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P. O. Box 7428 Seattle 33, Washington

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MODEL 540A

THERMAL TRANSFER STANDARD

540A serial no. 123 and above.

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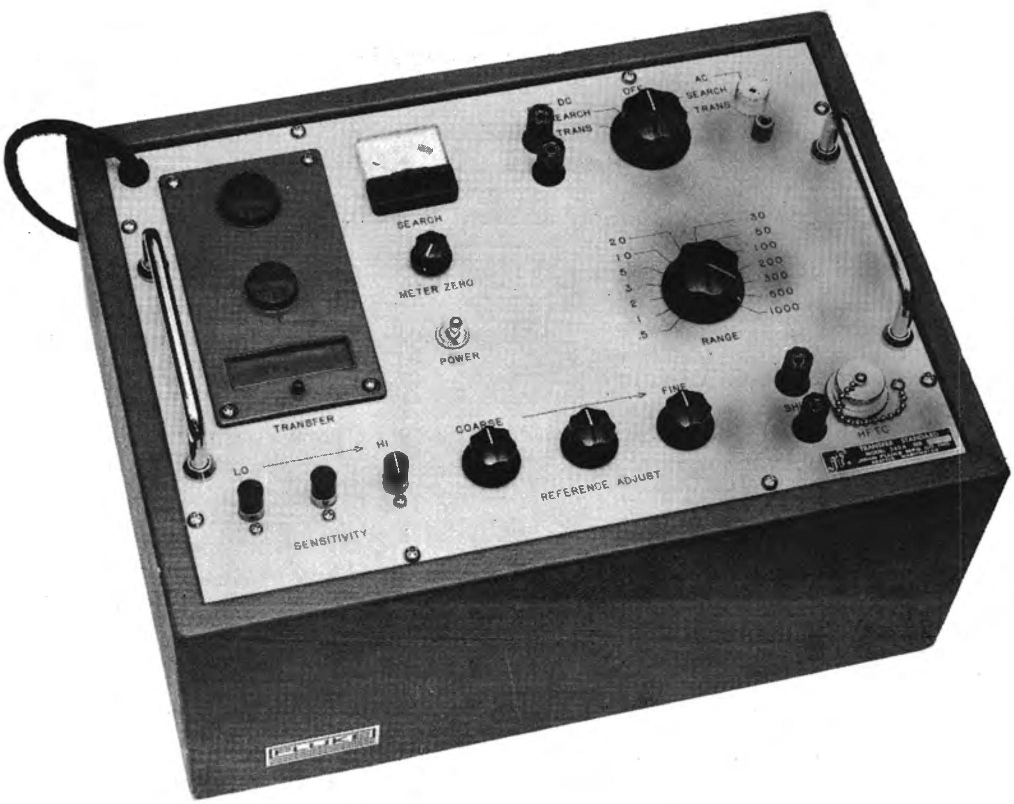


MODEL 540A THERMAL TRANSFER STANDARD

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

a. Resistance and voltage are the fundamental quantities used for nearly all electrical measurements. They are chosen because standard cells and resistors can be maintained constant and permanent to a high degree. All other electric and magnetic standards are derived from the ohm, DC volt, and mechanical units for the purpose of measurements in science and engineering. Unfortunately, it is difficult to derive and maintain adequate AC standards. Thus, there are no AC standards as such. As a result, all high accuracy AC measurements depend fundamentally on transfer instruments that ideally have an equal response to both direct and alternating current. There are three general types of AC to DC transfer instruments which relate the root-mean-square value of an alternating current to a direct current of the same value. They are grouped according to the particular law of interchange of energy on which they depend. They are the electrodynamic, electrostatic, and electrothermic instruments. Of these, the electrothermic instruments are the most useful because they have high accuracy over both a wide frequency and a wide voltage range. The Fluke Model 540A Thermal Transfer Standard is an excellent example of this type of instrument.

b. The Fluke Model 540A operates between 5 cps and 500 kc over a range of 0.225 to 1000 volts with AC to DC differences as little as 0.02% without calibration curves or correction tables. This instrument is capable of being used for setting up a predetermined AC voltage or current, measuring an AC voltage or current, and measuring the frequency response of various devices. Shunt binding posts are provided for attaching external current shunts, such as the Fluke Model A40 Current Shunts. The 540A and the A40 Current Shunts provide a current range from 2.5 milliamperes to 10 amperes. A connector is also provided for connecting external thermal converters, such as the Fluke Model A55 Thermal Converters, to the internal reference source. The A55 Converters provide a frequency response up to 50 megacycles over a range from 0.225 to 50 volts.

c. The high accuracy, wide frequency range, portability, compactness, ease of operation, inherent protection from accidental overload, low cost, and high reliability contribute to the outstanding performance that assures suitability for both production line testing and precision laboratory measurements. One feature that should be emphasized is the thermal construction which results in extremely low thermal drift. For example, the metal film resistors used in the main attenuator have a very low temperature coefficient. In addition, special heat sinks and thermal barriers are situated throughout the 540A. Also, the thermocouple is potted in polyurethane foam. Thus, the transfer circuit can be used immediately upon turn-on and provides high stability during continuous use. Protection of the thermocouple from accidental overload can be accredited to the inclusion of search circuits for both AC and DC input voltages. This allows for the selection of the proper voltage range before the AC or DC voltage is applied to the transfer circuit. The search circuits become operational a few minutes after turn-on. The ability to measure AC voltage at up to 500 kc is a result of the special frequency compensation networks contained in the 540A. As an additional design feature, the 540A contains a built in galvanometer for added convenience. This galvanometer has the capability for discerning 0.01% at any operating level from 2/3 to 1-1/2 times the nominal 540A range setting. As a result, the internal galvanometer provides sufficient sensitivity for a large majority of all measurements made with the 540A. However, binding posts are provided for connecting an external galvanometer when more sensitivity is desired.

d. The 540A Transfer Standard measures alternating current quantities by comparing the heating effect of an alternating current to the heating effect of a known direct current. When the heating effects are equal, the true rms value of AC voltage or current is equal to the known DC voltage or current. The responsive element of the 540A is a specially constructed vacuum thermocouple with an integral heater. A DC output voltage is produced across the thermocouple when AC or DC is placed across the heater. Since the output of the thermocouple is dependent on the energy of the input, an AC input will produce the same output as a DC input equal to the rms value of AC. An internal adjustable reference voltage is compared to the thermocouple output by means of three ranges of sensitivity on a built in high resolution galvanometer to establish a reference point. Since galvanometer sensitivity limits the useful range of the thermocouple from approximately 1/2 to 1-1/2 times its rated value, compensated impedances are placed in series with the thermocouple heater by range selection to give an operating range of 0.225 to 1000 volts DC or rms AC. To make current measurements, the thermocouple heater is shunted as necessary to maintain nominal heater current. Thus, an AC current can be measured by applying a DC current to a shunt that will produce the same output as the rms value of an AC current applied to the same shunt. Search circuits for AC and DC voltages indicate the proper range setting on a meter with a low-normal-high scale. A low indication means a lower range should be used and a high indication means a higher range should be used.

1-2. INPUT POWER

The 540A may be used on a 115 volt (±10%) or a 230 volt (±10%) line with a frequency from 50 to 60 cycles. Approximately 10 watts of input power is required. Like most Fluke instruments, the 540A is normally supplied with dual primary windings connected in parallel for 115 volt operation. Upon request, instruments are supplied for 230 volt operation with the primary windings connected in series. If it becomes desirable to convert from one mode of operation to the other, proceed as follows:

a. Remove eight screws on perimeter of front panel which secure the panel to case.

b. Carefully remove instrument from case. Four leads (orange, yellow, green and blue) will be seen extending from power transformer T1 to an adjacent terminal strip.

c. To convert from 115 volts to 230 volts operation:

(1) Remove jumper wire from between yellow and green transformer leads.

(2) Unsolder remaining jumper from blue lead and resolder to green lead.

(3) Replace 1/4 ampere line fuse with 1/8 ampere type. The fuse is located adjacent to rear of search meter inside instrument.

d. To convert from 230 volt to 115 volt operation:

(1) Unsolder jumper from green lead and resolder to blue lead.

(2) Solder a jumper wire from green lead to yellow lead.

(3) Replace 1/8 ampere line fuse with 1/4 ampere type. The fuse is located adjacent to rear of search meter inside instrument.

e. Place instrument in case and replace eight screws that fasten front panel to case.

1-3. DAMAGE IN SHIPMENT

Immediately upon receipt, thoroughly inspect for any damage that may have occurred in transit. If any damage is noted, follow the instructions outlined on the warranty page at the back of this manual.

1-4. SPECIFICATIONS

VOLTAGE RANGE: Each voltage range may be used from approximately 2/3 to 1-1/2 times nominal rating except 1000 volt range which is limited to 2/3 to 1 times nominal. Overall voltage range is 0.3 to 1000 volts in 14 ranges with nominal ratings of:

0.5	5	50	500
1	10	100	1000
2	20	200	
3	30	300	

By using an external galvanometer each voltage range may be used down to approximately 1/2 times nominal to give an overall range of 0.225 to 1000 volts.

MAXIMUM AC TO DC DIFFERENCE: The values below indicate the maximum percent difference between the 540A and zero error as defined by the National Bureau of Standards at Washington DC.

Range	Frequency	AC to DC Difference
0.5	5 cps - 100 kc	±0.02%
	100 kc - 500 kc	±0.05%
1 - 10	5 cps - 500 kc	±0.02%
20 - 50	5 cps - 100 kc	±0.02%
	100 kc - 500 kc	±0.20%
100 - 300	5 cps - 50 kc	±0.03%
500	5 cps - 50 kc	±0.05%
1000	5 cps - 20 kc	±0.05%

CALIBRATION: National Bureau of Standards Certificates are no longer issued by the Bureau on instruments of any kind. However, NBS will check a 540A and issue a test report at specified frequencies and voltages upon request. As requested by NBS, we are emphasizing that these tests can be done at Fluke's own traceable standards laboratory. Thus, Fluke can test any 540A indirectly against the national primary standard. This helps to reduce the NBS work load and also reduces customer waiting time. Fluke certified test reports showing the exact percent of AC to DC difference between any 540A and zero error as defined by NBS are available at extra cost. At this time, NBS is willing to state that their AC to DC difference measurement accuracy is known to at least ±0.01% up to 30 kc, ±0.02% from 30 kc to 50 kc, and ±0.03% from 50 kc to 500 kc.

TRANSFER INPUT IMPEDANCE: 200 ohms/volt.

SEARCH ACCURACY: Approximately ±15%.

SEARCH INPUT IMPEDANCE: DC--1.8 megohms, AC--1 megohm and 30 picofarads.

GALVANOMETER RESOLUTION: About 0.036%, 0.02%, and 0.01% per division when operating at 2/3 1, and 1-1/2 times voltage specified by range switch. It is possible to discern 1/4 of a division deflection giving a capability of 0.01% at any operating level.

INPUT POWER: Search circuits - Approximately 10 watts at 115/230 VAC ±10%, 50-60 cps. Reference supply circuit - One 1.34 volt Mallory RM-42R (size D) mercury battery. Life approximately 1000 hours continuous operation.

CABINET SIZE: 8-1/2" high x 14-1/2" wide x 10-3/4" deep.

WEIGHT: 11-1/2 pounds.

ACCESSORIES INCLUDED: Interconnecting cable for connecting optional Fluke A55 High Frequency Thermal Converters to 540A.

SECTION II

OPERATING INSTRUCTIONS

2-1. INSTALLING BATTERIES

The 1.34 volt Mallory RM-42R mercury battery used in the 540A reference supply circuit may be installed as follows:

a. Remove eight screws fastening front panel of 540A to case and carefully lift front panel and attached chassis from case assembly.

b. Remove retaining clip from battery holder and remove old battery.

c. Install new battery so that polarity marked on battery matches polarity marked on battery holder. Note that case of mercury battery is positive.

d. Replace retaining clip on battery holder.

e. Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

2-2. CONTROLS, TERMINALS, AND INDICATORS

The circuit symbol and a functional description of the operating controls, terminals, and indicators of the 540A Thermal Transfer Standard may be found in Figure 2-1. It is recommended that the operator read and understand the descriptions given in this figure before attempting to use the 540A.

2-3. AUXILIARY EQUIPMENT NEEDED

The 540A along with the auxiliary equipment listed in Figure 2-2 forms a complete system capable of calibrating an AC voltage or current, measuring an unknown AC voltage or current, and measuring the frequency response of various devices. It must be emphasized that the AC measurement accuracy is dependent not only on the 540A accuracy but also on the overall DC system accuracy. The best one can confidently hope to do, is to approach the AC measurement accuracy that the National Bureau of Standards can achieve. When attempting to do this, a test report showing the precise AC to DC difference between the 540A used and zero error as defined by the National Bureau of Standards at Washington DC must be used. NBS will check a 540A and issue a test report at specified frequencies and voltages upon request. However, as requested by NBS, we are emphasizing that these tests can be done at Fluke's own traceable standards laboratory. This helps to reduce the NBS work load and also reduces customer waiting time. It should also be kept in mind that the AC voltage being set up or being measured should be at least as stable as the accuracy one is attempting to attain.

2-4. PRELIMINARY OPERATION

a. Connect power plug to a 115 volt AC power source. If instrument has been wired for 230 volt operation, connect to 230 volts AC.

NOTE

The round pin on polarized three-prong plug connects instrument case to power system ground. Use three-to-two pin adapter supplied with instrument when connecting to a two-contact receptacle. For personnel safety, connect short lead to suitable ground.

b. Set function switch to OFF.

c. Set POWER switch to ON. Allow 2 or 3 minutes for search circuitry to warmup.

d. During warmup time, adjust galvanometer course and fine zero controls.

e. When warmup is completed, adjust METER ZERO control for zero deflection of SEARCH meter.

2-5. MEASURING AN UNKNOWN AC VOLTAGE

a. After completing preliminary operation, connect unknown AC voltage to AC input terminals. Keep leads short to reduce possible transmission line effects and to minimize IR drop.

b. Connect DC source to DC input terminals. Keep leads short to minimize IR drop.

CAUTION

Always connect grounded side of DC source to lower DC input post. The insulating bead of the thermocouple will breakdown if the lower input post is raised more than a few volts above ground.

c. If approximate value of AC voltage is unknown, set RANGE switch to 1000; otherwise, set RANGE switch as close as possible to approximate voltage.

d. Set function switch to AC SEARCH.

e. If SEARCH meter indicates HIGH or LOW, select a higher or lower range respectively until meter indicates NORMAL. A normal indication can usually be obtained on two ranges. Better galvanometer resolution is obtained at higher end of NORMAL band.

f. Set function switch to AC TRANS.

CONTROLS TERMINALS AND INDICATORS	CIRCUIT SYMBOL	FUNCTIONAL DESCRIPTION
POWER switch	S1	Applies AC line voltage to primary circuit of transformer for operation of search circuitry and galvanometer light. Also closes voltage divider circuit across mercury cell B1. Should be left in off position when 540A is not in use to prolong mercury cell life.
DC binding posts	J3, J4	Provided for connecting DC voltage to 540A. General purpose binding posts mounted on 3/4 inch centers.
AC input terminals	J1, J2	Provided for connecting AC voltage to 540A. Consists of a UHF type connector and a separate ground post located 3/4 inch from center of UHF connector so that a standard dual banana plug may be used if desired.
Function switch	S2	Selects either DC or AC input to instrument and allows selection of the SEARCH and TRANSfer modes for either input.
SEARCH meter	M2	Indicates proper instrument range to be selected prior to application of AC or DC input voltage to transfer circuit. Indication is presented on a LOW-NORMAL-HIGH scale. A lower voltage range should be selected if pointer is in LOW region. If pointer is in HIGH region, a higher range must be selected to prevent thermocouple damage when switching to the transfer circuit.
METER ZERO control	R68	Sets search meter to zero when transfer switch is set to OFF.
RANGE switch	S3	Selects proper impedances for each voltage range in the transfer, AC search, and DC search circuits.
Galvanometer	M1	Used to establish a reference point for comparison of AC and DC inputs. Is connected in transfer circuit between thermocouple output and internal reference supply.
Coarse and fine galva-nometer zero controls	None	Adjusts galvanometer light beam at any time galva-nometer SENSITIVITY pushbuttons are not depressed. Located on galvanometer.
SENSITIVITY switches	S4, S5, S6	Provide LOw, medium, and HIgh galvanometer sensitivity for nulling galvanometer with COARSE, medium, and FINE reference adjust controls respectively. On earlier models, HI SENSITIVITY switch had to be depressed before it could be turned clockwise.
REFERENCE ADJUST controls	R22, R23, R25	Vary voltage of mercury cell reference circuit to balance thermocouple output on galvanometer.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (sheet 1 of 2)

CONTROLS TERMINALS AND INDICATORS	CIRCUIT SYMBOL	FUNCTIONAL DESCRIPTION
SHUNT binding posts	J5, J6	Provided for attachment of current shunts across thermocouple heater when it is desired to measure AC current rather than voltage. Under no conditions are they to be used as voltage input terminals, as damage to thermocouple would possibly result. To help prevent inadvertant application of an input, these terminals are located on 1 inch enters. The SHUNT terminals provide a nominal range of 5 milliamperes (2. 5 to 7. 5 ma) without the use of an external shunt.
HFTC plug and jack	P2, J7	Used to attach an external high frequency thermal converter, such as the John Fluke Model A55. For normal operation without an external high frequency converter, three prong captive plug must be installed in jack. With plug installed, output of internal thermocouple appears in galvanometer circuit.
External galvanometer binding posts	J8, J9, J10	Provided inside small access door in bottom panel for attachment of an external galvanometer. Connecting leads to external galvanometer may be passed through small opening in side of instrument which is covered with a snap-button hole plug.
Galvanometer switch	S7	Shorts internal galvanometer when switched from NORMAL to EXTERNAL. Located adjacent to external galvanometer binding posts.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (sheet 2 of 2)

g. Null Galvanometer as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust COARSE REFERENCE ADJUST control for a null.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null.

