Model 515A Megohm Bridge

Instruction Manual

Contains Operating and Servicing Information

KEITHLEY

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the Cleveland factory, 440-248-0400. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

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To insure prompt repair or recalibration service, please contact your local field representatives.

To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

Model 515A Megohm Instruction Manual

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SPECIFICATIONS

RANGE: 10^5 to 10^{15} ohms with a 7-dial in-line readout.

ACCURACY: (when bridge is operated as described below):

Range, ohms	Standard Deviation (1σ)**	Bridge Voltage	Decade
10^5 to 10^7	.012%	10 v	10^5 to 10^6
10^7 to 10^8	.02%	10 v	10^7
10^8 to 10^9	.03%	10 v	10^8
10^9 to 10^{10}	.06%	10 v	10^9
10^{10} to 10^{11}	.08%	10 v	10^{10}
10^{11} to 10^{12}	.16%	10 v	10^{11}
10^{12} to 10^{13}	.25%	100 v	10^{12}
10^{13} to 10^{14}	.3%	500 v*	10^{12}
10^{14} to 10^{15}	1.5%	500 v*	10^{12}

INPUT: Built-in compartment or optional Remote Test Chamber with Teflon-insulated triaxial cable.

GROUNDING: One terminal of unknown is at ground potential.

NULL DETECTOR: Electrometer with sensitivity of 100 microvolts per division to 1 volt per division in five decade steps. Meter is non-linear past 1/3 of full scale for ease in determining null.

BRIDGE POTENTIAL: Internal: From 0 to + 110 volts dc in 1-volt steps. External With Keithley Model 240A or 241 High Voltage Supply, 1000 volts maximum, positive only.

INTERNAL CHECKS: Built-in zero check and leakage (guard to ground) check. Test jacks for checking wirewound standard resistors. Bootstrap calibration from wirewound standards for the 10^7 through 10^{12} decades.

ENVIRONMENT: Any ± 0.5°C span between 20 and 30°C, 20-50% relative humidity.

CONNECTORS: External Operate: Teflon-insulated triaxial panel jack, Gremar 5632A. External Bridge-Potential Input: UHF.

POWER: 105-125 or 210-250 volts, 50-60 Hz, 10 watts.

DIMENSIONS, WEIGHT: Standard 19" wide x 14" high rack mounting, 11-1/2" behind front panel (483 x 356 x 292 mm), total depth, 12-3/4" (324 mm); net weight, 28 pounds (12,5 kg).

NOTES: *External supply required above 10^{13} ohms.
**Based on theoretical analysis of bridge errors. See Instruction Manual for details on obtaining specified performance.

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Model 515A Megohm Bridge is an instrument for measuring resistance from 10^4 ohms to 10^{15} ohms with a limit of error from .05 to 1%. It comprises a solid-state, guarded, electrometer null detector; an ultra-stable, highly-regulated dc voltage source, and a Wheatstone bridge.

1-2. FEATURES.

a. Accuracy Verification: Accuracy is traceable to the National Bureau of Standards by use of the Model 5155 resistance standards available as an optional accessory.

b. Selectable Bridge Voltage: An internal voltage source spans a range from 1 to 110 volts in 1-volt steps.

c. Shielded Compartment: Connection to the bridge is made using a guarded terminal in the shielded compartment which minimizes noise pickup.

d. Standardize Mode: This mode can be selected for quick calibration of bridge elements to correct for slight changes in the standard high megohm resistors.

e. Guard Leakage Check: A quick self check of the guard to ground resistance can be made using test jacks on the front panel (inside the measuring compartment.

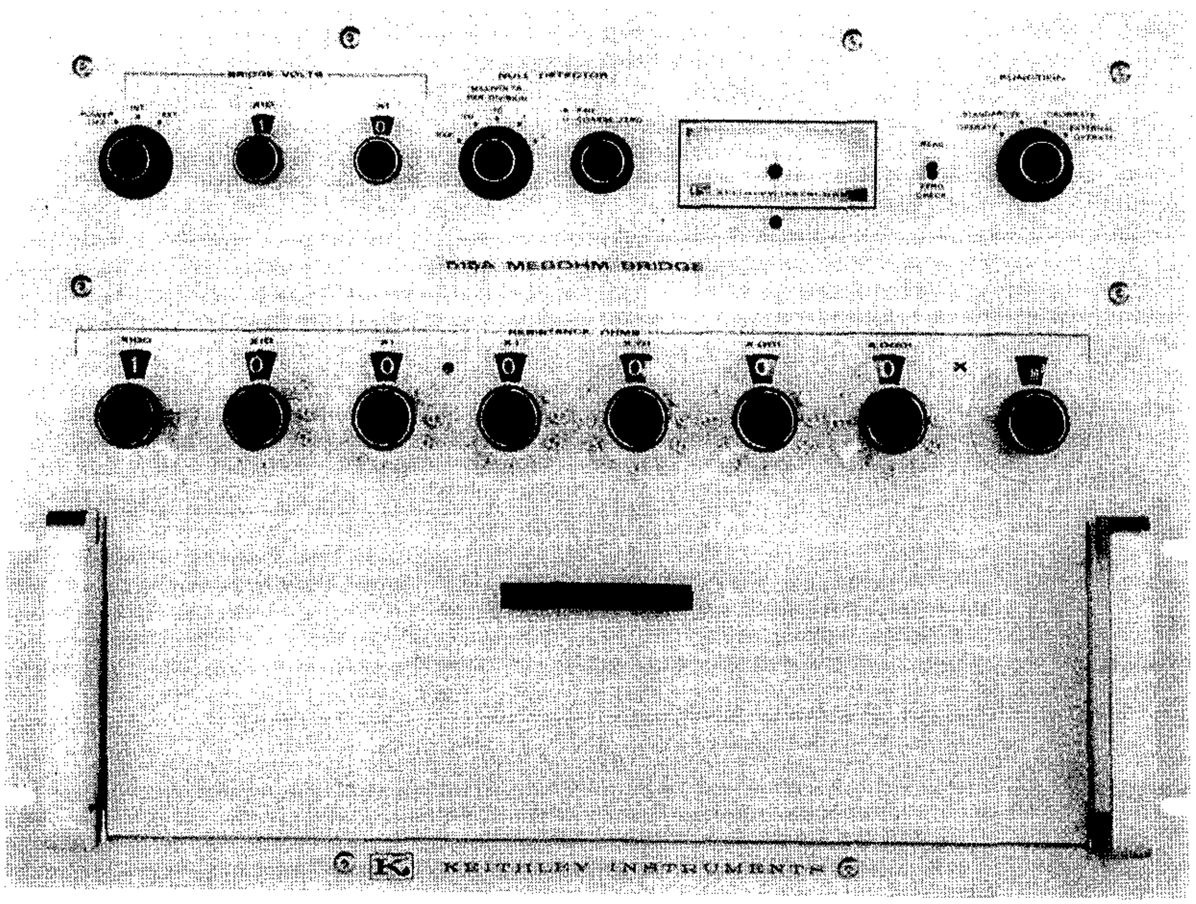


FIGURE 1. Front Panel.

TABLE 1-1.
Front Panel Controls.

Control	Functional Description	Paragraph
BRIDGE VOLTS		
Power Switch (S311)	Controls power to bridge; Selects INT or EXT.	2-2, a1
X1 Switch (S203)	Sets voltage in 1-volt steps.	2-2, a2
X10 Switch (S202)	Sets voltage in 10-volt steps.	2-2, a3
NULL DETECTOR		
Sensitivity Switch (S103)	Selects null detector sensitivity, .1 to 1000mV/div.	2-2, a4
FINE ZERO Control (R120)	Adjusts meter zero (inner knob).	2-2, a5
COARSE ZERO Control (S102)	Adjusts meter zero (outer knob).	2-2, a6
READ/ZERO CHECK (S201)	Selects READ or ZERO CHECK operation.	2-2, a7
FUNCTION Switch (S301)	Selects mode of operation; 4 positions.	2-2, a8
RESISTANCE		
X100 (S304)	Adjusts bridge balance in steps of 100.	2-2, a9
X10 (S305)	Adjusts bridge balance in steps of 10.	2-2, a10
X1 (S306)	Adjusts bridge balance in steps of 1.	2-2, a11
X.1 (S307)	Adjusts bridge balance in steps of .1.	2-2, a12
X.01 (S308)	Adjusts bridge balance in steps of .01.	2-2, a13
X.001 (S309)	Adjusts bridge balance in steps of .001.	2-2, a14
X.0001 (S310)	Adjusts bridge balance in steps of .0001.	2-2, a15
Multiplier Switch (S302)	Sets multiplier ratio from 10^5 to 10^{12}.	2-2, a16

TABLE 1-2.
Controls and Connections.
Front Panel Measuring Compartment.

Control	Functional Description	Paragraph
CALIBRATE Controls	Adjusts bridge elements in CALIBRATE mode.	2-2, b1
10^6 (R319)		
10^7 (R320)		
10^8 (R321)		
10^9 (R322)		
10^{10} (R323)		
10^{11} (R324)		
Safety Switch (S303)	Provides a safety interlock; removes bridge power when the compartment door is open.	2-2, b2
INPUT Terminal (J302)	Provides a guarded connection to INPUT high.	2-1, a
EXT. INPUT Terminal (J303)	Provides a guarded connection using a triaxial cable for external inputs.	2-1, a
Low Terminals	Provides a connection to INPUT low when using the guarded INPUT high terminal.	2-1, a
Test Jacks J201-210	Provide various circuit test points for checkout.	-

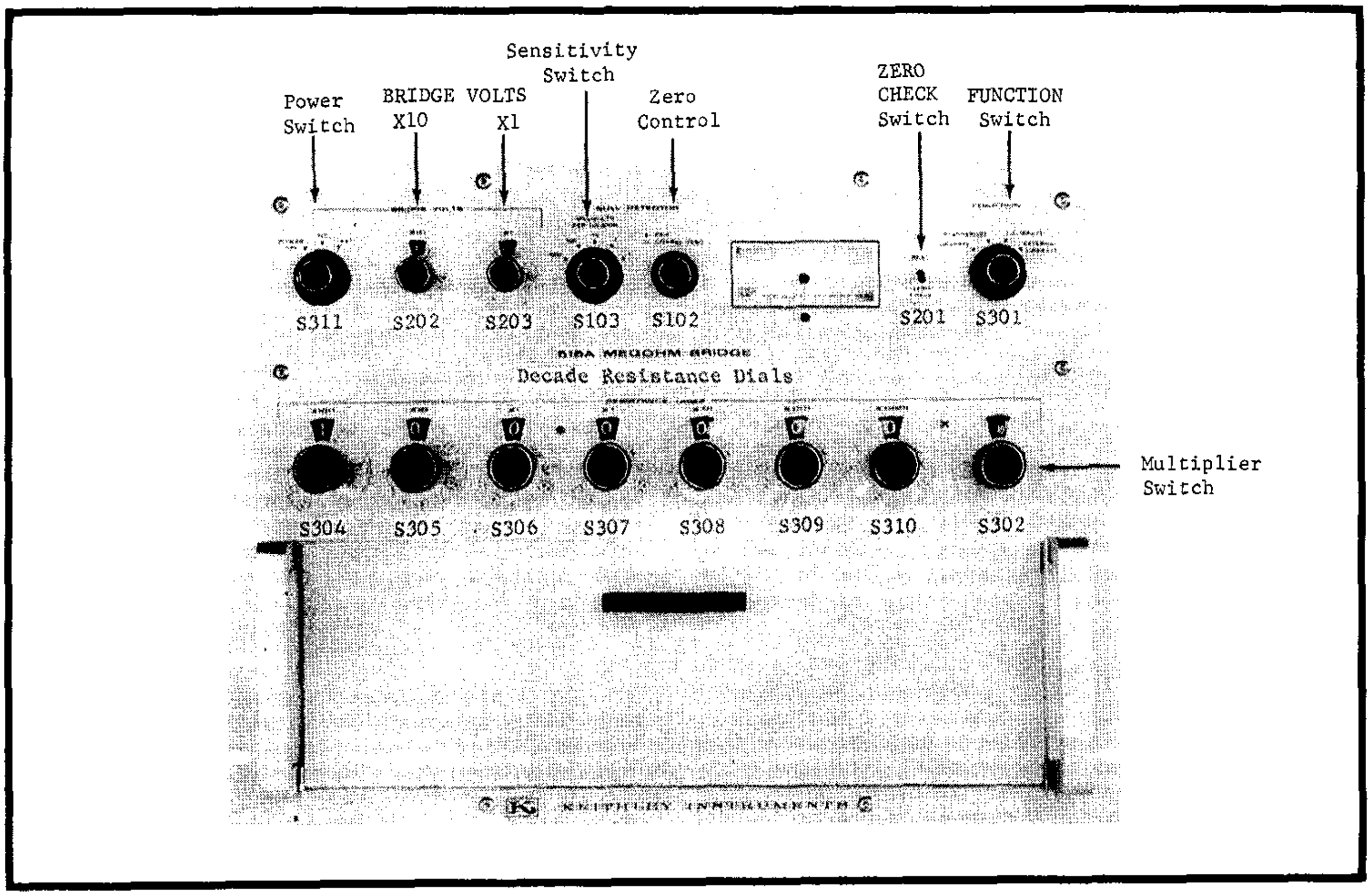


FIGURE 2. Front Panel Controls

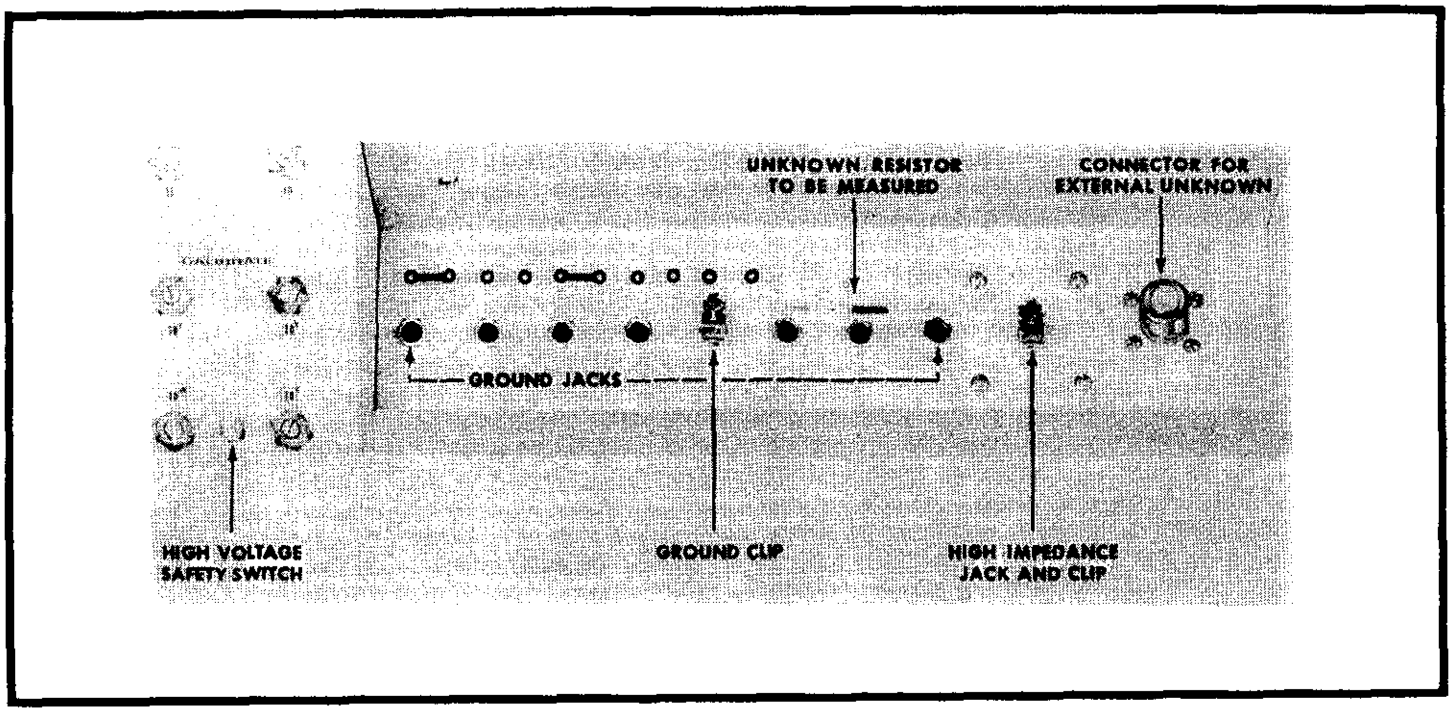


FIGURE 3. Shielded Measuring Compartment

SECTION 2. OPERATION

2-1. MEASUREMENT CONSIDERATIONS.

a. Connections.

1. Shielded Test Compartment. The Test Compartment shown in Figure 3 permits measurement of high resistance while minimizing noise pickup and the effects of leakage paths. Input connections can be made using a triaxial receptacle (EXTERNAL INPUT J303) or a guarded INPUT high receptacle (J302).

a.) High Megohm Resistors. Discrete resistors can be easily measured by connecting to the INPUT receptacle and any one of eight INPUT low receptacles. The receptacles are designed for use with test clips such as Grayhill #2-1 which have a banana plug on one end and a spring clip on the other. The INPUT low receptacles are spaced one inch apart for resistors up to 8 inches long. A typical resistor connection is shown in Figure 3.

b.) External Connections. A teflon-insulated, guarded, triaxial receptacle (EXTERNAL INPUT J303) is provided for external connections. The receptacle is a Gremar Type 5632A triaxial connector which mates with a Gremar Type 7991-1 triaxial plug (Keithley CS-69). An optional accessory cable is available (Keithley Model 5153) for external connections; a 60" triaxial cable with CS-69 connector on one end. The Keithley Model 5152 Remote Test Chamber permits external shielded measurements (with a 60" triaxial cable and CS-69 connector).

