INSTRUCTION BOOK
MODEL 63H
INDUCTANCE BRIDGE
5 kHz to 500 kHz

1-69

BOONTON ELECTRONICS CORPORATION

TEL: 201-887-5110
TWX: 710-986-8241
ROUTE 287 AT SMITH ROAD
PARSIPPANY, N. J.– 07054

TABLE OF CONTENTS

LIST OF FIGURES, TABLES, AND CHARTS

SECTION 1

SPECIFICATIONS

Inductance Measuring Range: 0.0002 μH to 110 mH in 5 steps as follows:

Multiplier	Inductance Range	Resolution of Inductance Reading
10.0	0 to 110 mH	0.01% + 2.0 μH
1.0	0 to 11 mH	0.01% + 0.2 μH
0.1	0 to 1100 μH	0.01% + 0.02 μH
0.01	0 to 110 μH	0.01% + 0.002 μH
0.001	0 to 11 μH	0.01% + 0.0002 μH

Inductance Measuring Accuracy: (0.25% + 300/C)% + 0.0002 μH

Where,

C is the resonating capacitance in pF of the test inductor at the frequency of test.

Series Resistance Measuring Range: 0.0002 ohm to 11K ohms in 5 ranges as follows:

Multiplier	Series Resistance Range	Accuracy
10.0	0 to 11K Ω	3% + Q/25% + 5.0 Ω
1.0	0 to 1100 Ω	3% + Q/25% + 0.5 Ω
0.1	0 to 110 Ω	3% + Q/25% + 0.05 Ω
0.01	0 to 11 Ω	3% + Q/25% + 0.005 Ω
0.001	0 to 1.1 Ω	3% + Q/25% + 0.001 Ω

Frequency Range: 5 kHz to 500 kHz with internal oscillator and detector.

Frequency Accuracy: ± 3%

NOTE:

The accuracy of the test frequency has negligible effect on the accuracy of the inductance measurement.

Frequency Stability: Approximately 0.5% after 30 minute warm-up.

Maximum AC Test Level: Approximately 3.0V, rms, open circuit.

Tube Complement:

Quantity	Type	Used In
1	12AT7	Oscillator
1	6AK5	Pre-Amplifier
1	6U8	Tuned Amplifier
2	6AU6	Amplifier
1	6BW4	Rectifier
2	OA2	Voltage Regulator
2	2N404A	Emitter-Follower
1	2N1605A	Emitter-Follower
1	2N1046	Emitter-Follower

Power Requirements: 105 to 125V, 50-60 Hz, 60 watts, or 210 to 250V, 50-60 Hz as specified.

Size: 19-1/4" w x 10-3/4" h x 11-1/4" d; case mounted.

Mounting: Case mounting is standard. Also available for 19-inch rack mounting.

Weight: Approximately 35 lb.

SECTION 11

GENERAL DESCRIPTION

2-1 GENERAL

2-1-1 The Model 63H is a highly advanced bridge which provides direct reading measurements of series inductance down to low values with fractional percentage accuracy, and under an unusually broad range of test conditions. The instrument also provides direct reading measurement of series resistance. The operational range of the Model 63H is shown in the diagram on page 2-2. Inductance and resistance ranges are covered in five steps; the frequency range is covered in two decades.

2-1-2 The instrument is completely self-contained, including bridge circuitry, variable frequency test oscillator and detector, null indicator, and power supplies. It is packaged as a single, compact bench cabinet. The Model 63H may be installed in a standard relay rack when the cabinet is removed.

2-2 BRIDGE CIRCUIT

2-2-1 The Model 63H embodies a modified Maxwell circuit (see simplified schematic on page 2-2). The test signal generator and null detection circuit are coupled to the bridge by a technique which constitutes a particularly practical approach to the design of a Maxwell bridge capable of precision measurements over wide ranges of inductance and test frequencies. The two sides of the bridge are driven 180 degrees out of phase by a well balanced low impedance transformer. This permits detection of the balance condition by coupling the detector to the high corners of the bridge through two small, carefully balanced capacitors.

2-2-2 It is characteristic of this bridge circuit that the inductance and resistance arms act independently of each other. By eliminating interaction between the two arms, the annoyance and ambiguity of false or sliding nulls is avoided.

2-2-3 Since the bridge is of the non-resonant type, the precision of frequency setting is not critical to the accuracy of measurement. Bridge accuracy is determined primarily by the balancing controls, the precision resistors in the range selector, plus the

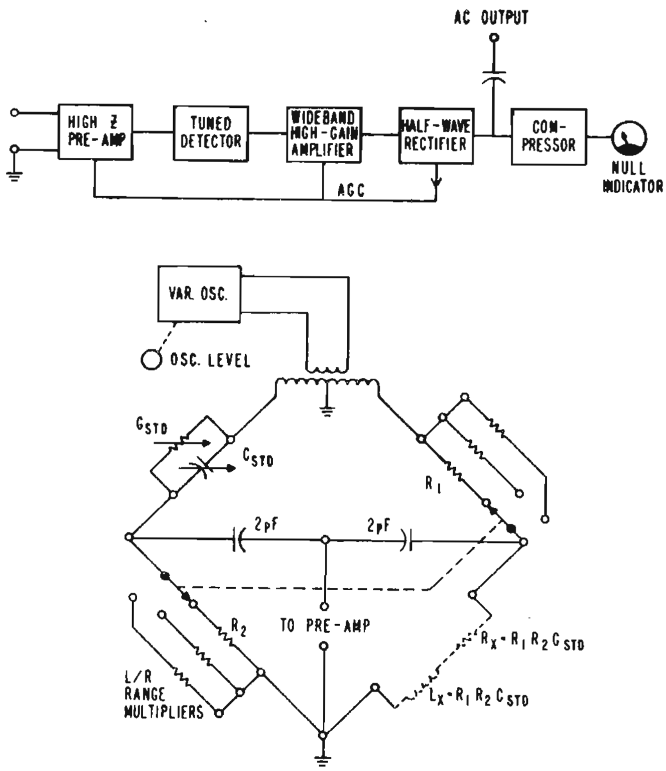


Figure 1. Simplified Diagram of the Model 63H

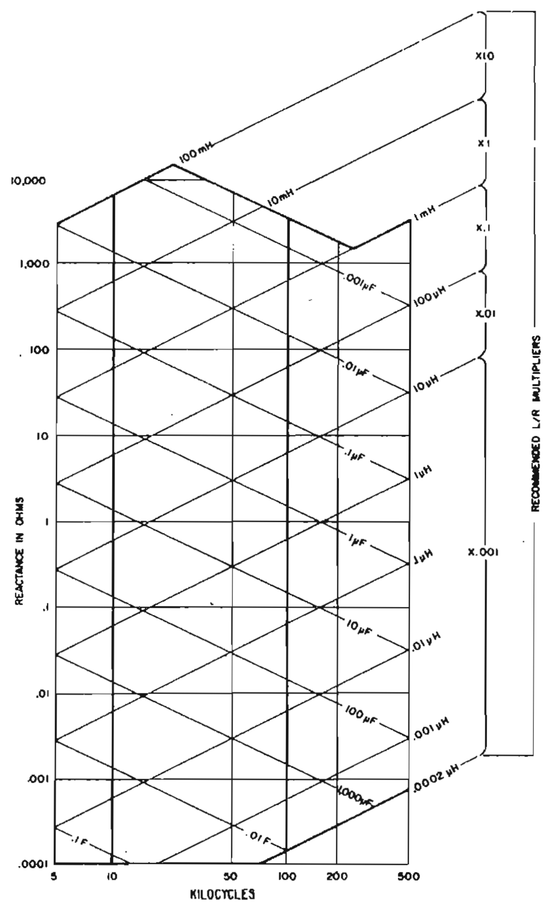


Figure 2. Range of Inductance Measurement vs. Frequency

silvered mica and variable air capacitors comprising the inductance decades. All of these components are adjusted to better than 0.1% accuracy.