(4) Turn HI SENSITIVITY switch counterclockwise.

h. Set function switch to DC SEARCH.

i. Adjust DC source voltage until SEARCH meter indicates NORMAL.

j. Set function switch to DC TRANS.

k. Null galvanometer by adjusting DC source voltage in each SENSITIVITY regarding proper LO, medium, and HI order. Do not move REFERENCE ADJUST controls.

l. Record DC source voltage.

m. Check for DC reversal error as follows:

(1) Repeat steps d through g.

(2) Reverse polarity of DC source. Make sure lower DC input post remains at ground potential.

(3) Repeat steps j through l. Note that DC search circuit operates on positive polarity only.

n. The rms value of the unknown AC voltage is equal to average of two DC voltages recorded. This procedure, steps d through m, should be repeated at least three times to be certain of a precise result. Watch for drift while repeating this procedure. Any error involved in the calibration accuracy or measurement accuracy of the DC voltage must be considered in addition to the basic accuracy of the 540A. If a 540A test report is used, calculate unknown AC voltage from the following equation:

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

Where: E_{dc} = average of two DC voltages recorded

$$a_o = \left(\frac{E_{ac} - E_{dc}}{E_{dc}}\right) 100$$ = AC to DC percent difference from test report

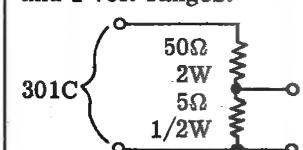
NOMENCLATURE	SPECIFICATIONS DESIRED FOR MAXIMUM ACCURACY	APPLICATION	RECOMMENDED INSTRUMENT
AC Voltage Source	AMPLITUDE STABILITY: 0.01% short term AMPLITUDE RESOLUTION: 0.002% at desired output voltage OUTPUT VOLTAGE: 0.225 to 1000 volts OUTPUT CURRENT: 5 to 10 ma FREQUENCY: Dependent on application	Supplying an AC voltage for setting up a calibrated AC voltage and measuring frequency response of voltage indicating instruments and voltage amplifiers.	No one AC source will meet the specifications desired for maximum accuracy over the frequency range covered by 540A Transfer Standard. However, AC signal sources and amplifiers that will give satisfactory results in most cases are made by Boonton Radio Corp., Hewlett Packard, Holt Inst. Lab., Krohn-Hite, Rohde and Schwarz, and Tektronix, Inc.
DC Voltage Source	AMPLITUDE STABILITY: 0.002% short term AMPLITUDE RESOLUTION: 0.002% at desired output voltage OUTPUT VOLTAGE: 0.225 to 1000 volts OUTPUT CURRENT: 5 to 10 ma	Supplying a DC voltage equal to the rms value of AC voltage to be calibrated or measured.	John Fluke Model 301C Note: The 301C requires the following voltage divider for use on 0.5 and 1 volt ranges.  Use low temperature coefficient wirewound resistors.
DC Voltage Measuring Equipment	RANGE: 0.225 to 1000 volts ACCURACY: 0.003%	Accurately measuring DC source voltage.	Julie Research Laboratories and Guildline Instruments have instruments which will provide a DC system accuracy of about 0.003%. However, the best obtainable DC accuracy is not required in most applications. In general, the Fluke Model 821A or 823A Differential Voltmeter along with the Model 80A Volt Divider, will provide more than enough accuracy (0.01% to 500 volts and 0.025% from 500 to 1000 volts).
Galvanometer	COIL RESISTANCE: 17Ω CRITICAL DAMPING RESISTANCE: 30 to 90Ω SENSITIVITY: 0.5 uv/millimeter	May be used to give greater sensitivity than internal galvanometer whenever desired. Mostly used when voltage is a fraction of full range and when test report is used.	Leeds and Northrup Model 2430A or Fluke Model 840B.

Figure 2-2. AUXILIARY EQUIPMENT (sheet 1 of 2)

NOMENCLATURE	SPECIFICATIONS DESIRED FOR MAXIMUM ACCURACY	APPLICATION	RECOMMENDED INSTRUMENT
AC Current Source	AMPLITUDE STABILITY: 0.01% short term AMPLITUDE RESOLUTION: 0.002% at desired output current OUTPUT CURRENT: 2.5 ma to 10 amperes OUTPUT VOLTAGE: 0.5 volts FREQUENCY: Dependent on application	Supplying an AC current for setting up a calibrated AC current and measuring frequency response of current indicating instruments.	In most cases it will be necessary to use a variable voltage source and an appropriate resistor.
DC Current Source	AMPLITUDE STABILITY: 0.002% short term AMPLITUDE RESOLUTION: 0.002% at desired output current OUTPUT CURRENT: 2.5 ma to 10 amperes OUTPUT VOLTAGE: 0.5 volts	Supplying a DC current equal to the rms value of AC current to be calibrated or measured.	In most cases it will be necessary to use a variable voltage source and an appropriate resistor. For many applications, the Fluke Model 382A Voltage/Current Calibrator will be very useful.
DC Current Measuring Equipment	RANGE: 2.5 ma to 10 amperes ACCURACY: As desired	Accurately measuring DC source current.	Use a standard resistor and DC voltage measuring equipment previously recommended.
AC Current Measuring Equipment	RANGE: 2.5 ma to 10 amperes ACCURACY: 10% FREQUENCY: Dependent on application	Approximate current measurement to prevent thermocouple damage.	Use common commercial ammeter.

Figure 2-2. AUXILIARY EQUIPMENT (sheet 2 of 2)

2-6. CALIBRATING AN AC VOLTAGE

a. Perform preliminary operation as stated in paragraph 2-4.

b. Connect DC source to DC input terminals. Keep leads short to minimize IR drop.

CAUTION

Always connect grounded side of DC source to lower DC input post. The insulating bead of the thermocouple will breakdown if the lower input post is raised more than a few volts above ground.

c. Connect AC source to AC input terminals. The instrument or other device for which calibrated AC voltage is intended should also be connected at the 540A so that impedance presented to AC source will remain constant. This will cause further AC source loading in addition to the 5 milliamperes through the 540A at rated voltage. Keep leads short to reduce possible transmission line effects and to minimize IR drop.

d. Adjust DC source until DC voltage exactly equals rms value of AC voltage desired. If 540A test report is used, adjust DC source voltage until DC voltage equals $\frac{100}{100 + a_o}$ times rms value of AC voltage desired. a_o is the AC to DC percent difference obtained from test report.

e. Set RANGE switch as close as possible to DC voltage.

f. Set function switch to DC SEARCH.

g. The SEARCH meter should indicate NORMAL. If not, determine and correct source of trouble. Remember that a normal indication can usually be obtained on two ranges. Better galvanometer resolution is obtained at high end of NORMAL band.

h. Set function switch to DC TRANS.

i. Null galvanometer as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust COARSE REFERENCE ADJUST control for a null.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null.

(4) Turn HI SENSITIVITY switch counterclockwise.

j. Set function switch to AC SEARCH.

k. Adjust AC source voltage until SEARCH meter indicates NORMAL.

l. Set function switch to AC TRANS.

m. Null galvanometer by adjusting AC source voltage in each SENSITIVITY regarding proper LO, medium, and HI order. Do not move REFERENCE ADJUST controls.

n. Record AC source voltage setting.

o. Check for DC reversal error as follows:

(1) Reverse polarity of DC source. Make sure lower DC input post remains at ground potential.

(2) Repeat steps h through n. Note that DC search circuit operates on positive polarity only.

p. Set AC source voltage amplitude control in center of two settings recorded. The rms value of the AC voltage now equals the desired value. This procedure, steps d through p, should be repeated at least three times to be certain of a precise result. Watch for drift while repeating this procedure.

2-7. MEASURING AN UNKNOWN AC CURRENT

The Model 540A may be used as an AC current transfer device. The Fluke Model A40 series of 13 current shunts along with a 540A allow accurate current measurements from 5 milliamperes to 10 amperes over a frequency range of 5 cps to 100 kc. The 540A will measure current from 2.5 to 7.5 milliamperes without a current shunt. When the current shunts are used, the range resistors, transfer switch, and search circuits are by-passed.

a. Perform preliminary operation as stated in paragraph 2-4.

b. Set RANGE switch to 1000 volt position.

c. Connect proper current shunt across SHUNT binding posts. A shunt is not needed if current to be measured is between 2.5 and 7.5 milliamperes.

CAUTION

> To prevent thermocouple burnout, always make sure that the rms value of AC current to be measured is equal to or less than 1-1/2 times the current rating of the shunt used. Do not exceed rating of 10 ampere shunt.

d. Using a coaxial cable (such as RG-8A/U) less than 30 cm in length, apply unknown current to binding posts on shunt or to SHUNT binding posts when a shunt is not used. Keep unshielded part of center conductor as short as possible.

e. Null galvanometer as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust COARSE REFERENCE ADJUST control for a null.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null.

(4) Turn HI SENSITIVITY switch counterclockwise.

f. Disconnect unknown AC current and connect DC current source. Make sure that DC current does not exceed 1-1/2 times shunt rating and does not exceed rating of 10 ampere shunt.

g. Null galvanometer by adjusting DC source current in each SENSITIVITY regarding proper LO, medium, and HI order. Do not move REFERENCE ADJUST controls.

h. Record DC source current.

i. Check for DC reversal error as follows:

(1) Repeat steps d and e.

(2) Repeat steps f through h with a DC current of opposite polarity.

j. The rms value of unknown AC current is equal to the average of the two DC currents recorded. This procedure, steps d through i, should be repeated at least three times to be certain of a precise result. Watch for drift while repeating this procedure. Any error involved in calibration accuracy or measurement accuracy of DC current must be considered in addition to basic accuracy of 540A and A40. If a test report is used, calculate unknown AC current from the following equation:

$$I_{ac} = \left(\frac{a_o}{100} - 1\right) I_{dc}$$

Where: I_{dc} = current indicated by DC current measuring equipment

$$a_o = \left(\frac{I_{ac} - I_{dc}}{I_{dc}}\right) 100$$ = AC to DC percent difference from test report

2-8. CALIBRATING AN AC CURRENT

a. Perform preliminary operation procedure as stated in paragraph 2-4.

b. Set RANGE switch to 1000 volt position.

c. Connect proper current shunt across SHUNT binding posts. A shunt is not required if current to be measured is between 2.5 and 7.5 milliamperes.

d. Using a coaxial cable (such as RG-8A/U) less than 30 cm in length, connect DC current source to binding posts on shunt or to SHUNT binding posts when a shunt is not used. Make sure that DC current does not exceed 1-1/2 times rated value of current shunt. Do not exceed rating of 10 ampere shunt. Keep unshielded part of center conductor as short as possible.

e. Adjust DC source until DC current exactly equals rms value of AC current desired. If an A40 test report is used, adjust DC source until DC current equals $\frac{100}{100 + a_o}$ times rms value of AC current desired. a_o is the AC to DC percent difference from test report.

f. Null galvanometer as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust LO REFERENCE ADJUST control for a null.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null.

(4) Turn HI SENSITIVITY switch counterclockwise.

g. Disconnect DC current source and connect AC current source. Make sure that AC current does not exceed 1-1/2 times shunt rating and does not exceed rating of 10 ampere shunt.

h. Null galvanometer by adjusting AC source current in each SENSITIVITY regarding proper LO, medium, and HI order. Do not move REFERENCE ADJUST controls.

i. Record AC source current setting.

j. Check for DC reversal error by repeating steps d through i with a DC current of opposite polarity.

k. Set AC source current in center of two settings recorded. The rms value of the AC current now equals the desired value. This procedure, steps d through j, should be repeated at least three times to be certain of a precise result. Watch for drift while repeating this procedure.

2-9. MEASURING FREQUENCY RESPONSE OF VOLTAGE INDICATING INSTRUMENTS

a. Perform preliminary operation as stated in paragraph 2-4.

b. Connect AC voltage source and device under test to AC input posts. Keep leads short to reduce possible transmission line effects and to minimize IR drop.

c. Adjust AC source to desired level.

d. Set RANGE switch as close as possible to AC voltage.

e. Set function switch to AC SEARCH. If SEARCH meter indicates HIGH or LOW, select a higher or lower range respectively until meter indicates NORMAL.

f. Set function switch to AC TRANS.

g. Null galvanometer as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust COARSE REFERENCE ADJUST control for a null. If 0.5%/mm to 2%/mm resolution is desired, proceed to step h.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null. If 0.1%/mm to 0.5%/mm resolution is desired, proceed to step h.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null. Resolution is approximately 0.01%/mm to 0.05%/mm.

CAUTION

Do not perform any switching of either voltage level or frequency range with 540A in circuit unless switching transient is known to be less than rated overload value of thermocouple.

h. Using SENSITIVITY range that has desired resolution, change frequency of AC source and hold galvanometer on null with AC amplitude control.

i. Record changes in voltage level, as indicated by device under test, at frequencies desired.

j. If greater accuracy is desired, follow procedure for calibrating an AC voltage (paragraph 2-6) at each frequency desired.

2-10. MEASURING FREQUENCY RESPONSE OF CURRENT INDICATING INSTRUMENTS

a. Perform preliminary operation as stated in paragraph 2-4.

b. Connect proper current shunt across SHUNT binding posts. A shunt is not needed if current to be measured is between 2.5 and 7.5 milliamperes.

CAUTION

To prevent thermocouple burnout, always make sure that the rms value of AC current to be measured is equal to or less than 1-1/2 times the current rating of the shunt used. Do not exceed rating of 10 ampere shunt.

c. Connect AC current source and device under test to binding posts on shunt or to SHUNT binding posts when a shunt is not used. Keep leads short.

d. Adjust AC current source to desired level.

e. Null galvanometer as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust COARSE REFERENCE ADJUST control for a null. If 0.5%/mm to 2%/mm resolution is desired, proceed to step f.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null. If 0.1%/mm to 0.5%/mm resolution is desired, proceed to step f.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null. Resolution is approximately 0.01%/mm to 0.05%mm.

CAUTION

Do not perform any switching of either current level or frequency range with 540A in circuit unless switching transient is known to be less than rated overload value of thermocouple.

f. Using SENSITIVITY range that has desired resolution, change frequency of AC source and hold galvanometer on null with AC amplitude control.

g. Record changes in current level, as indicated by device under test, at frequencies desired.

h. If greater accuracy is desired, follow procedure for calibrating an AC current (paragraph 2-8) at each frequency desired.

2-11. MEASURING FREQUENCY RESPONSE OF AC VOLTAGE AMPLIFIERS

If it is desired to make accurate frequency response measurements of an AC voltage amplifier, two 540A Transfer Standards will be required. Proceed as follows:

a. Perform preliminary operation as stated in paragraph 2-4 for both 540A Transfer Standards.

b. Connect one 540A and an AC voltage source to AC amplifier input.

c. Connect other 540A to AC amplifier output.

d. Adjust AC source to desired level.

e. Set RANGE switch on 540A at input as close as possible to AC voltage.

f. Set function switch on 540A at input to AC SEARCH. If meter indicates HIGH or LOW, select a higher or lower range respectively until meter indicates NORMAL.

g. Set function switch on 540A at input to AC TRANS.

h. Set RANGE switch on 540A at output to estimated amplifier output voltage.

i. The SEARCH meter should indicate NORMAL. If not, determine and correct source of trouble. Remember that a normal indication can usually be obtained on two ranges. Better galvanometer resolution is obtained at high end of NORMAL band.

j. Set function switch on 540A at output to AC TRANS.

k. Null both galvanometers as follows:

(1) Depress LO SENSITIVITY pushbutton and adjust COARSE REFERENCE ADJUST control for a null. If 0.5%/mm to 2%/mm resolution is desired, proceed to step l.

(2) Depress medium SENSITIVITY pushbutton and adjust medium REFERENCE ADJUST control for a null. If 0.1%/mm to 0.5%/mm resolution is desired, proceed to step l.

(3) Turn HI SENSITIVITY switch clockwise and adjust FINE REFERENCE ADJUST control for a null. Resolution is approximately 0.01%/mm to 0.05%/mm.

CAUTION

Do not perform any switching of either voltage level or frequency range with either 540A in circuit unless switching transients are known to be less than rated overload value of thermocouple.

l. Using SENSITIVITY range that has desired resolution, change frequency of AC source and hold galvanometer of 540A at input on null with AC amplitude control.

m. Note variations of amplifier output on galvanometer of 540A at output as frequency is changed.

n. The deflection indicated on galvanometer of 540A at output may be calibrated in percent as follows:

(1) Connect DC source to DC input posts of 540A at output of amplifier.

CAUTION

Always connect grounded side of DC source to lower DC input post. The insulating bead of the thermocouple may breakdown if the lower input post is raised more than a few volts above ground.