2. External Voltage Source. An external voltage source can be connected to the bridge using the rear panel UHF coaxial receptacle (J211). This connector is a Gremar Type 6804 UHF receptacle (Keithley CS-64) which mates with a Gremar Type 5127 plug (Keithley CS-49).

b. Guarding. A driven guard is used extensively in the bridge circuit to minimize the effects of spurious leakage currents.

1. Theory. In megohm bridge design, care must be taken to guard the high-resistance arm so that insulation leakage currents will not affect the balance point. Guarding in the Model 515A is shown in Figure 4. The guard enclosure is indicated by the dotted-line surrounding the high megohm STANDARD resistors, the electrometer null detector, and the guarded input terminal. The input high terminal utilizes a "guard ring" maintained approximately at the potential of the null detector low.

2. Circuitry. The guard potential is obtained from the null detector (electrometer) power supply common as illustrated in Figure 5. The potential of the "Driven Guard" is maintained at very nearly the Input High potential with the result that the High to Guard leakage is extremely small at bridge balance. The guard circuit is formed by a metal enclosure and plates which surround the STANDARD resistors, CALIBRATE resistors, the null detector, and the Input terminal.

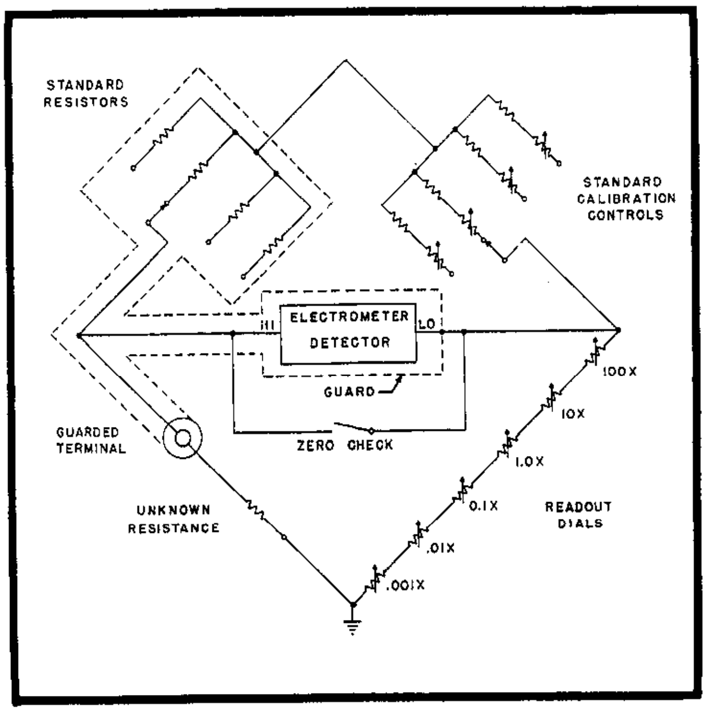


FIGURE 4. Guarding

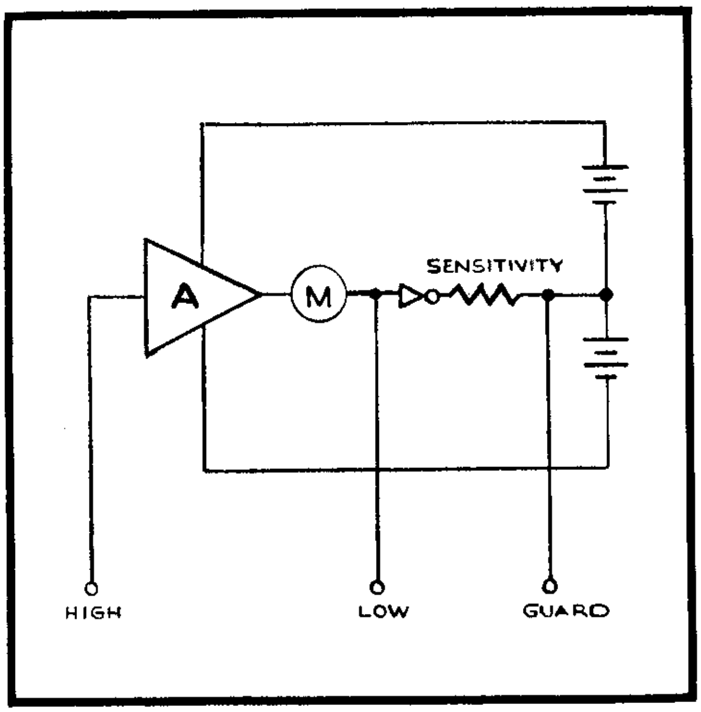


FIGURE 5. Null Detector

3. Use of the Guard.

a.) Connections to guard. The INPUT terminal (J302) is a guarded receptacle (Gremar, Type 6804) with a center High contact and an outer Guard ring. The EXTERNAL INPUT terminal (J303) is a guarded triaxial receptacle (Gremar, Type 5632A) with a center High contact, an inner Guard contact and an outer Low contact. A drawing of the connector construction is shown in Figure 6.

b.) Applications. The driven guard can be used for external measurements when it is necessary to minimize the effects of spurious leakage currents across the insulation. A typical external measurement can be accomplished using Keithley Model 5152 Remote Test Chamber and teflon-insulated triaxial cable. The use of the Model 5152 is completely described in Section 4, Accessories.

c.) Guard to Ground Leakage. The design of the guard circuit in the Model 515A maintains the Guard to Low (ground) resistance greater than 10^{11} ohms. The Guard to Ground resistance should be high with respect to the resistance from floating low to ground so that the shunting effects across the Readout Resistance will not be significant. For example the worst-case condition would be a Readout Resistance of 10 megohms or 10^7 ohms with a 0.02% tolerance. If the Guard to Ground resistance were 10^{11} ohms, an additional error of 0.01 % would result.

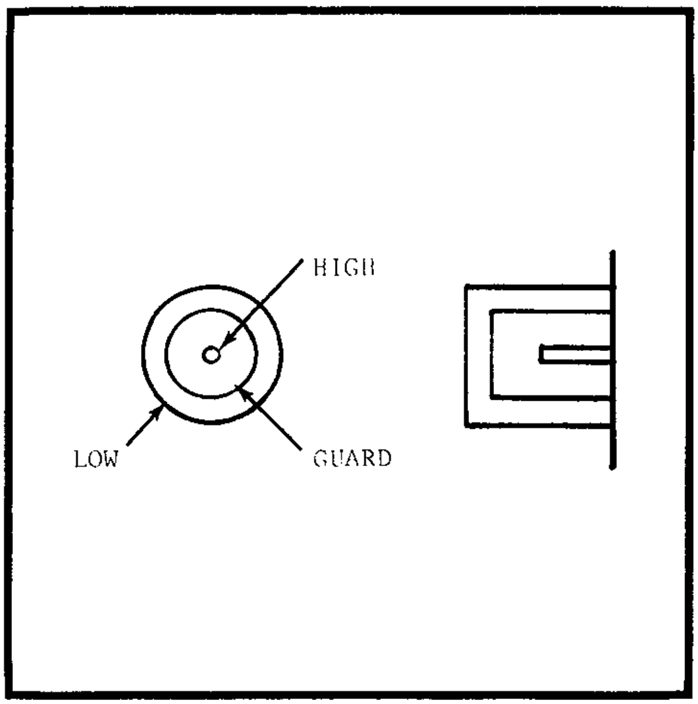


FIGURE 6. Triaxial Receptacle

c. Leakage. The Input terminals of the Model 515A have been designed using teflon insulation between High and Guard and Guard and Ground. In order to maintain the high insulation resistance, the terminals must be kept clean and dry. Preferred cleaning materials include: Chemically pure alcohol, sterile cotton swabs (to prevent contamination of alcohol), and a drying agent such as nitrogen. Leakage paths across the terminal can create intermittant errors or difficult bridge balance. The user should also take care to insure that the unknown resistor, holding fixtures and case are insulated properly. Glass envelopes (high megohm resistors) can be contaminated by oil and salts from improper handling. Paper base bakelite insulation can be degraded by improper handling and exposure to moisture. The humidity of the laboratory environment can also affect the measurement of very high resistances. See Specifications.

d. Noise. Noise pickup from ac electric and magnetic fields is minimized by the unit construction of the chassis and the use of a closed, shielded measuring compartment. When using an external unknown resistance, care should be taken to:

1. Use shielded cables such as Keithley Model 5153 triaxial cable.

2. Fasten down the cables so that flexure noise is minimized.

3. Maintain Guard to Ground insulation using teflon insulation.

4. Use an external shielded test box such as Keithley Model 5152 Remote Test Chamber.

e. Accuracy.

1. Specification. The specified accuracy for measurements on various ranges is valid for the following conditions.

a.) Minimum Bridge Potential. This potential is the minimum voltage required for resolution.

b.) Environment. The ambient temperature and relative humidity must be controlled within limits stated.

c.) Standardization. The Standardization procedure should be performed prior to very critical measurements.

d.) Proper Operating Technique. Care must be taken when connecting the unknown (See Measurement Considerations, Paragraph 2-1) and balancing the bridge (See Accuracy Considerations, Paragraph 2-7).

2. Verification. The Model 515A accuracy can be verified using the Model 5155 Megohm resistance standards.

3. Technique for Measuring 10^{10} to 10^{15} Ohm Resistances.

Set Controls as Indicated:

BRIDGE VOLTS:	0
FUNCTION SWITCH:	OPERATE OR EXTERNAL OPERATE
MULTIPLIER:	10^{10}, 10^{11}, or 10^{12}
RESISTANCE DECADE DIAL X100:	10
READ/ZERO SWITCH:	ZERO

Insert unknown resistor. Set READ/ZERO Switch to READ and note offset of null detector with MULTIPLIER setting to be used in measurement. Allow approximately 15 minutes for reading to stabilize. The offset of the null detector is due to offset current from the null detector and from stressing of Teflon insulation surrounding the Hi terminal of the bridge. Use the offset reading as null for measuring the unknown.

Set READ/ZERO Switch to ZERO. Select the Bridge potential for the measurement based on desired accuracy as described in detail in the OPERATION section of the manual. Set READ/ZERO Switch to READ and balance bridge using Resistance decade dials.

METER NOISE: In balancing the bridge when measuring resistances greater than 10^{10} ohms there is meter noise present due to 1/f noise, alpha particle noise, etc. It may be noted that the meter indication has a base-line from which meter fluctuations diverge. The actual null detector reading is this base-line when balancing the bridge.

NOTE

Care should be taken to allow enough time for bridge to stabilize to a reading. This time will vary from one measurement to another however, a minimum time of 15 minutes is advisable to determine final null reading.

2-2. CONTROLS AND SWITCHES.

a. Front Panel.

1. Power Switch (S311). This switch controls the power to the bridge including the bridge potential and null detector supplies. The INT position permits a setting of the bridge potential from 1 to 110 volts using the X1 and X10 BRIDGE VOLTS switches. The EXT position connects the external voltage input (J211) so that a bridge potential up to 1000 V can be applied using an external voltage supply such as Keithley Model 241.

2. X1 Switch (S203). This switch permits a setting of the bridge potential in 1-volt increments up to 10 volts.

3. X10 Switch (S202). This switch permits a setting of the bridge potential in 10-volt increments up to 100 volts.

4. Sensitivity Switch (S103). This switch selects the null detector sensitivity from .1 to 1000 millivolts per division.

5. FINE Control (R120). This control is the inner knob of a dual-concentric control. The FINE Control permits adjustment of the meter zero.

6. COARSE ZERO Switch (S102). This switch is the outer knob of a dual-concentric control. The COARSE Switch permits adjustment of the meter zero in 10 steps.

7. READ/ZERO CHECK Switch (S201). This switch selects READ or ZERO CHECK operation for the meter circuit. In ZERO CHECK position the null detector High and Low are shorted together.

8. FUNCTION Switch (S301). This switch selects the mode of operation in 4 position, OPERATE, STANDARDIZE, CALIBRATE, and EXTERNAL OPERATE. A complete discussion of these modes is given in paragraph 2-3.

9. X100 Resistance Switch (S304). This switch adjusts the "Readout" arm of the bridge in steps of 100.

10. X10 Resistance Switch (S305). This switch adjusts the "Readout" arm of the bridge in steps of 10.

11. X1 Resistance Switch (S306). This switch adjusts the "Readout" arm of the bridge in steps of 1.

12. X.1 Resistance Switch (S307). This switch adjusts the "Readout" arm of the bridge in steps of .1.

13. X.01 Resistance Switch (S308). This switch adjusts the "Readout" arm of the bridge in steps of .01.

14. X.001 Resistance Switch (S309). This switch adjusts the "Readout" arm of the bridge in steps of .001.

15. X.0001 Resistance Switch (S310). This switch adjusts the "Readout" arm of the bridge in steps of .0001.

16. Multiplier Switch (S302). This switch sets the multiplier ratio from 10^5 to 10^{12}.

b. Measuring Compartment.

1. CALIBRATE Controls. These controls are used to adjust the bridge when the FUNCTION Switch is set to CALIBRATE. The use of these controls is described in paragraph 2-4, d (Standardization procedure).

2. Safety Switch (S303). This switch is a normally-open interlock which removes bridge power when the compartment door is open. The safety interlock is defeated when the FUNCTION switch is set to EXTERNAL OPERATE.

c. Rear Panel. 117-234V Line Switch (S312). This switch sets the Model 515A for either 117V or 234V rms line power, 50-60 Hz.

2-3. MODES OF OPERATION.

a. Operate. This mode of operation permits measurements of high megohm resistances when connected to the INPUT receptacle. To select this mode, set the FUNCTION switch to OPERATE. Either the internal voltage source (bridge potential) or an external voltage source up to 1000 volts can be used. The safety interlock switch prevents operation of the bridge whenever the compartment door is open. If the unknown resistance must be measured externally, use the External Operate mode.

b. External Operate. This mode of operation permits resistance measurements the same as for the Operate mode. To select this mode set the FUNCTION switch to EXTERNAL OPERATE.

WARNING

When the FUNCTION Switch is set to EXTERNAL OPERATE the safety interlock feature is defeated. Therefore the bridge voltage (up to 1000 volts) is present at the Guard circuit at receptacle J303. The user should be cautious when using very high bridge voltages. For maximum safety, the Power Switch (S311) should be set to INT when not making a measurement.

c. Standardize/Calibrate. These modes of operation permit adjustment of the bridge elements to compensate for slight variations of the standard high megohm resistors. To select either mode set the FUNCTION Switch to STANDARDIZE or CALIBRATE as described in paragraph 2-4, d.

2-4. PRELIMINARY PROCEDURES.

a. Power.

1. Line Voltage. This instrument can be connected to 117 volt, 50-60 Hz line power when the Line Voltage Switch (on the rear panel) is set to 117V. The fuse should be a type 3AG, 1/4A, SLO-BLO. When using 234V power, set the Line Voltage Switch to 234V and replace fuse with a type 3AG, 1/8A, SLO-BLO.

2. Accessory Outlet. A three terminal power outlet (J301) is provided on the rear panel for operation of an accessory such as an external power supply. This outlet is wired to the line power cord and is not controlled by the Power Switch.

3. Power Cord. A three wire power cord is supplied (6 feet long). A third prong is used for earth ground connection for the chassis. An adapter is supplied for converting to a two prong outlet, but should only be used when a solid, earth-connection is made by some other means.

b. Meter Zero. The meter circuit can be zeroed by adjustment of COARSE ZERO and FINE ZERO Controls. The READ/METER ZERO Switch (S201) should be set to METER ZERO.

1. COARSE ZERO Switch (S102) (Outer Knob). This switch has eleven positions for adjustment of meter zero.

2. FINE ZERO Control (R120). This control provides fine (potentiometer) adjustment of the meter zero.

c. Warmup. The instrument should be allowed to stabilize with power on (at least 30 minutes). If the instrument has been exposed to an extreme ambient temperature change the warmup time should be extended to 24 hours or more.

d. Standardize Procedure. For critical measurements the instrument should be standardized prior to each measurement to compensate for slight changes of the standard high megohm resistors due to temperature variations and aging with time. The Standardize procedure should be performed as described in Table 2-1. A complete discussion of the Standardization technique is given in paragraph 2-5.

2-5. MEASUREMENT PROCEDURE.

a. Connect Unknown Resistance. Determine the method of connection to the unknown as discussed in paragraph 2-1.

b. Select the Bridge Potential. The minimum Bridge Potential should be determined for rated accuracy as stated in the specifications. The voltage can be applied internally (with Power Switch set to INT) or externally as described in paragraph 2-1.

c. Standardize Bridge. For measurements where the effects of variations of the bridge elements must be minimized, the Standardization procedure should be performed as described in paragraph 2-3, d.

d. Meter Zero. Adjust meter zero as necessary.

e. Bridge Balance. With the FUNCTION Switch set to OPERATE, proceed to balance the bridge (set the READ/ZERO Switch to READ). Increase the null sensitivity as necessary to obtain a precise bridge balance.

f. External Operate. If the unknown resistance is connected externally the FUNCTION Switch should be set to EXTERNAL OPERATE before bridge balance is attempted.

2-6. STANDARDIZE.

a. Purpose of Standardization Technique. Wirewound resistors have the greatest accuracy and keep their calibrations over long periods of time. Values greater than about one megohm, however, are too large and too expensive to be widely used. Film type resistors provide values up to 10^{12} ohms and higher with reasonable success and this type resistor is used in the Model 515A. But the value of these resistors changes with time, sometimes one percent per year. The Keithley Model 515A Megohm Bridge has been designed so that frequent compensations can be made for variations of its high-megohm standard resistors. This process is called Standardization and is carried out as in paragraph 2-4, d.