2-2-4 Great care has been taken in both the electrical and mechanical design of the Model 63H to compensate or eliminate the sources of residual error that commonly restrict the accuracy of measurement of bridges operating at these frequencies.

2-2-5 The excellent scale readability of the Model 63H allows full advantage to be taken of the instrument's capability for high precision and resolution. The combination of the outer "counter dial" and inner 20-to-1 vernier displays the total inductance measuring range across a scale effectively more than 200 inches long. This dial arrangement also assures convenient rapid scanning to locate the null, as well as accurate final adjustment.

2-3 NULL DETECTOR

2-3-1 As shown in the simplified schematic diagram on page 2-2,the null detector is coupled to the bridge at the high corners through two balanced capacitors. The untuned high impedance preamplifier prevents bridge loading and contributes to the overall system sensitivity. Adjustment of the tuned detector is independent of the test signal generator control so that the amplifier may be critically tuned without altering the test frequency.

2-3-2 Frequency response of the final wide band detector amplifier is essentially flat over the total frequency range of the instrument. It has a maximum gain of 65 dB for a total detector system gain of approximately 105 dB.

2-3-3 Output from the wide band amplifier is passed through a half-wave detector, compressed, and then metered. System sensitivity is further enhanced by use of a 50 microampere taut band meter for null indication.

2-3-4 The ac component of the rectified output from the wide band amplifier is also available at a rear jack for connection of an oscilloscope or other remote indicator.

2-4 TEST SIGNAL OSCILLATOR

2-4-1 The internal test signal oscillator is continuously adjustable in frequency from 5 kHz to 500 kHz. Accuracy of frequency setting is 3%. As stated above, in this bridge circuit precision of test frequency setting is not directly related to the accuracy of measurement. However, in the rare circumstance in which more accurate frequency adjustment is required, the test signal may be monitored with a counter and set more precisely. Stability of the test frequency is better than 0.5%.

2-4-2 The test signal level is continuously adjustable by means of a front panel control and may be monitored at the test terminals with a high impedance electronic voltmeter. Maximum open circuit level is 3 volts. Test current may also be monitored by means of a "clamp-on" type probe and a sensitive ac voltmeter. (See Paragraph 3-4-4)

2-4-3 The test current is independent of the balance condition of the bridge, a fact of considerable importance in applications involving such components as ferrite cores, since their permeability varies with the level of excitation current. Were the test current to change from the known level during balancing, meaningful measurements would be impossible.

2-4-4 A direct current may be superimposed on the test signal if desired. However, since the dc also flows through the bridge circuit, the maximum levels indicated for each range in Table 2 on page 3-11 should not be exceeded. This prevents exceeding the power dissipation limits of the bridge components.

NOTE:

Models having serial numbers 634 or higher are equipped with a dual-primary power transformer that is wired either for 117V ac or for 234V ac operation. The dual-primary transformer replaces two power transformers (T201 and T202) used in earlier models. A 0.6A fuse is supplied when the transformer is wired for 234V ac operation, and a 1.2A fuse is supplied when the transformer is wired for 117V ac operation.

SECTION 111

OPERATING PROCEDURE

3-1 GENERAL

3-1-1 This section describes in detail the operating procedure of the Model 63H Inductance Bridge. All information required for safe and proper operation of the instrument is included. BE SURE TO READ THIS SECTION BEFORE PLACING THE INSTRUMENT INTO OPERATION.

3-2 TURN-ON PROCEDURE

Step a. Before plugging the instrument into an appropriate outlet, make sure the power source is 105-125 volts, 50-60 Hz, unless otherwise specified on the instrument's identification plate.

Step b. Plug the instrument into the power outlet.

Step c. Set toggle switch to ON and allow a warm-up period of approximately two minutes (one hour or more after high humidity exposure or after long exposure to low temperature).

3-3 MEASUREMENT PROCEDURE

Step a. Connect the short circuit plug (or strap) supplied with the instrument across the TEST binding posts.

PRECAUTION

When using the X0.001 position of the MULTIPLY L AND R BY switch, the shorting link supplied with the bridge must be used for zeroing the bridge; on all other ranges the shorting plug may be used. If the shorting plug is used for the X0.001 range it may not be possible to zero the bridge.

Step b. Set oscillator range switch to either X1 or X10 position, depending upon the required test frequency. Use X1 if frequency is below 50 kHz; otherwise use X10 position.

NOTE:

This "Range Selector" also selects desired range for the Tuned Detector. Refer to page 2-2 to determine that both frequency and inductance fall within boundary area shown. For greater accuracy, refer to accuracy statement on page 1-1.

Step c. Set MULTIPLY L AND R BY switch to range recommended in table for inductance under test. (See Table 1 below)

Table 1

INDUCTANCE	MULTIPLY L AND R BY
0.0 to 11 µH	0.001
11.0 to 110 µH	0.01
110.0 to 1100 µH	0.1
1.1 to 11 mH	1.0
11.0 to 110 mH	10.0

Step d. Set both SERIES INDUCTANCE dials to read zero and both SERIES RESISTANCE dials to read zero.

Step e. Set OSC LEVEL control to the "RED LINE" position.

NOTE:

The red line on the oscillator level control indicates approximately one-half of its rotation. This is adequate for most measurements. If a higher test level is desired, it may be used at full rotation except on the X0.001 range where the "RED LINE" position should not be exceeded. Operating with a higher level on this range may cause overheating of the bridge resistors with resultant change in bridge accuracy and possible damage to components.

Step f. Set SENSITIVITY control to maximum.

Step g. Adjust DETECTOR TUNE control until null indicator deflection is at maximum. To avoid tuning the detector to a harmonic of the test frequency, the detector should be tuned to the peak which occurs in the FARTHEST COUNTERCLOCKWISE POSITION of the detector tuning knob (the low-frequency end of the multi-turn control).

Step h. Alternately adjust the ZERO ADJUST (L) control and the ZERO ADJUST (R) controls until the null indicator deflection is at a minimum point.

NOTE:

The "L ZERO" is a dual ratio control having a full traverse of approximately 3-1/2 turns. It will be noted that for about 270° of rotation, this control turns very easily. Beyond these limits the torque requirement increases abruptly, indicating a shift from the 36 to 1 "FINE" adjustment to the 6 to 1 "COARSE" adjustment. When the control reaches the end of its full traverse, the operator will sense another increase in torque requirements; since this control is friction driven, no damage will be sustained if the operator attempts to turn it beyond the end of its range.

The "R ZERO" adjustment consists of two separate controls; "COARSE" for rapid scanning, and "FINE" for precise adjustment in locating the null.

Step i. After obtaining minimum deflection of the null indicator, it is usually desirable to adjust the sensitivity control to reduce the residual noise level. Leaving all other controls undisturbed, adjust the sensitivity control until a reading of one and one-half (1-1/2) meter divisions is obtained. This sensitivity level is adequate for the vast majority of applications. It minimizes the effects of the total system noise; in addition, experience has shown that it is more convenient to locate a null with low meter readings rather than at half scale or above.