(2) Set function switch of 540A to DC SEARCH and adjust DC source until SEARCH meter indicates NORMAL.

(3) Set function switch to DC TRANS and adjust amplitude of DC source for a null on galvanometer using SENSITIVITY range that has desired resolution.

(4) Change DC source by an appropriate amount and note galvanometer deflection for SENSITIVITY range that has desired resolution.

(5) Use the following equation to compute percent change per galvanometer division.

$$\text{Resolution} = \frac{100\ (\text{change in DC voltage})}{(\text{original DC voltage})\ (\text{divisions of deflection})}$$

o. For greater accuracy, follow procedure described in paragraph 2-6 for adjusting AC amplifier input voltage and procedure described in paragraph 2-5 for measuring AC amplifier output voltage at each frequency desired.

2-12. HIGH FREQUENCY MEASUREMENTS WITH EXTERNAL THERMAL CONVERTERS

a. GENERAL. The HFTC jack on the 540A front panel is provided for attachment of external thermal converters for high frequency AC voltage measurements. The Fluke Model A55 series of nine thermal converters cover the same voltage ranges as the 540A to 50 volts. These thermal converters make possible extremely accurate AC voltage measurements up to 50 megacycles. When an external thermal converter is used, the 540A internal thermocouple, range resistors, transfer switch, and search circuits are not used. Therefore, external provisions must be made for protecting the external thermal converter. The instruction manual for the A55 Thermal Converters should be used to obtain the correction factor due to transmission line effects. This manual also gives instructions on how to find the precise AC to DC difference as would be obtained by using the standards at the National Bureau of Standards.

b. MEASURING AN UNKNOWN AC VOLTAGE. To measure an unknown high frequency AC voltage with an external thermal converter, proceed as follows:

(1) Connect 540A to AC line voltage and turn POWER switch to ON.

(2) Adjust galvanometer zero controls.

(3) Remove plug from HFTC jack and connect proper range A55 Thermal Converter to HFTC jack using interconnecting cable supplied with 540A for this purpose. This is a two-conductor shielded cable that connects the DC output of the external thermal converter to pins 1 and 3 of the HFTC jack. This cable allows the external thermal converter to be connected close to the AC voltage source and thus reduces transmission line effects.

CAUTION

Always use a thermal converter whose rated value is equal to or greater than the rms value of AC voltage to be measured. If approximate value of AC voltage is unknown, measure with a high frequency voltmeter.

(4) Apply unknown AC voltage to external thermal converter. The voltage applied may be from 1/2 to 1 times the rated value of each converter.

(5) Null galvanometer as in step g of paragraph 2-5.

(6) Remove unknown AC voltage from input of thermal converter and apply a known adjustable DC voltage of approximately the same value.

(7) Null galvanometer by adjusting DC voltage in each SENSITIVITY ragarding proper LO, medium, and HI order. Do not move REFERENCE ADJUST controls.

(8) Record DC source voltage.

(9) Check for DC reversal error by repeating steps (4) through (8) using a DC voltage of opposite polarity.

(10) The rms value of unknown AC voltage is equal to average of two DC voltages recorded. This procedure, steps (4) through (9), should be repeated at least three times to be certain of a precise result. Watch for drift while repeating this procedure. Any error involved in calibration accuracy or measurement accuracy of the DC voltage must be considered in addition to basic accuracy of the A55 Thermal Converter. Also, a

correction should be made for standing waves at frequencies above 5 megacycles. See the A55 Thermal Converter manual for instructions on computing this correction.

c. CALIBRATING AN AC VOLTAGE. To set up a high frequency AC voltage with an external thermal converter, proceed as follows:

(1) Connect 540A to AC line voltage and turn POWER switch to ON.

(2) Adjust galvanometer zero controls.

(3) Remove plug from HFTC jack and connect proper range A55 Thermal Converter to HFTC jack using interconnecting cable supplied with 540A for this purpose. This is a two-conductor shielded cable that connects DC output of external thermal converter to pins 1 and 3 of HFTC jack. This cable allows external thermal converter to be connected close to AC voltage source and thus reduces transmission line effects.

CAUTION

Always use a thermal converter whose rated value is equal to or greater than the rms value of AC voltage desired.

(4) Apply a known DC voltage equal to rms value of required AC voltage to input of thermal converter.

(5) If AC to DC differences from test report are used, see A55 Thermal Converter instruction manual for instructions on where to set DC voltage.

(6) If input impedance of device for which calibrated AC voltage is intended is not 50 ohms, it may be necessary to correct for voltage standing waves between center of tee and device at frequencies above 5 megacycles. In this case, adjust DC source voltage as indicated in instruction manual for A55 Thermal Converters.

(7) Null galvanometer as in step g of paragraph 2-5.

(8) Remove known DC voltage from input of thermal converter and apply AC voltage of approximately same value through a coaxial tee. The instrument or other device for which calibrated AC voltage is intended should be connected to third leg of coaxial tee so that impedance presented to AC source will remain constant.

(9) Null galvanometer by adjusting AC source voltage in each SENSITIVITY regarding proper LO, medium, and HI order. <u>Do not move REFERENCE ADJUST controls</u>.

(10) Record AC source voltage setting.

(11) Check for DC reversal error by repeating steps (4) through (10) using a DC voltage of opposite polarity.

(12) Set AC source voltage amplitude control in center of two settings recorded. The rms value of AC voltage now equals the desired value. This procedure, steps (4) through (11), should be repeated at least three times to be certain of a precise result. Watch for drift while repeating this procedure. Any error involved in calibration accuracy or measurement accuracy of the DC voltage must be considered in addition to basic accuracy of A55 Thermal Converter.

2-13. NOTES ON OPERATION

a. THERMAL DRIFT. The accuracy of any voltage or current measurement on the transfer principle is effected by the thermal stability of the transfer device over the period of time required to make a transfer measurement. The 540A incorporates low thermal circuit construction, thermal barriers, and low temperature coefficient components to obtain a high degree of temperature stability. Under the worst possible conditions of maximum applied voltage and "cold start" operation, stability of the 540A is 0.005% per minute. To meet this stability, the 540A should be allowed to warmup to room temperature when brought in from an extremely cold temperature. Speed in making the transfer measurement must be stressed under these conditions, since stability directly affects measurement accuracy. The operator should be thoroughly familiar with the procedure of operation so that a minimum amount of time is consumed in making a measurement.

b. ALTERNATE TRANSFER METHODS. There are many different methods of making accurate transfer measurements. The best procedures use the mean of the DC values for both directions of current flow and a means of checking for slow drift errors. The method used in the operating procedures uses the following sequence for measurements: adjust 540A reference supply voltage to equal heating effect of AC - adjust normal polarity DC to equal reference voltage - adjust 540A reference to equal heating effect of AC - adjust reversed polarity DC to equal reference voltage. The two values of DC are averaged and the process is repeated at least three times. The measurement is a precise one if the three results agree among themselves. A precise measurement indicates that measurement times have been similar and slow drift values have not had any appreciable affect on the measurement. Another equally good method is to use the following sequence: adjust 540A reference supply to equal heating effect of AC - adjust normal polarity DC to equal reference voltage - adjust reversed polarity DC to equal reference voltage - check to see that AC still equals reference voltage. The two DC values are averaged and the process is repeated several times to be certain of a precise result. Another method is to use the following sequence: adjust reference voltage to equal heating value of AC - adjust normal polarity DC to equal reference voltage - reverse polarity of DC and note offset from null - adjust normal and reversed polarity DC for equal and opposite offsets from null - check to see that AC still equals reference voltage. The final DC value is recorded and the process is repeated several times to be certain of a precise result.

c. DC REVERSAL ERROR. The DC reversal error is relatively permanent for any specific DC voltage. Hence, it is possible to eliminate the need to check for DC reversal error. All one must do is to determine the equal offsets on either side of galvanometer zero for opposite polarities of a specific DC voltage. Checks for reversal error when making measurements at this voltage are then no longer necessary. A table of DC reversal errors and offsets required may be made up for any desired voltages. This table can then be used by the operator to set the galvanometer to indicate the predetermined amount of offset for every subsequent transfer measurement at that voltage. In this manner, the speed of measurement is greatly increased.

d. LEAD LENGTH. When the 540A is at null, the DC voltage at the DC input terminals is equal to the AC voltage at the AC input terminals. However, if lead lengths are significantly long, the DC source voltage will be different than the voltage at the DC input terminals due to IR drop. Also, the AC voltage at the AC input terminals will be different than the AC voltage at its source due to IR drop and standing wave errors. It is therefore recommended that lead lengths be kept as short as possible. Keep in mind that approximately 5 ma is drawn through the leads by the thermocouple at rated voltage. Also, further AC source loading will result when the device for which a calibrated AC voltage is intended is connected at the 540A. The 5 ma thermocouple current itself will cause a difference of approximately 0. 01% at 0. 5 volt with 10 milliohms lead resistance. Two leads of number 18 wire that are 9 to 10 inches long will have about 10 milliohms of lead resistance.

e. GALVANOMETER RESOLUTION. The span over which each range of the 540A may be used is 1/2 to 1-1/2 times the range switch setting. The upper limit is set by the burnout point of the thermocouple while the lower limit is set by the ability of the galvanometer to resolve small changes in thermocouple output. Although the internal galvanometer can only be used from approximately 2/3 to 1-1/2 times the range switch setting, this is sufficient for the majority of all measurements to be made with the 540A. Since the range switch has range settings that are multiples of 10 times the basic 0. 5-1-2-3 series, there is overlap on all ranges. Better resolution is obtained at the high end of the normal band (near 1-1/2 times range setting) than at the low end of the normal band (near 2/3 times range setting). For example, select the 3 volt range (4-1/2 volts maximum) rather than the 5 volt range (3-1/3 volts minimum) for a 4 volt input. For a voltage that can only be nulled at the low end of the normal band, it may be necessary to use an external galvanometer to obtain the desired resolution.

f. CURRENT SHUNTS. Sometime the need may arise for a current shunt that is either out of the range of the Model A40 Current Shunts or is not immediately available. When this is the case, it is possible to make a current shunt of the desired value. As seen on the schematic diagram, the shunt binding posts parallel the thermocouple heater which has a nominal resistance of 90 ohms and a nominal current rating of 5 milliamperes. Therefore, the IR drop across the shunt is equal to the IR drop across the thermocouple (5 ma X 90 ohms = 0. 45 volts) and approximately 5 ma of the total current will flow through the thermocouple. Use the following equation to calculate the nominal resistance value of the shunt needed for desired AC current:

$$R_{shunt} = \frac{0.45\ V}{I_{desired} - 5\ ma}$$

Since a null may be obtained with a thermocouple input from 1/2 to 1-1/2 times the nominal heater current, the 540A may be used over a current range of 1/2 to 1-1/2 times the nominal current of the shunt. This also means the resistance of the shunt need not exactly equal the value calculated above. However, one must be extremely careful when making a shunt for high currents. The resistance of the shunt will change if heat is not dissipated in sufficient quantities. This will cause the thermocouple output to drift and thus result in measurement errors. Also, one must be certain the shunt has a good frequency response when it is to be used at high frequencies.

SECTION III

THEORY OF OPERATION

3-1. GENERAL

a. The 540A Thermal Transfer Standard consists of three major circuits: AC search, DC search, and thermal transfer. Figure 3-1 shows these circuits in block diagram form. For more detail, refer to the functional schematic diagram following Section V. This schematic is designed to aid in the understanding of circuit theory and troubleshooting. The signal flow is from left to right and the components are laid out in a functionally logical manner.

b. The overall operation of the transfer standard may be summarized as follows: When used to measure an unknown AC voltage, the unknown voltage is first applied to the AC search circuit. The search meter indicates when the range switch is properly set. Then, the AC voltage can safely be applied to the transfer circuit. The reference supply voltage is adjusted to equal the thermocouple output resulting from the heating value of the unknown AC voltage. A DC voltage is then applied to the DC search circuit and adjusted until the search meter indicates it is approximately equal to the unknown AC voltage. The DC voltage is then switched to the transfer circuit and adjusted until the galvanometer indicates that the thermocouple output again equals the reference voltage. The known DC voltage is now equal to the rms value of the AC voltage.

c. To accurately calibrate an AC voltage, a DC voltage equal to the rms value of the desired AC voltage is applied to the DC search circuit. After the proper range is determined, the DC voltage is switched to the transfer circuit and the reference supply is adjusted to equal the thermocouple output. An AC voltage is then applied to the AC search circuit and adjusted until the search meter indicates in the normal range. The AC voltage is then switched to the transfer circuit and adjusted to give the same thermocouple output.

d. In order to provide a more complete understanding of the 540A Transfer Standard, the following paragraphs describe each section of the circuit in detail.

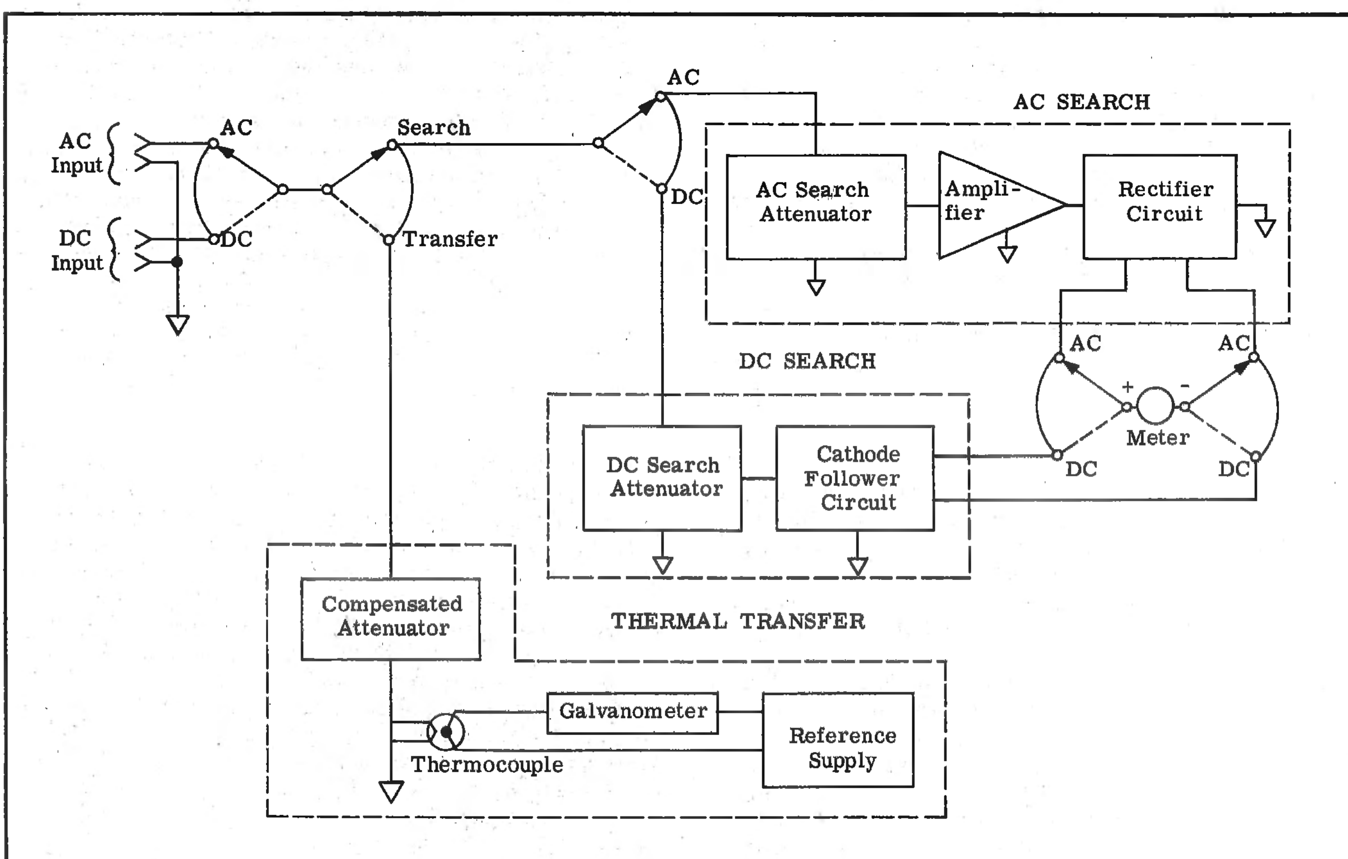


Figure 3-1. 540A THERMAL TRANSFER STANDARD BLOCK DIAGRAM

3-2. AC SEARCH

a. The AC search section of the 540A consists of an attenuator, an amplifier, and a rectifier-meter circuit. Since there are 14 ranges, it seems that there should be 14 frequency compensated attenuators to reduce the voltage span of each range to a common range usable by the amplifier to produce proper meter deflection. However, the ranges have been selected in multiples of 10 times the basic 0. 5-1-2-3 series. This serves two functions: (1) the entire range from 0. 5 to 1000 volts is adequately covered by 14 ranges; (2) only 5 attenuators have to be used instead of 14. The four frequency compensated attenuators selected by range switch sections S3C and S3D may be referred to as the thousands, hundreds, tenths, and units attenuators. Rated voltage on the 1 volt range is reduced to approximately 500 millivolts by the units attenuator. Rated voltage on any range is reduced to 0. 5, 1, 2, or 3 times 500 mv. Range switch section S3E selects the proper tap on the fifth attenuator to reduce any 0. 5, 1, 2, or 3 multiple of the 500 mv to approximately 250 mv. Cathode follower V1A is used to prevent the fifth attenuator from loading down any one of the other four attenuators.

b. Amplifier V1B serves to increase the normal full range signal of 250 mv from the attenuator network to a value sufficient to drive the rectifier-meter circuit. A high level of negative feedback is used to insure stability and flat frequency response over a wide frequency range. The output of the amplifier is fed to a rectifier-meter circuit. This is a typical bridge-type configuration having a germanium diode and a resistor in each branch with a DC milliammeter in series with a calibration resistor connected across branch midpoints. During the positive and negative half cycles equal currents flow through first one and then the other diode producing an average DC voltage across the meter. The current flowing through the meter is proportional to the average value of either half of the alternating voltage wave from the amplifier. This is approximately 100 ua for a mid-scale indication. The meter is calibrated to indicate when the input current is low, normal, or high. The normal band represents an input from 2/3 to 1-1/2 times the range switch setting. The small mark left of center on the normal band represents full range voltage. Variable resistor R47 is used to calibrate the meter for AC search.