TABLE 2-1.
Standardization.

Step		Procedure	Multiplier Dial Setting (S302)	FUNCTION Switch Setting (S301)	Calibrate Control
A	Power On	Set Power Switch to INT.	-	-	-
B	Meter Zero	Set READ/ZERO Switch to ZERO and adjust FINE Control for meter zero.	-	-	-
C	Standardize	Set Controls as indicated. Set READ/ZERO Switch to READ and balance bridge using RESISTANCE decade dials. Increase sensitivity as necessary. Set READ/ZERO Switch to ZERO and go to next step.	10^6	STANDARDIZE	-
D	Calibrate	With bridge at balance set FUNCTION Switch to CALIBRATE. Adjust calibrate potentiometer for bridge rebalance with the READ/ZERO Switch set to READ. Set READ/ZERO Switch to ZERO.	10^6	CALIBRATE	10^6
E	Standardize	Set Controls as indicated. Set READ/ZERO Switch to READ and balance bridge using RESISTANCE decade dials. Increase sensitivity as necessary. Set READ/ZERO Switch to ZERO and go to next step.	10^7	STANDARDIZE	-
F	Calibrate	With bridge at balance set FUNCTION Switch to CALIBRATE. Adjust calibrate potentiometer for bridge rebalance with the READ/ZERO Switch set to READ. Set READ/ZERO Switch to ZERO.	10^7	CALIBRATE	10^7
G	Standardize	Set Controls as indicated. Set READ/ZERO Switch to READ and balance bridge using RESISTANCE decade dials. Increase sensitivity as necessary. Set READ/ZERO Switch to ZERO and go to next step.	10^8	STANDARDIZE	-
H	Calibrate	With bridge at balance set FUNCTION Switch to CALIBRATE. Adjust calibrate potentiometer for bridge rebalance with the READ/ZERO Switch set to READ. Set READ/ZERO Switch to ZERO.	10^8	CALIBRATE	10^8
I	Standardize	Set Controls as indicated. Set READ/ZERO Switch to READ and balance bridge using RESISTANCE decade dials. Increase sensitivity as necessary. Set READ/ZERO Switch to ZERO and go to next step.	10^9	STANDARDIZE	-
J	Calibrate	With bridge at balance set FUNCTION Switch to CALIBRATE. Adjust calibrate potentiometer for bridge rebalance with the READ/ZERO Switch set to READ. Set READ/ZERO Switch to ZERO.	10^9	CALIBRATE	10^9
K	Standardize	Set controls as indicated, with zero Bridge volts and X100 Resistance decade dial set to 10. Set READ/ZERO Switch to READ. Note offset of null detector after allowing time for stabilizing after switching FUNCTION Switch (10 - 15 minutes). This offset is due to offset current. Use this offset reading as null for Standardizing 10^{10}.	10^{10}	OPERATE	-
		Set controls as indicated. Set READ/ZERO Switch to READ and balance bridge using Resistance decade dials. Increase sensitivity as necessary. Set READ/ZERO Switch to ZERO and go to next step.	10^{10}	STANDARDIZE	-
L	Calibrate	Use null detector zero for null in CALIBRATE. With bridge at balance set FUNCTION Switch to CALIBRATE. Adjust calibrate potentiometer for bridge rebalance with the READ/ZERO Switch set to READ. Set READ/ ZERO Switch to ZERO.	10^{10}	CALIBRATE	10^{10}
M	Standardize	Set controls as indicated, with zero Bridge volts and X100 Resistance decade dial set to 10. Set READ/ZERO Switch to READ. Note offset of null detector after allowing time for stabilizing after switching FUNCTION Switch (10 - 15 minutes). This offset is due to offset current. Use this offset reading as null for Standardizing 10^{11}.	10^{11}	OPERATE	-
		Set controls as indicated. Set READ/ZERO Switch to READ and balance bridge using Resistance decade dials. Increase sensitivity as necessary. Set READ/ZERO Switch to ZERO and go to next step.	10^{11}	STANDARDIZE	-
N	Calibrate	Use null detector zero for null in CALIBRATE. With bridge at balance set FUNCTION Switch to CALIBRATE. Adjust calibrate potentiometer for bridge rebalance with the READ/ZERO Switch set to READ. Set READ/ ZERO Switch to ZERO. Set FUNCTION to OPERATE.	10^{11}	CALIBRATE	10^{11}

b. Description of circuit and technique.

1. A simplified bridge circuit with FUNCTION switch in STANDARDIZE is shown in Figure 9.

2. With Resistance Multiplier Switch set at 10^6, then the bridge null is obtained for the condition $S_6/S_7 = B_6/A$, where "S_6", "S_7", "B_6", and "A" are defined as follows:

"S_6" = Standard resistor (10^6 ohm, .02%) selected by resistance multiplier switch set at 10^6.

"S_7" = Standard resistor (10^7 ohm, 1.0%).

"B_6" = 10^5 ohm, .02%.

"A" = Resistance decade potentiometer adjusted for null (10^6 ohms).

NOTE
This technique is used to determine the ratio of "S_6" to "S_7" accurately as read by resistance decade dials.

3. A simplified bridge circuit with FUNCTION switch in CALIBRATE is shown in Figure 10

4. In the CALIBRATE position, a resistance ratio network of 1:10 is connected in place of "S_6" and "S_7". The bridge null is obtained for the condition $R = B_7/A$, where "R", "B_7", and "A" are defined as follows:

"R" = Ratio network of 1:10 with .005% accuracy.

"B_7" = Calibrate potentiometer.

"A" = Resistance decade potentiometer adjusted previously in b2.

NOTE
This technique is used to set the calibrate potentiometer "B_7" such that error in "S_7" is compensated.

5. A simplified bridge circuit with FUNCTION switch in OPERATE is shown in Figure 11.

6. In the OPERATE position, the bridge null is obtained for the condition $S_7/X = B_7/A$, when resistance decade potentiometer "A" is properly adjusted.

7. A simplified bridge circuit with FUNCTION switch in OPERATE and resistance multiplier 10^6 is shown in Figure 8.

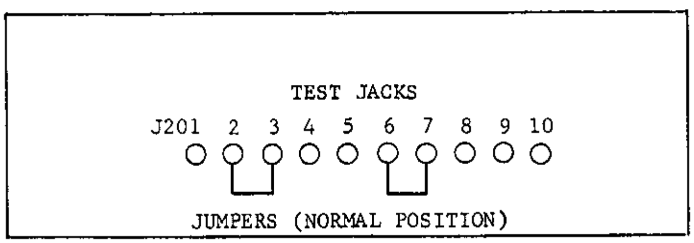


FIGURE 7. Test Jack Identification.

2-7. THEORY OF OPERATION.

a. Bridge Theory. The Megohm Bridge has been designed to measure very high resistances using a Wheatstone Bridge and a sensitive null detector. The Wheatstone Bridge circuit basically consists of four arms, identified as A, B, S, and X as shown in Figure 11. (A thorough discussion of bridge measurement is available in Electrical Measurement, F. K. Harris, Wiley, New York, 1952). The equation for the bridge at balance can be described by the equation:

$$X = S \times A/B$$

b. Null Detector Sensitivity. The sensitivity of the bridge can be described by the equation:

$$e = \frac{Sd}{(S+X)^2} \times E$$

e = sensitivity in volts
d = incremental unbalance (in terms of the unknown)
E = bridge potential
S = standard resistance
X = unknown resistance.

c. Voltage Across the Unknown. The Voltage across the unknown resistance can be determined for a given set of conditions where:

E = bridge potential (bridge volts setting)
S = standard resistance (multiplier setting)
X = unknown resistance (approximate value of the unknown)

$$V_X = \text{voltage across X} = E \frac{X}{X+S}$$

2-8. GUARD LEAKAGE CHECK.

The following procedure should be used to verify the guard to ground resistance. The test jacks are identified in Figure 7.

Procedure:

1. Connect power cord to line voltage.
2. Place jumpers between the following test jacks.
   J203 and J204
   J205 and J206
3. Set 515A controls as follows.

BRIDGE POWER	- EXT
MILLIVOLT PER DIVISION	- 1000
FUNCTION	- OPERATE
MULTIPLIER	- 10^5
READ/ZERO CHECK	- ZERO CHECK
X100 DIAL	- 1
DOOR	- CLOSED

4. Connect Keithley Model 240A Power Supply to EXTERNAL INPUT on the rear panel.
5. Set Model 240A to 1000 volts with OUTPUT to +.
6. Set READ/ZERO CHECK switch to READ.
7. Allow five minutes for the Model 515A reading to stabilize. Reading shall be less than 1000 mV.
   NOTE: The meter indicates the voltage drop across a 10^8 resistor in series with the leakage path. Leakage resistance from GUARD to GROUND is determined as follows.
   Leakage current = (Voltage drop ÷ 10^8 ohms)
   Leakage resistance = (1000V ÷ leakage current)
   Typical GUARD to GROUND resistance is greater than 10^{11} ohms.

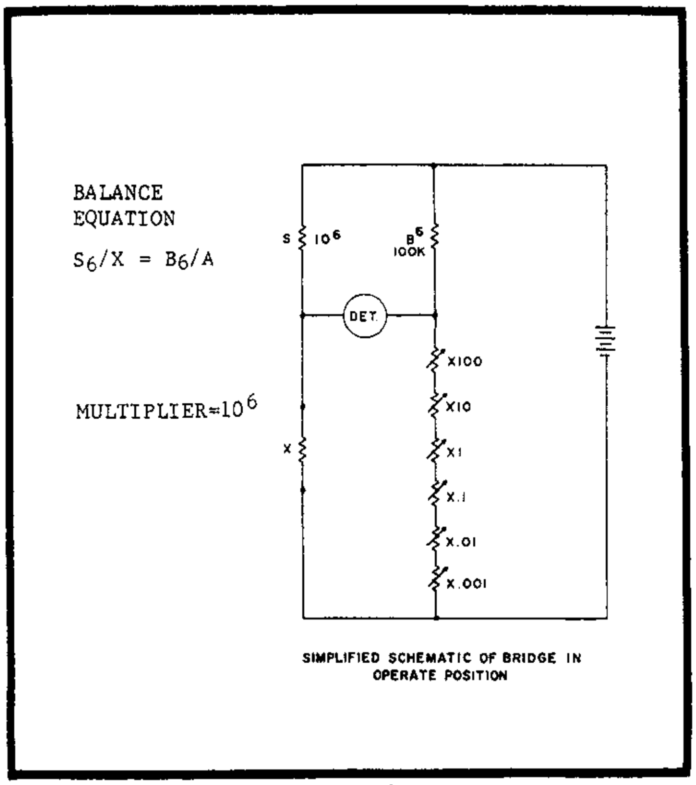


FIGURE 8.

Operate Position, 10^6 Multiplier.

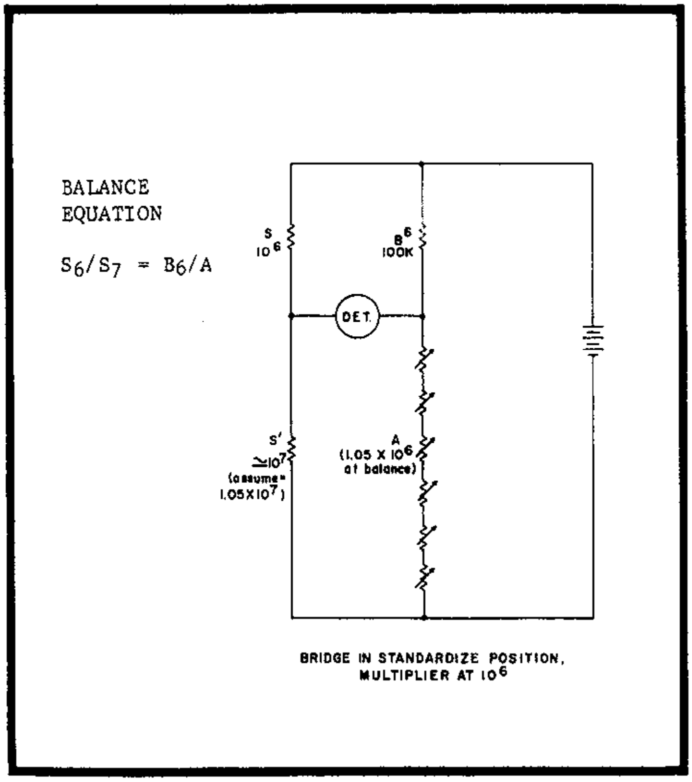


FIGURE 9.

Standardize Position, 10^6 Multiplier.

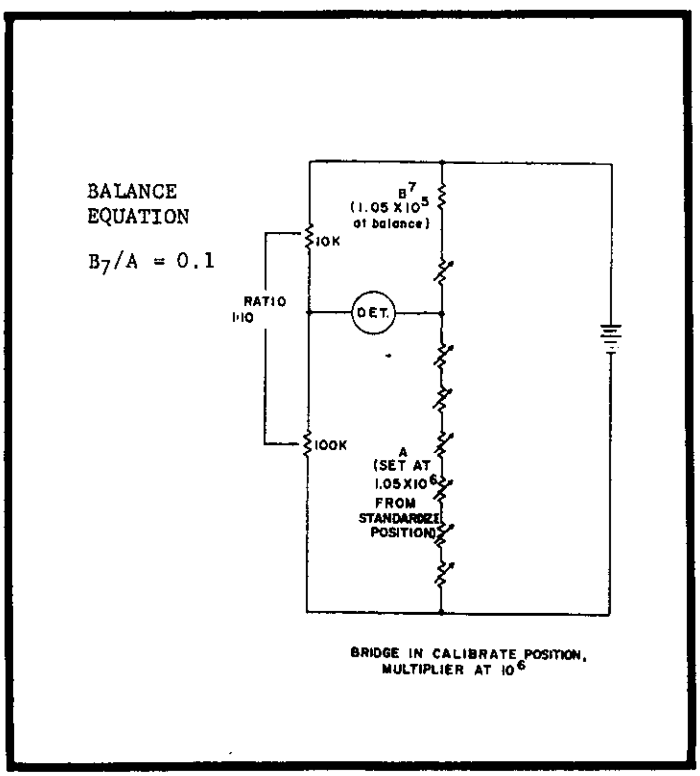


FIGURE 10.

Calibrate Position, 10^6 Multiplier.

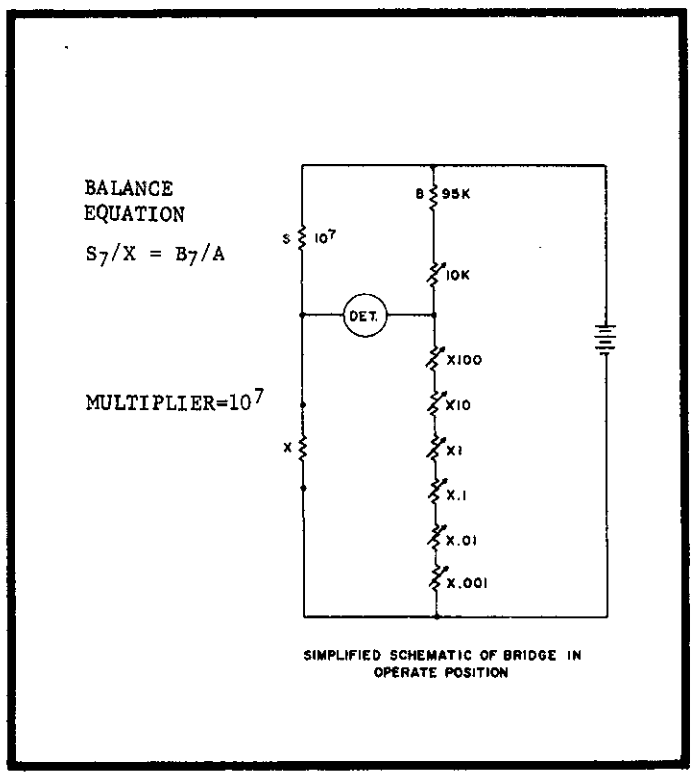


FIGURE 11.

Operate Position, 10^7 Multiplier.

2-9. ACCURACY CONSIDERATIONS.

a. Standard Deviation. The overall accuracy of the bridge given in the Specifications is defined as the "standard deviation" or 1σ-level. In a system where several components of error make up the total error, it is grossly unfair (when specifying the system) to use worst-case limits in describing accuracy. In many cases, the error so described may have a probability of less than one in a billion while human error (usually neglected in such an analysis) can easily contribute gross errors on the order of one in a thousand. It is far more reasonable to use a limit between one in a thousand (99.9% or 3.3) and one in ten thousand (99.99% or 3.9) as a specification of system accuracy. If the 3σ limits of two or more normally distributed ( ) randomly occurring components of error are summed in quadrature ($\sqrt{e_1^2 + e_2^2 \cdots}$) the sum is the 3σ error for the group. If three uniformly distributed ( ) randomly occurring components of error have equal limits, the arithmetic sum of these limits will closely represent the 3σ points of the near normal error distribution generated by the interaction of these error components. These 3σ limits may then be used to sum in quadrature with the 3σ limits of other normally distributed error components. The effect of error components which are not randomly distributed but are fixed or have a fixed rate of change (systematic errors) must be added directly to the random errors. If one component of error occurs more than once and does not have random change to have changed, it must be summed directly for the number of times occurred before being added in quadrature to other errors.

b. Error Analysis. The various factors which can be identified as sources of error include the following.

1. Bridge Arm. The errors pertaining to the bridge arm consist of the decade dial errors and the fixed arm to decade arm ratio.

a.) Decade Dial. The decade dial errors include the worst case dial setting within the decade span used, the inherent resistor error, the temperature and time stability of the resistors, and the effect of leakage resistance.

