FLUKE ®

Instruction Manual

MODEL A55

THERMAL CONVERTERS

and

MODEL 550A

THERMAL TRANSFER STANDARD

P/N 338442

NOVEMBER 1966

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within one year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

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If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or the nearest Service facility, giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way" prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC. will be happy to answer all application or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, ATTEN: Sales Dept. For European Customers: Fluke (Nederland) B.V., Zevenheuvelenweg 53, Tilburg, The Netherlands.

* For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., • P.O. Box 43210 • Mountlake Terrace, Washington 98043

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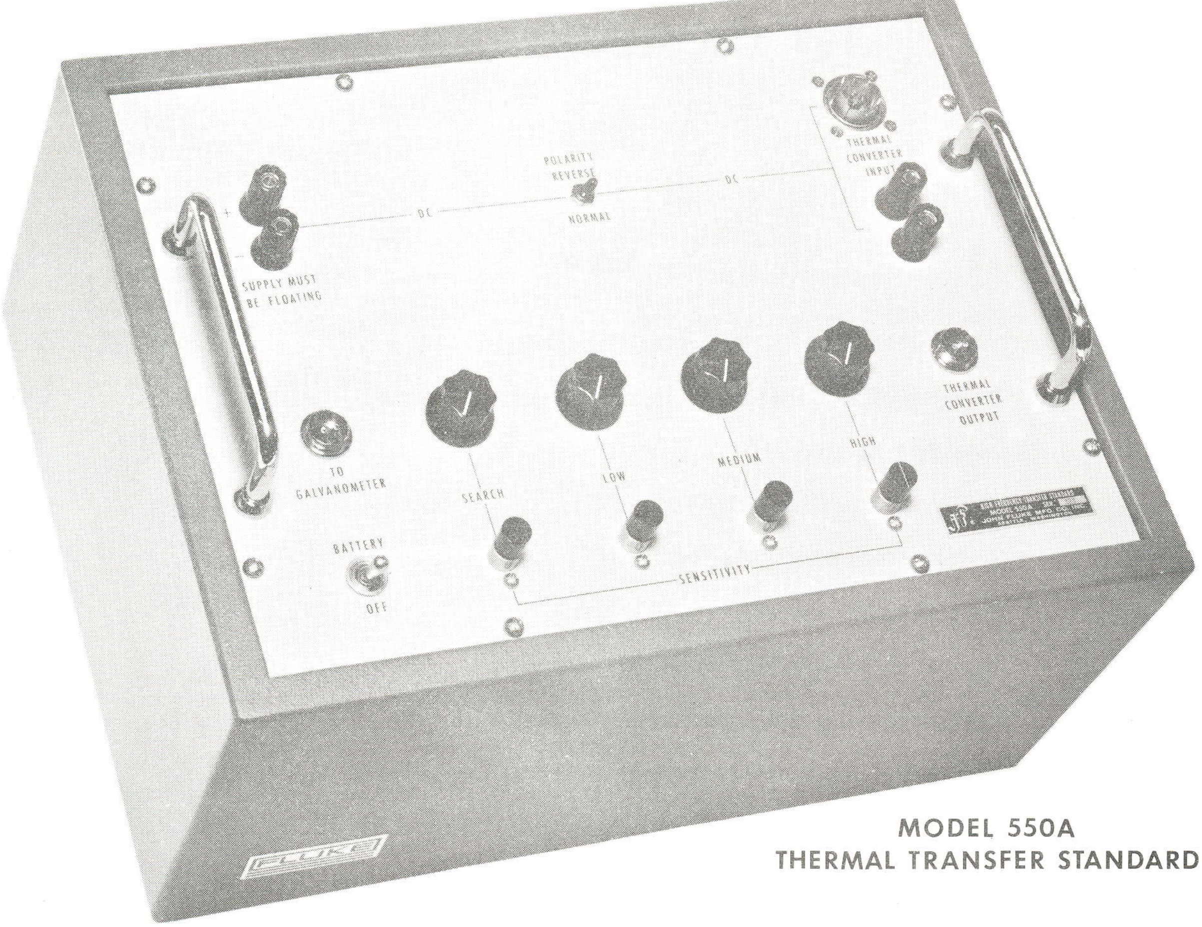
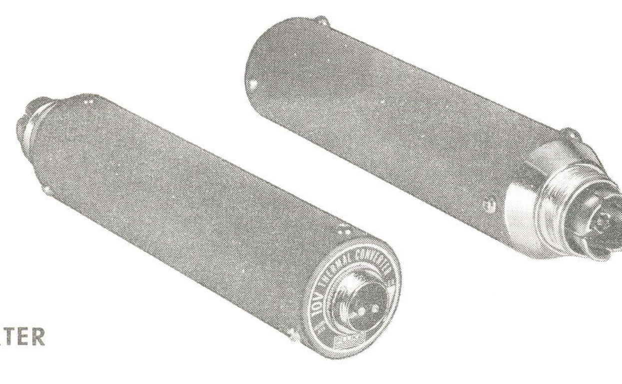


MODEL 550A
THERMAL TRANSFER STANDARD



MODEL A55 THERMAL CONVERTER

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. Nine Fluke Model A55 Thermal Converters are available, having ratings of 0.5, 1, 2, 3, 5, 10, 20, 30, and 50 volts. When used with the 550A, useage of each Thermal Converter should be restricted to the range between 1/2 and 1 times the rated voltage. A specially constructed bead thermocouple, selected for frequency characteristics and low dc reversal error, provides a nominal output of seven millivolts dc at rated input voltage for each converter. The thermocouple, range resistors, and compensation capacitors are mounted on a printed circuit board, with thermal isolation provided by foam or glass wool insulation.

1-3. The Model 550A Transfer Standard is designed to complement the Fluke Model A55 Thermal Converters. The 550A is mounted in a cabinet for bench-top operation, and has provision for connecting the dc source and thermal converters, as well as other required measuring equipment, to the front panel. The A55 with the 550A may be used as a laboratory standard: the thermal stability of the instruments also permit production use for calibration and measurement of ac instruments, and measurement of unknown ac voltages.

1-4. RECEIVING INSPECTION

1-5. This instrument has been thoroughly checked and tested prior to being shipped from the factory. Immediately after receiving the instrument, carefully inspect for any damage that may have occured in transit. If any damage is noted, follow the instructions outlined in the Warranty section in the back of this manual.

1-6. SPECIFICATIONS

1-7. MODEL A55

RANGE: Converters available having voltage ratings of 0.5, 1, 2, 3, 5, 10, 20, 30, and 50 volts. Each converter may be used from 1/2 to 1 times the rated voltage.

AC TO DC DIFFERENCE:

CONVERTER	FREQUENCY			
	1 MHz	10 MHz	30 MHz	50 MHz
0.5V	±0.01%	+0.10%	+0.60%	+1.50%
1V to 10V	±0.01%	±0.03%	±0.10%	±0.10%
20V to 50V	±0.01%	±0.05%	±0.10%	------

(A positive sign indicates that more alternating voltage than direct voltage is required.)

CALIBRATION: Certified to be within the above deviations from zero error as defined by the National Bureau of Standards, without calibration curves or correction tables. The 0.5V model is supplied with a test report indicating deviations to the nearest 0.01% at the above frequencies. For any converter, John Fluke or NBS certified test reports are available at extra cost. (NOTE: Calibration referenced to center of GR874-TL coaxial tee attached to converter input connector.)

INPUT IMPEDANCE: Approximately 200 ohms/volt.

OUTPUT VOLTAGE: 7 millivolts nominal at rated input.

OUTPUT RESISTANCE: 8 ohms nominal.

REVERSAL ERROR: Less than 0.025%. (Less than 0.1% for ser no. 123 to 827.)

INPUT CONNECTOR: GR type 874-L.

OUTPUT CONNECTOR: Amphenol 80-PC2M 2-pin, microphone type.

SIZE AND WEIGHT:

Converter	Diameter	Length	Weight
0.5V	1-3/8"	3-5/16"	10 oz.
1V, 2V	1-3/8"	5-3/16"	13 oz.
3V, 5V	1-3/8"	6-1/2"	15 oz.
10V, 20V	1-3/8"	7-1/16"	1 lb.
30V, 50V			

A55-110 OPTIONAL ACCESSORY KIT: The Model A55-110 Accessory Kit is recommended for use with the Model A55 Thermal Converters in virtually any calibration setup. The kit consists of the following items, manufactured by General Radio:

ITEM	DESCRIPTION
874-QBPL Adapter	Consists of an 874-BL connector and a BNC plug, and is used for connecting an 874 connector to a BNC jack.
874-QNPL Adapter	This adapter consists of an 874-BL connector and an N plug, and is used for connecting an 874 connector to an N jack.
874-QUPL Adapter	This adapter consists of an 874-BL connector and a UHF plug, and is used for connecting an 874 connector to a UHF jack.
874-TL Tee	Consists of a rigid coaxial tee terminated with three 874-BL connectors, and is used to connect an instrument or a stub in parallel with other instruments on a coaxial line.
874-R22LA Coaxial Cable	Consists of three feet of coaxial cable with a 874-CL58 locking connector on each end, and is used to connect an ac source to the coaxial tee.

1-8. MODEL 550A

REFERENCE VOLTAGE RANGE: 1.35 to 8.2 millivolts. (NOTE: Output voltage range of Fluke Model A55 Thermal Converters is approximately 1.8 to 7 millivolts from 1/2 to 1 times rated voltage).

GALVANOMETER RESOLUTION: (When used with Model A55 Thermal Converters and commercially available high-resolution galvanometers of the light-beam reflecting type).