3-3. DC SEARCH

The DC search section consists of an attenuator and a cathode-follower voltmeter. For full range input, the input voltage must be reduced to approximately 250 millivolts for proper meter deflection. This reduction is provided by 14 positions on the DC search attenuator that are selected by null switch section S3F. The 250 mv from the attenuator makes the cathode of V2A approximately 250 mv more positive than the cathode of V2B. This results in a current of approximately 100 microamperes flowing through the meter for a mid scale indication. Variable resistor R69 is used during calibration to balance the cathode followers V1A and V1B with R68 set at its center of rotation. This allows the search meter to be zeroed with R68 at any time deemed necessary. The meter is calibrated for DC by means of R66.

3-4. THERMAL TRANSFER

The thermal transfer section consists of a thermal converter, a compensated attenuator, a galvanometer circuit, and a reference supply.

a. THERMAL CONVERTER. The thermal converter consists of a junction of two dissimilar wires (a thermocouple) in thermal contact with an electrical heater all of which are enclosed in a small evacuated bulb. The thermal converter is often called a thermoelement or simply a thermocouple. When current passes through the heater, an output voltage is produced across the ends of the dissimilar wires that is proportional to the heating or rms value of the heater current. This is because the temperature produced is proportional to the square of the current flowing in the heater. This results in the very desirable feature of true rms measurements. However, it also results in a poor overload characteristic. Doubling the current, will result in four times the temperature and tripling the current will result in nine times the temperature. Thus, it does not take too large a current to reach a temperature that will be sufficient to melt the heater. Probable thermocouple burnout will occur at twice rated current. The thermocouple heater used in the 540A has a nominal current rating of 5 milliamperes and a resistance of about 90 ohms. Minimum heater current is limited by the ability of the galvanometer circuit to resolve small changes in thermocouple output. As a result, the thermocouple may be used from approximately 2/3 to 1-1/2 times the nominal heater current with the internal galvanometer and from approximately 1/2 to 1-1/2 with an external galvanometer. At the nominal heater current of 5 milliamperes, the thermocouple will produce an output of approximately 7 millivolts. Largely because absolute symmetrical construction is difficult to achieve, the junction temperature and thus the output voltage depend on the direction of current flow. For an alternating current, the output voltage is therefore the average output for the two directions of flow. Thus, a small error may occur if the average of the outputs for both directions of direct current is not used. At the time of shipment, the DC reversal error is no greater than 0. 1% and should not change under normal operating conditions. Therefore, the maximum error that can occur (if the average output for both directions of DC is not used) is 0. 1% divided by 2 or only 0. 05%.

b. COMPENSATED ATTENUATOR. For voltage measurements a resistance must be connected in series with the thermocouple heater to provide a current in the proper range. The correct resistance for each range is selected by range switch section S3A from 13 positions on the compensated attenuator. On the 0. 5 volt range the input voltage is connected directly across the thermocouple heater. The attenuator is designed to have a resistance of approximately 200 ohms per volt (1V/5 ma) for full range voltage on each range. Extremely accurate values of attenuator resistance are not required for making accurate voltage measurements. This is because the AC and DC voltages are applied to the same circuit. All that is required of the attenuator is to produce the same heater current for equal values of AC and DC. Therefore, the attenuator must have excellent short term stability and frequency response. Metal film resistors with low thermal coefficients have been used to reduce possible resistance changes during transfer measurements. Special heat sinks and thermal barriers are also used to ensure that the thermocouple and reference circuit temperature changes occur uniformly and at a very slow rate. The metal film resistors used also exhibit good frequency characteristics. To further ensure flat frequency response, the 540A uses special frequency compensated networks that are selected by range switch section S3B.

c. GALVANOMETER. The galvanometer serves as a high sensitive null detector to indicate when the internal reference voltage is equal to the thermocouple output voltage. The 540A uses a standard single light beam L & N 2436A galvanometer. It is composed of a galvanometer tube, a reflecting system, and a mounting plate. The galvanometer tube contains the actual measuring circuit. This circuit is of the permanent-magnet moving-coil (D'Arsonval) type consisting of a coil, filamentary suspension, mirror, and magnet. For proper operation, the 540A must be leveled carefully so that the coil hangs straight and centrally located in the air gap around the magnet. To indicate the coil position a small mirror is mounted on the coil. The main parts of the reflecting system are the lamp, focusing tube, and three mirrors. A light image is obtained when the lamp shines on an index line across a small rectangular opening inside the focusing tube. The three mirrors are used in a multiple reflecting system to increase the effective light-beam length and thus sensitivity. In operation, the rectangular spot of light from the focusing tube is projected on the coil mirror and reflected to the three multiple reflection system mirrors. The light reflected from the last mirror appears on the scale attached to the mounting plate. When current flows through the galvanometer, the coil rotates and the light image moves along the scale. For low and medium sensitivity, a 33 ohm resistor is connected across the galvanometer to provide critical damping. Reduced sensitivity is obtained by connecting a high and a low resistor in series with the galvanometer for the low and medium sensitivity respectively. For high sensitivity, the galvanometer is connected directly between the thermocouple output and the reference supply. The sensitivity of the galvanometer and the circuit impedances are such that the resolution is approximately 0.02% per division on high sensitivity for nominal heater current. At 2/3 and 1-1/2 times nominal, the resolution is approximately 0.036% per division and 0.01% per division respectively. Since it is possible to discern 1/4 of a division deflection, a capability of 0.01% is provided at any operating level. Medium and high galvanometer sensitivities provide 10 and 50 times less resolution than high sensitivity. Binding posts and a switch are provided for using an external galvanometer when more sensitivity is desired. If a Leeds and Northrup 2430A galvanometer is used, the sensitivity is about ten times that of the internal 2436A galvanometer. The switch which is used to select either the internal or external galvanometer is also used to short out the internal galvanometer during shipment to prevent damage from severe jolts.

d. REFERENCE SUPPLY. The reference supply provides the necessary reference voltage needed to null the output voltage from the thermocouple. Since the AC and DC input to the heater are adjusted to give equal outputs from the thermocouple, it is not necessary to measure the thermocouple output voltage. However, to make certain the outputs are equal, a highly stable reference supply is needed. The use of a 1.34 volt mercury cell assures a highly stable base value. Also, since the internal thermocouple may be used from 2/3 to 1-1/2 times nominal heater current with the internal galvanometer, the reference supply voltage must be variable. The reference voltage is therefore obtained from a resistive divider across the mercury cell. Three variable resistors in the divider provide for coarse, medium, and fine reference voltage adjustment. Since rated thermocouple output is 7 millivolts and the internal thermocouple can be used from 2/3 to 1-1/2 times nominal heater current, an output range of 3.11 to 15.75 mv, $(2/3)^2 \times 7$ and $(1\text{-}1/2)^2 \times 7$, is indicated. However, since the thermocouple does not exactly follow the square law, the output is about 14 mv at 1-1/2 times nominal heater current. The reference voltage has a range from approximately 1.02 to 17.7 mv. This is also sufficient to cover the output of the Fluke Model A55 Thermal Converters which have an approximate output of 1.8 to 7 mv from 1/2 to 1 times rated voltage. Earlier models of the 540A were designed to cover the A55 output from 2/3 to 1 times rated voltage.

SECTION IV

MAINTENANCE

4-1. GENERAL

The 540A Transfer Standard seldom requires any maintenance. Without extreme abuse, all that should be required is occasional cleaning of the galvanometer, adjustment of the galvanometer, calibration of the search circuits, and checking of the transfer circuit. Periodic maintenance consists only of cleaning dust off the light transmitting parts of the galvanometer as discussed in paragraph 4-2. A discussion of troubleshooting, a troubleshooting chart, and procedures for replacing certain parts are provided in paragraph 4-3. Galvanometer adjustments are given in paragraph 4-4. Paragraph 4-5 delineates the procedures for calibrating the search circuits and for checking the transfer circuit.

4-2. PERIODIC MAINTENANCE

Over a period of time, the galvanometer scale, focusing tube, mirrors, and galvanometer tube window become coated with dust. This reduces the brightness of the light image. To clean these items proceed as follows:

a. Remove eight screws fastening front panel of 540A to case assembly and carefully lift front panel and attached chassis from case.

b. Clean the galvanometer scale with soft cloth dampened with carbon tetrachloride.

CAUTION

Do not use water as the scale markings are soluble in water.

c. Clean focusing tube, mirrors, and galvanometer tube window with a soft cloth dampened with water. In extreme cases, use a mild soap solution.

d. When dry, wipe focusing tube lens and mirrors with silicon impregnated lens paper to prevent dust from sticking to these surfaces.

e. Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

4-3. CORRECTIVE MAINTENANCE

a. TROUBLESHOOTING. The purpose of troubleshooting is to quickly and accurately determine the cause of any abnormal condition. To assist in localizing most troubles which might occur, the causes and remedies for a number of symptoms are listed in the troubleshooting chart (Figure 4-1). Since failure of the DC search and AC search circuits are usually due to tube failure, it is recommended that tube substitution be tried before any other tests are made. However, the 540A is conservatively designed and should require very infrequent tube replacement. Any sudden failure within the thermal transfer circuit can usually be traced to the thermocouple. This is because the thermocouple has a lower overload voltage limit than the other components and thus acts as a protective device for the compensated attenuator, galvanometer, and reference supply. As an aid to troubleshooting all components may be located by referring to the figures shown in Section V. An understanding of the theory of operation (Section III) and frequent reference to the schematic diagram will be of great value in troubleshooting.

b. COMPONENT REPLACEMENT. Replacement of tubes or other components will not necessitate complete recalibration of the 540A. If V2 or any other component in the DC search circuit is replaced, calibrate the DC search circuit as set forth in paragraph 4-5b. Replacement of V1 or any other component in the AC search circuit will necessitate calibration of the AC search circuit per paragraph 4-5c. The thermal transfer circuit need not be calibrated or checked if it is necessary to replace the thermocouple. However, any existing test report will have to be replaced by a new one.

c. GALVANOMETER SYSTEM REPLACEMENT. The galvanometer tube (1, Figure 4-2) contains the galvanometer system consisting of a coil, filamentary suspension, mirror, and magnet. Since this is a very delicate mechanism with quality construction, the entire tube must be replaced if something goes wrong with the galvanometer system. However, because of the protective nature of the thermocouple, the galvanometer system needs to be replaced only in rare cases. To replace the galvanometer system, proceed as follows:

(1) Remove eight screws fastening front panel of 540A to case and carefully lift front panel and attached chassis from case assembly.

(2) Remove connections to galvanometer system terminals (3).

(3) Remove two screws (2) fastening galvanometer system (1) and yoke (4) to galvanometer mounting plate and lift galvanometer system and yoke from plate. Note arrangement of washers on screws since they must be replaced in the same sequence.

(4) Remove two screws (3) fastening galvanometer system to yoke and remove yoke.

(5) Mount yoke on new galvanometer system making sure that yoke is centered before tightening screws.

(6) Center FINE ADJUST control (6).

SYMPTOM	PROBABLE CAUSE	REMEDY
Continual galvanometer drift upscale on all ranges with thermocouple energized.	Mercury cell is failing.	Replace mercury cell.
Galvanometer swings upscale and will not null over complete operating range of instrument.	Mercury cell has failed or is out of socket.	Secure or replace cell as is necessary.
Galvanometer swings down scale and will not null on any range.	Thermocouple is burned out.	Replace thermocouple.
Galvanometer swings down scale and will not null over full operating range.	Thermocouple output low due to vacuum leak.	Replace thermocouple.
Erratic movement of light beam on all ranges when sensitivity switches are engaged.	Dirty contacts on sensitivity switches.	Clean by sliding paper between closed contacts.
Erratic movement of light beam on all ranges when sensitivity controls are rotated.	Dirt in sensitivity controls.	Clean by rotating vigorously from stop to stop.
Search meter does not work. Galvanometer light and pilot light not illuminated.	Open fuse.	Replace fuse.
Galvanometer light and pilot lamp not illuminated.	Burned out lamp.	Replace lamp.
Erratic movement of light beam on low voltage ranges when function or range switches are moved.	Dirt on contacts of function or range switch.	Clean contacts of mode switch and range switch.

Figure 4-1. TROUBLESHOOTING

(7) Mount galvanometer system and yoke on mounting plate so that coarse adjust control (5) extends through front panel and arms of yoke fit around shaft of FINE ADJUST control.

(8) Replace two screws with washers in proper order. Tighten screws enough to prevent galvanometer system from tilting but not tight enough to prevent FINE ADJUST control from moving yoke easily and smoothly.

(9) Replace connections to galvanometer system terminals in proper order.

(10) Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

d. GALVANOMETER LAMP REPLACEMENT. A spare lamp is clipped to the lamp housing. To replace the galvanometer lamp, proceed as follows.

(1) Remove eight screws fastening front panel of 540A to case assembly and carefully lift front panel and attached chassis from case.

(2) Loosen lamp-socket-holding screw (14, Figure 4-2) with Allen wrench (mounted on chassis next to galvanometer) enough to permit lamp socket (13) to slide out of housing.

(3) Remove old lamp and insert new lamp.

(4) Insert socket with lamp in housing and tighten lamp-socket-holding screw just enough to hold lamp socket in place.

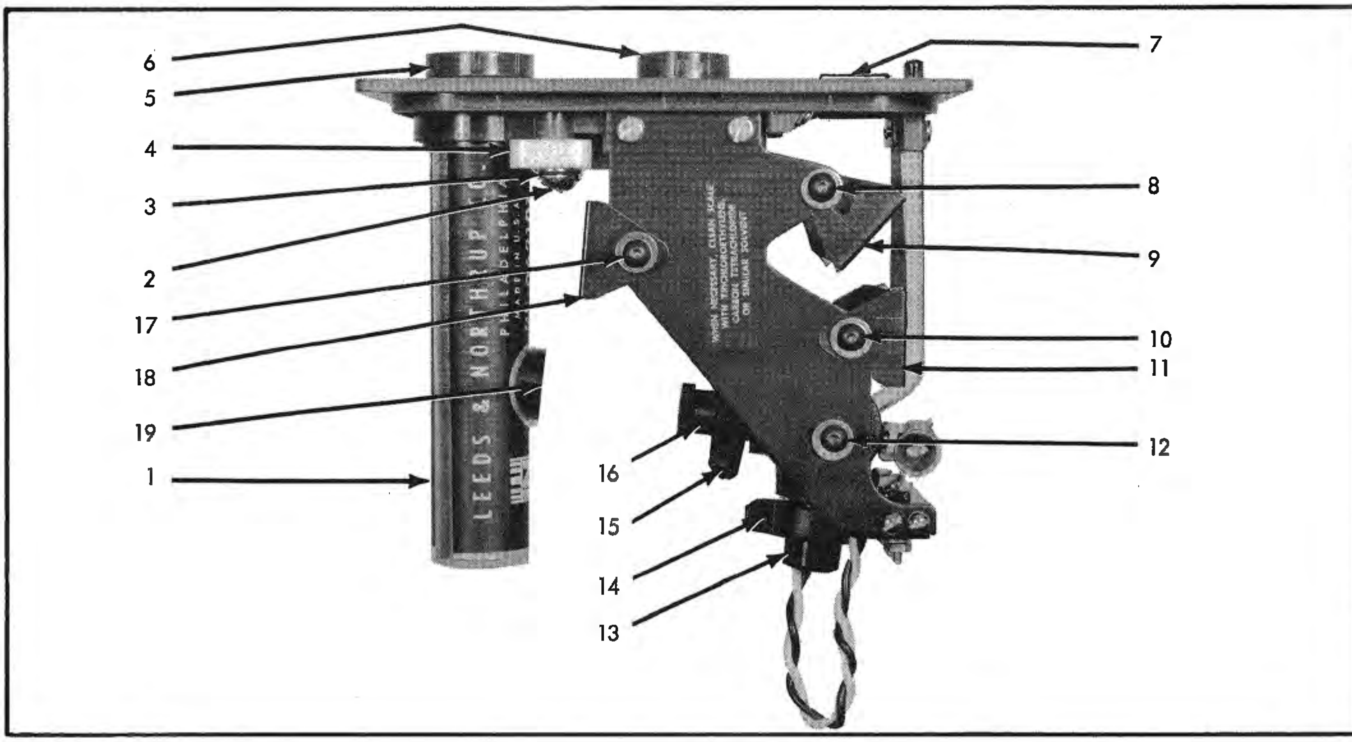


Figure 4-2. GALVANOMETER PART LOCATIONS

(5) Set POWER switch to ON and make sure that 540A is level and upright.