TABLE 2-2.
3σ Error Computation.

(All numbers in % of Reading with minimum bridge potential specified and dials between 1 and 10).

Range ohms	Zero Check	Null	Temp. Coef.	Laddering: Volt Coef.	Laddering: Temp. Coef.	Laddering: Null	Laddering: R_a/R_b	Bridge Arms	Leakage	Total Error %	Minimum Bridge Potential
10^5 - 10^7	.006	.006	-	-	-	-	-	.03	.001	.031	10
10^7 - 10^8	.006	.006	.02	.04	.002	.009	.005	.03	.001	.056	10
10^8 - 10^9	.006	.006	.03	.08	.004	.012	.010	.03	.001	.085	10
10^9 - 10^{10}	.006	.012	.03	.16	.006	.015	.015	.03	.001	.17	10
10^{10} - 10^{11}	.006	.012	.04	.24	.010	.020	.020	.03	.001	.25	10
10^{11} - 10^{12}	.006	.03	.05	.48	.022	.024	.025	.03	.001	.49	10
10^{12} - 10^{13}	.006	.12	.07	.72	.064	.04	.030	.03	.001	.74	100
10^{13} - 10^{14}	.006	.24	.07	.72	.064	.04	.030	.03	.01	.77	500 *
10^{14} - 10^{15}	.06	0.6	.07	.72	.064	.04	.030	.03	0.1	1.1	500 *

* To obtain this accuracy specification an external voltage supply is required. Accuracy (3σ) for 10^{15} range would be $\pm$ 6% at a bridge potential of 110 V.

b.) Fixed arm to decade arm ratio. The errors associated with the ratio accuracy include the basic Standard resistance error, the accumulative laddering error and the temperature and voltage coefficient of the Standard resistor.

2. Null Uncertainty. The errors pertaining to null uncertainty include the null detector sensitivity, the bridge voltage, the bridge ratio, and the 1/f noise.

c. Error Computation. The computation of total error at the 3σ-level is shown in Table 2-2 for each range.

NOTE

The assumptions made to simplify the error analysis include the following. 1. All individual resistors are within their tolerance limits and have a uniform random distribution between these limits. 2. The temperature coefficient and voltage coefficient on wirewound resistors are negligible in the face of other errors. 3. Peak-to-peak null detector meter excursions observed over several time constants represent the $\pm 3\sigma$ limit of a normally distributed random null certainty.

d. Error Factors.

1. Worst Case Dial Setting. For the "optimum-use range" between 1.0000 to 9.9999, the worst case dial setting would be 1.0999. Since each dial setting of 9 represents 3 resistors, the total contribution of dial settings .0999 would be:

$$3\sigma \text{ error} = \sqrt{(.005)^2+(.0025)^2+(.001)^2} \doteq \pm.006\%.$$

If this error is added to the base tolerance of .01% and divided by the higher resistor value (1.0999), the result is:

$$\% \text{ error} = \frac{.016}{1.0999} \doteq .015\%$$

If this error is separated into components, then the uniformly distributed error = .01% while the normally distributed error = .005%.

2. Resistor Accuracy. The resistor accuracy for the various dials is given in Table 2-3.

TABLE 2-3.
Dial Resistor Accuracy.

Dial Resistance	X100	10	1	.1	.01	.001	.0001
Tolerance	.5%	.01%	.01%	.01%	.05%	.25%	1%

3. Temperature Coefficient. The temperature coefficients for the Standard resistors are given in Table 2-4 (assuming a $\pm.5^{\circ}$C temperature).

TABLE 2-4.
Temperature Coefficient for Resistors (±%).

Resistance	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}
Coefficient	.00	.00	.02	.03	.03	.04	.05	.07

4. Leakage Resistance. Leakage causes an error since the Readout Dials are shunted by approximately 10^{11} ohms. The error should be added directly since it is a relatively fixed systematic error.

5. Voltage Coefficient. The voltage coefficient for each Standard resistor is given in Table 2-5.

TABLE 2-5.
Voltage Coefficient (1-10V)/V. in %.

Resistance	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}
Coefficient	-.005	-.005	-.01	-.01	-.03	-.03

6. Null Resolution. Null uncertainty is approximately the ratio of the smallest voltage drop across the bridge arm to the null resolution. As the bridge ratio departs from 1:1 the null uncertainty becomes more significant.

$$\text{Error} = \frac{\text{Null Resolution}}{\text{Bridge Voltage}} \times \left[2 + \left(\frac{1}{\text{Ratio}}\right) + (\text{Ratio})\right]$$

Table 2-6 gives the null uncertainty for the case where the ratio is 10:1 and the bridge voltage is 10V. (100:1 @ 100V for 10^{14} range and 1000:1 @ 500V for 10^{15} range).

7. Laddering. Laddering is the process of using the bridge to calibrate itself. Several errors compound during this process to increase the error of the bridge at higher resistances. The process consists of two modes: STANDARDIZE and CALIBRATE.

In CALIBRATE Mode: $\frac{R^6}{R^7} = \frac{B^6}{D}$

where R^6 is the 10^6 miltiplier ($\pm$0.01%) and R^7 is the 10^7 multiplier resistor ($\pm$0.01%), B^6 is the "fixed" arm associated with the 10^6 multiplier and D is the dial setting.

In STANDARDIZE Mode: $\frac{R_a}{R_b} = \frac{B^7}{D}$

where R_a/R_b is the 1:10 ratio pair ($\pm$0.005%) and B^7 is the "fixed" arm associated with the 10^7 multiplier (adjusted for proper ratio).

Thus, $B^7 = \frac{B^6}{R^6}\left(\frac{R_a}{R_b}\right)$ at the end of the first laddering. The dial accuracy drops from consideration and only 3 resistive error factors are included, B^6, R^6 and R_a/R_b. In addition, a nulling uncertainty at 10^6 and a nulling uncertainty at low impedance (use 0.006%) must be included.

It can be shown that further nullings give

$$\frac{B^8}{R^8} = \frac{B^6}{R^6}\left(\frac{R_a}{R_b}\right)\left(\frac{R_a}{R_b}\right)$$

thus adding one more R_a/R_b uncertainty, one more low impedance null uncertainty and an additional null uncertainty at 10^7 ohms. The voltage across

TABLE 2-6.

Null Uncertainty-Null Detector Resolution.

Range	10^5 to 10^6	10^6 to 10^7	10^7 to 10^8	10^8 to 10^9	10^9 to 10^{10}	10^{10} to 10^{11}	10^{11} to 10^{12}	10^{12} to 10^{13}	10^{13} to 10^{14}	10^{14} to 10^{15}
% Error	.006	.006	.006	.006	.012	.012	.03	.12	.24	.6
N.D. Resolution $\pm$ mV *	.05	.05	.05	.05	.10	.10	.25	1.0	-	-

* With a 10V bridge potential.

the hi-meg changes from about 10 volts in "STANDARDIZE" position to about 1 volt in the next "CALIBRATE" position. Since the voltage coefficient is always negative, these errors must be added together prior to the summing procedure in quadrature with other random variable. The effect of voltage coefficient need only be accounted for one time. Table 2-7 shows the sum of the voltage coefficient errors on each range during laddering. For laddering the measurement time can be assumed short with respect to internal temperature changes. (The thermal time constant for the Model 515A is about 10 minutes). Table 2-8 shows the total error for temperature changes.

TABLE 2-7.
Voltage Coefficient Errors.

Range	VC/V	V	VC Error	VC Error
10^7 - 10^8	.005	8V	.04	.04
10^8 - 10^9	.005	8V	.04	.08
10^9 - 10^{10}	.01	8V	.08	.16
10^{10} - 10^{11}	.01	8V	.08	.24
10^{11} - 10^{12}	.03	8V	.24	.48
10^{12} - 10^{13}	.03	8V	.24	.72

TABLE 2-8.
Temperature Errors During Laddering.

Range	Time to Calibrate	Temp. Change	TC	Total Error	TC *
10^7	1 min	0.05°C	.04	.002%	.002
10^8	1 min	0.05°C	.06	.003%	.004
10^9	1 min	0.05°C	.07	.0035%	.006
10^{10}	2 min	0.1°C	.08	.008%	.010
10^{11}	5 min	0.2°C	.10	.02%	.022
10^{12}	10 min	0.4°C	.15	.06%	.064

* TC represents the "root square sum" or total error for each range due to temperature coefficient errors during laddering.

TABLE 2-9.
Total Laddering Error.

Range	VC (a)	TC (a)	Lo Z nulls	Hi Z nulls	nulls (a)	B^6/R^6 (b)	R_a/R_b		R_a/R_b (a) (c)
10^7	.04	.002	1x.006%	.006	=.009	2x.01	1x.005	=	.005
10^8	.08	.004	2x.006	2x.006	=.012	2x.01	2x.005	=	.010
10^9	.16	.006	3x.006	3x.006	=.015	2x.01	3x.005	=	.015
10^{10}	.24	.010	4x.006	3x.006-.012	=.020	2x.01	4x.005	=	.020
10^{11}	.48	.022	5x.006	3x.006-2x.012	=.024	2x.01	5x.005	=	.025
10^{12}	.72	.064	6x.006	3x.006-2x.012-.03	=.040	2x.01	6x.005	=	.030

(a) Normal Distribution.
(b) Uniform Distribution.
(c) R_a/R_b will not change so addition of subsequent errors is direct, not in quadrature.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Model 515A comprises a solid-state, guarded, electrometer null detector; an ultra-stable, highly-regulated dc voltage source, and a Wheatstone Bridge.

3-2. NULL DETECTOR. A simplified diagram of the null detector circuit is shown in Figure 12. The null detector utilizes a Keithley Model 302 Electrometer Amplifier and a 3 μA/division meter (M101). Power is supplied by ±12 volt regulated supplies. (See paragraph 3-4.) The Sensitivity Switch (S103) has five positions which provide sensitivity from 1000 mV/division to 0.1 mV/division. The meter will indicate a center scale (zero) if there is no potential across the Sensitivity Switch resistors. With switch S201 set to ZERO CHECK, any offset indicated by the meter is due to the Model 302 offset voltage. By use of the COARSE (S102) and FINE (R120) zero controls the meter can be adjusted for center scale indication (thus the zero controls can be used to compensate for amplifier offset). With switch S201 set to READ, the potential difference between High and Low causes a current flow through the meter. A voltage is developed across the sensitivity resistor such that $I_M = e/R_S$, where I_M = meter current, R_S = sensitivity resistor and e = unbalance potential. Resistor R102, in series with the meter, and diodes D103 and D104 are used to obtain a non-linear meter response beyond five divisions. The voltage developed across R102 will forward bias either diode so that diode conduction occurs. The current is shunted around meter thus giving a logarithmic meter sensitivity. The null detector "Driven Guard" is the Common of the ±12 volt supplies. The ac potential of the "Driven Guard" follows the ac potential of the input High so that guarding of the input High can be used.

3-3. WHEATSTONE BRIDGE. The bridge circuit utilizes four resistance arms identified as Standard Resistor Arm "S", Unknown Resistor Arm "X", Calibrated Resistance Arm "C", and Read-out Resistance Arm "A".

a. Standard Resistor Arm. The Standard resistors R304 through R311 are connected to the Multiplier Switch S302. Resistors R304 and R305 are 0.01% wire-wound types; resistors R306 and R307 are 1% deposited carbon types; resistors R308 through R311 are specially selected High-Meg types. A 10:1 (.005%) ratio divider composed of R301 and R302 is used in the Standardization procedure. (See paragraph 2-4).

b. Unknown Resistor Arm. The unknown resistance "X" is connected at the Input connector (J302 or J303).

c. Calibrated Resistance Arm. The calibrated resistance arm consists of a 94.5 kilohm, 1% deposited carbon type in series with a 10 kilohm, wirewound variable resistor. Resistors R313 through R318 and potentiometers R319 through R324 are connected to the Multiplier Switch S302. The Calibration potentiometers can be adjusted during the Standardization procedure and are accessible on the front panel (inside the shielded enclosure).

d. Readout Resistance Arm. The Readout Arm is composed of Resistance Dials S304 through S310.

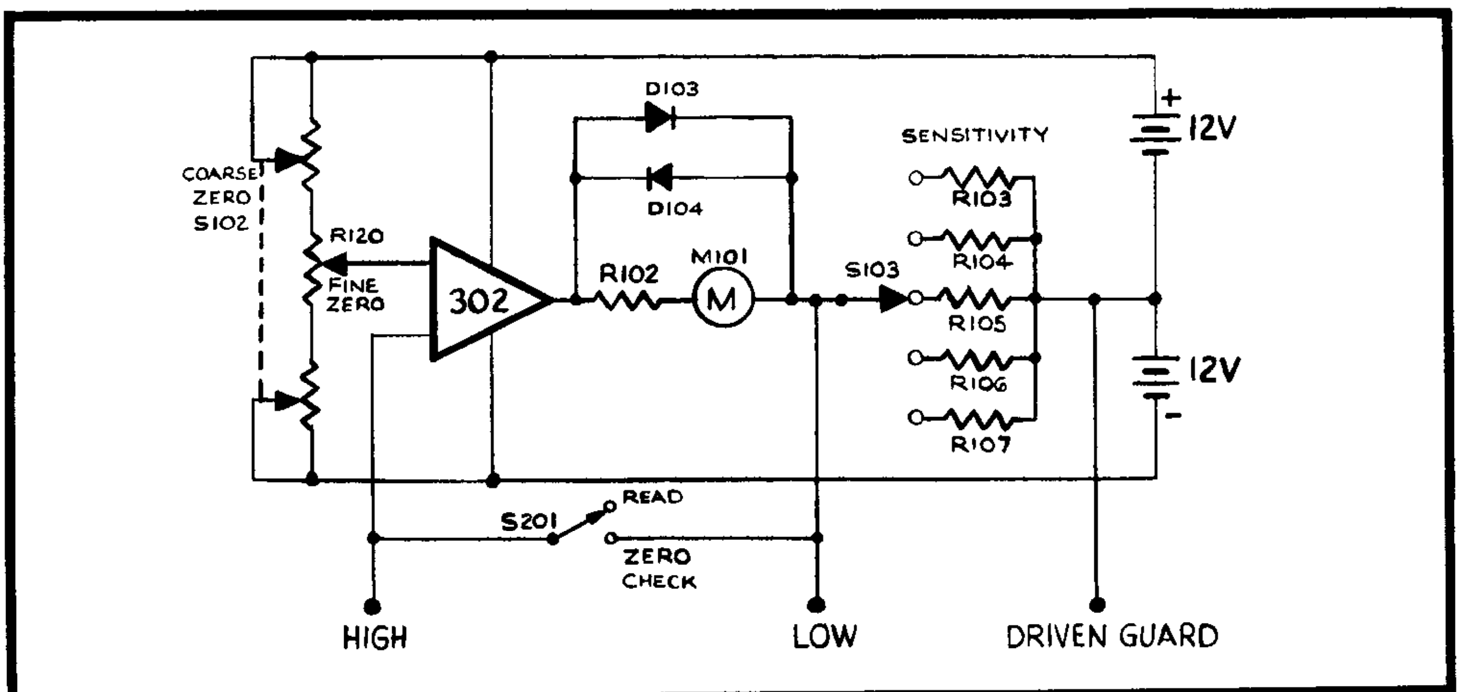


FIGURE 12. Null Detector.

3-4. POWER SUPPLY. The power supply consists of a series regulated supply for Bridge Voltage and a floating ±12 V supply for the null detector circuitry. T201 is the power transformer operating from power line, switch selectable for 117V-234V operation. One secondary is center-tapped and supplies a floating plus and minus voltage for the regulator amplifier. This secondary also drives the isolation transformer T101. The other secondary is full wave rectified to supply the unregulated voltage to series pass transistor Q206. Q201 and Q202 form a difference amplifier which compares the regulated output voltage to a reference voltage supplied by D203 in a resistance programmable power supply with the Bridge volts Adjustment setting a lma current thru the reference divider string. Q203 and Q204 are used as amplifier and driver for Q206, correcting for any change in load current or line voltage. The secondary of T101 is center-tapped and full-wave rectified to supply unregulated plus and minus voltage to Q101 and Q102 respectively which supply a constant load current. Zener diodes D103 and D104 set the null detector supply voltages to a nominal ±12 volts respectively. T101 is especially well insulated to provide the necessary insulation of guard to ground in the bridge circuit.

3-5. OVER-VOLTAGE PROTECTION CIRCUIT. The Model 515A utilizes a zener diode (D301) to prevent damage to the readout resistors (X1 and lower) from excessive bridge voltage from an external voltage source. The diode is connected (through auxiliary contacts on the X100 and X10 dials) across the bridge voltage terminals when in External Voltage mode only. Thus if both dials are set to zero the diode is directly across the bridge. For an external voltage greater than 100 volts, the zener will conduct. When using a current-limited voltage supply (such as Keithley Models 240A or 241) the diode will limit the voltage to 100 volts and prevent over-heating of the Dial resistors.

WARNING

If the voltage supply used does not have current limiting (10 mA approximately), the zener protection diode could be overheated causing possible damage to the Dial resistors.

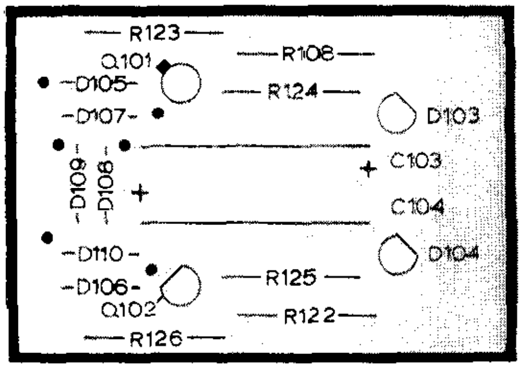


FIGURE 13. Null Detector, PC-233.