Step j. Remove the short circuit from across the TEST binding posts and connect the test specimen.

Step k. Adjust the SERIES INDUCTANCE "1000 μH" decade switch for minimum deflection of the null indicator. Adjust the MICROHENRIES dial to obtain a lower null indication. If null deflection is not reduced, then set this decade switch to next lower position and readjust MICROHENRIES dial for minimum deflection.

Step l. Now adjust the SERIES RESISTANCE control for further reduction of null indication. Use "100 Ω" decade switch if necessary.

Step m. Now alternately adjust the SERIES INDUCTANCE and SERIES RESISTANCE controls until null indicator deflection is an absolute minimum.

Step n. To obtain the value of inductance under test, add the readings on the two SERIES INDUCTANCE dials and multiply by the factor indicated on the MULTIPLY L AND R BY dial.

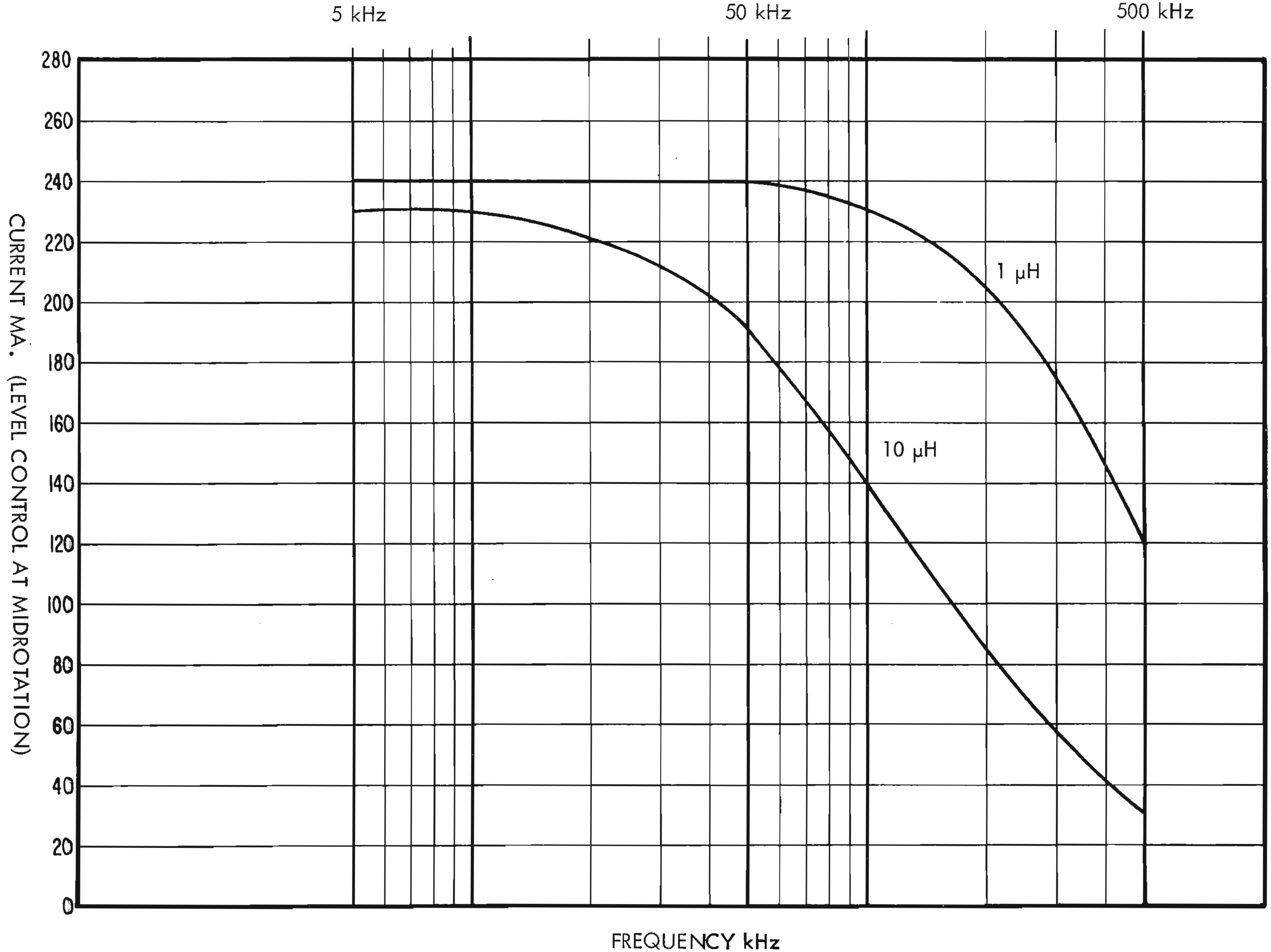


Chart 1
63H MAXIMUM AC TEST CURRENT X0.001 RANGE

Chart 2

63H MAXIMUM AC TEST CURRENT   X0.01 RANGE

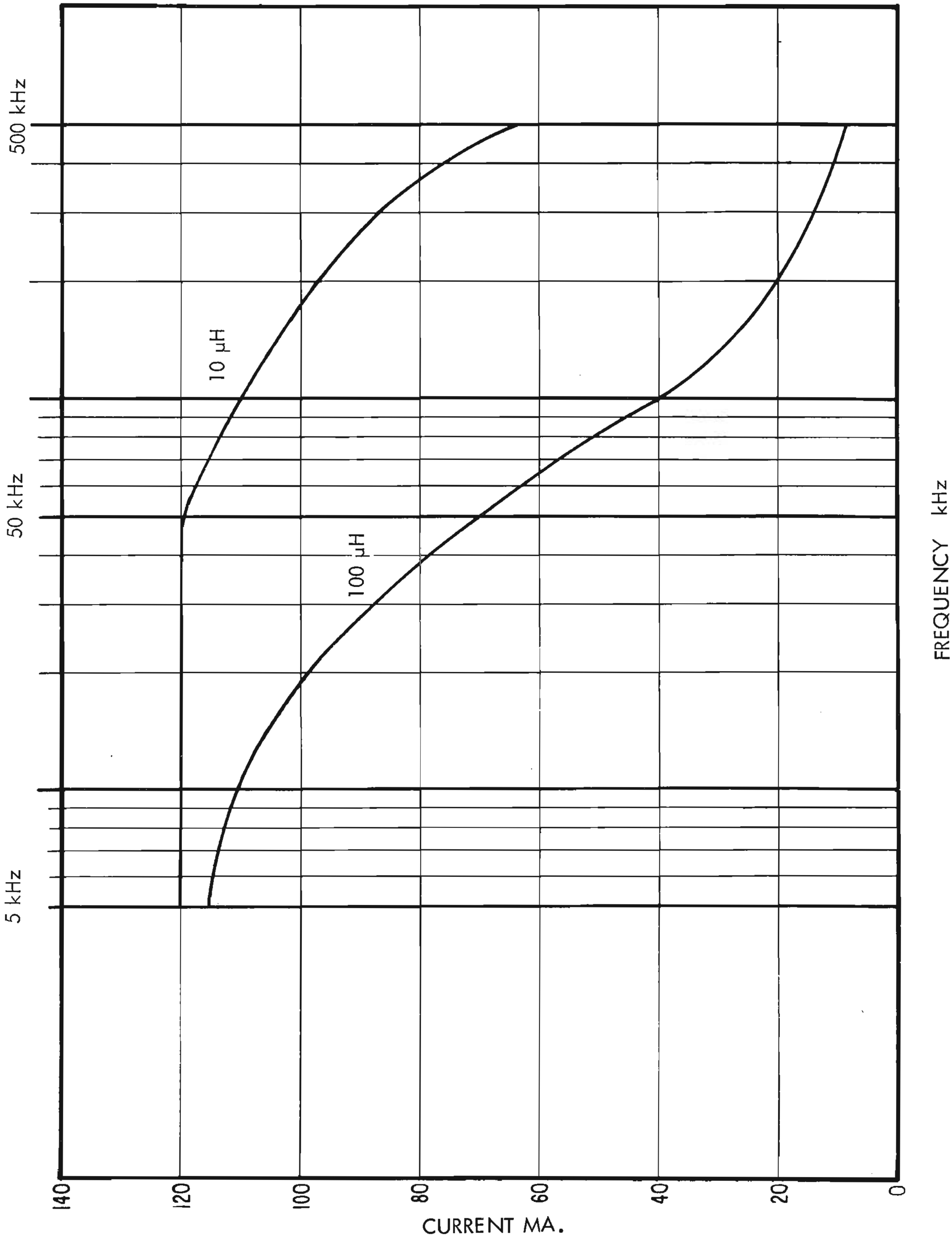


Chart 3

63H MAXIMUM AC TEST CURRENT   X0.1 RANGE

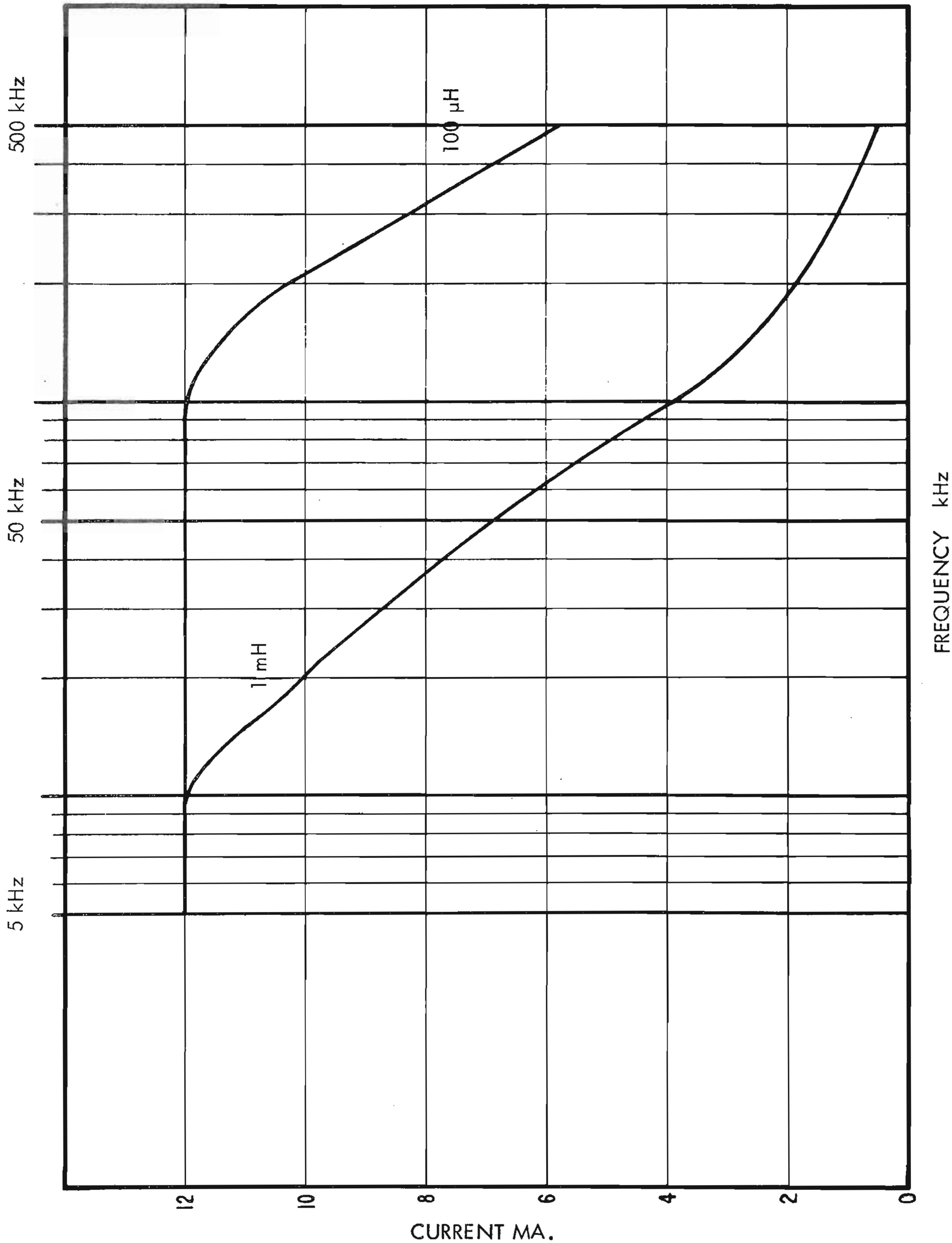


Chart 4

63H MAXIMUM AC TEST CURRENT X1 RANGE

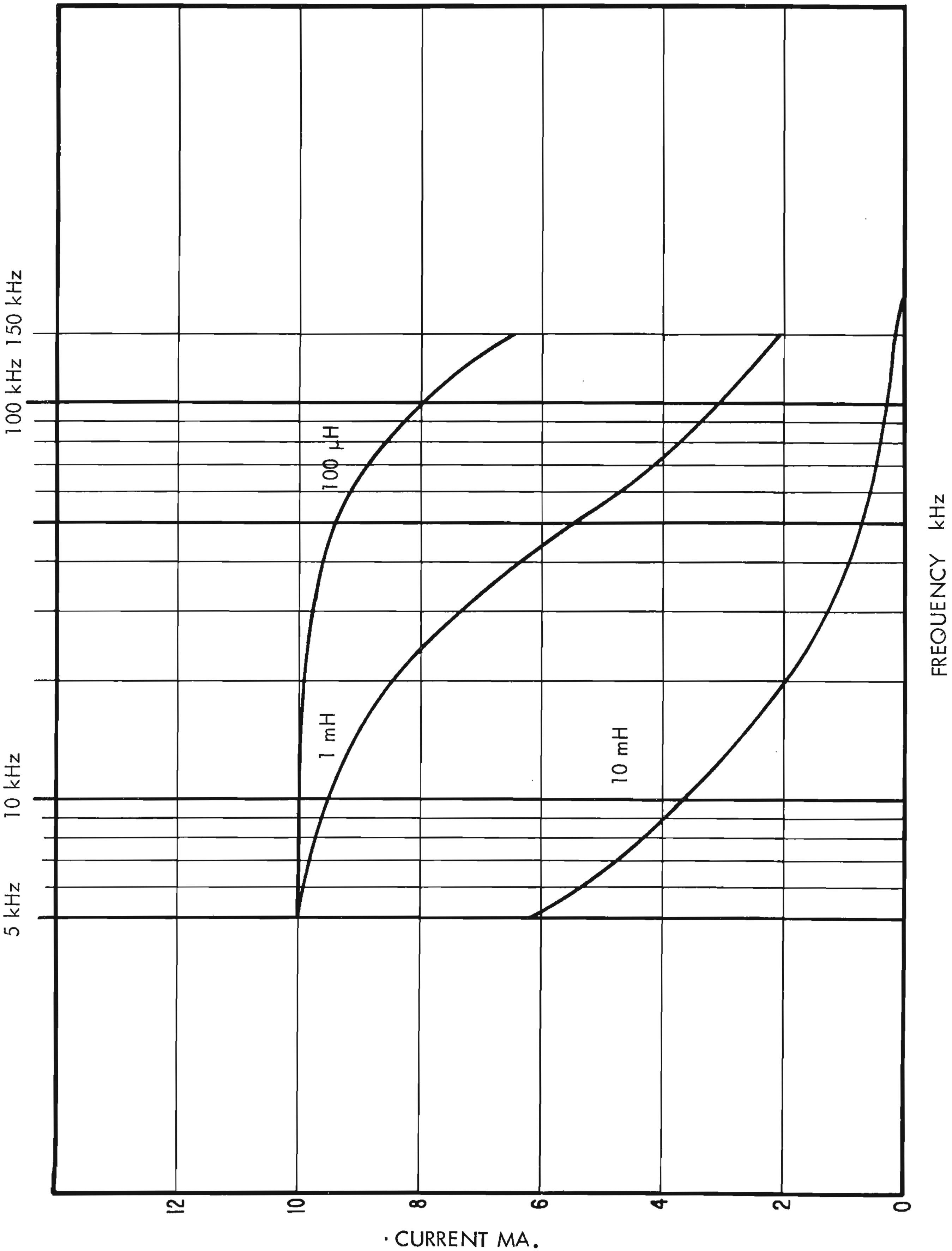
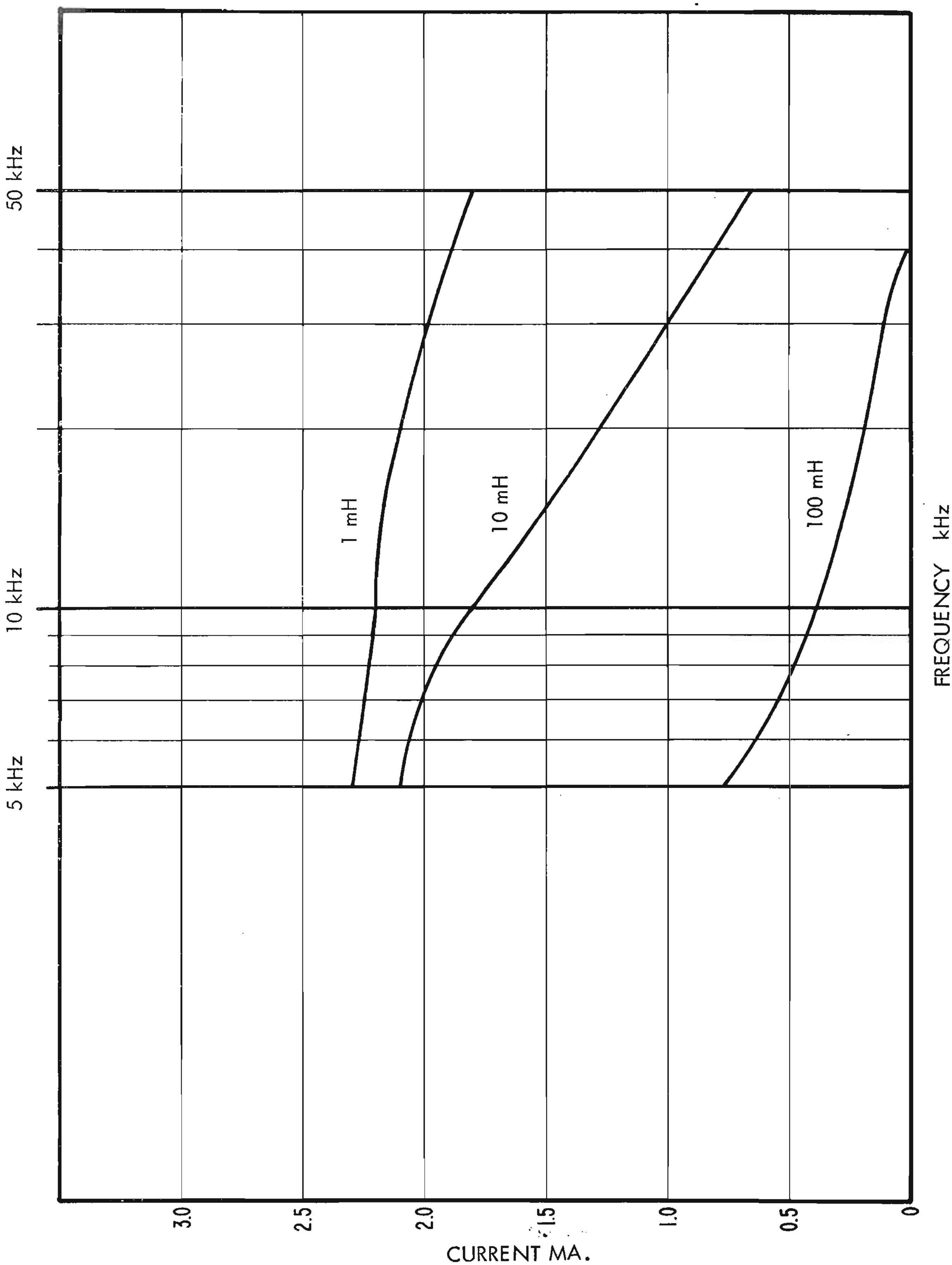


Chart 5
63H MAXIMUM AC TEST CURRENT X10 RANGE



Example:

Reading on 1000 μH dial	= 3000.0 μH
Reading on SERIES INDUCTANCE dial	= 437.5 μH
Sum	= 3437.5 μH

MULTIPLY L AND R BY dial = 0.1

Inductance of coil under test = 343.75 μH

Step o. To obtain the value of series resistance under test, add the readings on the two SERIES RESISTANCE dials and multiply by the factor indicated on the MULTIPLY L AND R BY dial.

Example:

Reading on 100Ω dial	= 0.0Ω
Reading on SERIES RESISTANCE dial	= 64.0Ω
Sum	= 64.0Ω

MULTIPLY L AND R BY dial = 0.1

Resistance of coil under test = 6.4Ω

3-4 AC TEST VOLTAGE AND CURRENT MEASUREMENTS

3-4-1 The ac voltage across the test specimen or the alternating current passing through the test can be adjusted from nearly zero to maximum by means of the OSC LEVEL control. Maximum open-circuit test voltage is approximately 3.0 volts rms on all ranges except on the X0.001 range, where it is approximately 1.5 V.

3-4-2 PRECAUTION: When operating on the X0.001 range, the oscillator level control should not be set beyond approximately the "RED LINE" position in order to avoid possible distortion of the test signal, and also to prevent heating of resistors in the bridge which might cause drift in null indication.

3-4-3 The voltage appearing across the test at balance can be measured by a high impedance vacuum tube voltmeter.