(6) Hold a piece of white paper in front of window (19) in galvanometer tube and adjust socket until image of lamp filament appears on paper at approximate center of window.

(7) Using an inspection mirror, check to see that image of filament appears on mirror inside window. If not, adjust socket until it does.

(8) Tighten lamp-socket-holding screw and make sure that socket does not move.

(9) Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

4-4. GALVANOMETER ADJUSTMENTS

a. GENERAL. From time to time it may be necessary to make certain galvanometer adjustment. When the 540A is plugged in and the power switch is set to on, a light square with a bisecting index line should appear on the galvanometer scale. If the index line does not come to rest at zero, adjust as in paragraph 4-4b. If the index line is not parallel to the lines on the scale or if the image on the scale is not in focus, adjust as in paragraph 4-4c. If the image is part way off scale or cannot be seen at all, adjust as in paragraph 4-4d.

b. ZERO ADJUSTMENT.

(1) Center FINE ADJUST control (6, Figure 4-2).

(2) Turn coarse adjust control (5) until index line of image is as close as possible to zero on scale.

(3) Bring index line to zero with FINE ADJUST control.

c. INDEX LINE POSITION AND FOCUS ADJUSTMENT.

(1) Remove eight screws that fasten front panel of 540A to case assembly and carefully lift front panel and attached chassis from case.

(2) Use small Allen wrench (mounted on chassis next to galvanometer) to loosen focusing-tube-clamping screw (15, Figure 4-2) just enough to permit tube (16) to be moved by hand.

(3) Slide focusing tube forward or backward to obtain proper focus and then rotate tube until index line is parallel to lines on scale.

(4) Tighten screws and make sure that tube does not move.

(5) Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

d. REFLECTION SYSTEM ADJUSTMENTS.

(1) Remove eight screws that fasten front panel of 540A to case assembly and carefully lift front panel and attached chassis from case.

(2) If window (19, Figure 4-2) does not line up with focusing tube (16) in the vertical plane, bottom view, adjust galvanometer system by removing and then replacing galvanometer system as when installing a new system per paragraph 4-3c steps (2) through (9).

(3) Hold a piece of white paper in front of window (19) in galvanometer tube. Image of lamp filament should appear on paper at approximate center of window.

(4) Using an inspection mirror, check to see that image of filament appears on mirror inside window.

(5) If conditions of steps (3) and (4) do not exist, proceed as follows: loosen two lamp-housing-holding screws (12) with Allen wrench (mounted on chassis next

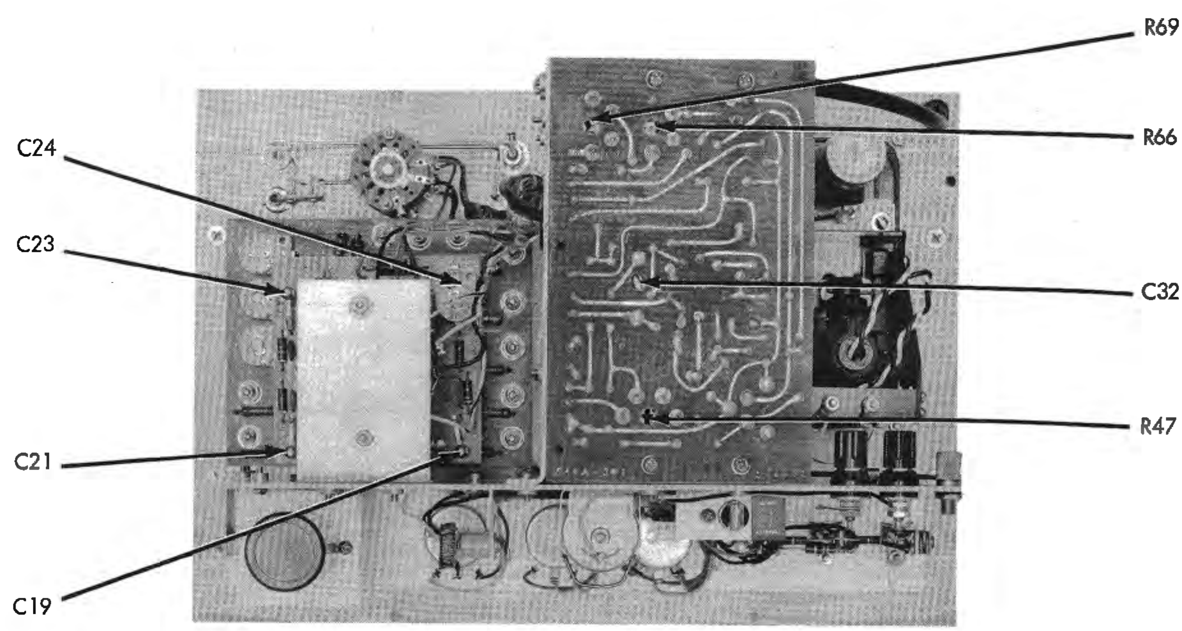


Figure 4-3. ADJUSTMENT LOCATIONS

to galvanometer) and tilt housing until focusing tube lines up with window as seen from a side view; tighten lamp-housing-holding screw; loosen lamp-socket-holding screw (14) and adjust socket until conditions in steps (3) and (4) exist; tighten lamp-socket-holding screw and make sure socket does not move.

(6) If light square with bisecting index line does not appear on scale (7) when coarse adjust control is turned, adjust reflection system mirrors as follows: loosen three mirror holding screws (8, 10, and 17) on each side of mounting bracket just enough to allow mirrors to be moved easily; tilt mirrors to approximate positions shown in Figure 4-2 making sure each end of mirror is adjusted the same; hold a piece of white paper in front of second mirror (18) and tilt first mirror (11) until light square is equidistant from top and bottom edges of second mirror--it may be necessary to turn coarse adjust control to bring light square near center of mirror; tilt second mirror and third mirror (9) until light square appears on scale; tighten six mirror holding screws to maintain proper position of mirrors.

(7) Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

4-5. CALIBRATION

a. GENERAL. The calibration procedure is divided into three main parts: DC search calibration, AC search calibration, and transfer response checking. DC and AC search calibration are normally required at intervals of one year or longer. Since the 540A is a working standard, the transfer response must be calibrated at intervals by comparison with reference standards such as those maintained by the John Fluke Mfg. Co. Therefore, for all practical purposes, the 540A transfer response can only be calibrated at the factory. However, the transfer response may be checked as in paragraph 4-5d. The transfer response should be checked about once a year depending on the frequency of use and the accuracy required. Based on NBS experience with instruments of this type, the frequency response will remain fixed for an indeterminate period of time. It is expected that the AC to DC difference will change over a period of a few years by an amount less than the normal NBS uncertainty (see specifications). Calibration should be accomplished in a draft free area with an ambient temperature of 72 ($\pm$3)^{o}F under laboratory conditions. Voltage sources and measuring equipment for AC and DC voltages as listed in Figure 2-2 will be required for DC search calibration, AC search calibration, and transfer response checking. In addition, a standard transfer instrument as discussed in paragraph 4-5d will be required for transfer response checking. All controls for DC and AC search calibration may be located with the aid of Figure 4-3.

b. DC SEARCH CALIBRATION

(1) Remove eight screws fastening front panel of 540A to case assembly and carefully lift front panel and attached chassis from case.

(2) Set controls on 540A as follows:

POWER	ON
RANGE	10
function	DC SEARCH

(3) Allow 540A to warmup for a few minutes and then center METER ZERO control.

(4) Adjust R69 to zero SEARCH meter.

(5) Apply 15 volts DC to DC input terminals.

(6) Adjust R66 until meter needle is between NORMAL and HIGH band.

(7) Remove DC voltage from DC input terminals and set function switch to off.

(8) Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

c. AC SEARCH CALIBRATION

(1) Remove eight screws fastening front panel of 540A to case assembly and carefully lift front panel and attached chassis from case.

(2) Set controls on 540A as follows:

POWER	ON
RANGE	500
function	AC SEARCH

(3) Apply an AC voltage of 500 cps between pin 2 of V1 and lower AC input terminal.

(4) Adjust amplitude of AC voltage until SEARCH meter needle is between NORMAL and HIGH band.

(5) Maintain amplitude of applied AC voltage and increase frequency to 500 kc.

(6) Adjust C32 until SEARCH meter needle is between NORMAL and HIGH band.

(7) Remove AC voltage from pin 2 of V1 and lower input post.

(8) Apply 14 volts AC at 500 cps to AC input terminals.

(9) Set RANGE switch to 10 volt position.

(10) Adjust R47 until SEARCH meter needle is between NORMAL and HIGH band.

(11) Set RANGE switch to 0. 5 volt position.

(12) Adjust AC voltage until SEARCH meter needle is between NORMAL and HIGH band.

(13) Maintain amplitude of applied AC voltage and increase frequency to 500 kc.

(14) Adjust C24 until SEARCH meter needle is between NORMAL and HIGH band.

(15) Set RANGE switch to 5 volt position.

(16) Adjust AC voltage amplitude at 500 cps until SEARCH meter needle is between NORMAL and HIGH band.

(17) Maintain amplitude of applied AC voltage and increase frequency to 500 kc.

(18) Adjust C23 until SEARCH meter needle is between NORMAL and HIGH band.

(19) Set RANGE switch to 50 volt position.

(20) Adjust AC voltage amplitude at 500 cps until SEARCH meter needle is between NORMAL and HIGH band.

(21) Maintain amplitude of applied AC voltage and increase frequency to 500 kc.

(22) Adjust C21 until SEARCH meter needle is between NORMAL and HIGH band.

(23) Set RANGE switch to 500 volt position.

(24) Adjust AC voltage amplitude at 500 cps until SEARCH meter needle is between NORMAL and HIGH band.

(25) Maintain amplitude of applied AC voltage and increase frequency to 500 kc.

(26) Adjust C19 until SEARCH meter needle is between NORMAL and HIGH band.

(27) Remove applied AC voltage and set function switch to off.

(28) Carefully place front panel and attached chassis into case assembly and replace eight screws that fasten front panel to case.

d. TRANSFER RESPONSE CHECKING. There are several ways to check a 540A that will indicate whether or not the instrument is within specifications. Basically, any method of checking a 540A consists of comparing the 540A to a standard instrument. The standard instrument used must have an AC-DC difference that deviates from zero error as defined by NBS at Washington DC by no more than 0. 01% or be correctable to ±0. 01% by means of calibration curves or test reports at the frequencies and voltages specified in Figure 4-4. It may not be necessary to check the 540A over its entire range if it is to be used only on some ranges. The John Fluke Model A55 Thermal Converters along with the 550A Transfer Standard may be used to check the 540A to 50 volts. The 540A may be checked over its entire range with another 540A and a test report that has been recently issued. In all cases, an AC voltage source, a DC voltage source, and DC voltage measuring equipment as specified in Figure 2-2 will be required. If the 540A is within the percent limit specified in the following procedure, it is reasonably certain that the 540A is within specifications over the entire frequency range. If the 540A is not within the percent limit specified on a particular range, this range and all ranges above it are not necessarily within specifications. However, if for some reason it is not feasible to send the instrument back to the factory, it may be checked at each frequency and voltage desired. This will result in a list of correction factors that may be used to obtain an AC to DC difference correct to ±0. 01% at these frequencies and voltages. Proceed as follows:

(1) Measure resistance between upper SHUNT binding post and pin 2 of HFTC jack.

CAUTION

To prevent thermocouple damage, do not apply more than 100 volts between these terminals.

The resistance measured is the insulation resistance between the thermocouple heater and the reference supply. The thermocouple used by Fluke has an insulation resistance of approximately 100 megohms. If the insulation resistance is less than 10 megohms, the thermocouple must be replaced. One way of measuring this resistance is to use a Fluke differential voltmeter (Model 801B, 803B, 803D, 821A, 823A, or 825A) as follows: set 540A function switch to OFF; set differential voltmeter RANGE switch to . 5 and NULL switch to . 01; connect differential voltmeter input between upper SHUNT binding post and pin 2 of HFTC jack; adjust voltage readout dials for full scale deflection of meter; subtract . 01000 from amount set on voltage readout dials and multiply the result by 1000 to find the insulation resistance in megohms (resistances from 1 megohm to 499 megohms can be measured with this particular setup).

SECTION V

LIST OF REPLACEABLE PARTS

5-1. GENERAL

a. The following assembly lists describe all normally replaceable parts of the Model 540A Transfer Standard. Each list has a corresponding illustration on which the parts for that list are pointed out. 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.

b. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the 540A. 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.

5-2. HOW TO OBTAIN PARTS

a. Standard components have been used whenever possible. Thus, most parts may be obtained locally. However, special components are used in some instances. All parts manufactured or altered by Fluke and all parts for which Fluke controls the design are designated by an asterisk (*) preceding the Fluke stock number. All structural parts and special parts should be purchased from your local Fluke representative or from the factory.

b. When ordering parts always include:

(1) Reference designation, description, and Fluke stock number.

(2) Instrument model and serial number.

(3) Most structural parts are not listed. In this case, give complete description, function, and location for the part.

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Final Assembly (see Figure 5-1)	*540A	
	Chassis Assembly (see Figure 5-2)	*138982	
	Amplifier Board Assembly (see Figure 5-3)	*122242	
	Range Switch Assembly (see Figure 5-4)	*122275	
M1	Galvanometer, 0.1 ua/mm, type 2436a (see Figure 5-5)	103341	
	Access Cover Assembly	*122135	
	Case Assembly	*122192	
	Knob, 1 inch with pointer	101287	
	Knob, 1-1/2 inch with pointer	101311	
	Knob, 3/4 inch with pointer	103077	
	Lid Assembly	*122184	
	Line cord, 3 wire	102822	
	Line cord adapter	100222	
	Rubber foot	103309	
	540A to A55 shielded cable	122325	