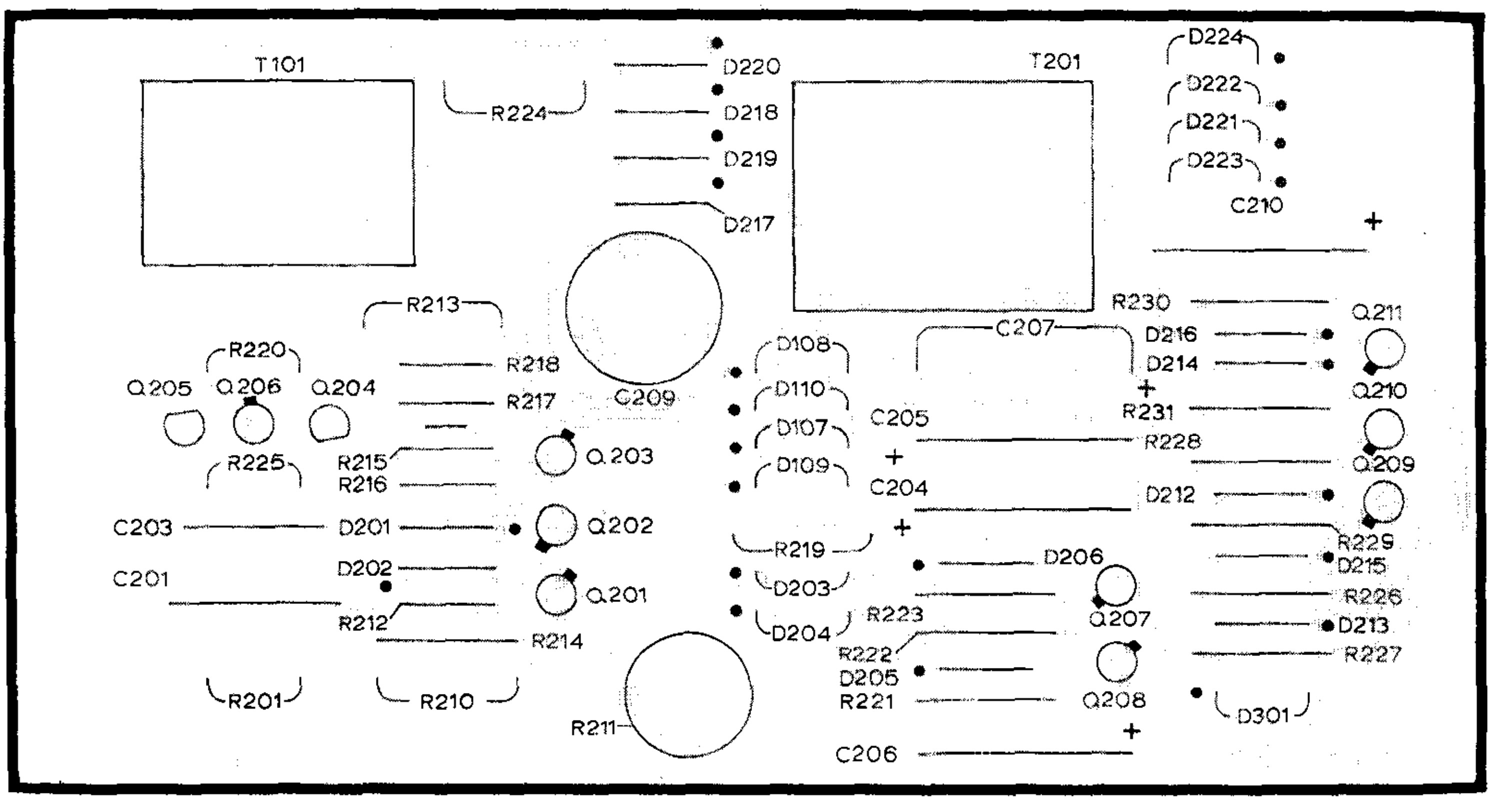


FIGURE 14. Bridge Voltage Supply, PC-244.

SECTION 4. ACCESSORIES

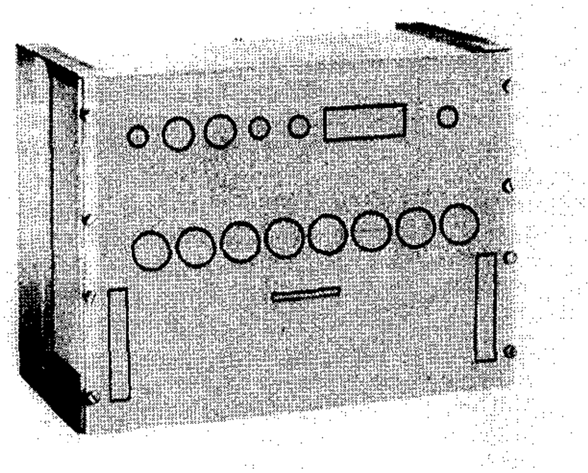
4-1. GENERAL. The following Keithley accessories can be used with the Model 515A to provide additional convenience and versatility.

4-2. OPERATING INSTRUCTIONS. A separate Instruction Manual is supplied with each accessory giving complete operating information.

Model 5151 End Frames

Description:

The Model 5151 is a bench mounting kit. The end frames provide convenience when carrying the instrument.



Model 5153 Triaxial Cable

Description:

The Model 5153 is a triaxial cable 60" long which mates with the EXT. INPUT connector on the Model 515A.

Application:

The Model 5153 can be used for external measurements which require a shielded and guarded cable.

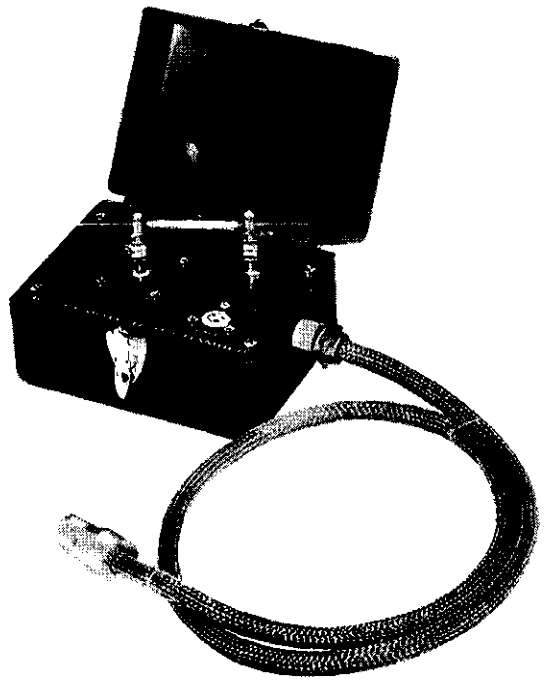
Model 5152 Remote Test Chamber

Description:

The Model 5152 is a shielded test chamber for remote resistance measurements. A 60 inch triaxial cable is provided.

Application:

The Model 5152 can be used for resistance measurements when the self-contained test compartment on the Model 515A is not useable. A separate GUARD terminal is provided on the Test Chamber.



Model 241 Regulated High Voltage Supply

Description:

The Model 241 is a very stable, accurate high voltage power supply especially useful as a laboratory reference.

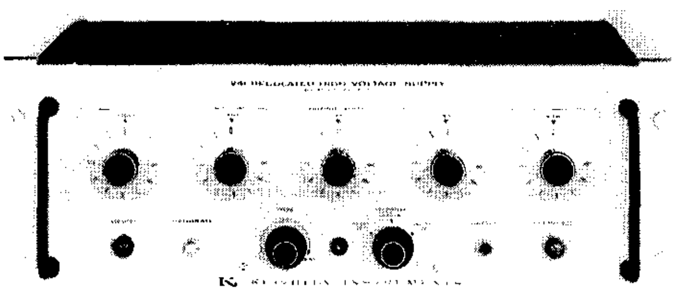
Application:

The Model 241 can be used as an external voltage supply for the Model 515A when applications require a bridge potential from 110V to 1000V. The Model 241 can be easily rack mounted with the Model 515A by use of the Model 5154 Cabinet.

Specifications:

OUTPUT:
- Voltage: 0 to 1000 volts dc in 0.01-volt steps.
- Current: 20 milliamperes dc maximum.
- Polarity: Positive or negative.
- Floating: 50 volts maximum off chassis ground.

ACCURACY: ±0.05% of dial setting or ±1 millivolt, whichever is greater.
RESOLUTION: A "Trim" potentiometer permits interpolation between steps with a resolution of better than 100 microvolts.
RESETABILITY: ±0.025%.
STABILITY: ±0.005% per hour with constant load, line and ambient temperature.
TEMPERATURE COEFFICIENT OF REFERENCE: ±10 ppm/°C.
LINE REGULATION: ±0.005% or 1 millivolt for 10% line change.
LOAD REGULATION: ±0.005% from no load to full load.
RIPPLE AND NOISE: Less than 1 millivolt rms above 5 Hz.
OUTPUT IMPEDANCE: Less than 0.05 ohm at dc.
RECOVERY TIME: No load to full load, less than 1 second to rated accuracy.
OVERLOAD PROTECTION: Output is disconnected within 50 milliseconds if current exceeds approximately 24 milliamperes.
CONNECTORS: Output: Teflon-insulated type UHF type.
POWER: 105-125 or 210-250 volts, 50-60 Hz, 105 watts.
DIMENSIONS, WEIGHT: 7" high x 19" wide x 12" deep, net weight, 26 pounds.
ACCESSORIES SUPPLIED: Mating connectors.



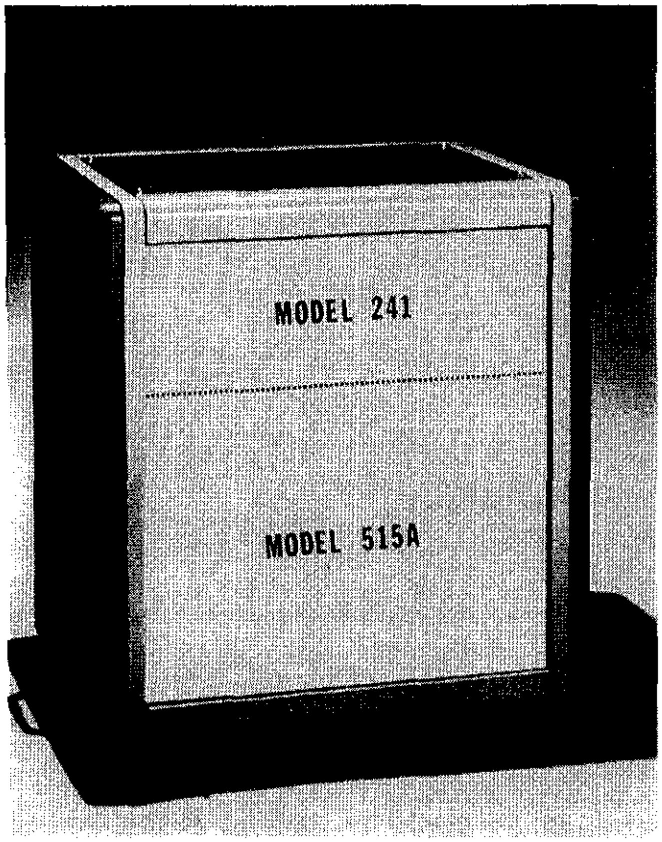
Model 5154 Cabinet

Description:

The Model 5154 is a rack style cabinet with dimensions 25" high x 21" wide x 16-1/2" deep.

Application:

The Model 5154 can be used to rack mount the Model 515A with an auxilliary power supply such as the Keithley Model 241.



Parts List:

Item No.	Description	Part No.
1	Cabinet	14343C
2	Panel, Blank	14203B
3	Cable, UHF-UHF	16639B

Model 5155 High Megohm Resistance Standards

Description:

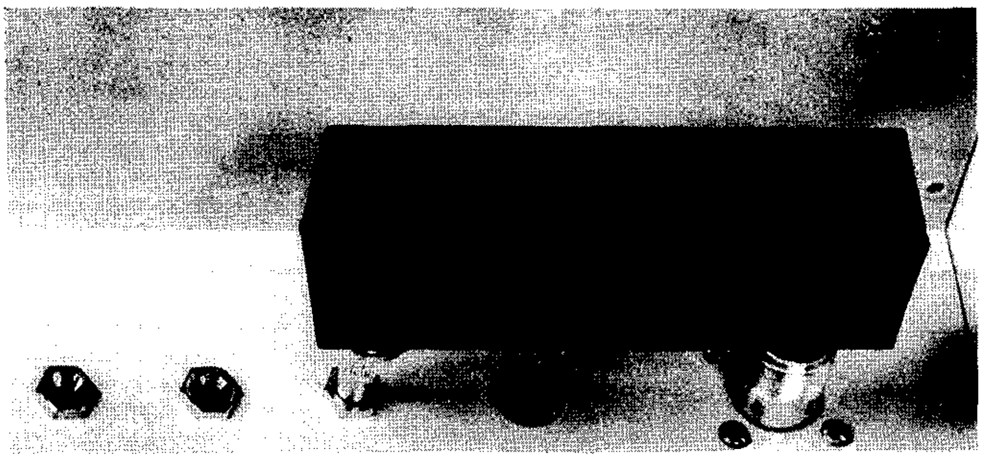
The Model 5155 has been developed to verify the calibration of the Keithley 515A Megohm Bridge with traceability to the National Bureau of Standards. These units are convenient to use, since they plug directly into the 515A. The 5155 consists of six individually encased high megohm resistors with values of 10^8 through 10^{13} ohms in decade steps. A certificate is included showing the actual value of each resistor with an accuracy limited by the maximum accuracy certified by National Bureau of Standards. Each resistor's temperature coefficient, voltage coefficient and history of measured values is also given.

Specifications:

RESISTOR VALUES: Six resistors 10^8, 10^9, 10^{10}, 10^{11}, 10^{12}, 10^{13} ohms $\pm 15\%$.
ACCURACY: $\pm 0.2\%$ of certified value except 10^{13} ohms which is $\pm 0.5\%$ (relative to N.B.S. certified standards).
STABILITY: Less than $\pm 0.1\%$ change in value per thousand hours.
VOLTAGE COEFFICIENT: -.03% per volt, nominal.
TEMPERATURE COEFFICIENT: -0.1% per $^{\circ}C$, nominal.
GUARDING: Case is at guard potential when the resistor Standard is used in a Keithley Model 515A Megohm Bridge.
INSULATION: Teflon.

DIMENSIONS: Each resistor standard is 4" long x 2" deep x 1" wide.
WEIGHT: Each resistor Standard is approximately 6 ounces. Six Standards in carrying case, 3-1/2 lbs.
SERVICE AVAILABLE: Recertification traceable to National Bureau of Standards.

Resistor Installation:



SECTION 5. REPLACEABLE PARTS

5-1. REPLACEABLE PARTS LIST: This section contains a list of componenets used in this instrument for user reference. The Replaceable Parts List describes the individual parts giving Circuit Designation, Description, Suggested Manufacturer (Code Number), Manufacturer's Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable. The complete name and address of each Manufacturer is listed in the CODE-TO-NAME Listing following the parts list.

TABLE 5-1.
Abbreviations and Symbols

A	ampere	F	farad	Ω	ohm
		Fig	Figure		
CbVar	Carbon Variable			p	pico (10^{-12})
CerD	Ceramic Disc	GCb	Glass enclosed Carbon	PC	Printed Circuit
Cer Trimmer	Ceramic Trimmer			Poly	Polystyrene
Comp	Composition	k	kilo (10^3)		
				Ref.	Reference
DCb	Deposited Carbon	μ	micro (10^{-6})		
Desig.	Designation			TCu	Tinner Copperweld
		M	Meg (10^6)		
EAL	Electrolytic, Aluminum	Mfr.	Manufacturer	V	volt
ETB	Electrolytic, tubular	MtF	Metal Film		
ETT	Electrolytic, tantalum	My	Mylar	W	watt
				WW	Wirewound
		No.	Number	WWVar	Wirewound Variable

5-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as discussed in Section 3. Table 5-2 identifies all schematic part numbers included.

5-3. HOW TO USE THE REPLACEABLE PARTS LIST. This Parts List is arranged such that the individual types of components are listed in alphabetical order. Main Chassis parts are listed followed by printed circuit boards and other subassemblies.

5-4. HOW TO ORDER PARTS.

a. Replaceable parts may be ordered through the Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

b. When ordering parts, include the following information.

1. Instrument Model Number.
2. Instrument Serial Number.
3. Part Description.
4. Schematic Circuit Designation.
5. Keithley Part Number.

c. All parts listed are maintained in Keithley Spare Parts Stock. Any part not listed can be made available upon request. Parts identified by the Keithley Manufacturing Code Number 80164 should be ordered directly from Keithley Instruments, Inc.

TABLE 5-2.

Description	Circuit Designation	Schematic
Megohm Bridge	PC-233, PC-244	24820E

NULL DETECTOR PARTS LIST
(PC-233)
CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C101	.02 µF	1000 V	CerD	56289	10SS-S20	C64-.02M	-
C102	Not Used	--	--	--	--	--	-
C103	100 µF	40	EAL	73445	C437AR/G100	C150-100M	13
C104	100 µF	40	EAL	73445	C437AR/G100	C150-100M	13

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D101	Transistor, NPN, Case TO-106	07263	2N3565	TG-39	-
D102	Transistor, NPN, Case TO-106	07263	2N3565	TG-39	-
D103	Silicon	01295	1N645	RF-14	13
D104	Silicon	01295	1N645	RF-14	13
D105	Zener	12954	1N706	DZ-1	13
D106	Zener	12954	1N706	DZ-1	13
D107	Silicon	01295	1N645	RF-14	13
D108	Silicon	01295	1N645	RF-14	13
D109	Silicon	01295	1N645	RF-14	13
D110	Silicon	01295	1N645	RF-14	13
D111	(TG-39*) Transistor, NPN, Case TO-106	07263	2N3565	24220A*	-
D112	(TG-39*) Transistor, NPN, Case TO-106	07263	2N3565	24220A*	-

*Selected. Order from factory.

