SECTION 3

MAINTENANCE

3.1 INTRODUCTION

This section describes routine maintenance of the ESI Model 250DE Impedance Bridge. The performance check shows whether the instrument is operating within the limit of accuracy listed in Table 1-1. Some instrument failures can be easily diagnosed and treated; these are discussed in this section. If the instrument is operating improperly and the malfunction is not discussed here, it should be returned to the ESI factory for repair and recalibration.

3.2 PERFORMANCE CHECK

It is presumed that the operator is familiar with the Model 250DE Impedance Bridge and with the equipment referred to in this section. Brief instructions for operating the bridge are inside the lid.

Whenever the instruction "measure" is given in this procedure, it means to operate the bridge under test as a measurement system.

The procedures in this section are for use with the equipment recommended in Section 3.2.2. Control and terminal nomenclature refer specifically to this equipment. If other equipment is used, be sure to note differences and revise the process accordingly. All connections to the instrument are made to R-L binding posts 1 and 2 or to C binding posts 2 and 3. Figure 3-1 shows the front panel of the instrument and the binding posts.

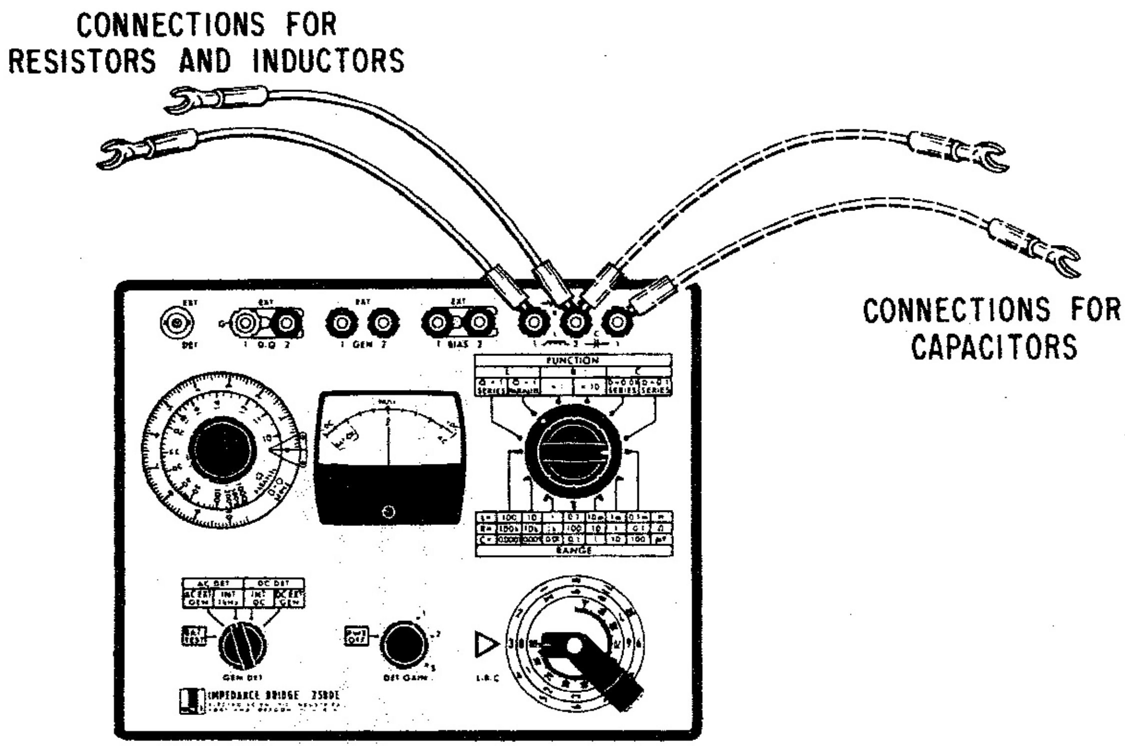


Figure 3-1. Model 250DE Impedance Bridge

3.2.1 Checking Method

The method used to check the ESI Model 250DE Bridge is outlined in the following table:

Item Under Test	Performance Specifications	Test Method
Resistance Range	0.1%	Measurements of standard resistances.
MAIN DIAL Linearity Calibration.	0.1% + 1 dial division	Measurements of series-connected resistance transfer standards and resistance decades.
Capacitance Calibration	0.1%	Measurement of standard capacitor.
D-Q Dial Linearity	1.0% + 1 dial division +0.005 $(1 + D^2)$ 1.0% + 1 Dial division +0.007 $(1 + 1/Q^2)$	Measurements of resistance-capacitance combinations.
Functional Tests	Bridge Balance on SERIES and PARALLEL inductances.	Measurement of inductances.

3.2.2 Equipment Requirements

Minimum use specifications will aid the selection of alternate equipment. Be sure alternate items meet the requirements before using them.

Item	Minimum Use Specifications	Recommended Equipment
1 & 2 Resistance, Transfer Standards	Resistances available: 1 Ω, 10 Ω, 100 Ω, 1 kΩ, and 10 kΩ through 120 kΩ, in 10 kΩ steps. Accuracy: ±0.003% or better.	ESI Model SR 1010 Resistance Transfer Standards (10 Ω/step and 10 kΩ/step) with ESI Model SB 103 shorting bars.
3 Capacitance Standard	Capacitance: 0.1 μF. Accuracy: ±0.02%.	
4 Resistance Decades	Resistances available: 0 thru 100 kΩ 0.1 Ω steps. Accuracy: ±(0.02% + 10 mΩ).	ESI Models DB 62 or DB 877. (Specify 111.111 kΩ total resistance for Model DB 62).
5 Capacitance Decades	Capacitances available: 10 pF thru 1 μF with 5-dial resolution. Dissipation factor: less than 2.5×10^{-4}.	ESI Model DC 57
6 Inductor	Inductance: 100 mH. Minimum Q: 10.	
7 Test Leads		ESI part numbers 4160 and 4168 (Supplied with Model 250DE)

3.2.3 Preparation

Remove lid from instrument and set GEN DET switch to BAT. TEST. Meter should deflect to BAT. OK zone. If not, replace batteries.* Battery replacement procedure is outlined on the instruction sheet on the inside of the instrument cover.

3.2.4 Environmental Conditions

For highest accuracy, the temperature should be 23°C ±2° (73°F ±4°). If the temperature is outside these limits, apply temperature coefficient corrections to find correct values of standard resistors and capacitors.

*If the instrument is equipped with a Model 1325 Power Pac, plug it in to charge the batteries.

3.2.5 Resistance Range Check

0.1-Ohm Range

1. Set FUNCTION selector to R x 1.

2. Set GEN-DET switch to INT DC. It should remain in this position throughout resistance range calibration and L-R-C decade calibration.

3. Connect test leads to R-L binding posts 1 and 2. They should remain so connected throughout range resistance calibration and L-R-C dial calibration.

4. Connect R1 through R10 of 10 Ω/step transfer standard (Item 1) in parallel with the shorting bars.

5. Set RANGE selector to 0.1 Ω.

6. Connect one test lead to each terminal on one of the shorting bars. (This allows the zero resistance to be measured.)

7. Measure the zero resistance and record the value in the space provided on the calibration record (Appendix A).

8. Connect one test lead to each shorting bar and measure resistance of the parallel-connected transfer standard. Record the measured value in the space provided on the calibration record.

9. Subtract the zero resistance from the measured resistance and record the difference in the space provided on the calibration record. The difference should be between 0.999 Ω and 1.0010 Ω.

1-Ohm Range

1. Set RANGE selector to 1 Ω.

2. Disconnect shorting bars from transfer standard and connect test leads to terminals A0 and C1 of 10 Ω/step transfer standard. This connects one 10-ohm resistor to the UNKNOWN terminals of the bridge.