3-4-4 The current through the test may be determined with a clip-on type ac milliammeter. It may also be determined by measuring the voltage drop across a one ohm resistor connected between the GND terminal and the specimen under test. The current in milliamperes can thus be read directly in terms of millivolts across the one ohm resistor. However, if the latter method is used, the one ohm of resistance must be subtracted from the indicated Series Resistance to obtain the correct value.

3-4-5 Maximum ac test current values versus frequency for each range are shown in the charts on pages 3-5 to 3-9.

3-5 APPLICATION OF SUPERIMPOSED DIRECT CURRENT

3-5-1 Superimposed direct current may be applied to the coil under test within the maximum limits indicated in the following table.

NOTE:

Values shown in this table are the maximum dc levels that may be superimposed on the full ac level without overheating the bridge resistors. Exceeding the value for any given range could cause heating of the bridge resistors, with resultant null drift, or altered bridge calibration. If the overload is prolonged or is substantially beyond specified limits, extensive damage to bridge components may result.

Table 2

MULTIPLY L/R RANGE	MAX. DIRECT CURRENT Milliamperes
0.001	300
0.01	150
0.1	70
1.0	70
10.0	50

3-5-2 The direct current source and milliammeter should be connected between the GND binding post and the low side of the test. (See accompanying diagram). A high-capacitance electrolytic capacitor* of adequate voltage rating should be connected across the dc source and milliammeter to minimize errors resulting from this series impedance. This impedance may also be measured and the values subtracted from the final measurement.

* Electrolytic capacitors with high effective series resistance should not be used.

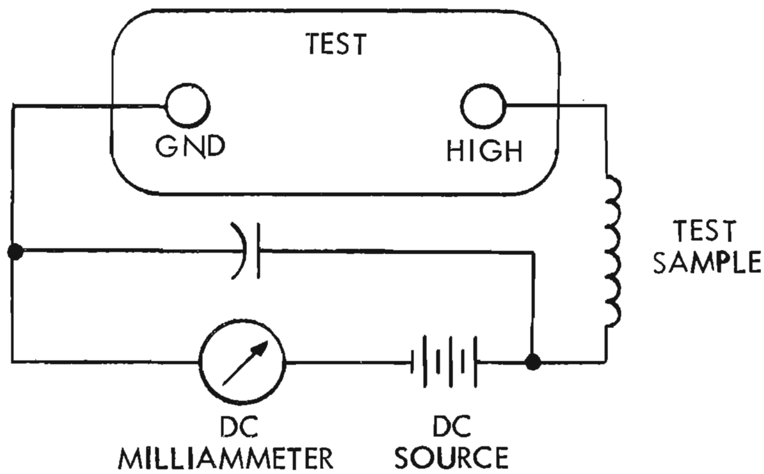


Figure 3. Circuit for applying superimposed dc.

3-6 INDUCTANCE STANDARDIZING TECHNIQUE

Inductance may be standardized by a series resonant method using precision capacitors and frequency standards. The Model 63H Inductance Bridge may be utilized to determine the series resonant condition.

3-6-1 Connect a stable external oscillator to the bridge transformer. Adjust the external signal source to the desired frequency using a precision electronic counter (0.01%).

3-6-2 Select a high Q, stable, mica capacitor having a capacitance slightly greater (not more than 5%) than that required to resonate the inductor to be standardized. This capacitance must be greater than the required value so that the final effective inductance will read up-scale on the dial.

3-6-3 Using a precision capacitance bridge, determine the absolute capacitance of the standard capacitor. A BEC Model 74D 100 kHz Capacitance Bridge may be used for this purpose. If a frequency other than 100 kHz is to be used for the calibration of the standard inductor, a Model 75C may be substituted.

Determine also the shunt conductance of the capacitor. The measurement of conductance should be made at the test frequency. This may be accomplished with a variable frequency capacitance bridge such as the BEC Model 75C.

Calculate the equivalent series resistance of the standard capacitor using the relationship:

$$\text{Series Resistance} = R_C = \frac{G}{\omega^2 C^2}$$

Where

G = the shunt conductance of the capacitor in mhos, measured at the test frequency.

C = the capacitance of the standard capacitor in farads

and

$\omega = 2\pi f$

3-6-4 Adjust the bridge at the test frequency for zero balance of both L and R on a suitable L/R range. The MULTIPLY L AND R BY switch may be set one step lower than would normally be used to measure the inductor to obtain a better readout for resistance.

3-6-5 Connect the test inductor and standard capacitor in series across the TEST binding post of the bridge. Connect the low side of the inductor to ground and the standard capacitor to the high side of the coil and test terminal of the bridge.

3-6-6 Balance the bridge and read the inductance and resistance values as well as the exact frequency of the external oscillator.

Record the inductance reading (ΔL)
Record the resistance reading (R_1)
Record the frequency (f)

3-6-7 Compute the equivalent negative inductance of the standard capacitor.

$$L_N = \frac{1}{\omega^2 C}$$

True inductance of standard = $L_N + \Delta L$

True resistance of standard = $R_1 - R_C$

3-6-8 Check the accuracy of the bridge resistance reading by substituting a decade resistance box such as a General Radio No. 1432 across the test terminals and adjusting the resistance box and reactive bridge controls for a null. Do not adjust the resistance dial.

3-6-9 The accuracy of this technique depends largely upon the care in measuring the standard capacitor and frequency in Steps 3-6-3 and 3-6-6. Precautions should be taken to avoid introducing stray capacitance across the test terminals as well as using short leads with a minimum of contact resistance while measuring the resistance in Step 3-6-8.

SECTION 1V

MAINTENANCE

4-1 CIRCUIT CHECKS

The following information is given to aid in trouble shooting the various circuits of the bridge as well as to determine if all circuits are operating properly.

Voltage measurements were made from the indicated point to chassis ground with a multitester such as a Simpson No. 260 or equivalent. The voltages are nominal and may vary slightly between units due to component tolerances. Voltage measurements are made at nominal line voltage and under full load conditions.

4-2 VOLTAGE MEASUREMENTS

4-2-1 Power Supply

V201 6BW4 - Rectifier tube voltage readings.

Pin No. 1	380V ac	Pin No. 7	380V ac
Pin No. 4	6.3V ac	Pin No. 9	+425V dc

Junction of L201, C202b and R202	+415V ac
Junction of D205 and D206	5.5V ac
Junction of D207 and D208	5.5V ac
Junction of D201 and D202	15 V ac
Junction of D203 and D204	15 V ac
Junction of D201, D203 and C201	-34 V ac

Voltage measurements made at the 12 pin connector, J201, are as follows:

Pin No. 3	+300V dc	Pin No. 7	6.3V ac
Pin No. 4	+300V dc	Pin No. 8	-6.6V dc
Pin No. 5	+150V dc	Pin No. 9	+6.6V dc
Pin No. 6	6.3V ac	Pin No. 11	-11.5V dc

The total power from the ac line, with a nominal line voltage of 120 volts, should be 60 watts as measured with a Sensitive Research, Model Univ. Wattmeter.

4-2-2 Oscillator

Oscillator tube voltage readings V101 12AT7

Pin No. 1	+200V dc	Pin No. 7	0V
Pin No. 2	0V	Pin No. 8	+1.7V dc
Pin No. 3	+2.9V dc	Pin No. 9	6.3V ac
Pin No. 6	+156V dc		

The total current drawn by the oscillator under normal conditions should be 7 mA.