MISCELLANEOUS PARTS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
T101	Transformer	80164	---	TR-121	14
M101	Meter	80164	---	ME-86	-
S102	Rotary Switch, COARSE ZERO	---	---	SW-294	-
S103	Rotary Switch, Null Detector Sensivity	---	---	SW-292	-
P101	Connector, Male, 15 Pins	27264	1625-15P	CS-227	-
J101	Connector, Female, 15 Pins	27264	1625-15R	CS-228	-
J102	Connector, Female, 15 Pins	27264	1625-15R	CS-228	-
P102	Connector, Male, 15 Pins	27264	1625-15P	CS-227	-

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R101	10 MΩ	10%, 1/2 W	Comp	01121	EB-10M	R1-10M	-
R102	12.1 kΩ	1%, 1/8 W	MtF	07716	CEA-12.1kΩ-1%	R88-12.1K	-
R103	333 kΩ	1%, 1/2 W	MtF	07716	CEC-333kΩ-1%	R94-333K	-
R104	33.3 kΩ	1%, 1/2 W	MtF	07716	CEC-33.3kΩ-1%	R94-33.3K	-
R105	3.33 kΩ	1%, 1/2 W	MtF	07716	CEC-3.33kΩ-1%	R94-3.33K	-

RESISTORS (cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R106	33.3 Ω	1%, 1/2 W	MtF	07716	CEC-33.3kΩ	R94-33.3K	-
R107	33.3 Ω	1%, 1/2 W	MtF	07716	CEC-33.3kΩ	R94-33.3K	-
R108	2.7 kΩ*	1%, 1/2 W	DCb	91637	DCF-1/2-2.7kΩ	R12-2.7K	13
R109	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R110	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R111	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R112	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R113	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R114	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R115	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R116	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R117	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R118	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R119	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	-
R120	10 kΩ	5%, 2 W	WWVar	12697	62JA-10kΩ	RP42-10K	-
R121	4.7 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-4.7kΩ	R12-4.7K	-
R122	2.7 kΩ*	1%, 1/2 W	DCb	91637	DCF-1/2-2.7kΩ	R12-2.7K	13
R123	700 Ω	1%, 1/2 W	DCb	91637	DCF-1/2-700Ω	R12-700	13
R124	4.99 kΩ	1%, 1/2 W	MtF	07716	CEC-4.99kΩ	R94-4.99K	13
R125	4.99 kΩ	1%, 1/2 W	MtF	07716	CEC-4.99kΩ	R94-4.99K	13
R126	700 Ω	1%, 1/2 W	DCb	91637	DCF-1/2-700Ω	R12-700	13
R127	15k Ω	1%, 1/8 W	MtF	07716	CEA-15k-1%	R88-15K	-

*Nominal value, selected in final test.

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q101	PNP, Case R-110	07263	S17638	TG-33	13
Q102	NPN, Case TO-106	07263	2N3565	TG-39	13

BRIDGE VOLTAGE SUPPLY PARTS LIST
(PC-244)
CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C201	0.5 μF	400 V	My	13050	SM1A-0.5μF	C117-.5M	14
C202	.0015 μF	600 V	CerD	72982	ED-.0015	C22-.0015M	14
C203	0.1 μF	400 V	My	13050	SM1A-0.1μF	C73-.1M	14
C204	100 μF	40 V	EAL	73445	C437AR/G100	C150-100M	14
C205	100 μF	40 V	EAL	73445	C437AR/G100	C150-100M	14
C206	100 μF	40 V	EAL	73445	C437AR/G100	C150-100M	14
C207	100 μF	40 V	EAL	73445	C437AR/G100	C150-100M	14
C208	Not Used						
C209	20 μF	450 V	EMC	37942	FP144-20μF	C36-20M	14
C210	100 μF	40 V	EAL	73445	C437AR/G100	C150-100M	14
C211	0.047 μF	100 V	Poly	-	MW9410473	C67-0.047M	-

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D201	Silicon	02735	1N3255	RF-17	14
D202	Silicon	02735	1N3255	RF-17	14
D203	Zener	04713	1N936	DZ-5	14
D204	Zener	12954	1N718	DZ-18	14
D205	Zener	12954	1N706	DZ-1	14
D206	Zener	12954	1N718	DZ-18	14
D207	Silicon	01295	1N645	RF-14	14
D208	Silicon	01295	1N645	RF-14	14
D209	Silicon	01295	1N645	RF-14	14
D210	Silicon	01295	1N645	RF-14	14
D211	Not Used	--	--	--	-
D212	Silicon	01295	1N645	RF-14	14
D213	Silicon	01295	1N645	RF-14	14
D214	Silicon	01295	1N645	RF-14	14
D215	Zener	12954	1N723	DZ-17	14
D216	Zener	12954	1N723	DZ-17	14
D217	Silicon	02735	1N3255	RF-17	14
D218	Silicon	02735	1N3255	RF-17	14
D219	Silicon	02735	1N3255	RF-17	14
D220	Silicon	02735	1N3255	RF-17	14
D221	Silicon	01295	1N645	RF-14	14
D222	Silicon	01295	1N645	RF-14	14
D223	Silicon	01295	1N645	RF-14	14
D224	Silicon	01295	1N645	RF-14	14

MISCELLANEOUS PARTS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
J211	Receptacle, UHF	91737	6804	CS-64	-
S201	Toggle Switch, ZERO CHECK	80164	---	SW-236	2
J201	Test Jack	71279	4352-1-0319	TJ-9	3
J202	Test Jack	71279	4352-1-0319	TJ-9	3
J203	Test Jack	71279	4352-1-0319	TJ-9	3
J204	Test Jack	71279	4352-1-0319	TJ-9	3
J205	Test Jack	71279	4352-1-0319	TJ-9	3
J206	Test Jack	71279	4352-1-0319	TJ-9	3
J207	Test Jack	71279	4352-1-0319	TJ-9	3
J208	Test Jack	71279	4352-1-0319	TJ-9	3
J209	Test Jack	71279	4352-1-0319	TJ-9	3
J210	Test Jack	71279	4352-1-0319	TJ-9	3
SL201	Shorting Link	71279	3771-20310	TJ-10	3
SL201	Shorting Link	71279	3771-20310	TJ-10	3
S203	Rotary Switch, X1 BRIDGE VOLTS	80164	---	SW-291	2
S202	Rotary Switch, X10 BRIDGE VOLTS	80164	---	SW-291	2
K201a	Solenoid, ZERO CHECK	---	E155	SOL-2	-
K201b	Reed Relay, SPST	95348	MR406	RL-25B	-
T201	Transformer	80164	TR-120	TR-120	14
K202	Relay, INTERLOCK	---	KA11DY	RL-36	-

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R201	56 Ω	10%, 1/2 W	Comp	01121	EB-56Ω	R1-56	14
R202	20 kΩ	1%, 1/2 W	MtF	07716	CEC-20kΩ	R94-20K	14
R203	10 kΩ	1%, 1/2 W	MtF	07716	CEC-10kΩ	R94-10K	14
R204	40.2 kΩ	1%, 1/2 W	MtF	07716	CEC-40.2kΩ	R94-40.2K	14
R205	40.2 kΩ	1%, 1/2 W	MtF	07716	CEC-40.2kΩ	R94-2K	14
R206	2 kΩ	1%, 1/2 W	MtF	07716	CEC-2kΩ	R94-2K	14
R207	1 kΩ	1%, 1/2 W	MtF	07716	CEC-1kΩ	R94-1K	14
R208	4.02 kΩ	1%, 1/2 W	MtF	07716	CEC-4.02kΩ	R94-4.02K	14
R209	4.02 kΩ	1%, 1/2 W	MtF	07716	CEC-4.02kΩ	R94-4.02K	14
R210	8.06 kΩ	1%, 1/2 W	MtF	07716	CEC-8.06kΩ	R94-8.06K	14
R211	2 kΩ	20%, 2 W	WWVar	71450	1NS-115-2kΩ	RP-50-2K	14
R212	10 kΩ	10%, 1/2 W	Comp	01121	EB-10kΩ	R1-10	14
R213	40.2 kΩ	1%, 1/2 W	MtF	07716	CEC-40.2kΩ	R94-40.2K	14
R214	40.2 kΩ	1%, 1/2 W	MtF	07716	CEC-40.2kΩ	R94-40.2K	14
R215	1 kΩ	10%, 1/2 W	Comp	01121	EB-1kΩ	R1-1K	14
R216	47 kΩ	10%, 1/2 W	Comp	01121	EB-47kΩ	R1-47K	14
R217	10 kΩ	10%, 1/2 W	Comp	01121	EB-10kΩ	R1-10K	14
R218	47 kΩ	10%, 1/2 W	Comp	01121	EB-47kΩ	R1-47K	14
R219	2 kΩ	1%, 1/2 W	MtF	07716	CEC-2kΩ	R94-2K	14
R220	47 kΩ	10%, 1/2 W	Comp	01121	EB-47kΩ	R1-47	14
R221	6 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-6kΩ	R12-6K	14
R222	500 Ω	1%, 1/2 W	DCb	91637	DCF-1/2-500Ω	R12-500	14
R223	6 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-6kΩ	R12-6K	14
R224	100 Ω	1%, 1/2 W	DCb	91637	DCF-1/2-100Ω	R2-100	14
R225	15 Ω	10%, 1/2 W	Comp	01121	EB-15Ω	R1-15	14
R226	68 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-68kΩ	R12-68K	14
R227	4.7 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-4.7kΩ	R12-4.7K	14
R228	1 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-1kΩ	R12-1K	14
R229	1 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-1kΩ	R12-1K	14
R230	700 Ω	1%, 1/2 W	DCb	91637	DCF-1/2-700Ω	R12-700	14

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q201	NPN, Case TO-18	73445	A1380	TG-32	14
Q202	NPN, Case TO-18	73445	A1380	TG-32	14
Q203	PNP, Case R-110	07263	S17638	TG-33	14
Q204	NPN, Case TO-106	07263	2N[illegible]65	TG-39	14
Q205	NPN, Case TO-106	07263	2N3565	TG-39	14
Q206	NPN, Case TO-5	02735	40327	TG-63	14
Q207	PNP, Case R-110	07263	S17638	TG-33	14
Q208	PNP, Case R-110	07263	S17638	TG-33	14
Q209	PNP, Case TO-5	02734	40319	TG-50	14
Q210	PNP, Case TO-5	02734	40319	TG-50	14
Q211	NPN, Case TO-5	02734	40317	TG-43	14

SWITCHING ASSEMBLIES
MISCELLANEOUS PARTS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
D301	Diode, Zener, 100V, 5W	04713	1N5378-B	DZ-46
DS301	Lamp, 24V, Clear	03508	1450	PL-53
F301	Fuse, SLO-BLO, .25A, 3AG	75915	313.250	FU-17
F301	Fuse, SLO-BLO, 1/8A, 3AG	71400	MDL	FU-20
J301	Receptacle, 3-Prong	---	1604	CS-248
J302	Receptacle, INPUT High, UHF	91737	6804	CS-64
J303	Receptacle, Triaxial, EXT. INPUT	91737	5632A/5321A14	CS-67
P301	Power Cord, 6 ft.	80164	---	CO-5

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
R301	10 kΩ	10:1 Divider Network, .005%		80164	--	23685A
R302	100 kΩ					
R303	10 kΩ	1%, 1/2 W	MtF	07716	CEC-10kΩ	R94-10K
R304	100 kΩ	.01%, 1 W	WW	15909	1252-100kΩ	R154-100K
R305	1 MΩ	.01%, 1 W	WW	15909	1252-1MΩ	R154-1M
R306	10 MΩ	1%, 1/2 W	DCb	91637	DCF-1/2-10MΩ	R12-10M
R307	100 MΩ	1%, 2 W	DCb	91637	DC-2-100MΩ	R14-100M
R308	10^9 Ω	Selected	---	80164	---	24159A
R309	10^{10} Ω	Selected	---	80164	---	24160A
R310	10^{11} Ω	Selected	---	80164	---	24161A
R311	10^{12} Ω	Selected	---	80164	---	24162A
R312	100 kΩ	.01%, 1 W	WW	15909	1252-100kΩ	R154-100K
R313	94.5 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-94.5kΩ	R12-94.5K
R314	94.5 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-94.5kΩ	R12-94.5K
R315	94.5 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-94.5kΩ	R12-94.5K
R316	94.5 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-94.5kΩ	R12-94.5K
R317	94.5 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-94.5kΩ	R12-94.5K
R318	94.5 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2-94.5kΩ	R12-94.5K
R319	10 kΩ	20%, 1/4 W	DCb	71450	45-10kΩ	RP81-10K
R320	10 kΩ	20%, 1/4 W	DCb	71450	45-10kΩ	RP81-10K
R321	10 kΩ	20%, 1/4 W	DCb	71450	45-10kΩ	RP81-10K
R322	10 kΩ	20%, 1/4 W	DCb	71450	45-10kΩ	RP81-10K
R323	10 kΩ	20%, 1/4 W	DCb	71450	45-10kΩ	RP81-10K
R324	10 kΩ	20%, 1/4 W	DCb	71450	45-10kΩ	RP81-10K
R325	20 MΩ	.5%, 2 W	DCb	03888	PT2000-20MΩ	R52-20M
R326	10 MΩ	.5%, 2 W	DCb	03888	PT2000-10MΩ	R52-10M
R327	40 MΩ	.5%, 2 W	DCb	03888	PT2000-40MΩ	R52-40M
R328	40 MΩ	.5%, 2 W	DCb	03888	PT2000-40MΩ	R52-40M
R329	2 MΩ	.01%, 2 W	WW	15909	1179-2MΩ	R155-2M
R330	1 MΩ	.01%, 2 W	WW	15909	1179-1MΩ	R155-1M
R331	4 MΩ	.01%, 2 W	WW	15909	1179-4MΩ	R155-4M
R332	4 MΩ	.01%, 2 W	WW	15909	1179-4MΩ	R155-4M
R333	200 kΩ	.01%, 1 W	WW	15909	1252-200kΩ	R154-200K
R334	100 kΩ	.01%, 1 W	WW	15909	1252-100kΩ	R154-100K
R335	400 kΩ	.01%, 1 W	WW	15909	1252-400kΩ	R154-400K

RESISTORS (cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
R336	400 kΩ	.01%, 1 W	WW	15909	1252-400kΩ	R154-400K
R337	20 kΩ	.01%, 1 W	WW	15909	1252-20kΩ	R154-20K
R338	10 kΩ	.01%, 1 W	WW	15909	1252-10kΩ	R154-10K
R339	40 kΩ	.01%, 1 W	WW	15909	1252-40kΩ	R154-40K
R340	40 kΩ	.01%, 1 W	WW	15909	1252-40kΩ	R154-40K
R341	2 kΩ	.04%, 1/2 W	WW	01686	1142-2kΩ	R99-2K
R342	1 kΩ	.04%, 1/2 W	WW	01686	1142-1kΩ	R99-1K
R343	4 kΩ	.04%, 1/2 W	WW	01686	1142-4kΩ	R99-4K
R344	4 kΩ	.04%, 1/2 W	WW	01686	1142-4kΩ	R99-4K
R345	200 Ω	.1%, 1/2 W	MtF	07716	CECT1-200Ω	R135-200
R346	100 Ω	.1%, 1/2 W	MtF	07716	CECT1-100Ω	R135-100
R347	400 Ω	.1%, 1/2 W	MtF	07716	CECT1-400Ω	R135-400
R348	400 Ω	.1%, 1/2 W	MtF	07716	CECT1-400Ω	R135-400
R349	20 Ω	1%, 1/2 W	MtF	07716	CEC-20Ω	R94-20
R350	10 Ω	1%, 1/2 W	MtF	07716	CEC-10Ω	R94-10
R351	40 Ω	1%, 1/2 W	MtF	07716	CEC-40Ω	R94-40
R352	40 Ω	1%, 1/2 W	MtF	07716	CEC-40Ω	R94-40
R353	100 MΩ	1%, 2 W	DCb	91637	DC2-100MΩ	R14-100M

SWITCHES

Circuit Desig.	Type	Mfr. Code	Mfr. Part	Keithley Part No.
S301	Rotary Switch, FUNCTION	80164	---	SW-293
S302	Rotary Switch, MULTIPLIER	80164	---	SW-335
	Knob Assembly, MULTIPLIER	80164	---	
S303	Safety Interlock			SW-94
S304	Rotary Switch, X100	80164	---	SW-295
---	Knob Assembly, X100	80164	---	14829A
S305	Rotary Switch, X10	80164	---	SW-295
	Knob Assembly, X10	80164	---	14829A
S306	Rotary Switch, X1	80164	---	SW-296
	Knob Assembly, X1	80164	---	14829A
S307	Rotary Switch, X.1	80164	---	SW-296
	Knob Assembly, X.1	80164	---	14829A
S308	Rotary Switch, X.01	80164	---	SW-296
	Knob Assembly, X.01	80164	---	14829A
S309	Rotary Switch, X.001	80164	---	SW-296
	Knob Assembly, X.001	80164	---	14829A
S310	Rotary Switch, X.0001	80164	---	SW-296
	Knob Assembly, X.0001	80164	---	14829A
S311	Rotary Switch, BRIDGE VOLTS	80164	---	SW-297
	Knob Assembly, BRIDGE VOLTS	80164	---	14838A
S312	Slide Switch, 117-234V	80164	---	SW-151

CODE—TO—NAME LIST

CODE TO NAME List of Suggested Manufacturers.
Reference: Federal Supply Code for Manufacturers, Cataloging Handbook H4-2.