SENSITIVITY RANGE	MAXIMUM CONVERTER INPUT	MINIMUM CONVERTER INPUT
Search	1.3%/mm	4.9%/mm
Low	0.13%/mm	0.63%/mm
Medium	0.013%/mm	0.063%/mm
High	0.001%/mm	0.006%/mm

BATTERY: Two mercury cells are used for the internal reference supply, eliminating the need for a line connection, and thus eliminating all problems due to internal ac fields. The normal operating life of the batteries is greater than 2000 hours.

GALVANOMETER AND THERMAL CONVERTER INPUT CONNECTOR: Amphenol 80-PC2M two-pin microphone type.

DC INPUT CONNECTOR: Two banana jacks with 3/4" spacing.

DC OUTPUT CONNECTOR: General Radio type 874 and two banana jacks with 3/4" spacing for measuring dc voltage at the output connector.

INPUT CONNECTORS FOR GALVANOMETER AND THERMAL CONVERTER: Amphenol 80-PC2M two-pin microphone type.

SIZE: 15" long x 10-3/4" wide x 9-3/8" high (including cover).

WEIGHT: 14-1/2 lbs. (including accessories and cover).

ACCESSORIES INCLUDED:

ITEM	DESCRIPTION
Shielded Galvanometer Cable	Consists of approximately four feet of shielded two-wire cable with an Amphenol 80-PC2M two-pin connector at one end. A connector which will fit the galvanometer to be used may be connected to the other end of the shielded cable, or the cable may be permanently connected to the galvanometer.
A55-550A Interconnecting Cable for Thermal Converter	Consists of approximately four feet of shielded two-wire cable with an Amphenol 80-PC2M two-pin connector at each end. Used to connect the A55 Thermal Converter to THERMAL CONVERTER OUTPUT connector on 550A Transfer Standard.

SECTION II

OPERATING INSTRUCTIONS

2-1. INTRODUCTION

CAUTION!

Do not operate any A55 Thermal Converter at a voltage higher than the rated value. The reversal error may change if the converters are operated at more than their rated voltage, and the thermocouple will burn out at approximately 100% overload. Do not perform any switching of either voltage level or frequency range with the converter in the circuit unless the switching transient voltage is known to be less than the rating of the converter.

2-2. A John Fluke certified test report for each A55 Thermal Converter may be used to obtain the precise ac to dc difference at various frequencies. These reports state the percent difference between the rms value of an ac voltage (at a certain frequency) required to produce a given output voltage, and the mean value of dc voltage (for both directions of current flow) required to produce the same output.

2-3. FUNCTION OF EXTERNAL CONTROLS AND TERMINALS

2-4. The function of external controls and terminals of the 550A is given in Figure 2-1.

CONTROL or TERMINAL	LOCATION	REFERENCE DESIGNATION	FUNCTION
DC input terminals	Front panel	J1 & J2	The dc input voltage is applied to these terminals. The terminals are general purpose binding posts mounted on 3/4" centers. The dc supply must be floating.
THERMAL CONVERTER INPUT connector	Front panel	J3, J4, & J5	The thermal converter input is connected to the coaxial connector (J5). A dc voltmeter is connected to the binding posts (J3 & J4) to measure the dc voltage available at the coaxial connector. The input connector of the A55 mates with J5.
THERMAL CONVERTER OUTPUT connector	Front panel	J7	The thermal converter output is connected to this terminal with the shielded cable provided.
POLARITY switch	Front panel	S1	This switch reverses the polarity of the dc voltage applied to the THERMAL CONVERTER INPUT terminals. Due to the fast action of the switch, the galvanometer can remain connected while switching the voltage polarity.
TO GALVANOMETER connector	Front panel	J6	Connecting the galvanometer to this terminal with the shielded cable provided places the galvanometer in the circuit between the thermal converter output and the variable reference potential. The galvanometer is used to establish a reference point for comparison of the ac and dc inputs to the thermal converter.
BATTERY switch	Front panel	S2	Closes the circuit of the voltage divider across the series connection of batteries B1 and B2.
SENSITIVITY switches	Front panel	SEARCH-S3 LOW-S4 MEDIUM-S5 HIGH-S6	These pushbutton switches vary the galvanometer sensitivity for nulling the galvanometer with the SENSITIVITY controls.
SENSITIVITY controls	Front panel	SEARCH-R1A, R1B LOW-R2A, R2B MEDIUM-R3 HIGH-R5	These variable resistors permit adjustment of the reference potential so as to balance the thermocouple output, as indicated by the galvanometer.

Figure 2-1. FUNCTION OF EXTERNAL CONTROLS AND TERMINALS

2-5. AUXILIARY EQUIPMENT

2-6. The 550A with the auxiliary equipment listed in Figure 2-2 forms a system capable of calibrating an ac instrument, measuring an unknown ac voltage, or measuring the frequency response of ac devices.

2-7. CALIBRATING AN AC INSTRUMENT

Note!

To obtain specified accuracy, elapsed time for a transfer measurement should not exceed thirty seconds. Beyond this time, the temperature coefficient of the transfer circuit may affect accuracy as much as 0.005% per minute.

a. Connect the equipment as shown in Figure 2-3. The dc source must be floating. The thermal converter used must have a voltage rating that is equal to or greater than the rms value of voltage being measured.

b. Set the BATTERY switch to on.

c. Mechanically zero the galvanometer.

d. Set the POLARITY switch to NORMAL.

e. Adjust the dc source voltage until the dc voltmeter indicates the approximate rms value of ac voltage desired.

f. Connect the thermal converter to THERMAL CONVERTER INPUT coaxial connector.

g. Adjust the dc source voltage until the dc voltmeter indicates the exact rms value of ac voltage desired. If the ac to dc differences from the certified test report are to be used, adjust the dc source voltage until the voltmeter indicates $\frac{100}{100 + a_o}$ times the rms value of the ac voltage desired.

$$a_o = \frac{V_{ac} - V_{dc}}{V_{dc}} 100 =$$

the ac to dc percent difference at the center of the tee for the frequency used.

h. If the input impedance of the instrument being calibrated is not 50 ohms, it may be necessary to correct for the standing wave between the center of the tee and the instrument being calibrated at frequencies above 5 MHz. In this case, adjust the dc source voltage until the dc voltmeter indicates $\frac{100}{100 + a_1}$ times the rms value of the ac voltage desired. Calculate a_1 from the following equation:

$$a_1 = \left\{ \left(\frac{a_o}{100} + 1\right) \left(\frac{1}{\cos\beta X - Z_c B \sin\beta X + jZ_c G \sin\beta X} \right) - 1 \right\} 100$$

where:

a_1 = ac to dc per cent difference at input of instrument being calibrated at the frequency used

a_o = ac to dc per cent difference at the center of the tee at the frequency used

$Z_c = \sqrt{\frac{L}{C}}$ = characteristic impedance of transmission line in ohms

$\beta = \frac{2\pi}{\lambda} = \omega\sqrt{LC}$ = phase constant of line in radians/meter

X = line length in meters from center of tee to instrument

Y = G + jB = input admittance of instrument in mhos

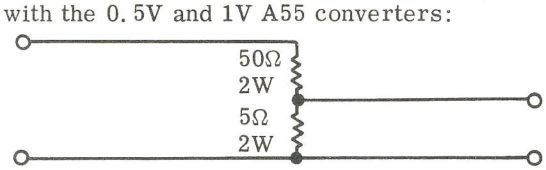
EQUIPMENT RECOMMENDED	SPECIFICATIONS FOR MAXIMUM ACCURACY
Galvanometer, Leeds & Northrup Model 2430A	Coil resistance of 17 ohms. Critical damping resistance of 30 to 90 ohms. Sensitivity of 0.5uv/mm.
DC Differential Voltmeter, Fluke Model 881A	Range of 0.25V to 50V dc. Accuracy of 0.01%.
DC Source, Fluke Model 301C, 301E, or 313A	Stability of 0.002%, short term. Resolution of 0.002% at any calibrating voltage. Output Voltage of 0.25V to 50V dc, floating. Output Current of 10 ma NOTE: The 301C and 301E require the following voltage divider for use with the 0.5V and 1V A55 converters:  Use wirewound resistors having a low temperature coefficient.
AC Source. Various Models made by Boonton Radio Corp, Hewlett Packard, Holt Inst. Lab., Krohn-Hite, Rhode & Schwarz, and Tektronix, Inc., are suitable. The instrument used will depend on the frequency range desired.	Amplitude Stability of 0.01%, short term. Amplitude Resolution of 0.002%, at any calibrating voltage. Output Voltage of 0.25V to 50V ac. Output Current of 10 ma.

Figure 2-2. AUXILIARY EQUIPMENT

i. Null the galvanometer as follows:
(1) Depress the SEARCH SENSITIVITY pushbutton, and adjust the SEARCH SENSITIVITY control for a null.
(2) Depress the LOW SENSITIVITY pushbutton, and adjust the LOW SENSITIVITY control for a null.
(3) Depress the MEDIUM SENSITIVITY pushbutton, and adjust the MEDIUM SENSITIVITY control for a null.
(4) Depress and lock (turn CW) HIGH SENSITIVITY pushbutton, and adjust HIGH SENSITIVITY control for a null.

Note!

To obtain specified accuracy from a "cold" start, repeat step i. (4) after three to four minutes. (Not necessary for successive measurements).

j. Check for dc reversal error as follows:
(1) Set the POLARITY switch to REVERSE.
(2) If the galvanometer moves off null, thermal converter reversal error is present. To compensate for error, reduce off-null error by exactly one-half with the HIGH SENSITIVITY control.
(3) Set the POLARITY switch to NORMAL, and observe if an equal and opposite deflection occurs. If necessary, repeat adjustment and polarity reversal until equal and opposite deflections occur.
k. Unlock (turn CCW) the HIGH SENSITIVITY pushbutton
l. Make sure the ac source voltage does not exceed the rated voltage of the converter being used.
m. Remove the thermal converter from THERMAL CONVERTER INPUT.
n. Connect thermal converter to General Radio 874-TL tee.
o. Null the galvanometer by adjusting the ac source voltage while depressing the SENSITIVITY pushbuttons in SEARCH, LOW, MEDIUM, and HIGH sequence. Do not adjust the reference voltage. The rms value of the ac voltage now equals the desired value.
p. Set the BATTERY switch to OFF.