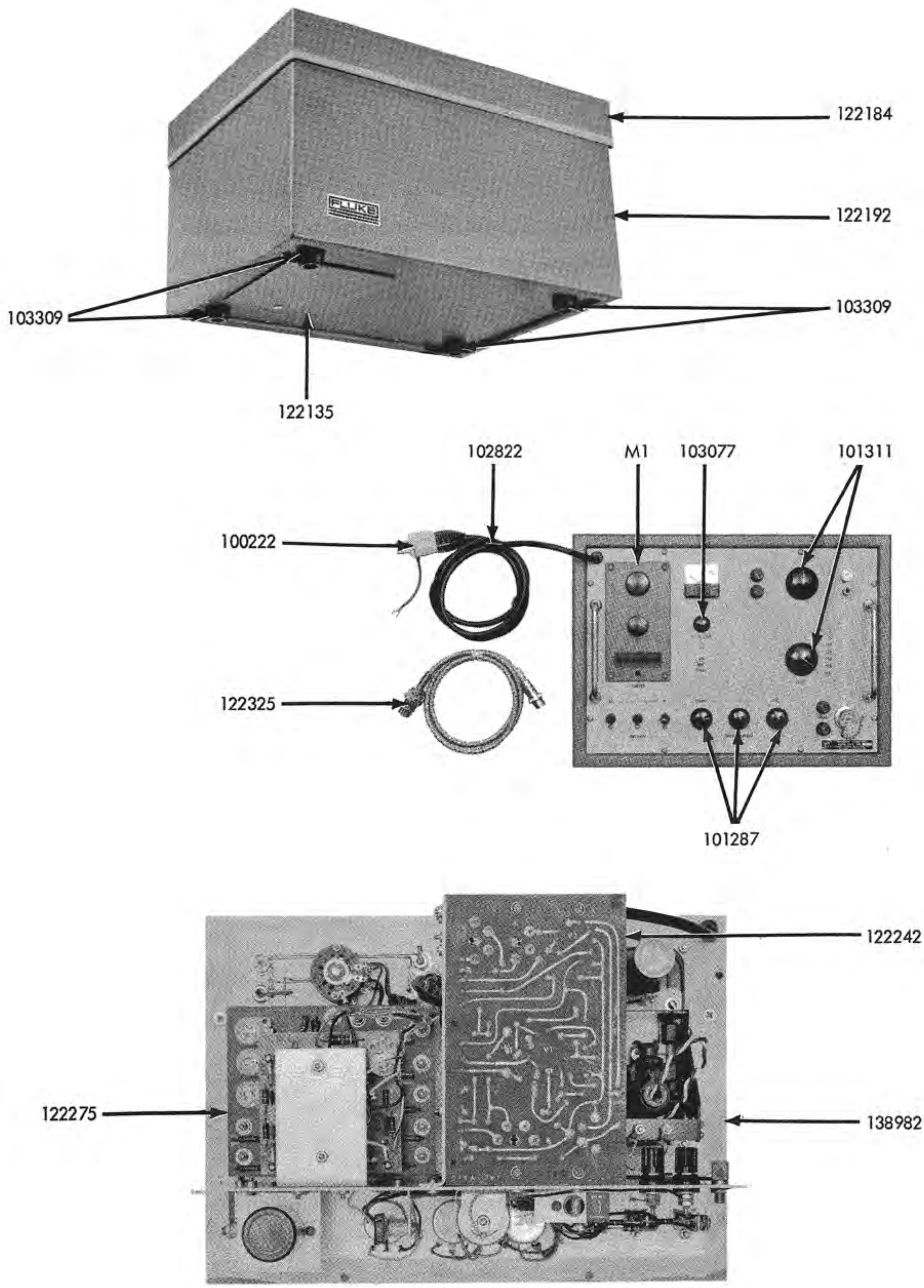


Figure 5-1. FINAL ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Chassis Assembly	*138982	
B1	Battery, mercury cell, 1.34 volts, 14,000 ma-hours, Mallory RM-42R	103226	
CR4	Diode, silicon, 0.75 amp, 600 PIV	112383	
F1	Fuse, 0.25 amp, fast acting	109314	
	Fuse holder	103283	
J1	Connector, uhf	102871	
J2, J10	Binding post, uninsulated	102707	
	Binding post cap	102889	
J3, J5	Binding post, red	103325	G
J3, J5	Binding post, brass, red	142976	H
J4, J6	Binding post, black	103333	G
J4, J6	Binding post, brass, black	142984	H
J7	Connector, 3 pin, HFTC	103101	
	Chain and cap shorting plug	122267	
J8	Binding post, red	103325	G
J8	Binding post, copper, red	149856	H
J9	Binding post, black	103333	G
J9	Binding post, copper, black	149864	H
M2	Meter, 0 to 200 ua dc ±3%, search	110981	
R17	Resistor, composition, 180Ω ±10%, 1/2W	108571	
R18	Resistor, composition, 750Ω ±5%, 1/2W	108894	
R19	Resistor, composition, 33Ω ±10%, 1/2W	108456	
R20	Resistor, wirewound, 7.5Ω ±5%, 1/4W	131797	
R21	Resistor, composition, 680Ω ±5%, 1/2W	EB6515	A
	Resistor, composition, 560Ω ±5%, 1/2W	109124	B
R22	Resistor, variable wirewound, 35Ω ±10%, 2W	112789	
R23AB	Resistor, variable wirewound dual section, 200Ω ±10%, 2W	112771	
R24	Resistor, composition, 33Ω ±5%, 1/2W	EB3305	A
	Resistor, composition, 15Ω ±5%, 1/2W	109132	B
R25	Resistor, variable wirewound, 3Ω ±10%, 2W	P3	A
	Resistor, variable wirewound, 1Ω ±10%, 2W	113001	B
R68	Resistor, variable wirewound, 35Ω ±10%, 2W	112789	
S1	Switch, toggle, dpst, power	114835	
S2	Switch, rotary, function	*122358	
S4	Switch, high sensitivity	SP5	A
		115030	B
S5, S6	Switch, push-button, medium and low sensitivity	SP6	A
		115048	B
S7	Switch, galvanometer selector	SP5	A
		115030	B

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
T1	Transformer, power	*122333	
TC1	Thermocouple	*122259	

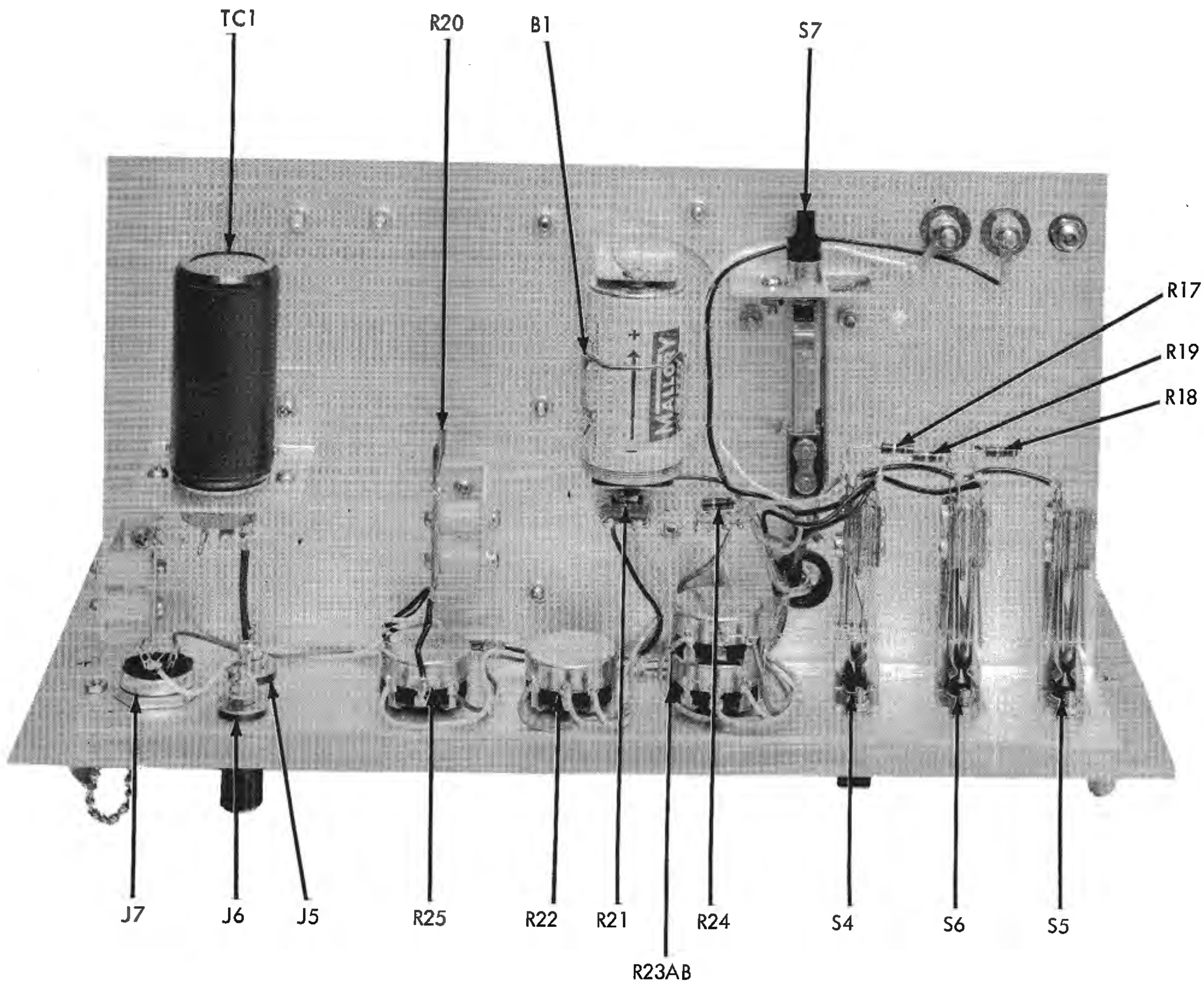


Figure 5-2. CHASSIS ASSEMBLY (sheet 1 of 2)

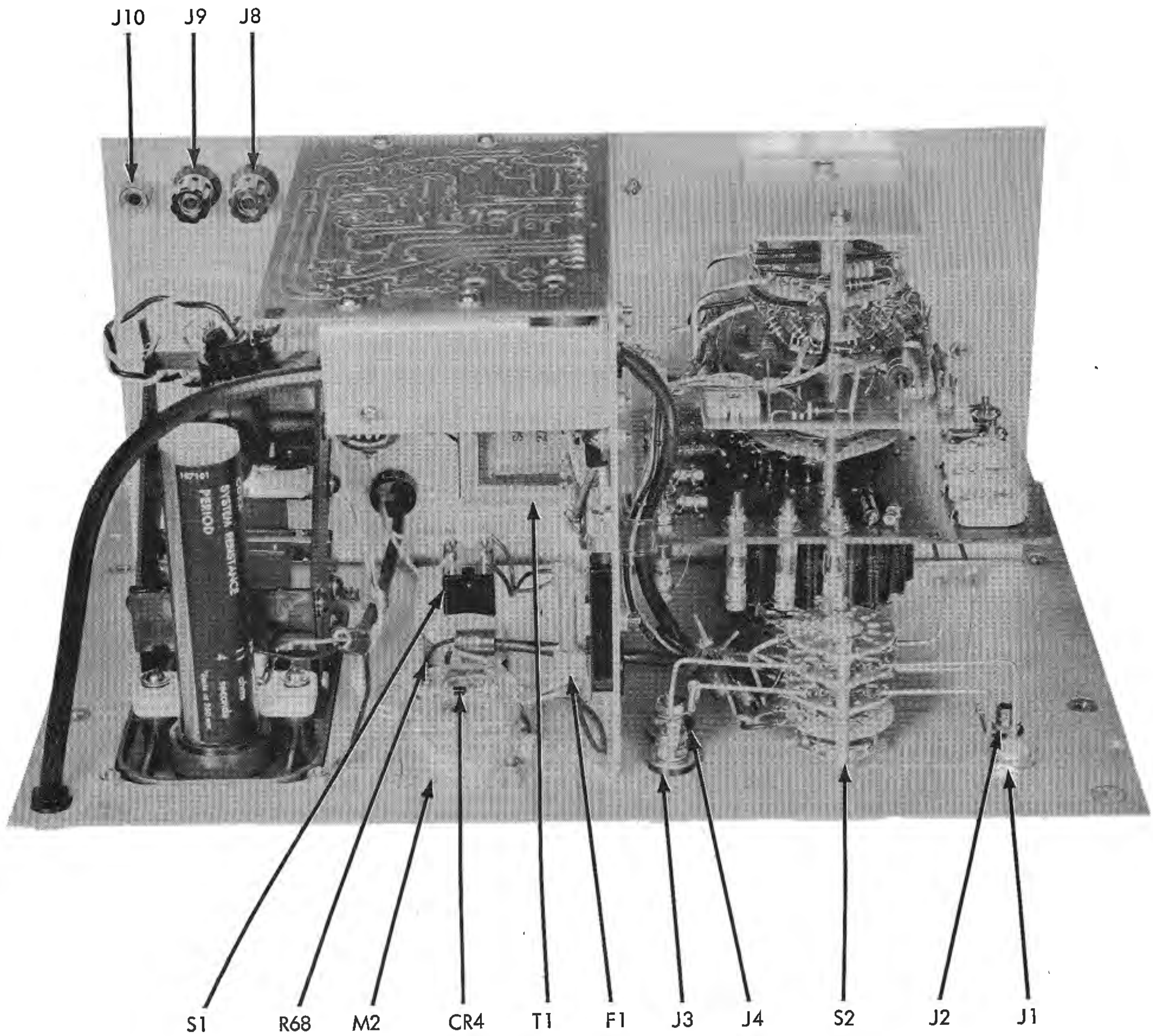


Figure 5-2. CHASSIS ASSEMBLY (sheet 2 of 2)

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Amplifier Board Assembly	*122242	
C29	Capacitor, paper, 0.022 uf ±20%, 600V	105411	
C30	Capacitor, electrolytic, 100 uf -10/+100%, 25V	106518	
C32	Capacitor, variable, ceramic, 7 to 45 uuf, 500V	106302	
C33	Capacitor, ceramic, 20 uuf ±10%, 500V	106369	
C34	Capacitor, electrolytic, 500 uf -10/+150%, 3V	106484	C
	Capacitor, electrolytic, 500 uf -10/+100%, 3V	106328	D
C35	Capacitor, paper, 5 uf ±20%, 200V	106468	E
	Capacitor, plastic, 5 uf ±5%, 200V	106997	F
C36AB	Capacitor, electrolytic, 40-40 uf -10/+100%, 150V	106609	
CR1, CR5, CR6	Diode, silicon, 0.75 amp, 600 PIV	112383	
CR2, CR3	Diode, germanium, 25 ma, 50 PIV	100354	
R31	Resistor, composition, 150K ±10%, 1/2W	108167	
R32	Resistor, composition, 10K ±10%, 1/2W	108118	
R33	Resistor, composition, 10M ±10%, 1/2W	108142	
R34	Resistor, composition, 100Ω ±10%, 1/2W	108100	
R35, R40	Resistor, composition, 2.7K ±10%, 1/2W	108837	
R41	Resistor, composition, 18K ±10%, 1/2W	108183	
R42	Resistor, composition, 10K ±10%, 1/2W	108118	
R43	Resistor, composition, 220Ω ±10%, 1/2W	108191	
R44	Resistor, composition, 150K ±10%, 1/2W	108167	
R45, R46	Resistor, composition, 3.3K ±10%, 1/2W	108373	
R47	Resistor, variable wirewound, 1K ±20%, 1-1/4W	111575	
R64	Resistor, composition, 100Ω ±10%, 1/2W	108100	
R65	Resistor, composition, 470Ω ±10%, 1/2W	108415	
R66	Resistor, variable wirewound, 1K ±20%, 1-1/4W	111575	
R67	Resistor, composition, 470Ω ±10%, 1/2W	108415	
R69	Resistor, variable wirewound, 500Ω ±10%, 1-1/4W	112433	
R70	Resistor, composition, 220Ω ±10%, 1/2W	108191	
R73	Resistor, composition, 100Ω ±10%, 1/2W	108100	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R74	Resistor, composition, 1.8K ±10%, 1W	109751	
V1, V2	Tube, duo triode, 12AT7	115923	