Code	Name and Address
00656	Aerovox Corp. 740 Belleville Ave. New Bedford, Mass. 02741
00686	Film Capacitors, Inc. 100 Eighth St. Passaic, N.J.
01121	Allen-Bradley Corp. 1201 South 2nd St. Milwaukee, Wisc. 53204
01295	Texas Instruments, Inc. Semiconductor-Components Div. Dallas, Texas 75231
01686	RCL Electronics, Inc. 195 McGregor St. Manchester, N.H. 03102
02101	Varo Inc. Electrokinetics Div. Santa Barbara, Calif. 93102
02660	Amphenol Corp. 2801 South 25th Ave. Broadview, Ill. 60153
02734	Radio Corp. of America Defense Electronic Products Camden, N.J.
02735	Radio Corp. of America Receiving Tube Div. Somerville, N.J.
02777	Hopkins Engineering Co. 12900 Foothill Blvd. San Fernando, Calif. 91342
02985	Tepro Electric Corp. 5 St. Paul St. Rochester, N.Y. 14604
03508	General Electric Co. Semiconductor Products Dept. Syracuse, N.Y. 13201
04009	Arrow-Hart & Hegeman Electric Co. 103 Hawthorne St. Hartford, Conn. 06106
04713	Motorola Semiconductor Prod. Inc. 5005 E. McDowell Rd. Phoenix, Ariz. 85008
05079	Tansistor Electronics, Inc. 1000 West Road Bennington, Vt. 05201
05397	Union Carbide Corp. Electronics Div. New York, N.Y. 10017
06751	Components, Inc. Arizona Div. Phoenix, Ariz. 85019
06980	Varian Assoc. EIMAC Div. 301 Industrial Way San Carlos, Calif. 94070
07137	Transistor Electronics Corp. Hwy. 169 - Co. Rd. 18 Minneapolis, Minn. 55424
07263	Fairchild Camera & Inst. Corp. 313 Frontage Road Mountain View, Calif.
07716	IRC, Inc. 2850 Mt. Pleasant Burlington, Iowa 52601
08811	GL Electronics Div. of GL Industries, Inc. Westville, N.J. 08093
09052	Gulton Industries, Inc. Alkaline Battery Div. Metuchen, N.J.
09823	Burgess Battery Co. Div. of Servel Inc. Freeport, Ill.
09922	Burndy Corp. Richards Ave. Norwalk, Conn. 06852
10582	CTS of Asheville Inc. Mills Gap Road Skyland, N.C.
11502	IRC Inc. Greenway Road Boone, N.C. 28607
11837	Electro Scientific Indus., Inc. 13645 NW Science Park Dr. Portland, Or. 97229
12040	National Semiconductor Corp. Commerce Drive Danbury, Conn. 06813
12065	Transitron Electronic Corp. 144 Addison St. East Boston, Mass.
12697	Clarostat Mfg. Co., Inc. Lower Washington St. Dover, N.H. 03820
12954	Dickson Electronics Corp. 302 S. Wells Fargo Ave. Scottsdale, Ariz.
13050	Potter Co. Highway 51 N. Wesson, Miss. 39191
13327	Solitron Devices, Inc. 256 Oak Tree Road Tappan, N.Y. 10983
13934	Midwec Corp. 602 Main Oshkosh, Nebr. 69154
14655	Cornell-Dubilier Electric Corp. 50 Paris Street Newark, N.J.
14659	Sprague Electric Co. P.O. Box 1509 Visalia, Calif. 93278
15238	ITT Semiconductors Div. of ITT Corp. Lawrence, Mass. 01841
15909	Daven Div. of T.A. Edison Ind. McGraw Edison Co. Livingston, N.J.
16170	Teledyne Systems Co. Communications Div. Los Angeles, Calif. 90066
17554	Components, Inc. Smith St. Biddeford, Ma. 04005
23020	General Reed Co. 174 Main St. Metuchen, N.J. 08840
24655	General Radio Co. 22 Baker Ave. West Concord, Mass. 01781
27682	Hathaway Instruments, Inc. 5800 E. Jewell Ave. Denver, Colorado 80222
28520	Heyman Mfg. Co. 147 N. Michigan Ave. Kenilworth, N.J.
29309	Richey Electronics Inc. 1307 Dickerson Rd. Nashville, Tenn. 37213
35529	Leeds and Northrup 4901 Stenton Ave. Philadelphia, Pa. 19144
37942	Mallory, P. R. and Co., Inc. 3029 E. Washington St. Indianapolis, Ind. 46206
44655	Ohmite Mfg. Co. 3601 Howard St. Skokie, Ill. 60076
53201	Sangamo Electric Co. 1301 North 11th Springfield, Ill. 62705
54294	Shallcross Mfg. Co. 24 Preston St. Selma, N.C.
56289	Sprague Electric Co. North Adams, Massachusetts
58474	Superior Electric Co., The 383 Middle St. Bristol, Conn. 06012
61637	Union Carbide Corp. 270 Park Ave. New York, N.Y. 10017

CODE TO NAME List (Continued).

63060	Victoreen Instrument Co. 5806 Hough Ave. Cleveland, Ohio 44103	75042	IRC Inc. 401 North Broad St. Philadelphia, Pa. 19108	86684	Radio Corp. of America Electronic Components & Devices Harrison, N.J.
70309	Allied Control Co., Inc. 2 East End Ave. New York, N.Y.	75915	Littlefuse, Inc. 800 E. Northwest Hwy. Des Plaines, Ill. 60016	87216	Philco Corp. Lansdale Div., Church Rd. Lansdale, Pa. 19446
70903	Belden Mfg. Co. 415 So. Kilpatrick Chicago, Ill. 60644	76055	Mallory Controls, Div. of Mallory P. R. & Co., Inc. Frankfort, Ind.	90201	Mallory Capacitor 3029 East Washington Indianapolis, Ind. 46206
71002	Birnbach Radio Co., Inc. 147 Hudson St. New York, N.Y.	76493	Miller, J. W. Co. 5915 S. Main St. Los Angeles, Calif. 90003	90303	Mallory Battery Co. Tarrytown, New York
71279	Cambridge Thermionic Corp. 430 Concord Avenue Cambridge, Mass.	76545	Mueller Electric Co. 1583 E. 31st St. Cleveland, Ohio 44114	91637	Dale Electronics, Inc. P.O. Box 609 Columbus, Nebr. 68601
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.	77764	Resistance Products Co. 914 S. 13th St. Harrisburgh, Pa. 17104	91662	Elco Corp. Willow Grove, Pennsylvania
71450	CTS Corp. 1142 W. Beardsley Ave. Elkhart, Ind.	79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.	91737	Gremar Mfg. Co., Inc. 7 North Ave. Wakefield, Mass.
71468	ITT Cannon Electric, Inc. 3208 Humbolt St. Los Angeles, Calif. 90031	80164	Keithley Instruments, Inc. 28775 Aurora Road Cleveland, Ohio 44139	91802	Industrial Devices Inc. 982 River Rd. Edgewater, N.J. 07020
71590	Centralab Div. of Globe-Union, Inc. Milwaukee, Wisc. 53212	80294	Bourns, Inc. 6135 Magnolia Ave. Riverside, Calif. 92506	91929	Honeywell Inc. Micro Switch Div. Freeport, Ill. 61032
71785	Cinch Mfg. Co. and Howard B. Jones Div. Chicago, Ill. 60624	81073	Grayhill, Inc. 561 Hillgrove Ave. La Grange, Ill. 60525	93332	Sylvania Electric Products, Inc. Semiconductor Products Div. Woburn, Mass.
72619	Dialight Corp. 60 Stewart Ave. Brooklyn, N.Y. 11237	81483	International Rectifier Corp. 1523 East Grand Ave. El Segundo, Calif.	93656	Electric Cord Co. 1275 Bloomfield Ave. Caldwell, N.J.
72653	G-C Electronics Co. 400 S. Wyman Rockford, Ill. 61101	82389	Switchcraft, Inc. 5527 N. Elston Ave. Chicago, Ill. 60630	94144	Raytheon Co., Industrial Operation Components Div. Quincy, Mass.
72699	General Instrument Corp. Capacitor Division Newark, N.J. 07104	83125	General Instrument Corp. Capacitor Division Darlington, S.C. 29532	94154	Tung-Sol Electric, Inc. Newark, New Jersey
72982	Erie Technological Prods Inc. 644 W. 12th St. Erie, Pa. 16512	83330	Smith, Herman H., Inc. 812 Snediker Ave. Brooklyn, N.Y. 11207	94310	Tru-Ohm Products Memcor Components Div. Huntington, Ind. 46750
73138	Beckman Instruments, Inc. Helipot Division Fullerton, Calif. 92634	83594	Burroughs Corp. Electronic Components Div. Plainfield, N.J. 07061	94696	Magnecraft Electric Co. 5579 North Lynch Chicago, Ill.
73445	Amperex Electronic Co., Div. of North American Philips Co., Inc. Hicksville, N.Y.	83701	Electronic Devices, Inc. Brooklyn, New York	95348	Gordos Corp. 250 Glenwood Ave. Bloomfield, N.J. 07003
73690	Elco Resistor Co. 1158 Broadway New York, N.Y.	84171	Arco Electronics, Inc. Community Drive Great Neck, N.Y. 11022	95712	Dage Electric Co., Inc. Hurricane Road Franklin, Ind.
74276	Signalite Inc. 1933 Heck Ave. Neptune, N.J. 07753	84411	TRW Capacitor Div. 112 W. First St. Ogallala, Nebr.	97933	Raytheon Co. Components Div. Semiconductor Operation Mountain View, Calif.
74970	Johnson, E. F., Co. 297 Tenth Ave. S.W. Waseca, Minn. 56093	84970	Sarkes Tarzian, Inc. E. Hillside Dr. Bloomington, Ind.	99120	Plastic Capacitors, Inc. 2620 N. Clybourn Ave. Chicago, Ill.

APPENDIX

RESISTANCE DIAL ACCURACY CHECK.

The following procedure should be used to verify the accuracy of the various resistors of the decade dials. The test jacks are identified in Figure 7.

Procedure:

1. Set the Model 515A controls as follows:
   FUNCTION - OPERATE
   MULTIPLIER - 10^5
   DECADE DIALS - ALL 0
2. Connect ESI Model 242 Resistance Bridge between test jack J202 and GROUND.
3. Measure the resistance of the DECADE DIAL resistors for dial positions 0, 1, 2, 4, and 8 as in the table X.0001 through X10

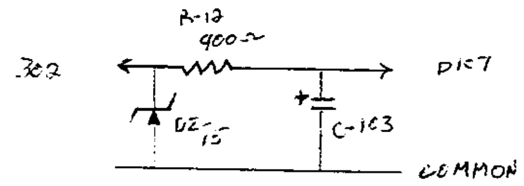
4. Connect ESI Model 242 between test jacks J201 and J203.
5. Measure the resistance of the X100 DIAL resistors for dial positions 1, 2, 4, and 8.

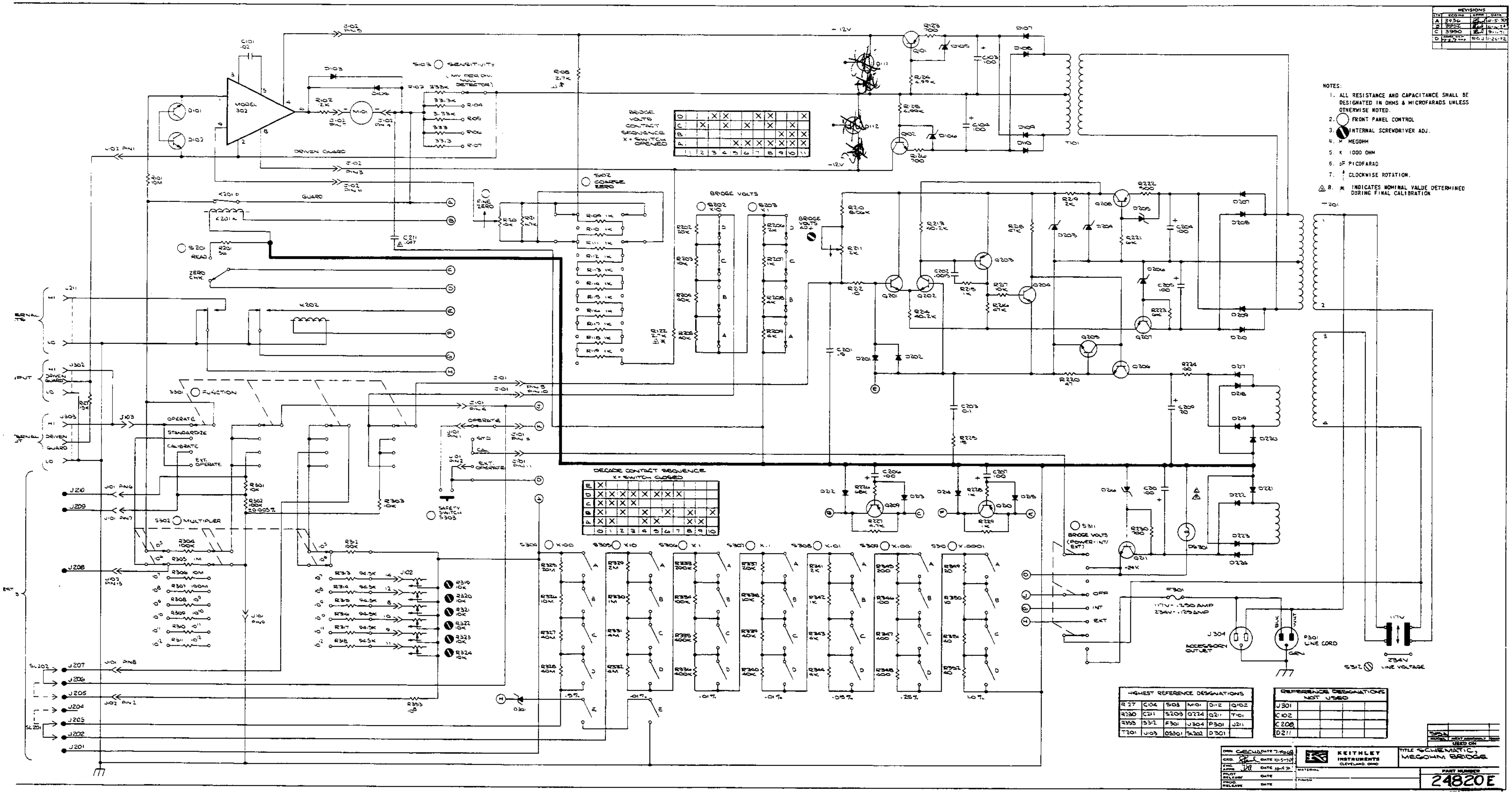
6. Measure the resistance of the remaining resistors by connecting ESI Model 242 between the test jacks specified in the table

CONNECT TO J202 AND CHASSIS

	DIAL	NOMINAL	TOLERANCE	R%	
ZERO R	ALL 0	0.130	1 OHM		
X.0001	1	10	±1%		*
	2	20	±1%		*
	4	40	±1%		*
	8	80	±1%		*
X.001	1	100	±0.1%		
	2	200	±0.1%		
	4	400	±0.1%		
	8	800	±0.1%		
X.01	1	1K	±0.04%		
	2	2K	±0.04%		
	4	4K	±0.04%		
	8	8K	±0.04%		
X.1	1	10K	±0.01%		
	2	20K	±0.01%		
	4	40K	±0.01%		
	8	80K	±0.01%		
X 1	1	100K	±0.01%		
	2	200K	±0.01%		
	4	400K	±0.01%		
	8	800K	±0.01%		
X 10	1	1M	±0.01%		
	2	2M	±0.01%		
	4	4M	±0.01%		
	8	8M	±0.01%		
	CONNECT TO J203 AND J201				
X 100	1	10M	±0.5%		
	2	20M	±0.5%		
	4	40M	±0.5%		
	8	80M	±0.5%		
	CONNECT TO J205 AND J201				
R353	-	100M	±0.01%		
	CONNECT TO J207 AND J201				
R312	-	100K	±0.01%		
	CONNECT J208 AND CHASSIS				
R305	-	1M	±0.01%		
	CONNECT J209 AND CHASSIS				
** R302	-	100K	±0.01%		
	CONNECT TO J210 AND J209				
** R301	-	10K	±0.01%		

**Difference must be less than 50 ppm.





NOTES:

1. ALL RESISTANCE AND CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. FRONT PANEL CONTROL
3. INTERNAL SCREWDRIVER ADJ.
4. M MEGOHM
5. K 1000 OHM
6. pF PICOFARAD
7. CLOCKWISE ROTATION.
8. ✳ INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION

HIGHEST REFERENCE DESIGNATIONS					
R127	C104	S103	M101	D112	Q102
R230	C211	S203	D224	Q211	T101
R353	S312	F301	J304	P301	J211
T201	J103	DS301	SL202	D301	

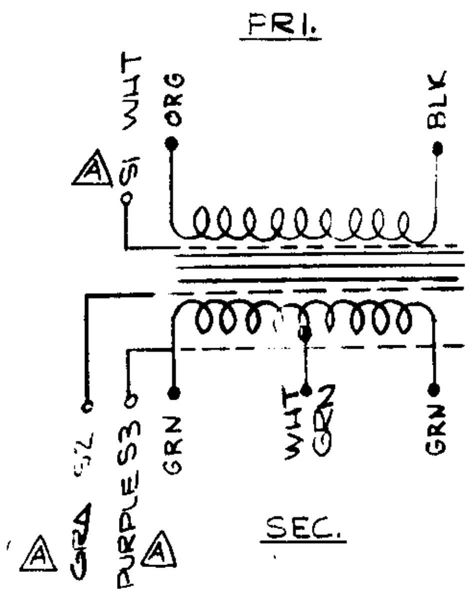
REFERENCE DESIGNATIONS NOT USED
J301
C102
C208
D211

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

TITLE SCHEMATIC, MEGOHM BRIDGE

PART NUMBER 24820E

REVISIONS		
SYM	DESCRIPTION	DATE
A	REVISED PRI.& SEC. SHIELDS	4-22-[illegible]
B	PCM 1228	5-26-70



TEFLON INSULATED LEADS ON SECONDARY (LENGTH: 20")

PRIMARY: 4" INSULATED LEADS.