The following are nominal ac voltages taken at the junction of R107 and R108 with a Ballantine 314 VTVM:

X1 Range:	5 kHz	6.6V	25 kHz	6.2V
	10 kHz	6.4V	50 kHz	6.2V
V10 Range:	50 kHz	6.4V	250 kHz	6.2V
	100 kHz	6.4V	500 kHz	6.2V

4-2-3 Emitter Follower

The following are nominal dc voltages throughout the emitter follower circuit. CAUTION: In making voltage measurements it is absolutely necessary not to short the test lead to ground from any point being measured.

Q101	2N404A	Emitter	-21.5 volts	
		Base	-21.0 volts	
		Collector	-34 volts	Supply
Q102	2N404A	Emitter	-21.5 volts	
		Base	-21.5 volts	
		Collector	-34 volts	Supply
Q103	2N1605	Emitter	-21.5 volts	
		Base	-21.5 volts	
		Collector	-18.0 volts	
Q104	2N1046	Emitter	-21.0 volts	
		Base	-21.5 volts	
		Collector	-34	Supply

4-2-4 Tuned Detector

Tuned detector tube voltage readings. V501 6U8

Pin No. 1	+130V dc	Pin No. 6	+85V dc
Pin No. 2	0V	Pin No. 7	+1.3V dc
Pin No. 3	+ 90V dc	Pin No. 8	+6.2V dc
Pin No. 4	+6.6V dc	Pin No. 9	0V
Pin No. 5	Ground		

4-2-5 Preamplifier

Preamplifier tube voltage readings. V401 6AK5

Pin No. 1	0V	Pin No. 5	+21V dc*
Pin No. 2	No pin	Pin No. 6	+60V dc*
Pin No. 3	Ground	Pin No. 7	+1.5V dc*
Pin No. 4	+6.6V dc		

* These voltages are with no signal input and will vary widely with signal input.

4-2-6 Wideband Amplifier

The following voltage readings are made with SENSITIVITY control at maximum gain and no input signal.

V601 6AU6

Pin No. 1	0V	Pin No. 6	+178V dc
Pin No. 4	6.3V ac	Pin No. 7	+2.5V dc
Pin No. 5	+185V dc		

V602 6AU6

Pin No. 1	0V	Pin No. 6	+150V dc
Pin No. 4	6.3V ac	Pin No. 7	+4V dc
Pin No. 5	+208V dc		

Wideband amplifier gain vs. frequency.
Input Level - 0.001V
Gain Controls - Maximum

Frequency	Input Level	Output Level	Gain in dB
5 kHz	0.001V	1.9V	65.5 dB
10 kHz	0.001V	1.9V	65.5 dB
50 kHz	0.001V	1.9V	65.5 dB
100 kHz	0.001V	1.9V	65.5 dB
500 kHz	0.001V	1.0V	60.0 dB

Input level measured at J601.
Output level measured at C612, C613 and D601.

4-3 CALIBRATION AND ADJUSTMENT OF OSCILLATOR AND TUNED DETECTOR

4-3-1 The oscillator dial has one calibration of from 5.0 to 50 and with the use of the X1 and X10 multiplier the frequency is covered in two ranges of from 5 kHz to 50 kHz and 50 kHz to 500 kHz. The accuracy of calibration is ±3% and should be maintained. Errors in low frequency calibration may be due to changes in the resistors R101, R102, R103 and R104. High frequency calibration may be adjusted by C104 adjustment No. 1.

4-3-2 Tuned Detector Adjustment

Before adjustment of the tuned detector, the cover over the oscillator-detector chassis as well as the preamplifier must be in place and all screws tightened.

Disconnect the power plugs J602 and P602 to the wideband amplifier, also J101 and P101 to the oscillator section.

Use a coaxial "T" connector at J601, the input to the wideband amplifier, for connecting a vtvm such as a Ballantine 314 and an oscilloscope. Long coaxial leads should not be used because of the added capacitance. The input of the wideband amplifier should not be disconnected.

Set the MULTIPLY L AND R BY switch S303 to the X0.1 range.

Connect a 5 kHz to 1 MHz oscillator to the bridge TEST terminals through an attenuator. The input at the TEST terminals should be monitored and kept at 0.01 volt, with a Ballantine 314 voltmeter or equivalent.

Set the frequency multiply switch S501 to the X1 position, set the oscillator to 5 kHz and alternately adjust DETECTOR TUNE control and adjustment No. 6 so that the discrimination at 10 kHz will be 25 to 30 dB.

Set oscillator to 50 kHz maintaining 0.01 V into the bridge test terminals, and alternately adjust the DETECTOR TUNE control and adjustment No. 3 so that the discrimination at 100 kHz will be 25 to 30 dB.

Now recheck between 5 and 50 kHz and readjust No. 6 and No. 3 until these readings are obtained with no oscillations.

Set the frequency multiply switch S501 to the X10 position, and set the oscillator to 50 kHz at 0.01 volt input. Alternately adjust the DETECTOR TUNE control and adjustment No. 5 so that the discrimination at 100 kHz will be 25 to 30 dB.

Set frequency to 500 kHz with input level maintained at 0.01 volt. Alternately adjust the DETECTOR TUNE control and adjustment No. 2 so that the discrimination at 1 MHz will be 25 to 30 dB.

Now recheck between 50 and 500 kHz and readjust No. 2 and No. 5 until these readings are obtained with no oscillations. It may be necessary to remove the cover to adjust C504 No. 4 at 500 kHz in order to obtain only one tuning point with no oscillation.

4-4 BRIDGE SECTION ADJUSTMENTS

CAUTION: Adjustments to the bridge section and MULTIPLY L AND R BY switch should not be made if at all possible. Such adjustments are preferably factory made. The following information is primarily for determining the proper functioning of the bridge. Replacement and movement of components in the bridge section may result in bridge inaccuracies.

4-4-1 Variable Capacitor Calibration (C302)

The variable capacitor should be checked with a 20 kHz capacitance bridge. The bridge circuit should be opened at A' which is the wire braid to the ceramic standoff in the bridge section. Also the lead to the bridge input transformer T301 should be opened at B. The resistor R302 should be opened where it connects to R301. (Reference schematic 830183). Switch S302 (Inductance Decade) should be set on zero. The leads to the L and R zero controls need not be opened. C301 should be set at minimum capacitance and R304 set at maximum resistance. R306 should be set near maximum resistance but may be used as a fine conductance adjustment, the same as the capacitance bridge conductance zero adjustment.

The first 200 (100 pF) dial divisions of the capacitor should be calibrated every 10 divisions (5 pF) and must be within ±0.1 pF. This should be done on the X0.1 range of the capacitance bridge. The remaining 800 dial divisions may be calibrated every 100 divisions (50 pF) and may be done on the X1 range. All readings must be within ±0.1%.

Care should be taken to keep leads as short as possible when connecting the capacitance bridge to the inductance bridge; all clip leads should be kept as far from the variable capacitor as possible, so when all calibration is complete, removing the leads will not affect the calibration.

In calibration of the first 200 dial divisions, it will be necessary to return to zero and recheck after almost every plate adjustment as the minimum capacitance will be changed considerably over the first part of the calibration.

4-4-2 Inductance Decade Switch Calibration (S302)

The arrangement of leads for calibration of the decade switch can be the same as for the variable capacitor calibration. However, a bridge shield cover, with holes for adjustment purposes should be used to insure the best accuracy. The variable capacitor should be set on zero.