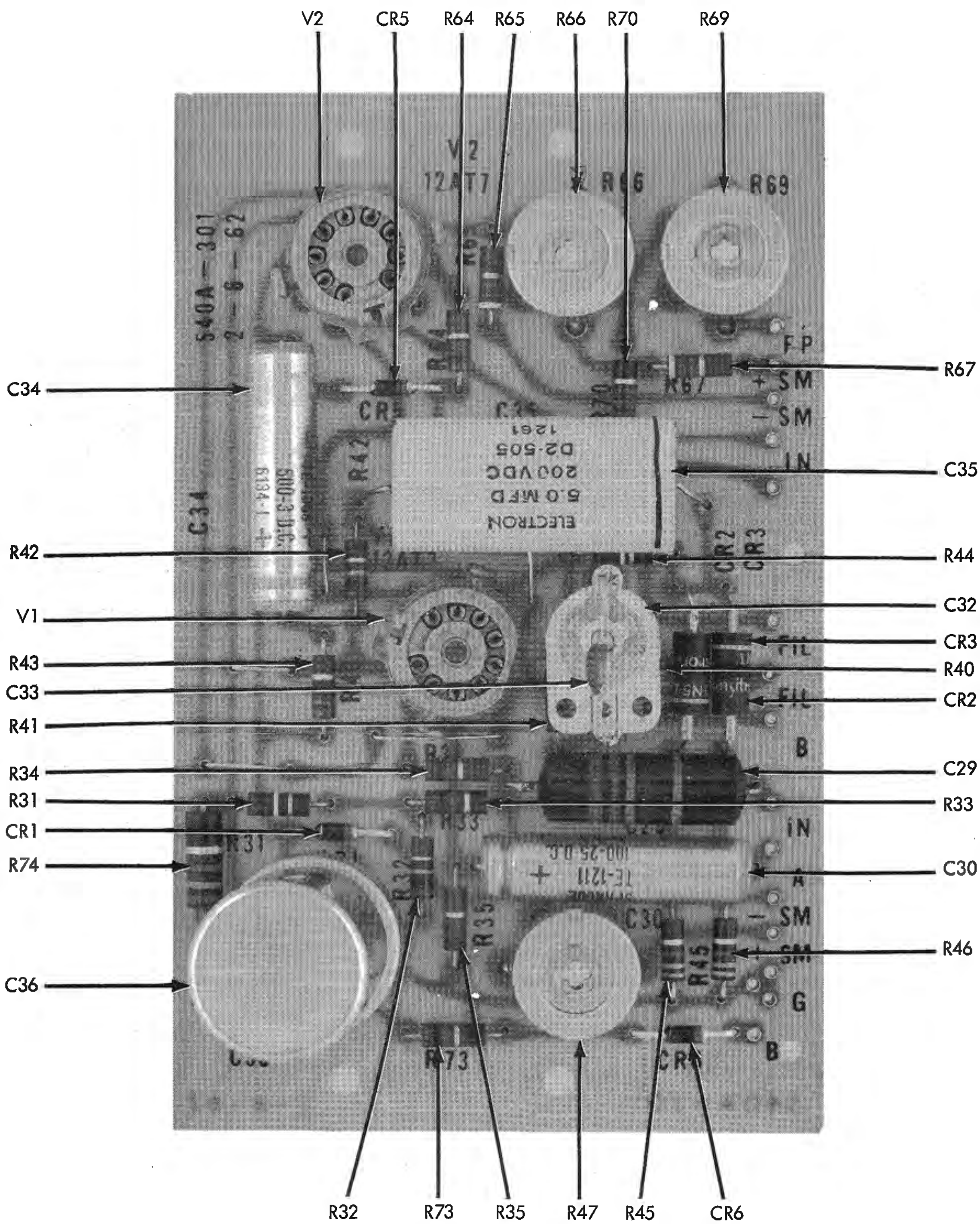


Figure 5-3. AMPLIFIER BOARD ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Range Switch Assembly	*122275	
	AC Input Search Board Assembly (see Figure 5-4A)		
C18, C20, C22	Capacitor, ceramic, 2.2 uuf ±0.25 uuf, 600V	106625	
C19, C21, C23	Capacitor, variable ceramic, 0.7 to 3.0 uuf, 350V	106476	
C24	Capacitor, variable ceramic, 3 to 12 uuf, 500V	106120	
C25	Capacitor, ceramic, 20 uuf ±10%, 500V	106369	
C26	Capacitor, ceramic, 0.0033 uf ±20%, 500V	106674	
C27	Capacitor, ceramic, 500 uuf -0%, 500V	105692	
C28	Capacitor, ceramic, 20 uuf ±10%, 500V	106369	
R27	Resistor, composition, 430Ω ±5%, 1/2W	109058	
R28	Resistor, composition, 4.7K ±5%, 1/2W	108886	
R29	Resistor, composition, 47K ±5%, 1/2W	108738	
R30	Resistor, composition, 1M ±5%, 1/2W	108639	
R48	Resistor, composition, 470K ±5%, 1W	109819	
	Compensation Board Assembly (see Figure 5-4B)		
C1	Capacitor, ceramic, 22 uuf ±2%, 500V	106641	
C2, C3	Capacitor, variable air, 1 to 12 uuf, 750V	106617	
C4	Capacitor, variable ceramic, 7 to 45 uuf, 500V	106302	
C5	Capacitor, variable air, 1 to 12 uuf, 750V	106617	
C6	Capacitor, ceramic, 39 uuf ±2%, 500V	106658	
C7	Capacitor, variable air, 1 to 12 uuf, 750V	106617	
C8	Capacitor, ceramic, 10 uuf ±0.5 uuf, 500V	106633	
C9	Capacitor, variable air, 1 to 12 uuf, 750V	106617	
C10	Capacitor, ceramic, 10 uuf ±0.5 uuf, 500V	106633	
C11 thru C15	Capacitor, variable air, 1 to 12 uuf, 750V	106617	
C16	Capacitor, ceramic, 39 uuf ±2%, 500V	106658	
C17, C37	Capacitor, variable ceramic, 7 to 45 uuf, 500V	106302	
R7	Resistor, deposited carbon, 52.14K ±1%, 1/2W	107284	
R9, R11 R71, R72	Resistor, deposited carbon, 61.9K ±1%, 1/2W	107847	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R75	Resistor, deposited carbon, 167K ±1%, 1/2W	107581	
	Range Switch Deck Assembly (see Figure 5-4C)		
C31	Capacitor, ceramic, 220 uuf ±10%, 500V	105528	
R1A thru R1E, R2A, R2B, R3, R4	Resistor, metal film, 20K ±1%, 1W	107813	
R5	Resistor, metal film, 10K ±1%, 1/2W	107839	
R6	Resistor, metal film, 4K ±1%, 1/2W	107888	
R8, R10	Resistor, metal film, 2K ±1%, 1/2W	107870	
R12	Resistor, metal film, 1K ±1%, 1/2W	107805	
R13	Resistor, metal film, 400Ω ±1%, 1/2W	107862	
R14, R15	Resistor, metal film, 200Ω ±1%, 1/2W	107821	
R16	Resistor, metal film, 100Ω ±1%, 1/2W	107854	
R26	Resistor, composition, 910K ±5%, 2W	110171	
R36	Resistor, composition, 1K ±5%, 1/2W	108597	
R37	Resistor, composition, 510Ω ±5%, 1/2W	108951	
R38	Resistor, composition, 180Ω ±5%, 1/2W	108944	
R39	Resistor, composition, 330Ω ±5%, 1/2W	108936	
R49	Resistor, composition, 470K ±5%, 1W	109819	
R50	Resistor, composition, 470K ±5%, 1/2W	108969	
R51	Resistor, composition, 240K ±5%, 1/2W	108449	
R52	Resistor, composition, 75K ±5%, 1/2W	108928	
R53	Resistor, composition, 62K ±5%, 1/2W	108522	
R54	Resistor, composition, 47K ±5%, 1/2W	108738	
R55	Resistor, composition, 24K ±5%, 1/2W	108654	
R56	Resistor, composition, 7.5K ±5%, 1/2W	108910	
R57	Resistor, composition, 6.2K ±5%, 1/2W	108621	
R58	Resistor, composition, 4.7K ±5%, 1/2W	108886	
R59	Resistor, composition, 2.4K ±5%, 1/2W	108902	
R60	Resistor, composition, 750Ω ±5%, 1/2W	108894	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R61	Resistor, composition, 620Ω ±5%, 1/2W	108704	
R62, R63	Resistor, composition, 470Ω ±5%, 1/2W	108787	
S3	Switch, rotary, range	*122341	

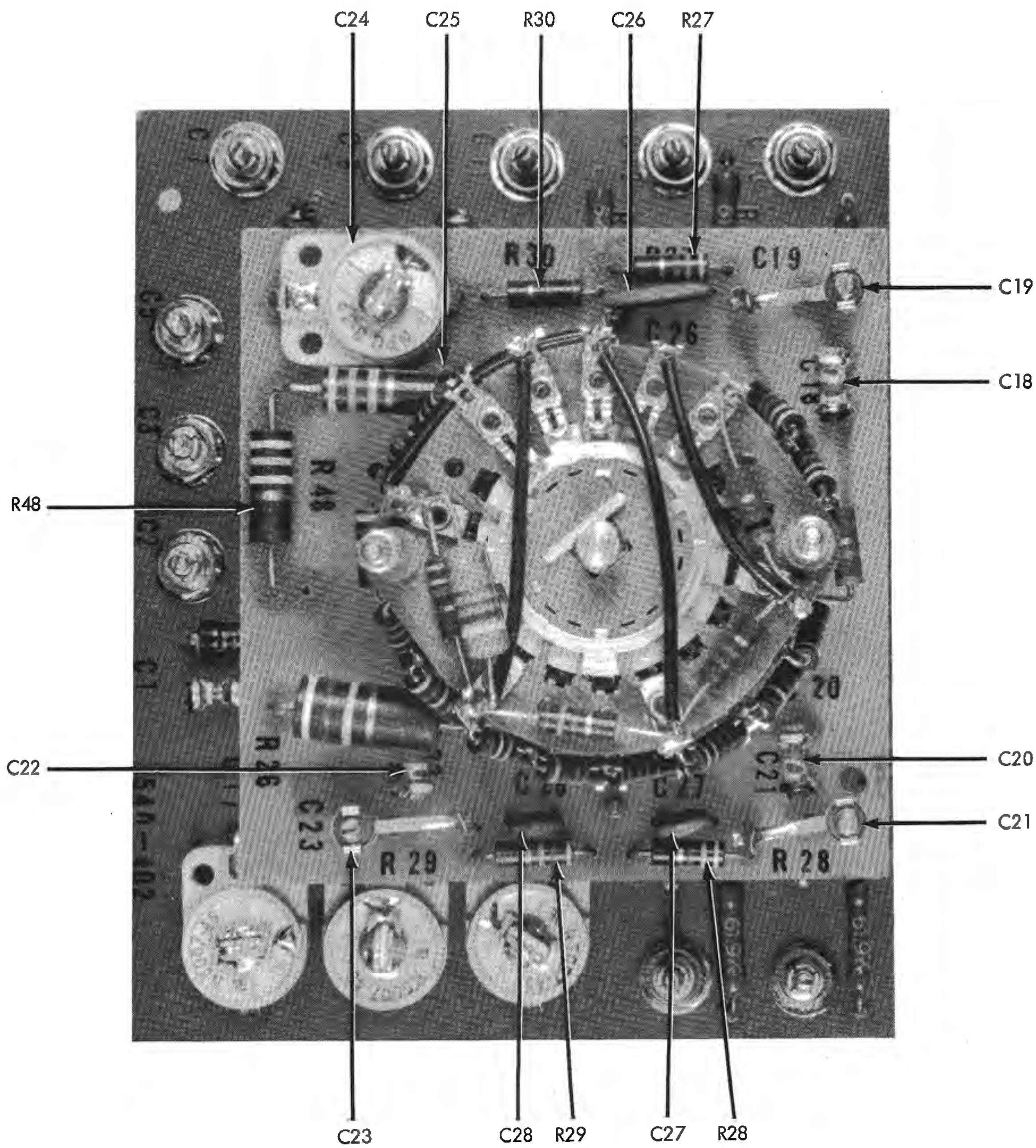


Figure 5-4A. AC INPUT SEARCH BOARD ASSEMBLY

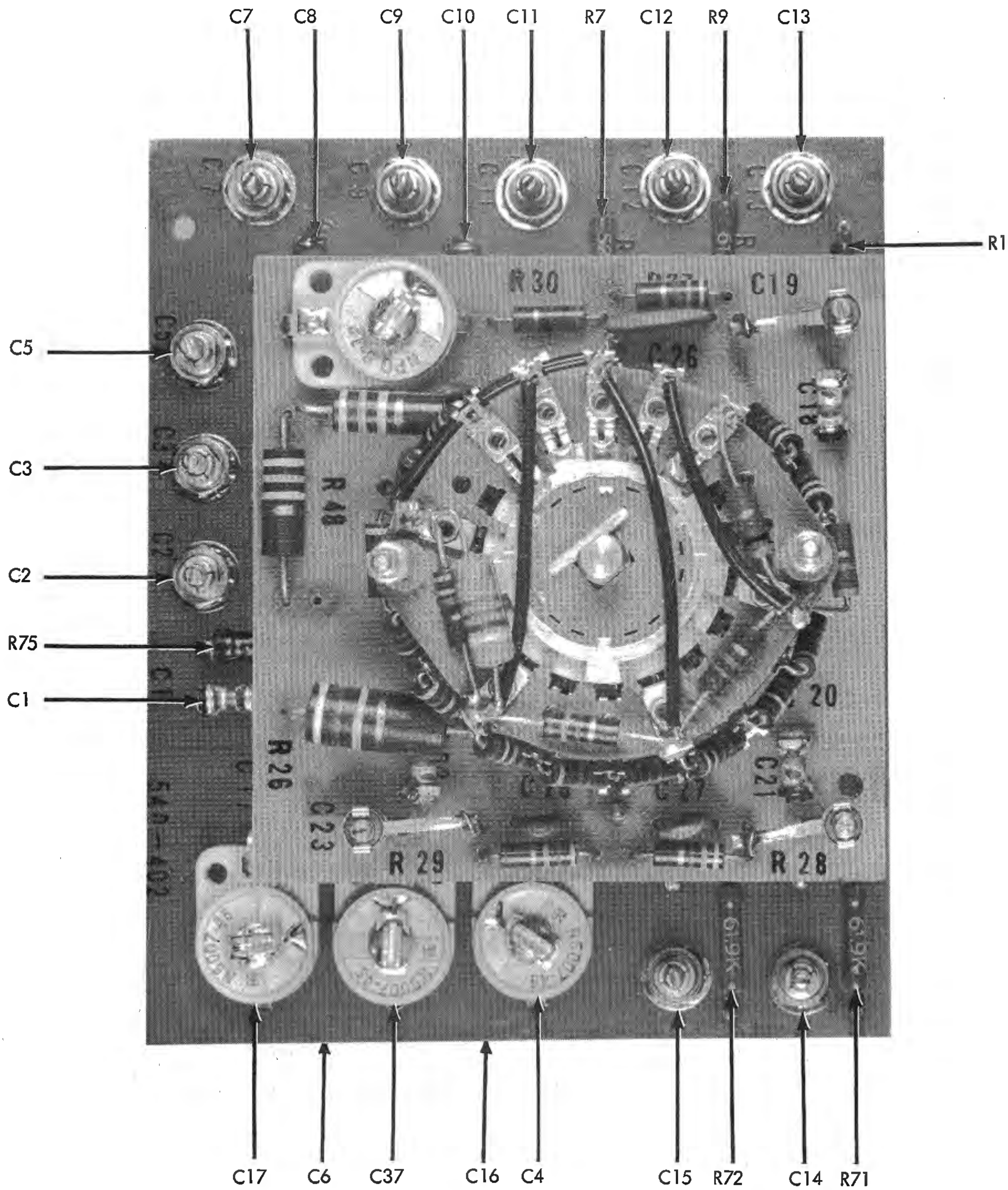


Figure 5-4B. COMPENSATION BOARD ASSEMBLY

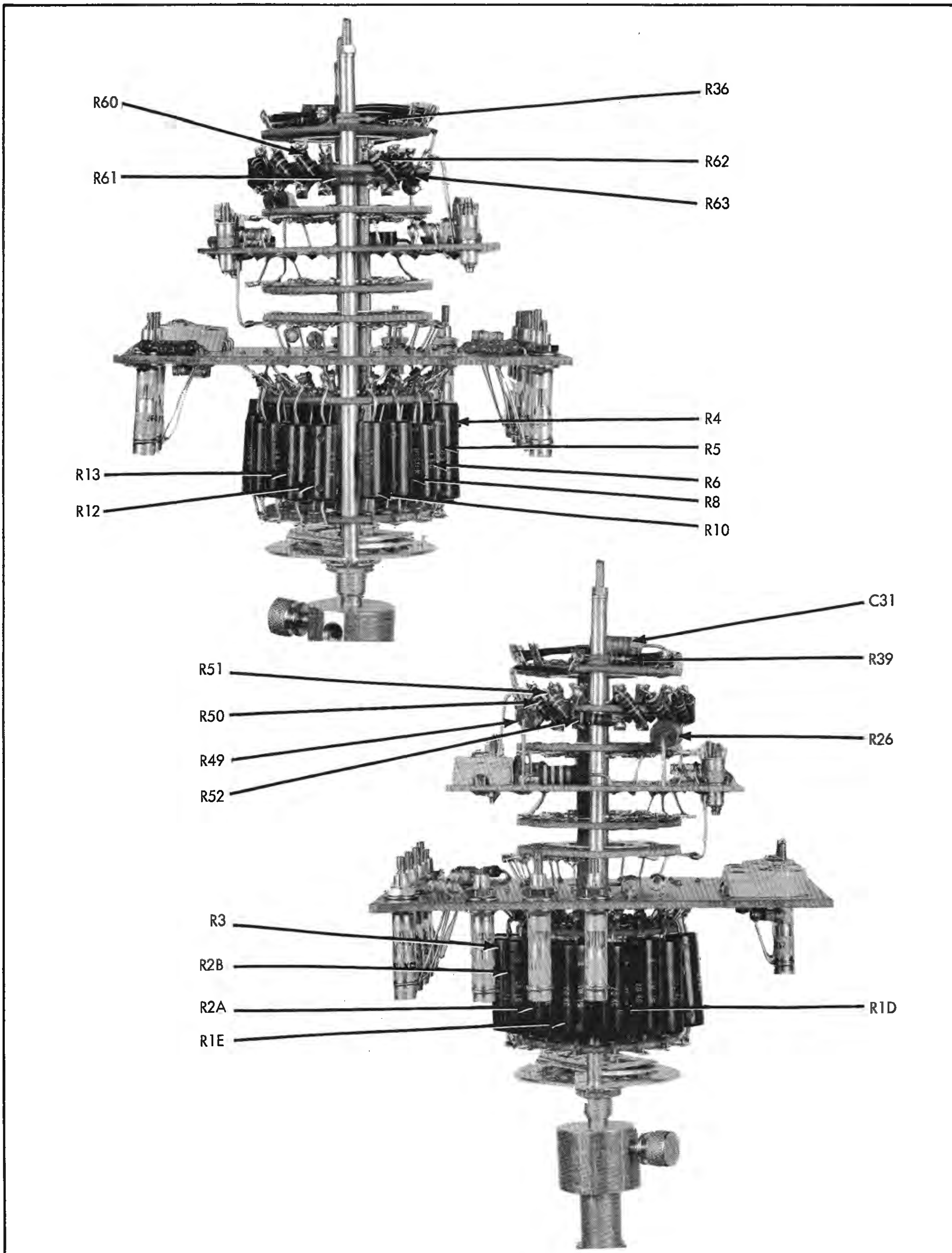


Figure 5-4C. RANGE SWITCH DECK ASSEMBLY (Sheet 1 of 2)