TRANSFORMER

SUPPLIER CENTRAL TRANSFORMER CO.

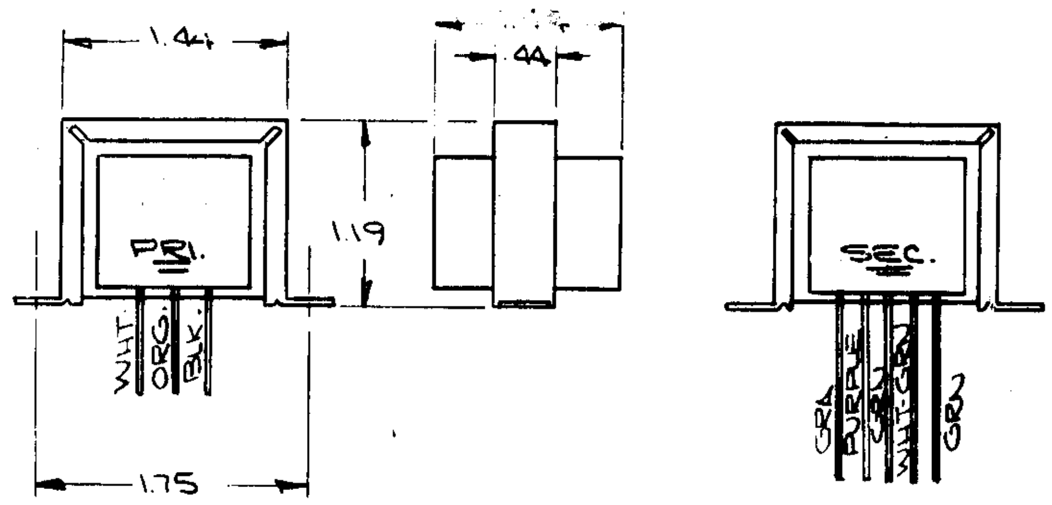
SUPPLIER PART NO.

SPECIFICATIONS:

FREQUENCY: 50-60 cps (SINE WAVE)

WINDING	VOLTS	CURRENT
PRIMARY	50V.	
Sec. #1	25-0-25V.	6 ma
Sec. #2		
Sec. #3		
Sec. #4		
Sec. #5		
Sec. #6		

FRAME SIMILAR TO TRANSFORMER K1-14B



NOTES:

A LEAKAGE TEST: TIE ALL SECONDARY LEADS TOGETHER; TIE ALL PRIMARY LEADS AND FRAME TOGETHER. WITH 1000 V. D.C. APPLIED BETWEEN PRIMARY AND SECONDARY, THE RESISTANCE BETWEEN PRIMARY AND SECONDARY MUST BE GREATER THAN 10^{12} OHMS AT 60% RELATIVE HUMIDITY.

515A

MATERIAL PURCHASED		FINISH —
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: MFR'S / MFR'S / MFR'S	TITLE: TRANSFORMER, Power	KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO
SCALE — NO. REQ'D —	DRAWN RGJ DATE 6-18-68	DRAWING NUMBER
NEXT ASSY.	CHECKED JG DATE 6-18-68	TR-121
	APPROVED [illegible] DATE 6-18-68	

JUL 16 1991

KEITHLEY INSTRUMENTS, INC.
REPAIR & CALIBRATION FORM

MODEL NO. __________
SERIAL NO. __________

DATE ____________________

R-

SHIP INSTRUMENT & FORM TO:

SALES SERVICE DEPT.
KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

FROM:

USER'S NAME ____________________
RETURN ADDRESS ____________________
____
CITY ____________________
STATE ____________________ ZIP __________
TELEPHONE ____________________

1. REASON FOR RETURN. Check appropriate box.
   - ☐ Repair and Recalibration
   - ☐ Recalibration only. (If repairs are required to meet specifications, an additional repair charge will be added to recalibration cost.)

2. CALIBRATION REPORT. Specify report desired. (See reverse side of form for details.)
   - ☐ Calibration Report (Certified Traceable to N.B.S.)
   - ☐ Calibration Report (Production Calibration Equipment at the factory)
   - ☐ Certificate of Compliance

3. DESCRIPTION OF PROBLEM. (Include a block diagram of instruments connected in system. Recorder charts or other data would be helpful.)

____
____
____
____

   Is problem constant or intermittent? ____________________

4. OPERATING CONDITIONS.
   Control setting (range, multiplier, etc.) ____________________
   Line voltage used ____________________ Line frequency used ____________________
   Temperature ____________________ °F Temperature variation ± ____________________ °F
   Humidity (high, medium, low) ______
   Other (please specify, such as line transients, etc.) ____________________

5. EQUIPMENT USED.
   Signal source ____________________ Source impedance ____________________
   Readout device ____________________ (Recorder, oscilloscope, etc.)
   Cables used ____________________ Length ____________________

6. ADDITIONAL INFORMATION. Please indicate any other pertinent information which may help the Keithley Repair and Calibration Department. (If repairs or modifications have been made to instrument by other than Keithley personnel, please specify below.)

____
____
____
____

REV 0172

CALIBRATIONS AVAILABLE AT KEITHLEY INSTRUMENTS. EFFECTIVE: FEBRUARY 1, 1972

Listed and defined below are the four types of calibrations and their associated report formats which are presently available at Keithley Instruments. They fall into the following categories:

1. Report of Calibration Certified Traceable to the National Bureau of Standards
2. Calibration Report
3. Certificate of Compliance
4. Recalibration

All calibration and certification performed by Keithley Instruments is in accord with MIL-C-45662A.

Prices shown below are in addition to repair charges for any work necessary to place a customer's unit into first class condition prior to the calibration.

1. Report of Calibration Certified Traceable to the National Bureau of Standards.
This is a completely documented report, including all basic errors or deviations from nominal settings on appropriate ranges, terminals, dials, etc. Work is performed using the primary standards of the company with secondary transfers kept to a minimum. The NBS test numbers for the latest recalibration of the primary standards are furnished.

By definition, the above is performed in our Standards Laboratory so that random operator induced error is minimized and maximum protection to the equipment used is maintained.

This type of calibration is not recommended for instruments with a basic inaccuracy of 1% or greater. The precision involved in this report makes it uneconomical for such instruments. The Calibration Report listed below (No. 2) would be better suited in this case.

The Report of Calibration Certified Traceable to the National Bureau of Standards is available on the following instruments at the prices listed:

Model 140	$275	Model 5155-10^8	$ 50
Model 260	$225	Model 5155-10^9	$ 50
Model 261	$375	Model 5155-10^{10}	$ 50
Model 662	$275	Model 5155-10^{11}	$ 60
Model 5155 (Complete Set)	$295	Model 5155-10^{12}	$ 60
		Model 5155-10^{13}	$ 80

2. Calibration Report.
This report shows only the cardinal range, terminal, dial, etc. errors as determined by production calibration equipment and personnel. The production equipment is maintained traceable by transfer techniques against the primary standards maintained by the company. We attest to this fact and list basic deviations from nominal but the conditions of calibration are not as precisely controlled as the previous report nor are NBS test numbers supplied.

This report is available for any instrument in our line. The following price has been established for this report:

Model 261 . . . .$ 60
Prices for other units can be estimated upon request.

3. Certificate of Compliance.
This is merely a restatement of the basic guarantee that the instrument was calibrated on equipment that is maintained by our standards personnel against primary standards. No report is issued.

This Certificate of Compliance is available at no charge for any instrument with the exception of the Model 261.

A newly purchased Model 261 or one returned for repair or recalibration is automatically supplied with a Calibration Report (as described in (2) above). The nature of this instrument makes it necessary to complete this report to ascertain specified accuracy. This Calibration Report is forwarded to the customer with the instrument. The $60 charge is incorporated as part of the normal calibration charge of the Model 261.

4. Recalibration.
This is a recalibration of the instrument according to our factory calibration procedures.

Model 260	$ 90	(No report supplied. A Certificate of Compliance can be had at no charge if requested).
Model 261	$ 60	(Calibration Report as described in (2) above is supplied. See (3) for explanation).

All other instruments are on a time and material basis for the particular unit involved.

All prices subject to change without prior notification.

KEITHLEY INSTRUMENTS, INC.

INSTRUCTION MANUAL
CHANGE NOTICE
MODEL 515A MEGOHM BRIDGE

INTRODUCTION: Since Keithley Instruments is continually improving product performance and reliability, it is often necessary to make changes to Instruction Manuals to reflect these improvements. Also, errors in Instruction Manuals occasionally occur that require changes. Sometimes, due to printing lead time and shipping requirements, we can't get these changes immediately into printed Manuals. The following new change information is supplied as a supplement to this Manual in order to provide the user with the latest improvements and corrections in the shortest possible time. Many users will transfer this change information directly to a Manual to minimize user error. All changes or additions are underlined.

CHANGES:

(1) Page 26, Replaceable Parts, Resistors, Add the following resistor as follows:
R354, 100Ω, 10%, 1/2W, Comp, 01121, EB-100Ω, R1-100

(2) Page 21, Replaceable Parts, Diodes, Change D105, D106, D111, D112, D113, and D114 to read as follows:
D105, Not Used.
D106, Not Used.
D111, Not Used.
D112, Not Used.
D113, Zener, 15V, 1/4W, 12954, IN718, DZ-18
D114, Zener, 15V, 1/4W, 12954, IN718, DZ-18

(3) Page 22, Replaceable Parts, Resistors, Change R123, R124, R125, and R126 to read as follows:
R123, 845Ω, 1%, 1/2W, MtF, 07716, CEC-845Ω, R94-845
R124, Not Used
R125, Not Used
R126, 845Ω, 1%, 1/2W, MtF, 07716, CEC-845Ω, R94-845

(4) Page 22, Replaceable Parts, Transistors, Change Q101 and Q102 to read as follows:
Q101, Not Used
Q102, Not Used

28775 AURORA ROAD • CLEVELAND, OHIO 44139 • (216) 248-0400
TELEX: 98-5469 • CABLE: KEITHLEY

REPORT ON CHANGE IN SPECIFICATIONS 8/18/71

MODEL 515A

Distribution: All Officers, Nichols, Sheridan, Herron, Streetz, Kifer, Sutphin, Butler, Kaplan, Allen, Cech, Nowac, Kronenwetter, Bartos, Sarkisian, Naylor, Angeline, Peabody, Engrg. File, Seifert

The following change has been approved by an executive committee and will be implemented according to the following schedule:

Change: Model 515A ACCURACY specifications are changed from:

ACCURACY: (when bridge is operated as described below)

Range, ohms	Standard Deviation (1σ)**	Bridge Voltage	Decade
10^5 to 10^7	.012%	10 v	10^5 -10^6
10^7 to 10^8	.02 %	10 v	10^7
10^8 to 10^9	.03 %	10 v	10^8
10^9 to 10^{10}	.06 %	10 v	10^9
10^{10} to 10^{11}	.08 %	10 v	10^{10}
10^{11} to 10^{12}	.16 %	10 v	10^{11}
10^{12} to 10^{13}	.25 %	10 v	10^{12}
10^{13} to 10^{14}	.3 %	100 v	10^{12}
10^{14} to 10^{15}	.5 %	500 v*	10^{12}

* External supply required above 10^{14} ohms.
** Based on theoretical analysis of bridge errors, see instruction manual for details on obtaining specified performance.

to:

ACCURACY:

Range, ohms	Standard Deviation (1σ)**	Bridge Voltage	Decade
10^5 to 10^7	.012%	10 v	10^5 -10^6
10^7 to 10^8	.02 %	10 v	10^7
10^8 to 10^9	.03 %	10 v	10^8
10^9 to 10^{10}	.06 %	10 v	10^9
10^{10} to 10^{11}	.08 %	10 v	10^{10}
10^{11} to 10^{12}	.16 %	10 v	10^{11}
10^{12} to 10^{13}	.25 %	100 v	10^{12}
10^{13} to 10^{14}	.3 %	500 v *	10^{12}
10^{14} to 10^{15}	1.5 %	500 v*	10^{12}

* External supply required above 10^{13} ohms.
** Based on theoretical analysis of bridge errors, see instruction manual for details on obtaining specified performance.

ACTION

<u>Manufacturing</u>: Set up manufacturing procedures as necessary to achieve the revised specification. Give notice of the change to applicable personnel in tech check-out and repair.

<u>Engineering</u>: Note revision and change any applicable drawings for instrument or its parts.

<u>Sales</u>: Issue notice of change to entire world-wide sales organization, applications engineers, etc.

Change 515A manual and any other applicable manuals to reflect revision.

AMP:ew

KEITHLEY INSTRUMENTS, INC.

PRELIMINARY INSTRUCTION MANUAL

MODEL 515A

MEGOHM BRIDGE

This Preliminary Instruction Manual is supplied to permit earliest possible delivery of your instrument.

It contains Specifications, Operation Instructions, Circuit Description, Replaceable Parts List and Schematics. The Final Edition will contain Servicing and Calibration information to maintain the instrument.

Please detach, fill out and return the Warranty Card attached to the instrument so that the Final Edition Instruction Manual can be sent to your attention. If you have further questions, please contact your Keithley Representative or the Sales Service Department.

Product Literature Department

28775 AURORA ROAD · CLEVELAND, OHIO 44139 · (216) 248-0400
TELEX: 98-5469 · CABLE: KEITHLEY

KEITHLEY

FREE PRODUCT/UPGRADE INFORMATION

To receive future information on product upgrades and enhancements, complete this card and mail, or FAX to 440/248-6168.

MODEL ____________ SERIAL NO. __________________ DATE ____________________

NAME TITLE

COMPANY MAIL STOP

ADDRESS

CITY STATE/PROVINCE ZIP COUNTRY

PHONE FAX

E-MAIL

For FREE additional information, check below:

Application Notes

- ☐ Low Level Measurements
- ☐ Semiconductor Measurements
- ☐ General Purpose Measurements
- ☐ Component Test Applications

Reference Publications

- ☐ Low Level Handbook
- ☐ Switching Handbook
- ☐ Gas Sensors Handbook

Catalogs

- ☐ Keithley Instruments
- ☐ Channel K / Keithley Metrabyte

Facility (Check One)

- ☐ K Aerospace/Defense
- ☐ S Automotive/Parts Mfg.
- ☐ Q Chemical/Petroleum Processing
- ☐ H Components Mfg. (Non-Semi)
- ☐ N Computer/Peripherals
- ☐ T Consumer Electronics
- ☐ L Digital ICs
- ☐ U Discrete Components
- ☐ D Displays
- ☐ V Distributors/Resellers/Rental
- ☐ F Education/University
- ☐ 3 Health Services
- ☐ B Industrial Controls Mfg.
- ☐ R Medical Equip. and Services
- ☐ Y Mixed-Signal Components
- ☐ Z Office Equipment Mfg.
- ☐ O Optoelectronic Components
- ☐ 5 Other Discrete Manufacturing
- ☐ I Process Control Industries
- ☐ C Regulatory
- ☐ E Research Laboratories
- ☐ J Semi. Components - Other
- ☐ 1 Semiconductor Mfg.
- ☐ 2 Semi. Pkg. Part Testing
- ☐ P Telecommunications Equip.
- ☐ G Test/Measurement Equipment Mfg.
- ☐ M Utility
- ☐ 4 VAR/System Integrator/Consultant
- ☐ X Other ______________

Job Function (Check One)

- ☐ 4 Calibration/Metrology
- ☐ 6 Component Test
- ☐ C Consulting
- ☐ G Corp./General Mgmt.
- ☐ 7 Education
- ☐ 3 Engineering Design
- ☐ 1 Engineering Management
- ☐ 5 Mfg. Production Test
- ☐ 0 Purchasing
- ☐ 8 Quality Assurance/Control
- ☐ 2 Research & Development
- ☐ S Safety Manager
- ☐ 9 Service/Repair
- ☐ E System Engineering/Integration
- ☐ T Test Technician
- ☐ X Other ______________

Product Interest(s)

- ☐ G Communications Test
- ☐ 7 Current/Voltage Source
- ☐ V C-V Measurements
- ☐ 2 Digital Multimeters
- ☐ 4 Electrometers/Picoammeters
- ☐ A Flat Panel Display Test
- ☐ F Function Generators
- ☐ 3 High Resistance Meters
- ☐ C Industrial Gas Sensors
- ☐ I I-V Characterization
- ☐ N LCZ Meters
- ☐ 5 Nanovoltmeters
- ☐ 6 Ohmmeters
- ☐ 8 Precision Power Supplies
- ☐ U Source/Measure Instruments
- ☐ S Switching Systems/Scanners
- ☐ 0 Temperature Measurements
- ☐ X Other ______________

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KEITHLEY INSTRUMENTS INC
PO BOX 391260
CLEVELAND OH 44139-9653

1. What other Keithley products do you currently use?

2. What effects, devices or phenomena do you measure with this instrument?

3. What was the main reason a *Keithley* unit was purchased?

4. Do you have any design suggestions concerning this unit?

PLEASE REFOLD SO YOUR NAME IS INSIDE, TAPE AND MAIL.