3. Measure the resistance of the 10-ohm resistor and record the value in the space provided on the calibration record.

4. Subtract the zero resistance from the measured resistance and record the difference in the space provided on the calibration record. The difference should be between 9.990 Ω and 10.010 Ω.

10-Ohm Range

1. Set RANGE selector to 10 Ω.

2. Disconnect test lead from terminal C1 of the 10 Ω/step transfer standard and connect it to terminal A10. This connects ten 10-ohm resistors in series to the UNKNOWN terminals of the bridge.

3. Measure the resistance of the series-connected transfer standard and record the value in the space provided on the calibration record.

4. Subtract the zero resistance from the measured resistance and record the difference in the space provided on the calibration record. The difference should be between 99.90 Ω and 100.1 Ω.

100-Ohm Range

1. Set RANGE selector to 100 Ω.

2. Connect R1 through R10 of the 10 kΩ/step transfer standard in parallel with the shorting bars.

3. Disconnect test leads from 10 Ω/step transfer standard and connect one test lead to each shorting bar on the 10 Ω/step transfer standard.

4. Measure the resistance of the parallel-connected transfer standard and record the value in the space provided on the calibration record. The measured value should be between 999.0 Ω and 1001.0 Ω. (From this point on, zero resistance is not subtracted because it is insignificant compared to the tolerance.)

1-Kilohm Range

1. Set RANGE selector to 1 kΩ.

2. Disconnect shorting bars from transfer standard and connect test leads to terminals A0 and C1 of the 10 kΩ/step transfer standards. (This connects one 10-kilohm resistor to the UNKNOWN terminals of the bridge.)

3. Measure the resistance of the 10-kilohm resistor and record the value in the space provided on the calibration record. The measured value should be between 9.990 kΩ and 10.010 kΩ.

10-Kilohm Range

1. Set RANGE selector to 10 kΩ.

2. Disconnect test lead from terminals C1 of the 10 kΩ/step transfer standard and connect it to terminal A10. This connects ten 10-kilohm resistors in series to the UNKNOWN terminals of the bridge.

3. Measure the resistance of the series-connected transfer standard and record the value in the space provided on the calibration record. The measured value should be between 99.90 kΩ and 100.10 kΩ.

100-Kilohm Range

1. Set RANGE selector to 100 kΩ.

2. Measure the resistance of the series-connected transfer standard on this range. Record the measured value in the space provided on the calibration record. The measured value should be between 99.90 kΩ and 100.1 kΩ.

R x 10 Range

1. Set FUNCTION selector to R x 10.

2. Set RANGE selector to 1 kΩ.

3. Measure the resistance of the series-connected transfer standard and record the value in the space provided on the calibration record. The measured value should be between 99.90 kΩ and 100.10 kΩ.

Table 3-1. First Dial Calibration

1 First Dial Setting	2 Transfer Standard Resistance	Dial Setting Tolerances 3 Upper Limit	4 Lower Limit
0	10kΩ	0.X02	0.998
1	20kΩ	1.X03	1.997
2	30kΩ	2.X04	2.996
3	40kΩ	3.X05	3.995
4	50kΩ	4.X06	4.994
5	60kΩ	5.X07	5.993
6	70kΩ	6.X08	6.992
7	80kΩ	7.X09	7.991
8	90kΩ	8.X10	8.990
9	100kΩ	9.X11	9.989
10	110kΩ	10.X12	10.988
11	120kΩ	11.X13	11.987

Table 3-2. Second Dial Calibration

1 Second Dial Setting	2 Transfer Standard Resistance	Dial Setting Tolerances 3 Upper Limit	4 Lower Limit
0	10Ω	0.0(101)	0.099
1	20Ω	0.1(101)	0.199
2	30Ω	0.2(101)	0.299
3	40Ω	0.3(101)	0.399
4	50Ω	0.4(101)	0.499
5	60Ω	0.5(102)	0.598
6	70Ω	0.6(102)	0.698
7	80Ω	0.7(102)	0.798
8	90Ω	0.8(102)	0.898
9	100Ω	0.9(103)	0.997
X	110Ω	0 X(104)	0.X96