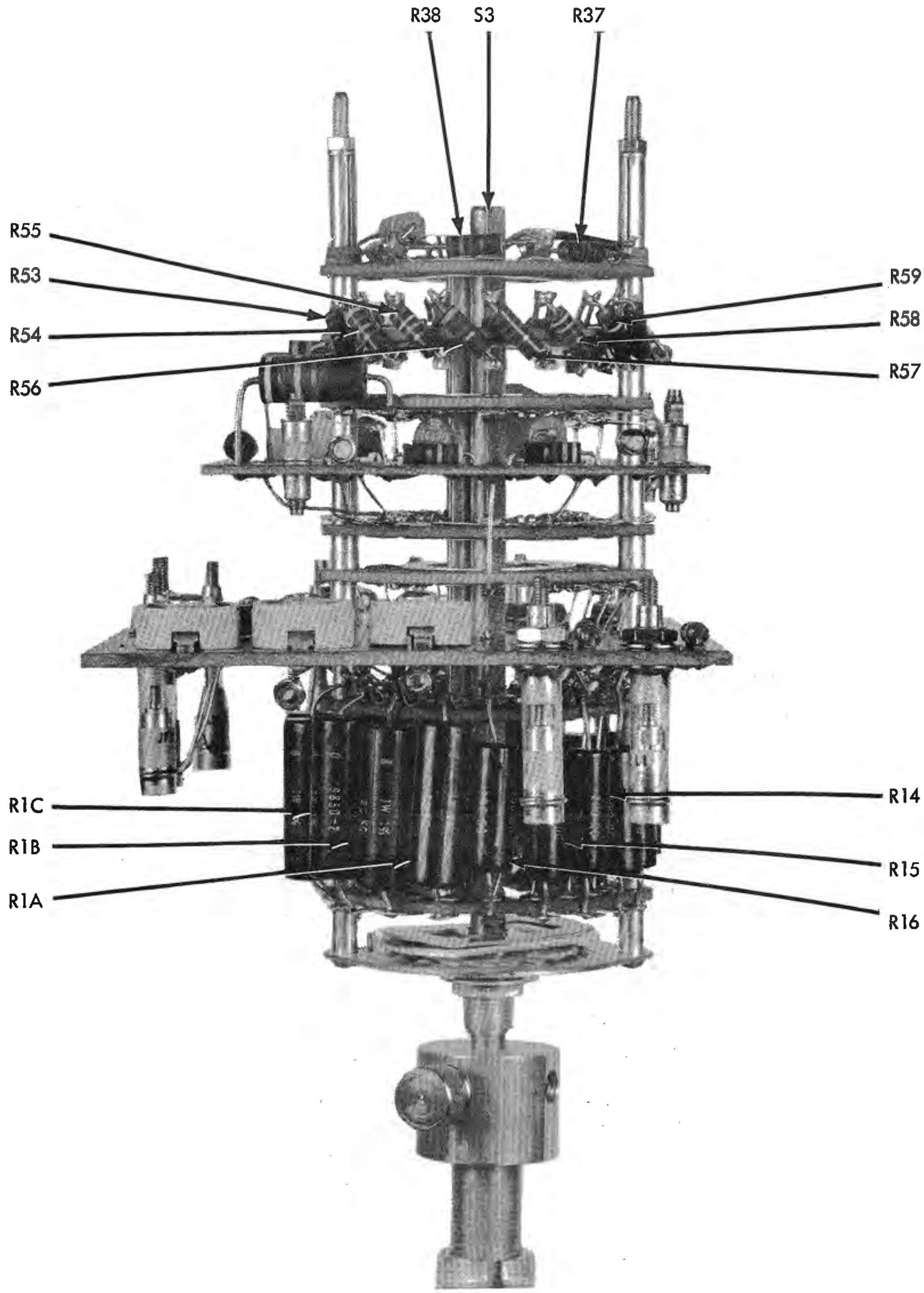


Figure 5-4C. RANGE SWITCH DECK ASSEMBLY (Sheet 2 of 2)

REFERENCE DESIGNATION	DESCRIPTION	L & N STOCK NO.	USE CODE
M1	Galvanometer, 0.1 ua/mm, type 2436a	2436a	
	Galvanometer system	062101	
	Lamp, GE #50, 7.5 volts, 0.22 amps		
	Lamp socket, with leads	040258	
	Scale	058403	
	Plane mirror, without bracket	051033	
	Yoke, holds galvanometer system in place	160003	
	Retainer for scale	027188	
	Condensing lens	050085	
	Galvanometer window	Std. 2101-A	
	Index	048064	
	Lucite rod	026085	

NOTE: All parts for the galvanometer should be ordered directly from Leeds & Northrup, 4901 Stenton Avenue, Philadelphia 44, Pa.

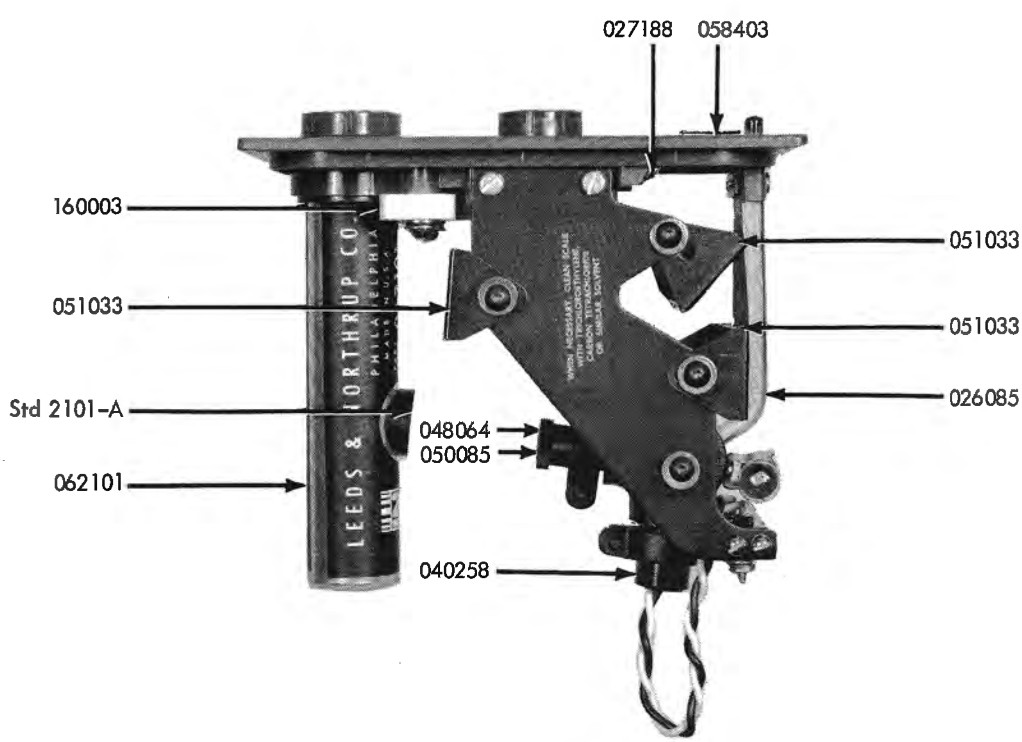


Figure 5-5. GALVANOMETER

USE CODE EFFECTIVITY

The following list of use codes is intended to allow the customer to determine the effectivity of all replaceable parts. All parts with no code are used on all instruments with serial numbers above 123. New codes will be added as necessary on forthcoming instruments.

USE CODE	EFFECTIVITY
No Code	Model 540A serial number 123 and on.
A	Model 540A serial number 123 thru approximately 237.
B	Model 540A approximately serial number 238 and on.
C	Model 540A serial number 123 thru approximately 289.
D	Model 540A approximately serial number 290 and on.
E	Model 540A serial number 123 thru approximately 298.
F	Model 540A approximately serial number 299 and on.
G	Model 540A serial number 123 to 374.
H	Model 540A serial number 375 and on.

SECTION VI

ACCESSORIES

6-1. MODEL A55 THERMAL CONVERTERS

a. Nine Fluke Model A55 Thermal Converters are available with ratings of 0.5, 1, 2, 3, 5, 10, 20, 30, and 50 volts, each of which may be used from 1/2 to 1 times the rating. These converters provide an output, nominally 7 millivolts DC at rated input, that is virtually the same for a DC voltage as for an AC voltage from 5 cycles to 50 megacycles. The AC to DC difference of the converters is comparable to that maintained by the National Bureau of Standards.

b. By connecting the output of an A55 converter to the HFTC input jack on the 540A, the internal transfer circuit of the 540A is bypassed so that only the null detector and reference supply are used. Thus, the function of the 540A is to set up a stable reference voltage equal to the A55 converter output with a fixed level input of one type, so that the same converter output may be produced by applying an adjustable input of a different type. The heating value of the two inputs are then the same.

c. A specially constructed thermocouple, selected for frequency characteristics and low DC reversal error, is the thermally responsive element of the A55 series. AC and DC input voltages are applied directly across the thermocouple heater on the 0.5 volt model. For higher voltages, low temperature coefficient metal-film resistors provide the proper range multipliers.

d. The thermocouple, range resistors, and compensation components are compactly mounted on a printed circuit board, with thermal isolation and mechanical rigidity of the thermocouple provided by encasement in rigid polyurethane foam.

e. To store the A55 converters and accessories, a Model C55 container with a molded high impact styrene insert is available. The C55 is designed to accommodate a complete set of nine converters and accessories, and is furnished at no charge with an order for a complete set of nine converters.

SPECIFICATIONS

RANGE: 0.5, 1, 2, 3, 5, 10, 20, 30, and 50 volts. (NOTE: Each converter may be used from 1/2 to 1 times voltage rating.)

AC/DC DIFFERENCE

CONVERTER	1MC	10MC	30MC	50MC
0.5V	±0.01%	+0.10%	+0.50%	+1.50%
1V-10V	±0.01%	±0.03%	±0.10%	±0.10%
20V-50V	±0.01%	±0.05%	±0.10%	

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.)

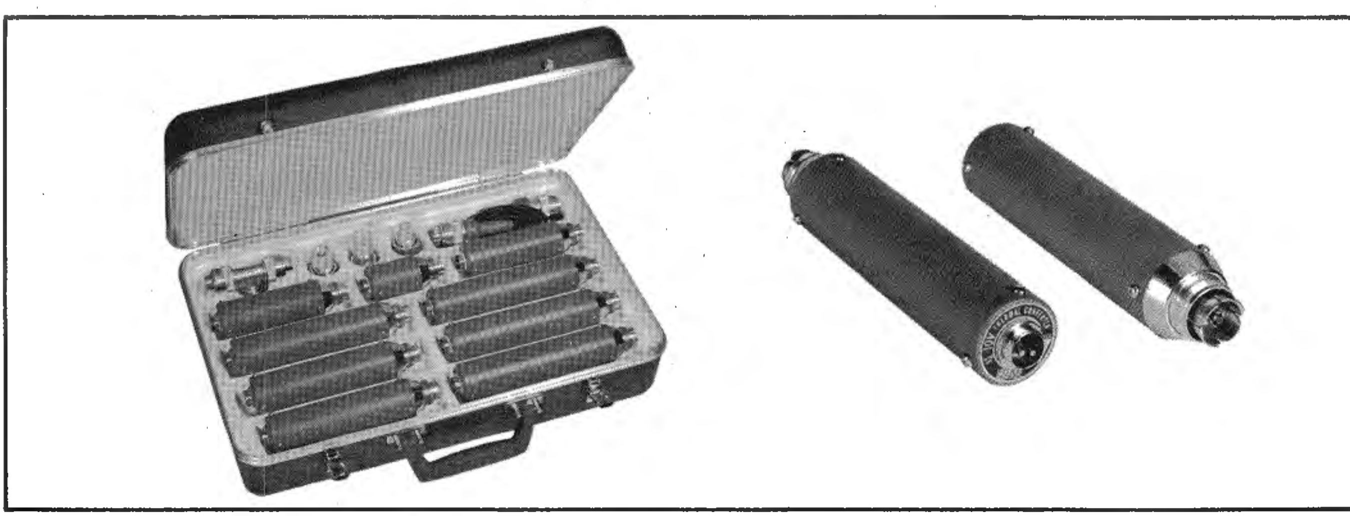
INPUT IMPEDANCE: Approximately 200 ohms/volt.

OUTPUT VOLTAGE: 7 millivolts nominal at rated input.

OUTPUT RESISTANCE: 8 ohms nominal.

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	1-3/8"	7-1/16"	1 lb.

OPTIONAL ACCESSORY KIT:

Model A55-110 Accessory Kit is recommended for use with Model A55 Thermal Converters in virtually any calibration or measurement setup. The kit includes:

(1) Coaxial Tee for A55 Input (GR Type 874-TL).

(2) Three Coaxial Adapters for A55 Input (GR Type 874 to UHF, BNC, and Type N jacks).

(3) Interconnecting coaxial cable, AC source to coaxial tee.

6-2. MODEL A40 CURRENT SHUNTS

a. Thirteen Fluke Model A40 Current Shunts are available with ratings of 10, 20, 30, 50, 100, 200, 300, and 500 milliamperes; 1, 2, 3, 5, and 10 amperes for use with the 540A. The 10 ampere shunt may be used from 1/2 to 1 times rating and all the other shunts may be used from 2/3 to 1-1/2 times rating. The 540A provides a nominal range of 5 milliamperes which allows current transfer measurements from 2.5 to 7.5 ma without the use of an external shunt. Thus, the transfer standard and current shunts form an rms current measuring device with a range from 2.5 ma to 10 amperes and a frequency response from 5 cycles to 100 kilocycles.

b. The current shunts plug into a pair of front panel binding posts on the 540A, and electrically shunt the thermocouple heater. Thus, the nominal heater current rating of 5 ma is maintained at the nominal shunt rating.

c. Internal construction of the shunts includes straight-wire, bifilar-wound ribbon, and four-terminal folded-ribbon resistive elements, depending on shunt size. The resistive elements are in good thermal contact with the shunt case, which in the larger shunts is an efficient finned-aluminum extrusion.

d. To store or transport the A40 current shunts, a Model C40 Royalite case with a molded high impact styrene insert is available. The C40 is designed to accommodate a complete set of thirteen current shunts, and is furnished at no charge with an order for a complete set of shunts.

SPECIFICATIONS

NOMINAL SHUNT RATINGS: 10, 20, 30, 50, 100, 200, 300 and 500 milliamperes; 1, 2, 3, 5, and 10 amperes. NOTE: Each shunt except 10 ampere may be used from 1/2 to 1-1/2 times nominal rating; 10 ampere shunt limited to 1/2 to 1 times rating.

OVERALL CURRENT RANGE: 2.5 milliamperes to 10 amperes. (5 ma nominal rating of 540A thermal converter heater allows current transfers from 2.5 ma to 7.5 ma without shunts.)

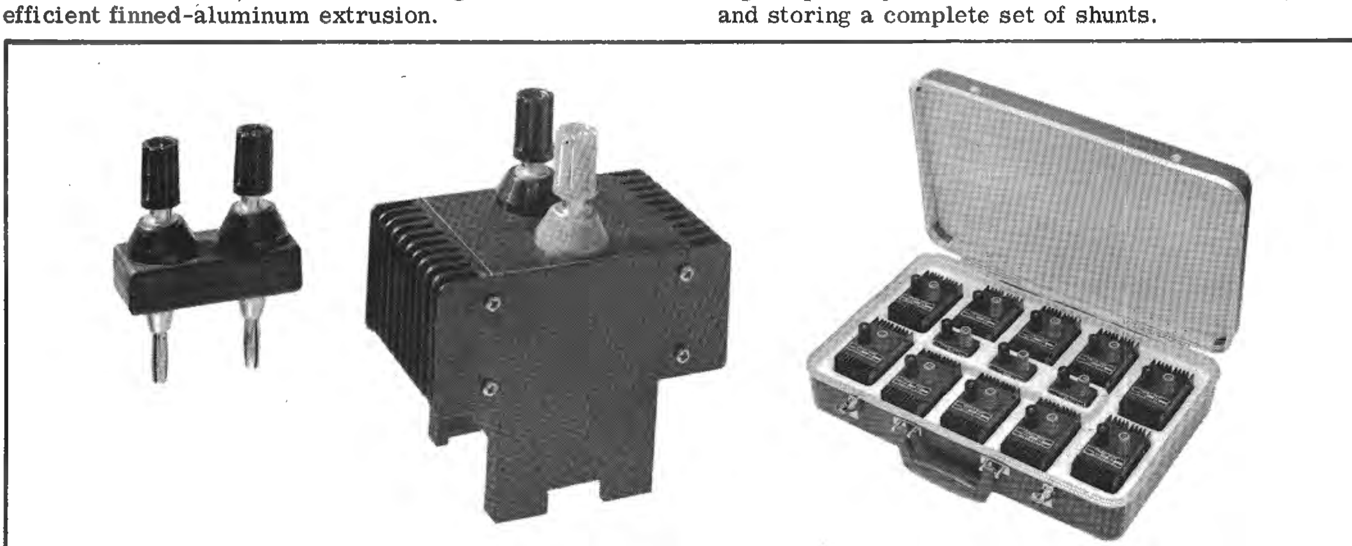
ACCURACY (% of input):

SHUNT	FREQUENCY	AC/DC DIFFERENCE
10 ma thru 5 amp (also applies to 540A used without a shunt from 2.5 to 7.5 ma)	5 cps - 20 KC	±0.03%
	20 KC - 50 KC	±0.05%
	50 KC - 100 KC	±0.10%
10 amp	5 cps - 20 KC	±0.03%
	20 KC - 50 KC	±0.10%

NOTE: Above figures apply to shunts calibrated to a specific 540A. When used with any 540A, add 0.02% to 5 cps - 20 KC specification, and 0.05% to all other specifications.

CALIBRATION: Certified to be within the above deviation from zero error as defined by the National Bureau of Standards, without calibration curves or correction tables. John Fluke or NBS test reports to nearest ±0.01% available at extra charge.

ACCESSORIES: Model C40 Royalite case with molded high impact styrene insert is available for transporting and storing a complete set of shunts.



WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., 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 prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. 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

The instrument should be thoroughly inspected immediately upon receipt. 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 fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON

NOTES:

1. * OPTIMUM VALUE SELECTED AT FACTORY AVERAGE VALUE SHOWN

2. ** FOR SER. 123 TO APPROX. 237
   R21 WAS 680
   R24 WAS 33
   R25 WAS 3

3. ON THE COMPENSATION BOARD ASSEMBLY IN SOME EARLIER INSTRUMENTS, C37 AND R75 HAVE BEEN DESIGNATED AS C36 AND R73

FUNCTIONAL SCHEMATIC α

TRANSFER STANDARD

MODEL 540A

540A SER. NO. 123 & ON

FLUKE JOHN FLUKE MFG. CO. INC.
P.O. Box 7428 Seattle, Washington 98133