2-8. MEASURING AN UNKNOWN AC VOLTAGE

a. Connect the equipment as shown in Figure 2-4. The dc source must be floating. If the approximate value of the ac voltage is unknown, measure the ac with a high frequency voltmeter. Always use a thermal converter having a voltage rating equal to or greater than the rms value of the ac voltage to be measured.
b. Set the BATTERY switch to on.
c. Adjust the dc source voltage to less than the rated voltage of the converter.
d. Adjust mechanical zero of galvanometer, if necessary.
e. Set the POLARITY switch to NORMAL.
f. Connect the thermal converter to the General Radio 874 adapter.
g. Null the galvanometer as in step i. of paragraph 2-7.
h. Unlock (turn CCW) the HIGH SENSITIVITY pushbutton.
i. Remove thermal converter from the adapter.
j. Connect the thermal converter to THERMAL CONVERTER INPUT coaxial connector.
k. Null the galvanometer by adjusting the dc source voltage with the SENSITIVITY pushbuttons depressed in SEARCH, LOW, MEDIUM, and HIGH sequence. Do not adjust the reference voltage.
l. Depress HIGH SENSITIVITY pushbutton and check for reversal error as in step j. of paragraph 2-7, except adjust the galvanometer by varying the dc source voltage. Do not adjust the reference voltage. The adjusted dc source voltage measured at the THERMAL CONVERTER INPUT terminals is now equal to the rms value of the ac source voltage.
m. Since the thermal converters are calibrated at the center of the General Radio 874-TL tee, and the tee is not used in this measurement, a correction must be made for the standing wave that would have occurred between the center of the tee and the plane of the insulating bead at the input to the converter. Another standing wave correction must be made if anything, such as an 874 adaptor, is connected between the ac source and the thermal converter input. The equation given

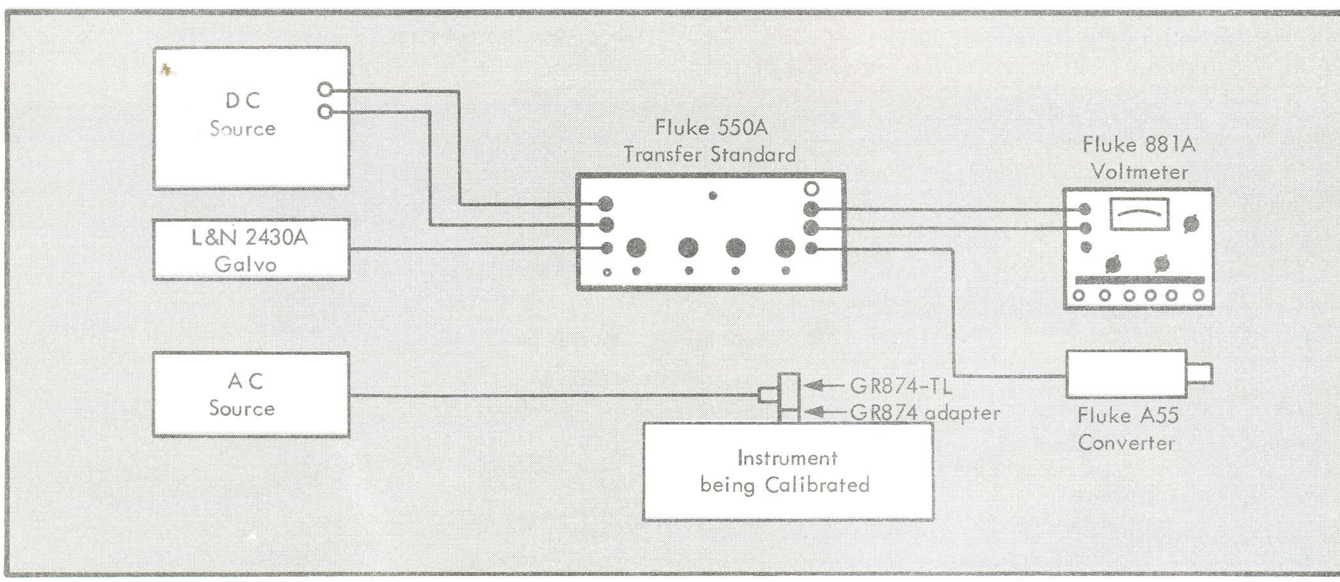


Figure 2-3. VOLTAGE CALIBRATION SETUP DIAGRAM

here corrects for these standing waves and for any calibration error. Below five megahertz, the voltage standing wave error is usually insignificant. Calculate E_{ac} (the rms value of ac at output connector of ac source) from the following equation:

$$E_{ac} = \left(\frac{a_3}{100} + 1\right) E_{dc}$$

where:

E_{dc} = voltage indicated by dc voltmeter

a_3 = ac to dc per cent difference at output connector of ac source at frequency used

a_3 must be calculated from the following equation:

$$a_3 = \left\{ A\left(\frac{a_o}{100} + 1\right) (\cos\beta X - Z_C B_2 \sin\beta X + jZ_C G_2 \sin\beta X) - 1 \right\} 100$$

where:

$A = \frac{E_2}{E_o}$ = ratio of ac voltage at the plane of the insulating bead on input of converter to ac voltage at center of tee. Obtained from Figure 2-5.

$a_o = \left(\frac{E_{ac} - E_{dc}}{E_{dc}}\right) 100$ = ac to dc percent difference at center of tee for the frequency used

$Z_C = \sqrt{\frac{L}{C}}$ = characteristic resistance of transmission line in ohms

$\beta = \frac{2\pi}{\lambda} = \sqrt{LC}$ = phase constant of line in radians/meter

X = length of line from thermal converter to ac source in meters

$Y_2 = G_2 + jB_2$ = input admittance of thermal converter. Obtained from Figure 2-6.

n. Set battery switch to OFF.

2-9. MEASURING FREQUENCY RESPONSE

a. Connect the equipment as shown in Figure 2-7. The thermal converter used must have a rated voltage that is equal to or greater than the rms value of ac voltage being measured.

b. Set the BATTERY switch to on.

c. Adjust the ac source to the approximate desired level.

d. Adjust mechanical zero of galvanometer, if necessary.

e. Connect the thermal converter to the 874-TL tee.

f. Null the galvanometer as follows:

(1) Depress SEARCH SENSITIVITY pushbutton and adjust the SEARCH SENSITIVITY control for a null. If only 1%/mm to 6%/mm resolution is sufficient, proceed to step g.

(2) Depress LOW SENSITIVITY pushbutton and adjust LOW SENSITIVITY control for a null. If only 0.1%/mm to 0.6%/mm resolution is sufficient, proceed to step g.

(3) Depress MEDIUM SENSITIVITY pushbutton and adjust MEDIUM SENSITIVITY control for a null. If only 0.01%/mm to 0.06%/mm resolution is sufficient, proceed to step g.

(4) Depress the HIGH SENSITIVITY pushbutton and adjust the HIGH SENSITIVITY control for a null. Resolution is approximately 0.001%/mm to 0.006%/mm.

CAUTION!

Do not perform any switching of either voltage level or frequency range with the thermal converter in the circuit unless the switching transient is known to be less than the voltage rating of the converter.

g. While depressing the desired SENSITIVITY pushbutton, change the frequency of the ac source and hold galvanometer null by adjusting the amplitude of the ac source.

h. Record changes in voltage level at frequencies desired.

i. If greater accuracy is necessary follow the procedure for calibrating an ac instrument at each frequency desired (see paragraph 2-7).

j. Set the BATTERY switch to OFF.

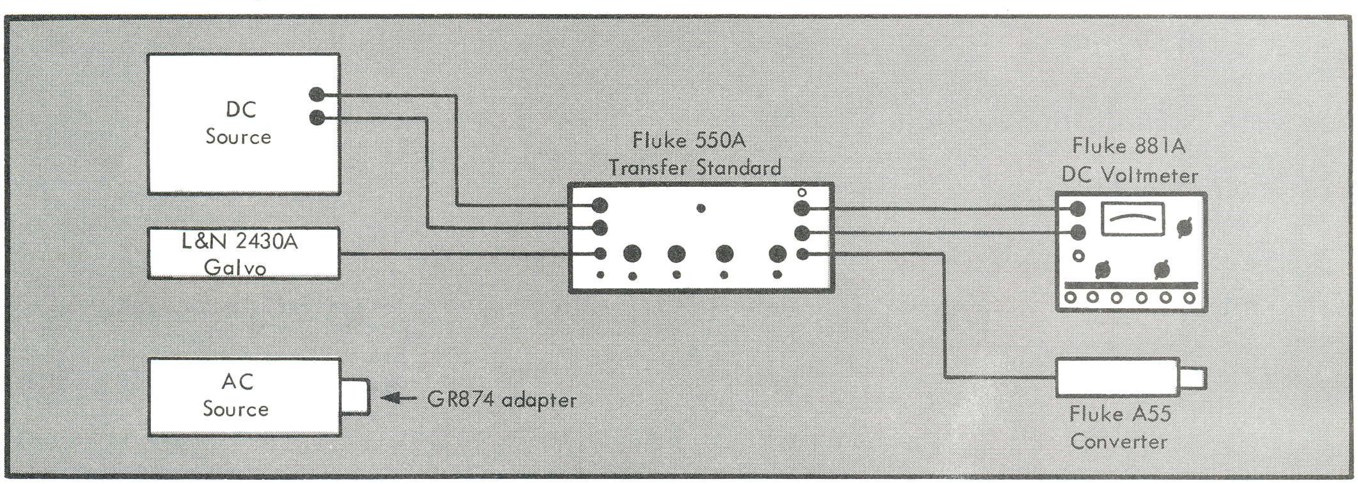


Figure 2-4. VOLTAGE MEASURING SETUP DIAGRAM

	CONVERTER RANGE								
FREQ.	0.5V	1V	2V	3V	5V	10V	20V	30V	50V
1 MC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3 MC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5 MC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0001	1.0001	1.0001	1.0001
10 MC	1.0000	1.0001	1.0001	1.0001	1.0001	1.0002	1.0002	1.0002	1.0002
20 MC	0.9999	1.0003	1.0004	1.0005	1.0005	1.0009	1.0009	1.0009	1.0009
30 MC	0.9997	1.0007	1.0009	1.0011	1.0011	1.0019	1.0020	1.0020	1.0020
50 MC	0.9991	1.0020	1.0024	1.0030	1.0030	1.0054	1.0057	1.0056	1.0055
NOTE: The above typical values of A are believed to be accurate to ±0.0001 at 10 megacycles, ±0.0002 at 20 megacycles, ±0.0005 at 30 megacycles, and ±0.0010 at 50 megacycles for the various converters.									

