signal tracing techniques to find where the signal is lost.