Table 3-3. Third Dial Calibration

1 Third Dial Setting	2 Transfer Standard Resistance	Dial Setting Tolerances 3 Upper Limit	4 Lower Limit
10	10Ω	0.011	0.009
20	20Ω	0.021	0.019
30	30Ω	0.031	0.029
40	40Ω	0.041	0.039
50	50Ω	0.051	0.049
60	60Ω	0.061	0.059
70	70Ω	0.071	0.069
80	80Ω	0.081	0.079
90	90Ω	0.091	0.089
*0	100Ω	0.0(101)	0.099

3.2.6 L-R-C Dial Check

First Dial

1. Set RANGE selector to 10 kΩ.
   NOTE: The next three steps are repeated for each setting of the first L-R-C dial. Refer to Table 3-1 for nominal dial settings, standard resistance values, and dial-setting tolerances.

2. Set first (outer) dial to the setting listed in column 1 of Table 3-1.

3. Connect test leads to 10 kΩ/step transfer standard in such a way that the resistance listed in column 2 of Table 3-1 is connected to UNKNOWN terminals.

4. Balance the bridge without changing position of first dial. Record L-R-C dial setting in the space provided on the calibration record. The upper and lower limits of this dial setting are listed in columns 3 and 4 of Table 3-1.

Second Dial

1. Set RANGE dial to 100 Ω.

2. Set first (outer) dial to 0.
   NOTE: The next three steps are repeated for each setting of the second L-R-C dial. Refer to Table 3-2 for nominal dial settings, standard resistance values, and dial setting tolerances.

3. Set second dial to the setting listed in column 1 of Table 3-2.

4. Connect test leads to 10 Ω/step transfer standard in such a way that the resistance listed in column 2 of Table 3-2 is connected to UNKNOWN terminals.

5. Balance the bridge without changing position of second dial. Record L-R-C dial setting in the space provided on the calibration record. The upper and lower limits of this dial setting are listed in columns 3 and 4 of Table 3-2.

Third Dial

1. Set RANGE dial to 1 kΩ.

2. Set first (outer) dial to 0.

3. Set second dial to 0.
   NOTE: The next two steps are repeated for each setting of the third L-R-C dial Refer to Table 3-3 for nominal dial settings, standard resistance values and dial-setting tolerances.

4. Connect test leads to 10 Ω/step transfer standard in such a way that the resista listed in column 2 of Table 3-3 is connected to UNKNOWN terminals.

5. Balance the bridge with third dial only. Record L-R-C dial setting in the spa provided on the calibration record. The upper and lower limits of this dial setting are listed in columns 3 and 4 of Table 3-3.

3.2.7 Capacitance Check

1. Connect the test leads to C binding posts 2 and 3. They should remain so connected throughout capacitance calibration check and D-Q dial linearity calibration check.

2. Set GEN-DET switch to INT 1 kHz. It should remain in this position for the remainder of the procedure.

3. Set FUNCTION switch to C, D x 0.01.

4. Connect the test leads to the standard capacitor (Item 3).

5. Measure ths standard capacitor and record the reading in the space provided in the data table. Value should be within 11 divisions of the third L-R-C decade dial of the calibrated value of the standard capacitor.

6. If dial reading is not within the specified tolerance, the trim capacitor may need adjustment. See Section 3.6.

3.2.8 D-Q Dial Linearity Check

1. Set FUNCTION dial to C, D x 0.01.

2. Connect resistance decade and capacitance decade (Items 4 and 5) in series and connect to test leads.

3. Set RANGE selector to 0.01 μF and set L-R-C dial to 10.000.
   NOTE: The next four steps are repeated ten times for both D-Q dial ranges. Refer to Table 3-4 for resistance decade settings, nominal D-Q dial settings, and dial-setting tolerances.