Figure 2-5. TYPICAL VALUES OF "A"

2-10. MEASURING FREQUENCY RESPONSE OF AN AC AMPLIFIER

a. Connect the equipment as shown in Figure 2-8. The dc source must be floating. The thermal converters used must have a voltage rating equal to or greater than the rms value of ac voltage to be measured.

b. Adjust the ac source voltage to the approximate desired level.

c. Adjust the dc source voltage to less than the rating of converter no. 2.

d. Adjust mechanical zero of each galvanometer, if necessary.

e. Connect converter no. 1 to the 874-TL tee, and connect converter no. 2 to the ac amplifier output.

f. Null both galvanometers as follows:

(1) Depress the SEARCH SENSITIVITY pushbutton and adjust the SEARCH SENSITIVITY control for a null. If 1%/mm to 6%/mm resolution is sufficient, proceed to step g.

(2) Depress the LOW SENSITIVITY pushbutton and adjust the LOW SENSITIVITY control for a null. If 0.1%/mm to 0.6%/mm resolution is sufficient, proceed to step g.

(3) Depress the MEDIUM SENSITIVITY pushbutton and adjust the MEDIUM SENSITIVITY control for a null. If 0.01%/mm to 0.06%/mm resolution is sufficient, proceed to step g.

(4) Depress the HIGH SENSITIVITY pushbutton and adjust the HIGH SENSITIVITY control for a null. Resolution is approximately 0.001%/mm to 0.006%/mm.

CAUTION!

Do not perform any switching of either voltage level or frequency range with the thermal converter in the circuit unless the switching transient is known to be less than the rated value of the converters.

g. While depressing the desired SENSITIVITY pushbutton on transfer device no. 1, change the frequency of the ac source, holding galvanometer no. 1 on null by adjusting the amplitude of the ac source voltage.

h. Note the variation of output of converter no. 2 as the frequency is changed.

	FREQUENCY						
CONVERTER RANGE	1 MC	3 MC	5 MC	10 MC	20 MC	30 MC	50 MC
0.5V	10.9-j0.0124	10.9-j0.0429	10.9-j0.0732	10.9-j0.148	10.9-j0.295	10.9-j0.444	10.9-j0.729
1V	4.98+j0.0131	4.98+j0.0297	4.98+j0.0472	4.98+j0.0926	4.98+j0.185	4.98+j0.275	4.98+j0.449
2V	2.52+j0.0162	2.52+j0.0395	2.52+j0.0634	2.52+j0.125	2.52+j0.249	2.52+j0.372	2.52+j0.627
3V	1.67+j0.0210	1.67+j0.0545	1.67+j0.0883	1.67+j0.175	1.67+j0.349	1.67+j0.520	1.68+j0.860
5V	1.02+j0.0206	1.02+j0.0540	1.02+j0.0875	1.02+j0.173	1.02+j0.346	1.03+j0.515	1.03+j0.863
10V	0.500+j0.0415	0.500+j0.117	0.500+j0.192	0.500+j0.383	0.503+j0.763	0.505+j1.14	0.511+j1.91
20V	0.236+j0.0446	0.236+j0.126	0.237+j0.207	0.238+j0.413	0.238+j0.823	0.240+j1.23	0.244+j2.07
30V	0.153+j0.0433	0.153+j0.123	0.154+j0.202	0.154+j0.401	0.154+j0.801	0.157+j1.19	0.160+j2.01
50V	0.0926+j0.0433	0.0926+j0.120	0.0926+j0.198	0.0934+j0.394	0.0939+j0.786	0.0961+j1.17	0.1000+j1.97
NOTE: The above typical values of converter admittance ($Y_2 = G_2 + jB_2$) are in millimhos as measured at the plane of the input connector insulating bead.							

Figure 2-6. TYPICAL VALUES OF CONVERTER ADMITTANCE

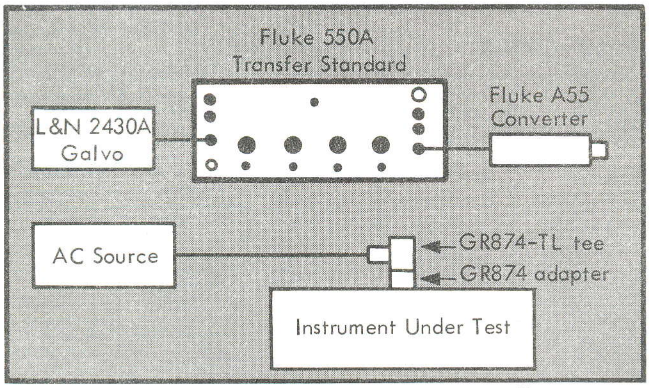


Figure 2-7. FREQUENCY RESPONSE CONNECTION DIAGRAM

i. The deflection of the galvanometer may be calibrated in per cent as follows:

(1) Remove thermal converter no. 2 from the amplifier output.

(2) Connect thermal converter no. 2 to the THERMAL CONVERTER INPUT coaxial connector.

(3) Null the galvanometer as in step i. of paragraph 2-7.

(4) Change the dc source voltage by an appropriate amount and note the galvanometer deflection.

j. For greater accuracy at each frequency desired, follow the procedure described in paragraph 2-7 for adjusting the ac amplifier input voltage and the procedure described in paragraph 2-8 for measuring the ac amplifier output voltage.

k. Set the BATTERY switch to OFF.

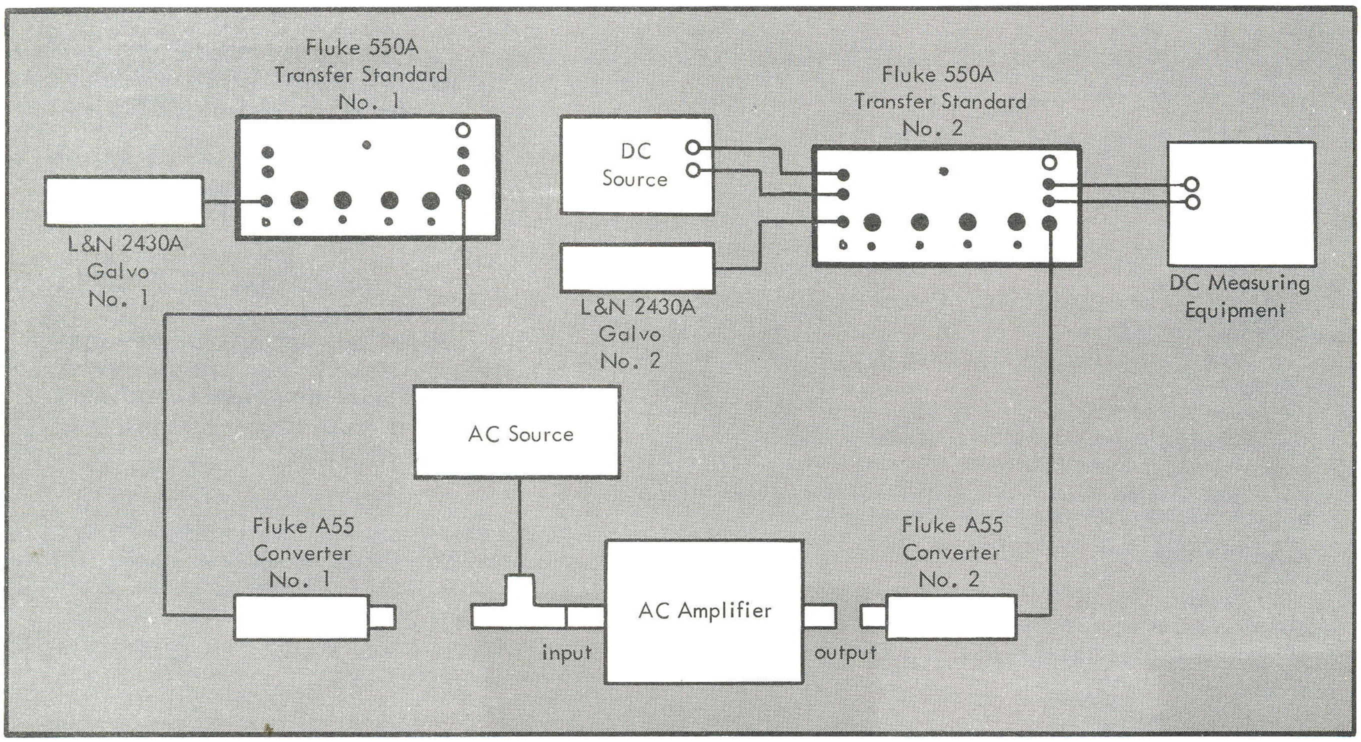


Figure 2-8. FREQUENCY RESPONSE SETUP DIAGRAM FOR AC AMPLIFIERS

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. This section of the manual describes the theory of operation of the Model A55 and the Model 550A. Reference is made to the functional schematic following Section V. This schematic is intended to aid in understanding the theory of operation of the 550A. A diagram of the A55 is given in Figure 3-1.

3-3. MODEL 550A

3-4. The purpose of the 550A is to provide a stable dc reference voltage equal to the A55 converter output voltage. Equalization of the two voltages is indicated by a null on an external galvanometer. If the ac voltage into the converter is adjusted so that the galvanometer indicates a null with the same 550A reference voltage, then the ac voltage into the converter is equal to the previous (known) dc voltage. Consequently, the 550A consists of a variable resistance (R1 through R5) connected across an emf (B1 and B2). Since B1 and B2 are mercury batteries, this provides a stable source of variable voltage, which is connected in series with the A55 output.

3-5. MODEL A55

3-6. The Model A55 Thermal Converter utilizes a bead thermocouple to provide a dc output proportional to the temperature of the thermocouple junction. The temperature of the junction depends on the ambient temperature, and on the heating effect of the current (ac or dc) through the thermocouple heater. If the ac impedance of the thermocouple heater is the same as the dc resistance, the heating effect of dc and an equivalent rms ac are equal. As shown in Figure 3-1, frequency compensation is used to minimize the ac impedance difference at higher frequencies, except on the 0.5V converter. Consequently, the 0.5V converter doesn't provide the best accuracy for measurement of higher frequencies.

3-7. TRANSMISSION LINE CORRECTIONS FOR THE A55

3-8. INTRODUCTION

3-9. The input admittance of the A55 converters does not match the characteristic admittance of the coaxial transmission line, nor the characteristic admittance of the coaxial tee. Consequently, a standing wave exists

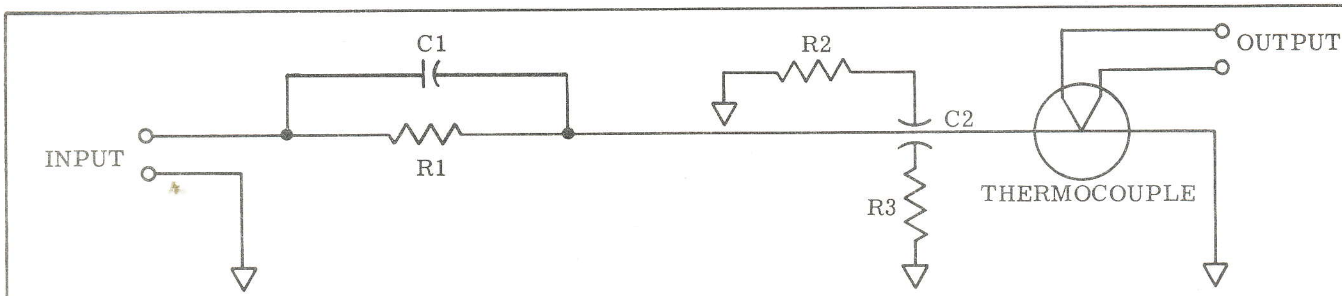


TABLE OF TYPICAL COMPONENTS

CONVERTER	R1	R2	R3	C1	C2
0.5V	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED
1V	110Ω	NOT USED	NOT USED	SPECIAL	SPECIAL
2V	310Ω	560Ω	560Ω	SPECIAL	SPECIAL
3V	510Ω	560Ω	560Ω	SPECIAL	SPECIAL
5V	910Ω	680Ω	680Ω	SPECIAL	SPECIAL
10V	1.9K	1.2K	1.2K	SPECIAL	SPECIAL
20V	3.9K	NOT USED	NOT USED	SPECIAL	SPECIAL
30V	6K	NOT USED	NOT USED	SPECIAL	SPECIAL
50V	10K	NOT USED	NOT USED	SPECIAL	SPECIAL

Figure 3-1. MODEL A55 SCHEMATIC DIAGRAM

on the coaxial line and between the converter and the tee. However, since the center of the tee has been chosen as the calibration point, the standing wave between the converter and the tee is of no consequence. In many applications in which a lower accuracy is required, the converter can be used without the tee, and no corrections are necessary. The maximum error that can occur at any frequency is listed below.

FREQUENCY	MAXIMUM ERROR
5 MHz	0.02%
10 MHz	0.05%
20 MHz	0.13%
30 MHz	0.25%
50 MHz	0.60%

3-10. The behavior of voltage, current, and impedance on lines at very high frequencies is closely approximated by the theory of lossless transmission lines. Consequently, the following corrections are based on lossless transmission line theory.

3-11. On a lossless line it can be shown that:

$$E_X = E_R \cos\beta X + jZ_C I_R \sin\beta X \qquad (1)$$

where:

E_X = voltage at a point x meters from the receiving end

E_R = voltage at receiving end

$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{\text{wavelength}} = \omega\sqrt{LC}$ = phase constant of line, in radians/meter

X = distance in meters from receiving end to point of interest

I_R = current at receiving end

$Z_C = \sqrt{\frac{L}{C}}$ = characteristic impedance of transmission line, in ohms

Since $I_R = E_R Y_R$ and $Y_R = G_R + jB_R$, equation (1) can be rewritten as:

$$\frac{E_X}{E_R} = \cos\beta X - Z_C B_R \sin\beta X + jZ_C G_R \sin\beta X \qquad (2)$$

where:

B_R = susceptance of termination, in mhos

G_R = conductance of termination, in mhos

Equation (2) can be used to transfer the calibration point from the center of the tee (used with the A55) to any place along the coaxial line.

3-12. COMPENSATION FACTOR

3-13. The compensation factor (a) is the ac to dc difference from zero, as defined by the National Bureau of Standards, at the center of the tee.

That is,

$$a = \left(\frac{V_{ac} - V_{dc}}{V_{dc}}\right) 100$$

Thus, the compensation factor for any point X is:

$$a_X = \left(\frac{E_X - E_{dc}}{E_{dc}}\right) 100 = \left(\frac{E_X}{E_{dc}} - 1\right) 100 \qquad (3)$$

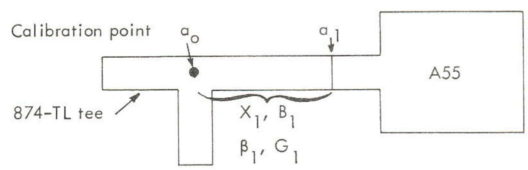
or

$$\frac{E_X}{E_{dc}} = \frac{a_X}{100} + 1$$

If an accuracy better than the published specifications of the A55 is required, the compensation factor should be used. Also, to transfer calibration to any point x, first determine a_X.

3-14. COMPENSATION FACTOR AT INPUT OF A55

3-15. The material in paragraph 3-12 can be applied to determine the compensation factor necessary in transferring calibration from the center of the tee to the plane of the input connector of the A55. This is determined as follows:



$$a_1 = \left(\frac{E_1}{E_{dc}} - 1\right)100$$

$$= \left(\frac{E_1}{E_o} \cdot \frac{E_o}{E_{dc}} - 1\right)100$$

$$= \left(\frac{E_o}{E_{dc}} \cdot \frac{E_1}{E_o} - 1\right)100$$

but: $$\frac{E_o}{E_{dc}} = \left(\frac{a_o}{100} + 1\right)$$

thus, $$a_1 = \left\{\left(\frac{a_o}{100} + 1\right)\frac{E_1}{E_o} - 1\right\} 100$$

let $$A = \frac{E_1}{E_o} = \frac{1}{\cos\beta_1 X_1 - Z_C B_1 \sin\beta_1 X_1 + jZ_C G_1 \sin\beta_1 X_1}$$

then:

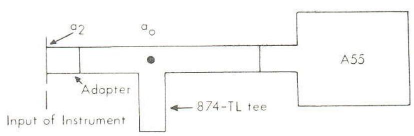
$$a_1 = \left\{\left(\frac{a_o}{100} + 1\right) A - 1\right\} 100$$

$$= Aa_o + 100\,(A-1)$$

Typical values of "A" are tabulated in Figure 2-5 for the General Radio 874-TL tee. The values of a_o for different frequencies are listed on the certified test report. When the tee is not used, the use of a_1 will insure an accuracy within the normal uncertainty of $\frac{3 + f\ MHz}{100}$ %

3-16. COMPENSATION FACTOR AT INPUT OF INSTRUMENT BEING CALIBRATED

3-17. If the input admittance of the instrument being calibrated does not match the admittance of the line, error can be caused by the standing wave between the center of the 874-TL tee and the input of the instrument being calibrated. If the input admittance of the instrument being calibrated is known or can be measured, a compensation factor can be computed as follows:



$$a_2 = \left(\frac{E_2 - E_{dc}}{E_{dc}}\right) 100$$

$$= \left(\frac{E_2}{E_{dc}} - 1\right) 100$$

$$= \left(\frac{E_2}{E_o} \cdot \frac{E_o}{E_{dc}} - 1\right) 100$$

$$= \left(\frac{E_o}{E_{dc}} \cdot \frac{E_2}{E_o} - 1\right) 100$$

but:

$$a_o = \left(\frac{E_o}{E_{dc}} - 1\right) 100,$$

or

$$\frac{E_o}{E_{dc}} = \left(\frac{a_o}{100} + 1\right)$$

then:

$$a_2 = \left\{\left(\frac{a_o}{100} + 1\right) \frac{E_2}{E_o} - 1\right\} 100$$

$$= \left\{\left(\frac{a_o}{100} + 1\right) \left(\frac{1}{\cos\beta_2 X_2 - Z_c B_2 \sin\beta_2 X_2 + jZ_c G_2 \sin\beta_2 X_2}\right) - 1\right\} 100$$

where:

β_2 = phase constant of line in radians/meter

G_2 = input conductance of instrument under test

B_2 = input susceptance of instrument under test

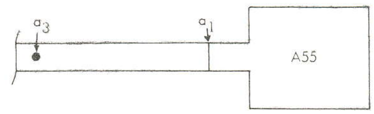
a_2 = compensation factor at instrument input in per cent

a_o = compensation factor at center of the tee in per cent

X_2 = line length in meters

If the line length x_2 consists of the General Radio 874-TL tee and 874 adapter, then $\beta_2 X_2 \cong 1.467 \times 10^{-3} f_{MHz}$ radians.