4. Set capacitance decade to 99.999 nF.

5. Set resistance decade to setting listed in column 2 of Table 3-4.

6. Alternately adjust D-Q dial and capacitance decade for sharpest null. Do not adjust L-R-C dial or resistance decade. Do not be too concerned with the relative insensitivity of the bridge to capacitance change at high D-Q dial settings. Reduce detector gain as necessary and concentrate on balancing D-Q dial.

7. Record D-Q dial setting in space provided on calibration record. The upper and lower limits of this dial setting are listed in columns 3 and 4 of Table 3-4.

Table 3-4. D-Q Dial Check

Funtion Range	Nominal D-Q Dial Setting	Resistance Decade Setting	D-Q Setting Tolerances	
			Upper Limit	Lower Limit
D x 0.01	1	15.9 Ω	1.11	0.89
	2	31.8 Ω	2.12	1.88
	3	47.7 Ω	3.13	2.87
	4	63.7 Ω	4.14	3.86
	5	79.6 Ω	5.15	4.85
	6	95.5 Ω	6.16	5.84
	7	111.4 Ω	7.17	6.83
	8	127.3 Ω	8.18	7.82
	9	143.2 Ω	9.19	8.81
	10	159.2 Ω	10.20	9.80
D x 0.1	1	159 Ω	1.11	0.89
	2	318 Ω	2.12	1.88
	3	477 Ω	3.13	2.87
	4	637 Ω	4.14	3.86
	5	796 Ω	5.15	4.85
	6	955 Ω	6.16	5.84
	7	1114 Ω	7.17	6.83
	8	1273 Ω	8.18	7.82
	9	1432 Ω	9.19	8.81
	10	1592 Ω	10.20	9.80

3.2.9 Functional Tests

NOTE: There is no accuracy requirement in the following tests. Just be sure that it is possible to balance the bridge with the FUNCTION control in both listed positions.

1. Set FUNCTION selector to L PARALLEL.
2. Set RANGE control to 0.1 H.
3. Connect 100-millihenry inductor (Item 6) to UNKNOWN terminals.
4. Measure inductance of inductor. It should be 0.1 Henry.
5. Set FUNCTION selector to L SERIES.
6. Connect resistance decade (Item 5) in series with inductance.
7. Set resistance decade to 638 ohms.
8. Measure inductance of inductor. It should be approximately 0.1 Henry and the Q should be approximately 1.

3.3 REMOVAL OF INSTRUMENT FROM CASE

1. Remove the phillips head screw from lower back of case (batteries need not be removed).

2. Carefully pull the front panel of the instrument away from the case. The catch on the upper back of this panel is released by pulling the lower part of the panel out ahead of the upper part.

3. The panel may be moved about 15 cm (6 in.) from the case without removing the plug that connects the batteries to the instrument. This plug is removed by carefully pulling it out of the socket in back of the instrument panel.

3.4 REPLACING INSTRUMENT IN CASE

1. Make certain plug connecting battery to instrument is firmly in its socket.

2. Insert instrument into case making certain that the upper catch is properly secured beneath the inside rim of the case. This is accomplished by first placing the upper portion of the front panel into the case and pushing up on the bottom of the panel until it snaps into place.

3. Replace the phillips screw in the back of the case.

3.5 CLEANING PRINTED CIRCUIT BOARD CONTACTS

Occasionally the contacts on the printed circuit board become dirty, resulting in loss of contact between the board and the remainder of the circuit. The most common symptom is an unusually large misalignment of the pointer in the meter when pointer alignment is checked (see Section 2.4). To clean the contacts, proceed as follows:

1. Remove instrument from case (see Section 3.3).

2. Remove two phillips screws from upper section of printed circuit board. Carefully pull board assembly out of socket.

3. Use a soft pencil eraser to erase dirt from contacts on the board.

4. Clean the contacts with freon or methanol to remove grit left by the eraser.

5. Clean socket contacts with freon or methanol.

6. Replace board in the socket and replace the phillips screws.

7. Replace the instrument in its case (see Section 3.4).

3.6 ADJUSTING TRIM CAPACITOR

Adjustment of the trimming capacitor, C11, may be necessary to compensate for drift of the standard capacitor, C1, due to age. When the result of the capacitance calibration check, Section 3.2.7 (Step 5), is not within the specified tolerance of 11 dial divisions, the trim capacitor may be adjusted to correct the error. The procedure for adjustment of the trimming capacitor is as follows:

1. Remove instrument from case, leaving battery plug in place (see Section 3.3).

2. Set GEN-DET switch to INT 1 kHz.

3. Set FUNCTION switch to C, D x 0.01.

4. Set RANGE switch to 0.1 µF.

5. Set L-R-C dial to 1.000.

6. Connect test leads to C binding posts 2 and 3 and to 0.1 µF, standard capacitor (Item 3, Section 3.2.2).

7. Adjust D-Q dial and trim capacitor (attached to standard capacitor which is located above the transformer) alternately until null is obtained on meter.

   NOTE: The trim capacitor is a three-turn trimmer which has a range of about 260 pF to 1300 pF. If the meter cannot be nulled by adjustment of this capacitor, the padding capacitor, C13 may have to be changed. When changing padding capacitor the new capacitor should be a mica capacitor chosen so that the trim capacitor is adjusted near the center of its range when the meter nulls. This provides for future adjustment of the trimmer without further changes of the padding capacitor.

8. Remove test leads from instrument and carefully place instrument back into case (Section 3.4).

GENERATOR-DETECTOR ASSEMBLY, A2

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C2	Capacitor, 0.1 μF	313-06470
C3-C4, C6-C7, C11-C12, C14, C18, C26, C31	Capacitor, 39 μF	314-06473
C5, C22	Capacitor, 0.01 μF	313-12260
C13, C16-C17	Capacitor, 180 μF	314-06474
C15	Capacitor, 2.2 μF	313-13283
C23-C25, C29	Capacitor, 1 μF	314-06472
C27	Capacitor, 1000 pF	313-07094
CR1-CR2	Diode, 1N276	321-13287
F1	Assembly, Input Filter	343-13292
F2	Assembly, Detector Network	343-13291
F3	Assembly, Generator Network	343-13290
Q1-Q8, Q10-Q11	Transistor, 2N2925	321-06467
Q9, Q12	Transistor, 2N1307	321-13243
R5, R8	Resistor, 8.2 kΩ, ¼ W, ±10%	307-13932
R6, R29, R32	Resistor, 10 kΩ, ¼ W, ±10%	307-13933
R7, R9, R36	Resistor, 3.3 kΩ, ¼ W, ±10%	307-13926
R10	Resistor, 5.6 kΩ	307-13928
R11, R33	Resistor, 100 kΩ, ¼ W, ±10%	307-13945
R12	Resistor, 390 Ω, ¼ W, ±10%	307-13914
R13	Resistor, 1.5 MΩ, ¼ W	307-13961
R14, R16	Resistor, 1.2 kΩ, ¼ W, ±10%	307-13921
R17, R20	Resistor, 1 kΩ, ¼ W, ±10%	307-13920
R18, R28	Resistor, 27 kΩ, ¼ W, ±10%	307-13938
R22, R26	Resistor, 22 kΩ, ¼ W, ±10%	307-13937
R27	Resistor, 56 kΩ, ¼ W, ±10%	307-13943
R30	Resistor, 4.7 kΩ, ¼ W, ±10%	307-13927