3-18. COMPENSATION FACTOR FOR ANY POINT



$$a_3 = \left(\frac{E_3}{E_{dc}} - 1\right) 100$$

$$= \left(\frac{E_3}{E_1} \cdot \frac{E_1}{E_{dc}} - 1\right) 100$$

but:

$$\frac{E_1}{E_{dc}} = \frac{a_1}{100} + 1$$

then:

$$a_3 = \left\{\left(\frac{a_1}{100} + 1\right) \frac{E_3}{E_1} - 1\right\} 100$$

$$= \left\{\left(\frac{a_1}{100} + 1\right) \left(\cos\beta_3 X_3 - Z_c B_1 \sin\beta_3 X_3 + jZ_c G_1 \sin\beta_3 X_3\right) - 1\right\} 100$$

however:

$$a_1 = Aa_o + 100\ (A-1)$$

or

$$\frac{A_1}{100} + 1 = A\left(\frac{a_o}{100} + 1\right)$$

therefore:

$$a_3 = \left\{A\left(\frac{a_o}{100} + 1\right)\left(\cos\beta_3 X_3 - Z_c B_1 \sin\beta_3 X_3 + jZ_c G_1 \sin\beta_3 X_3\right) - 1\right\} 100$$

where:

β_3 = phase constant of line in radians/meter

X_3 = line length in meters from A55 to point of interest

G_1 = input conductance of A55

B_1 = input susceptance of A55

Z_c = characteristic impedance of transmission line.

a_3 = compensation factor at specified point.

Typical values of $Y_1 = G_1 + jB_1$ have been computed for the A55, and are given in Figure 2-6.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. The A55 and 550A utilize simple circuitry, and should require little maintenance. Preventive maintenance is discussed in paragraph 4-3. A discussion of troubleshooting and a troubleshooting chart are presented in paragraph 4-5. Calibration checking of the A55 is discussed in paragraph 4-7.

4-3. PREVENTIVE MAINTENANCE

4-4. Preventive maintenance of the 550A consists primarily of battery replacement. End of battery life if characterized by drift in one direction as indicated by the galvanometer. Batteries should be replaced at least once a year. Proceed as follows:

a. Remove the eight screws in the front panel, and lift the front panel from the cabinet.

b. Remove the old batteries, and install the new batteries, observing the polarity marked on the battery clips. The case of the mercury battery is positive.

c. Replace the front panel, and install the eight panel screws.

4-5. TROUBLESHOOTING

4-6. A troubleshooting chart for the A55 and 550A is given in Figure 4-1. To prevent burning out the thermocouple when measuring the A55 with a multimeter, connect a 1K resistor in series with the test leads of the multimeter.

4-7. CALIBRATION CHECKING OF A55

4-8. The accuracy of each A55 converter should be periodically checked against the accuracy of the converter having the nearest rated voltage. If a converter is out of tolerance, it must be returned to the factory for repair. The equipment required for calibration checking is listed in Figure 2-2. Calibration is checked as follows:

a. Connect the test equipment according to Figure 4-2. The converters used must have adjacent voltage ratings, for example, 3 v and 5 v or 3 v and 2 v.

SYMPTOM	PROBABLE CAUSE	REMEDY
No output from thermocouple.	Open heater or open thermocouple.	Return to factory for replacement of thermocouple.
Radio Frequency pickup in thermocouple circuit.	Shorted insulating bead in thermocouple.	
Low output from thermocouple.	Broken vacuum seal in thermocouple.	
Change in frequency response.	Change in thermocouple characteristics due to overload.	Return to factory for repair or recalibration.
Erratic output.	Broken solder joint.	Return to factory for repair.
Erratic results in reversal error measurement of 550A	Varying contact resistance in S1.	Replace switch.

Figure 4-1. TROUBLESHOOTING CHART

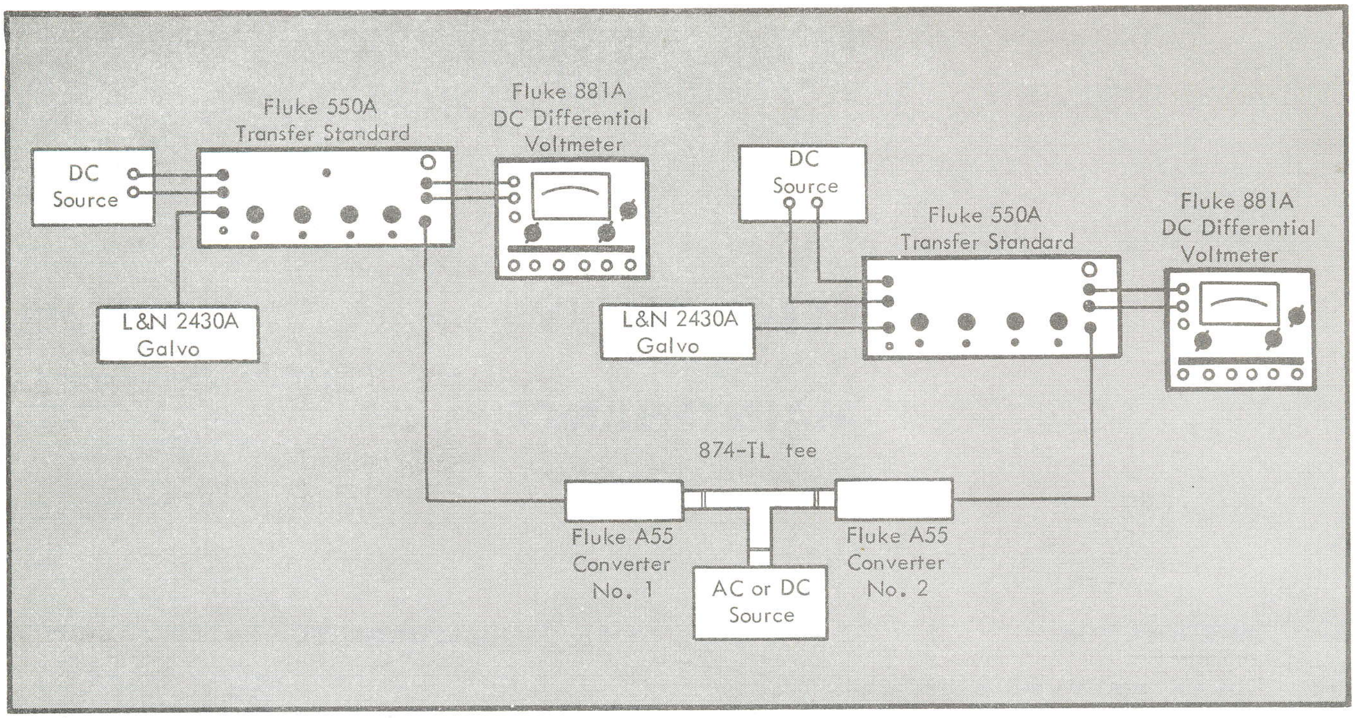


Figure 4-2. CONNECTION DIAGRAM FOR CALIBRATION CHECKING

b. Set the ac source voltage to the lowest rated voltage of the two thermal converters being used.

c. Adjust the galvanometer for mechanical zero.

d. Set the BATTERY switch to on.

e. Set the POLARITY switch to NORMAL.

f. Null the galvanometer as in paragraph 2-7 i.

g. Unlock (turn CCW) the HIGH SENSITIVITY pushbutton.

h. Disconnect Thermal Converter #1 from the 874-TL tee, and connect to the THERMAL CONVERTER INPUT connector.

i. Null the galvanometer by adjusting the voltage of the dc source with each SENSITIVITY pushbutton depressed in SEARCH, LOW, MEDIUM, and HIGH sequence. Do not move the SENSITIVITY (reference voltage) adjustments.

j. Push HIGH SENSITIVITY poshbutton and check for reversal error as in paragraph 2-7j except change galvanometer indicated by varying the dc source voltage instead of varying the HIGH SENSITIVITY control. Do not adjust the reference voltage.

k. Record the dc source voltage.

l. Disconnect converter #1, and connect converter #2 to the THERMAL CONVERTER INPUT connector.

m. Repeat steps f. through k. The measured value of dc voltage should agree with the specification limits.

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section contains information necessary to describe all normally replaceable parts. Separate assembly lists are used to describe the parts on the final assembly and various assemblies and subassemblies. Each list has a corresponding illustration on which the parts for that list are identified. Parts are called out on both lists and illustrations by reference designations from the schematic diagram. Those parts (mechanical) which have no reference designation are shown on the illustrations by Fluke stock number.

5-3. Each list provides the following information on each part:

a. The REF DESIG. column indicates the reference designation used on the schematic diagram.

b. The DESCRIPTION column describes the part in words, along with any applicable values, tolerances, etc. Indentation is used to show assembly, subassembly, and parts relationship. See abbreviations and symbols on next page.

c. Entries in the FLUKE STOCK NO. column indicate the number by which Fluke stocks the part. This number should be used when ordering parts from the Fluke factory or your Fluke representative.

d. Entries in the MFR. column indicate a typical manufacture of the part by the manufacturer's code number. Appendix A lists the manufacturers and their code numbers.

e. Entries in the MFR. PART NO. column are part numbers assigned by the manufacturer indicated in the Mfg. column.

f. The number in the TOT. QTY. column indicates the total quantity of the part used in the instrument. "REF" indicates that the total quantity of the part has been previously given. The total quantity of each part is listed the first time the part appears. All other listings of the same part refer back to the reference designation of the first appearance of the part for the total quantity.

g. The number in the REC. QTY. column indicates the recommended spares quantity necessary to support approximately one to five instruments for a period of two years. The basis used to select the recommended spares quantity is that a small group of parts will be required to correct a majority of the problems that occur. Since there is a chance that any part may fail, a stock of at least one of every part used in addition to the recommended parts will be needed for complete maintenance during one year of isolated service.

h. The USE CODE column identifies certain parts which have been added, deleted, or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List at the end of this section. These changes are normally made when improved components become available or when the latest circuit improvements are developed by our engineering department. The serial number listed indicates the instruments in which that particular part was used. The symbol "∼" is used to indicate an approximate use code. If a different part should be used for replacement, it is listed by Fluke stock number in the description column.

5-4. HOW TO OBTAIN PARTS

5-5. Standard components have been used whenever possible. Thus, most parts can be obtained locally. However, parts may be ordered directly from the manufacturer using the manufacturer's part number or from Fluke using the Fluke stock number. In addition, the most commonly replaced parts that can not be obtained locally may be obtained from your Fluke representative. If a part you have ordered has been replaced by a new or improved part, Fluke will normally send you this part along with an explanation.

5-6. When ordering parts from Fluke always include:

a. Reference designation, description, and Fluke stock number.

b. Instrument model and serial number.

c. Most structural parts are not listed. In this case, give complete description, function, and location of part.

5-7. ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

ac	alternating current
Al	aluminum
assy	assembly
cap	capacitor
car flm	carbon film
cer	ceramic
comp	composition
conn	connector
cps	cycles per second
db	decibel
dc	direct current
dpdt	double pole double throw
dpst	double pole single throw
elect	electrolytic
fxd	fixed
Ge	germanium
gmv	guaranteed minimum value
Hz	hertz (cycles per second)
K	kilohm
kc or Kc	kilocycle
kHz or KHz	kilohertz (kilocycles per sec)
kv	kilovolt
kva	kilovolt-ampere
ma	milliampere
Mc or MC	megacycle
MHz	megahertz (megacycles per sec)
meg or M	megohm
met flm	metal film
mfg	manufacturer
mv	millivolt
mw	milliwatt
na	nanoampere
pf	picofarad
piv	peak inverse voltage
plstc	plastic
pp	peak-to-peak
ppm	parts per million
rect	rectifier
res	resistor
rms	root-mean-square
sb	slow-blow
Si	silicon
S/N	serial number
sw	switch
spdt	single pole double throw
spst	single pole single throw
Ta	tantalum
tc	temperature coefficient
tstr	transistor
ua	microampere
uf	microfarad
uv	microvolt
va	volt ampere
vac	alternating current volts
var	variable
vdc	direct current volts
w	watt
wvdc	direct current working volts
ww	wirewound

PREFIX SYMBOLS

T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
K or k	kilo	10^{3}
h	hecto	10^{2}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
u	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	anto	10^{-18}

QUANTITY SYMBOLS

a or amp	ampere
f	farad
h	henry
hr	hour
Ω	ohm
sec	second
v or V	volt
w or W	watt

SPECIAL NOTES AND SYMBOLS

~	Approximate use code, or serial number.
Use 0000-000000	Part number indicated should be used if replacement is required.

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Final Assembly (See Figure 5-1)	550A	89536				
	Case Assembly	1402-122515	89536		1		
	Lid Assembly (not illustrated)	1402-122184	89536		1		
	Panel Assembly (See Figure 5-2)	3158-138990 (550A-402)	89536		1		
B1, B2	Battery, mercury 1.34V, 14,000 ma-hr	4001-103226	37942	RM-42R	2	2	
J1	Binding post, red	2811-103325	81073	29-3 Red	2		
J2	Binding post, black	2811-103333	81073	29-3 Black	2		
J3	Binding post, red	2811-103325	81073	Same as J1	REF		
J4	Binding post, black	2811-103333	81073	Same as J2	REF		
J5	Connector Assembly				1		
	Inner transition	2106-103721	24655	874-64	1		
	Insulating bead	2106-103739	24655	874-70	1		
	Inner conductor	2106-103747	24655	874-61-4	1		
	Sleeve	2106-103754	24655	874-642-5	1		
	Retaining ring	2106-103762	24655	874-81	2		
	Outer conductor	2106-103770	24655	874-60-3	1		
	Coupling nut	2106-103788	24655	874-6187	1		
J6, J7	Connector, receptacle (not illustrated)	2103-103713	02660	80-PC2M	2		
R1A, R1B	Res, var, WW, dual 250Ω ±10%, 2W	4702-112979	12697	CM29333	1		
R2A, R2B	Res, var, WW, dual 100Ω ±10%, 2W	4702-112987	12697	CM29332	1		
R3	Res, var, WW, 10Ω ±10%, 2W	4702-112995	12697	CM29335	1		
R4	Res, comp, 22Ω ±5%, 1W	4704-109900	01121	GB2205	1		
R5	Res, var, WW, 1Ω ±10%, 2W	4702-113001	12697	CM29343	1		
R6	Res, comp, 1.2K ±5%, 1W	4704-109892	01121	GB1225	1		
R7	Res, WW, 7.5Ω ±5%, 1/2W	4707-131797	89536		1		
R8	Res, comp, 22K ±10%, 1/2W	4704-108209	01121	EB2231	1		
R9	Res, comp, 2.2K ±10%, 1/2W	4704-108605	01121	EB2221	1		
R10	Res, comp, 220Ω ±10%, 1/2W	4704-108191	01121	EB2211	1		

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
R11	Res, comp, 47Ω ±10%, 1/2W	4704-108688	01121	EB4701	1		
S1	Switch, toggle, 115 VAC, 5A	5106-115113	95146	MST215N	1		
S2	Switch, toggle, 125 VAC, 6A	5106-114835	14099	81024-GB	1		
S3, S4, S5	Switch, push button, DPDT	5104-115030	82389	9S-1093	3		
S6	Switch, locking, DPDT	5104-115048	82389	9S-1094	1		
	Cable, Galvanometer	6002-122523	89536				
	Cable, Converter	6002-122531	89536				