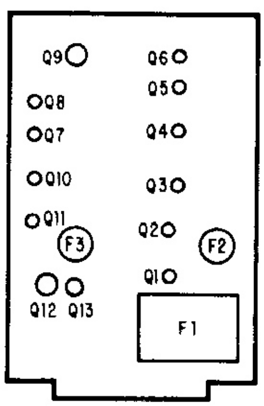
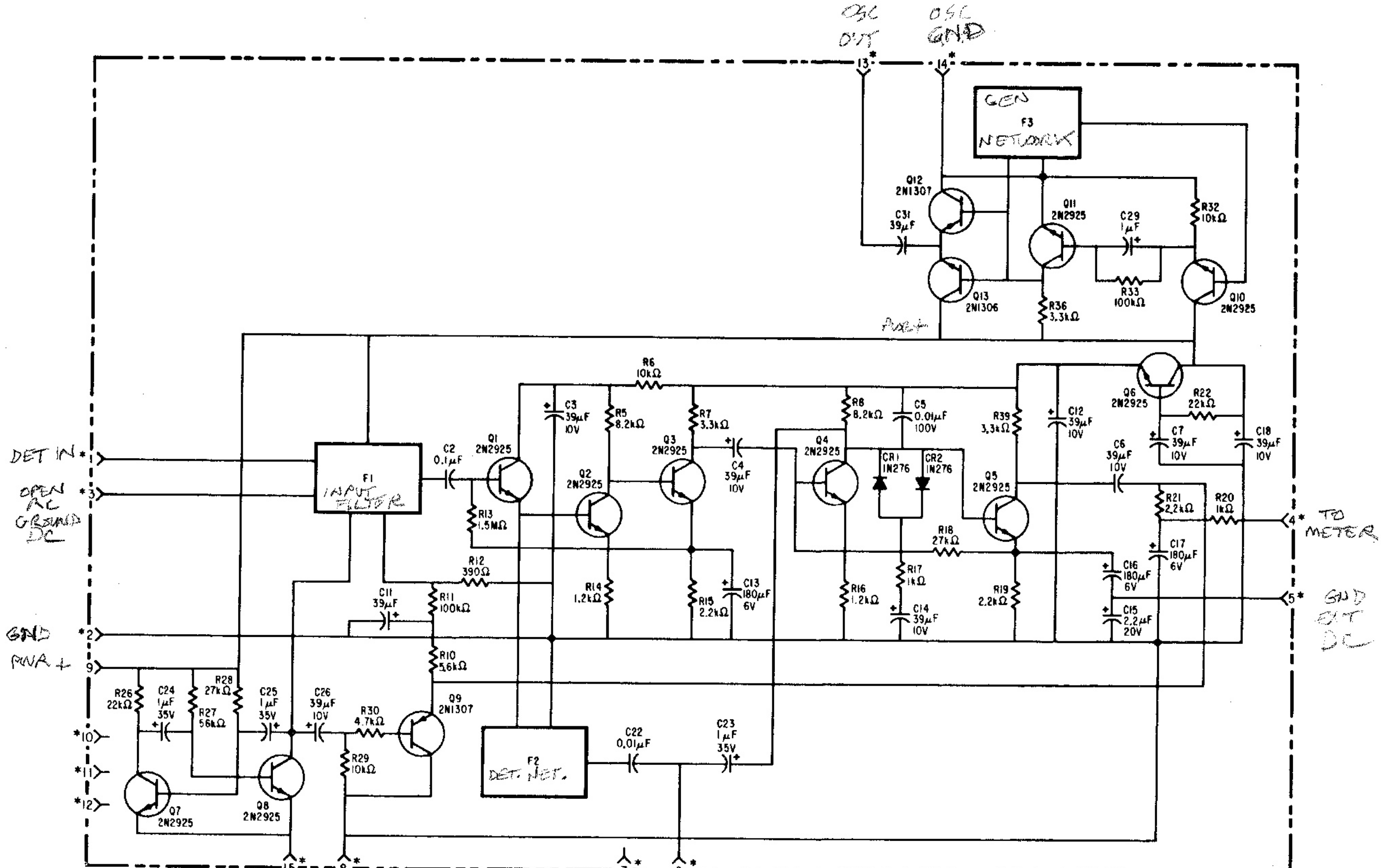


Figure 4-2. Location of Components on Circuit Board Assembly 13216



NOTES:
* Numbers refer to sequence only and may differ from actual marking on connector
Resistors 10% 1/4 watt unless noted

Figure 4-3. Generator-Detector Assembly A2 Schematic Diagram