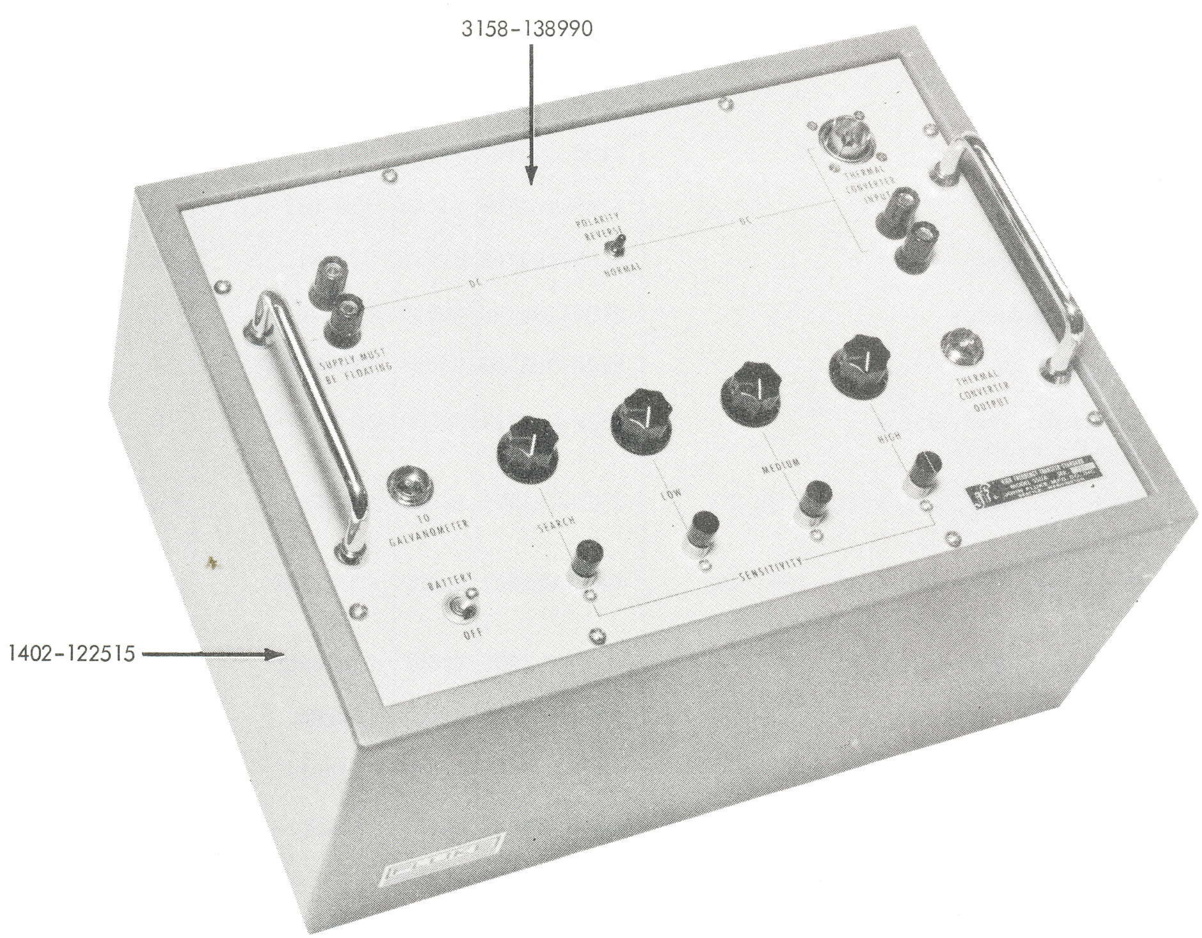


Figure 5-1. FINAL ASSEMBLY

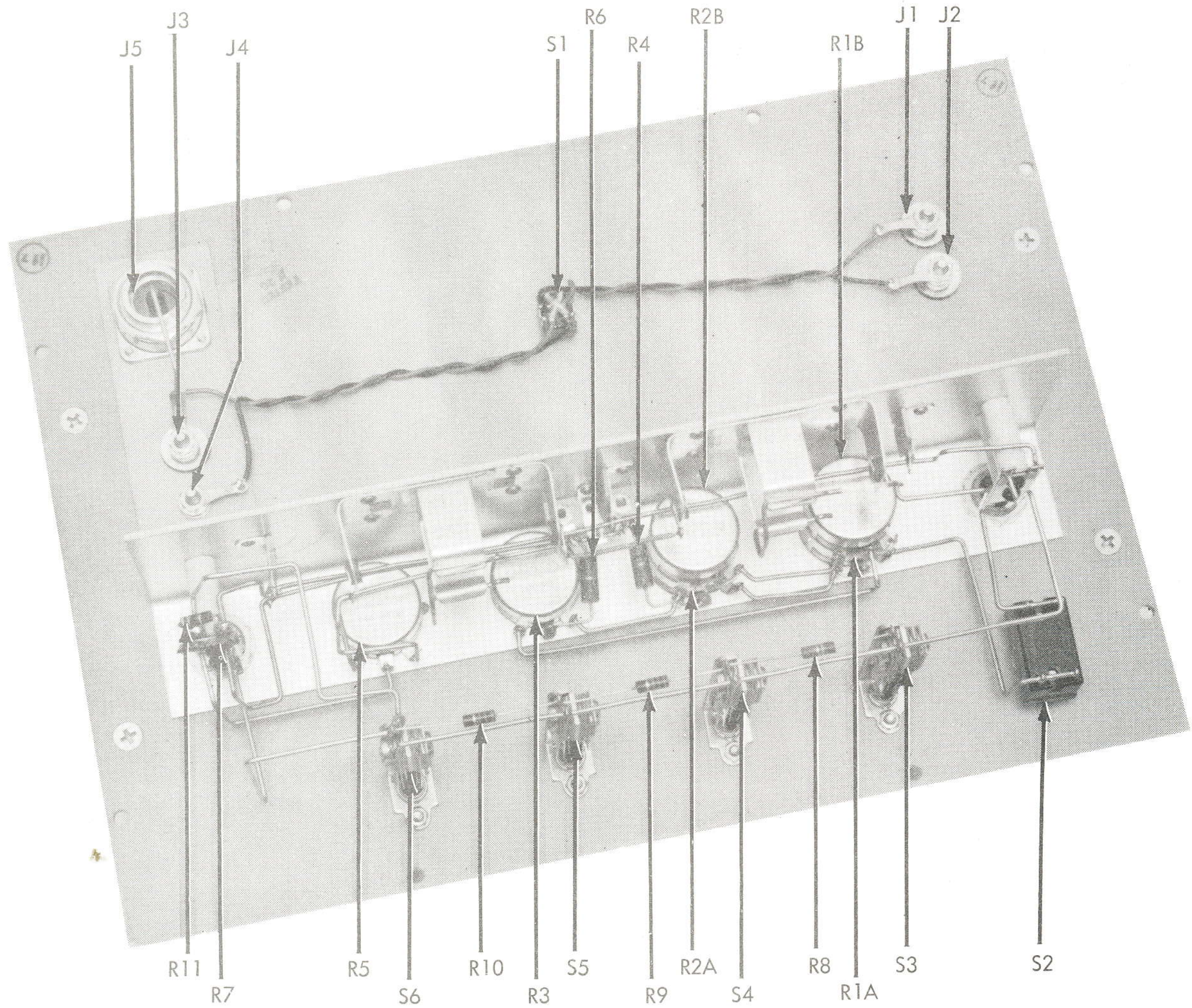


Figure 5-2. PANEL ASSEMBLY

5-8. USE CODE EFFECTIVITY

5-9. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the A55 & 550A. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all instruments with serial numbers above 123. New codes will be added as required by instrument changes.

USE CODE	EFFECTIVITY
No Code	Model 550A serial number 123 and on

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5. The following information is presented in this section:

List of Abbreviations
Federal Supply Codes for Manufacturers
Fluke Technical Service Centers — U.S. and Canada
Sales and Service Locations — International
Sales Representatives — U.S. and Canada

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
^oC	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal (seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
^oF	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch (es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm (s)
kV	kilovolt (s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere (s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt (s)
mv	multivibrator
MΩ	megohm (s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(–) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmable read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond (s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt (s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm (s)
μ	micro (10^{-6})

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisberg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884 - use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571 - use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
Ross Milton, Co., The
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Division
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, MA

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933 - use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept.
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988 - use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, MN

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

Federal Supply Codes for Manufacturers (Continued)

11711
General Instrument Corp
Rectifier Division
Hickville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Division
AMF Canada LTD.
Guelph, Onatrio, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
Budd Co. The, Polychem Products
Plastic Products Div.
Bridgeport, PA

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606 - use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors, formerly
Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
G T E Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Buckeye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co. Corporate H.Q.
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
A B Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

Federal Supply Codes for Manufacturers (Continued)

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
Mallory, P.R. & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp, formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, Californai

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnbach Radio Co., Inc.
Freeport, LI New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village, Chicago, Illinois

72005
Driver, Wilber B., Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrence, California

73445
Amperex Electronic Corp.
Hicksville, LI, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp., Mepco Div.
A North American Phillips Co.
Morristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183 - use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Stevens, Arnold Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
Carr Co., The United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Division
Eatontown, New Jersey

83330
Smith, Herman H., Inc.
Brooklyn, New York

83478
Rubbercraft Corp. of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products,
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co. Div of
P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211 - use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737 - use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154 - use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
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95264
Replaced by 98278

95275
Vitramon Inc.
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95303
RCA Corp.
Receiving Tube Div.
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95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic Hdware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect. Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779 - use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
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El Monte, California

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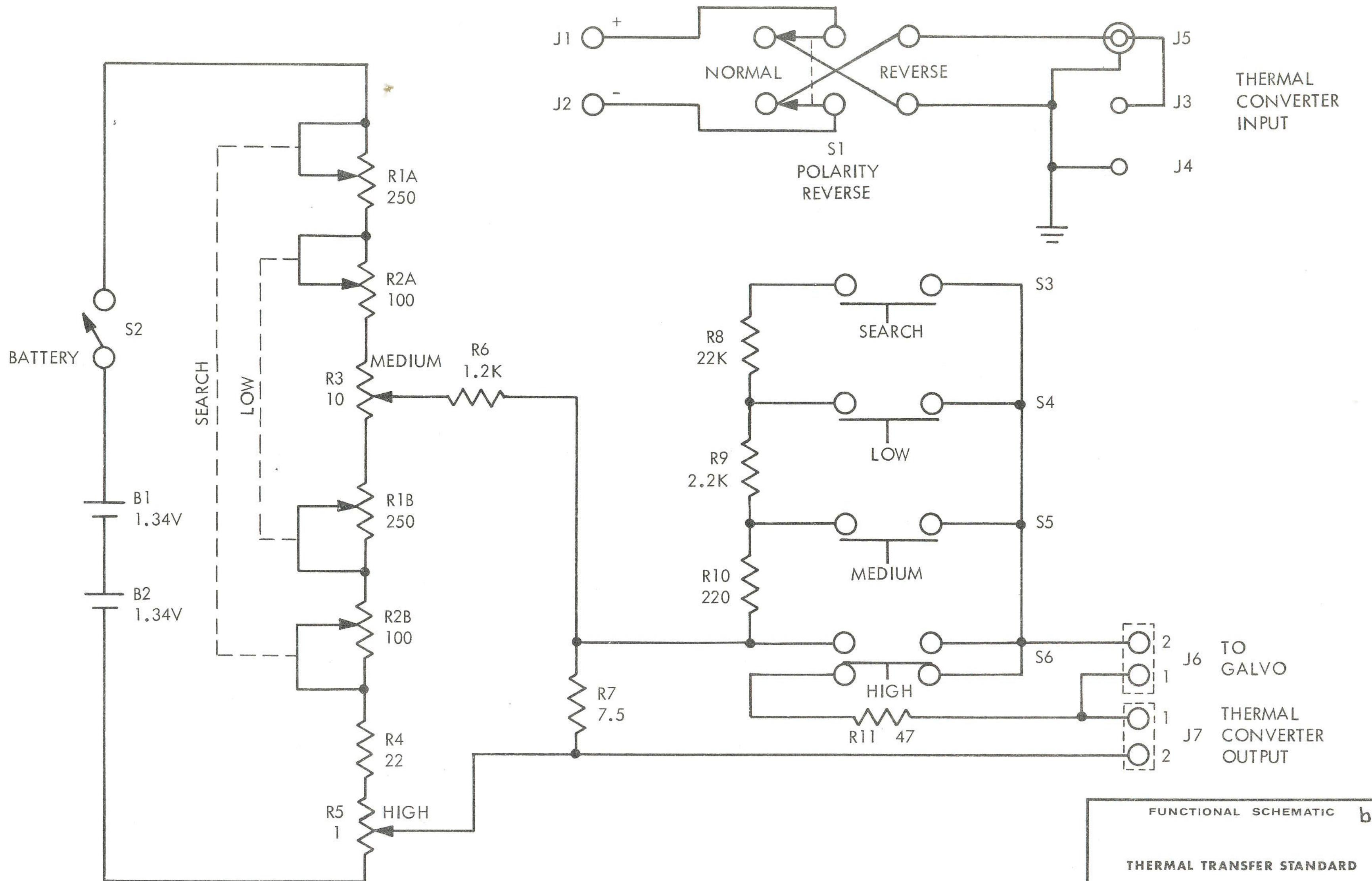

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