In position No. 1 (1000 μH), the capacitance should be 500 pF ±0.1% and adjusted by No. 10 (C304).

Position No. 2 (2000 μH) should be 1000 pF ±0.1% and adjusted by No. 13 (C311).

Position No. 3 (3000 μH) should be 1500 pF ±0.1% and adjusted by No. 9 (C303). This position is a combination of capacitors C304, C305 and C310, C311.

If an error is indicated on this position, read the value of error and reset the capacitance bridge to zero offset by the amount of error and in the opposite direction; that is, if the capacitance if 2 pF high, set the bridge at minus 2 pF from zero and adjust No. 9 (C303) for zero. Return bridge to zero, rebalance and recheck positions 1, 2 and 3. Repeat this procedure until each position is within ±0.1% of nominal.

Position No. 4 (4000 μH) should be 2000 pF ±0.1% and adjusted by No. 12 (C309).

Position No. 5 (5000 μH) should be 2500 pF ±0.1% and adjusted by No. 11 (C306).

The remaining positions are each an increase of 500 pF and have no adjustments. If each capacitor is properly adjusted from position 1 to 5, each remaining position should check as follows:

No. 6	3000 pF	±0.1%
No. 7	3500 pF	±0.1%
No. 8	4000 pF	±0.1%
No. 9	4500 pF	±0.1%
No. 10	5000 pF	±0.1%

Restore all connections within the bridge section.

4-4-3 Balance Capacitor Adjustment (C315)

It is necessary to balance the circuitry associated with the balance capacitor C315 to obtain correct adjustment during the further calibration procedures. The MULTIPLY L AND R BY switch should be set on the X0.01 position, and the bridge should be tuned and operating at 10 kHz. The bridge circuit should be opened at point D, also the bridge test terminals must be open. The rotor of the variable capacitor (C302) should be shorted to the stator with a short lead. Then by alternately adjusting No. 19 and No. 20 on the balance capacitor, a minimum meter reading will be obtained. The meter will not indicate zero at the null but there will be a definite null condition. Care in making this adjustment will make further adjustments unnecessary.

4-4-4 Resistance Decade Check and Resistance Dial (S301 and R301)

Set the MULTIPLY L AND R BY switch to X1.0 with the resistance dial set on zero and a General Radio 1432T Decade Resistance Box connected to the bridge test terminals. Check each 100Ω position of the resistance decade switch from one hundred to one thousand ohms. Each position must be within 0.5%. Repeat this procedure with resistance dial.

4-4-5 Product Arm Adjustment (MULTIPLY L AND R BY switch)

The adjustment of the product arm is made on a dc resistance measurement basis. A resistance bridge accurate to five places is required. The three leads to the resistance bridge should all be the same length. The resistance of the leads should be measured and used as a correction factor. One lead should be connected between the ground side of the resistance bridge and a ground on the inductance bridge preferably where the rear section of the MULTIPLY L AND R BY switch is connected to ground. The other two leads should be each of a different color to identify them and one should be connected to point A on the rear of the MULTIPLY L AND R BY switch; the other lead will be connected to point C either in the MULTIPLY L AND R BY switch or at the balance capacitor. The lead from A' to the bridge section should be opened where it leaves the MULTIPLY L AND R BY switch. The bridge test terminals must also be open; that is, no shorting plug should be connected. Now it will be possible by connecting either the A or C lead to the high post of the resistance bridge to measure the dc resistance from A to D or C to D. All solder connections must be carefully made to insure no high resistance connections which could cause considerable error in the measurements. Extreme care should be used in making the measurements, as well as reading the values on the bridge and making the necessary calculations to insure the best possible accuracy in these measurements. The rotation of the X0.001 down to the X10 range should be followed. The X0.001 and X10 ranges have separate resistors which are not dependent upon another range; however, the X0.01 to the X1 range should be adjusted in that order as each is dependent on the value of the other.

The procedure to be followed, for example, on the X0.001 range is as follows. First the resistance is measured from CD which will be in the order of 5 ohms. The correction factor which is the resistance of the leads will be subtracted from this value. This gives a corrected value for CD. On the X0.001 range the product of the bridge arms CD x AD is 2×10^3. The value of 2×10^3 should be divided by the corrected value of CD to obtain AD. To this value is added the correction factor (lead resistance) to obtain a value of AD, which is then set up on the resistance bridge with the appropriate leads and adjustment 14 is varied to obtain this reading. This procedure should then be followed for the remaining four ranges.

4-4-6 Adjustment of Zeroing Controls

The bridge should be capable of being zeroed on every range at every useable frequency. The X0.001, X0.01 and X0.1 range should be able to be zeroed at any frequency, the X1.0 range should be able to be zeroed to at least 250 kHz and the X10 range should be zeroed up to 100 kHz. If the bridge will not zero on any particular range, a check should be made to determine if the proper shorting connector is being used. On the X0.001 range it is necessary to use the shorting link supplied; on the other ranges, the shorting plug supplied should be used. Using the proper shorting connectors, the bridge should zero over the frequency range given above. To locate troubles in zeroing, the main controls may be used to zero the bridge which will show the approximate magnitude and if the fault is due to inductance or resistance.

4-4-7 Bridge Sensitivity and Noise Level

With the front panel SENSITIVITY control at maximum gain, the noise level should not exceed 10 μA at any frequency. Any higher noise level indicates either a noisy 6AK5 (V401) or the tuned detector is adjusted near a point of oscillation thereby increasing the noise.

The following are nominal sensitivity checks:

SENSITIVITY control = Maximum

Range X1.0 OSC LEVEL = Maximum
50 kHz 0.2 μH unbalance = 20 μA

When checking sensitivity, a check should be made to make sure the meter M601 does not read offscale at maximum unbalance (which is with open circuit test terminals) and with detector tuned. This adjustment is No. 8 on the rear of the meter, which can be set for just under full scale reading at maximum unbalance, with maximum level.

It should be noted that this adjustment will probably require readjustment each time a new tube V401 (6AK5) is put in the circuit.

4-4-8 Reading of Inductance and Resistance Standards

The basic inductance accuracy of the bridge is $\pm 0.25\% + \frac{300}{C}$ where C is the resonating capacitance of the coil at the test frequency.

The accuracy of the resistance measurements should be within the bridge specification of $\pm 3\% + \frac{Q}{25}$.

In making inductance measurements where the resonating capacitance is small and series resistance measurements where the Q is high, the full basic accuracy statement must be used. Also, consult the reactance chart, page 2-2, to determine if the measurement is being made within the recommended range.

4-4-9 AC Test Level

The maximum open circuit test level on the X0.01 to X10 range should be 3.0 volts rms ±10% over the frequency range. The maximum test level on the X0.001 range should be 1.5 volts rms with the oscillator level control set at red line. The level control should never be used at maximum on the X0.001 range.

SECTION V

REPLACEABLE PARTS LIST

NOTE:

Component parts in the bridge section are not listed because their replacement usually must be followed by adjustments that require specialized equipment and techniques.

Power Supply Section

C201	Capacitor	3200 μF at 40V			283,155
C202	Capacitor	30/10 μF at 475V			283,154
C203	Capacitor	0.1 μF at 400V			236,001
C204	Capacitor	1000/1000 μF at 15V			283,131
D201	Diode	1N538			532,008
D202	Diode	1N538			532,008
D203	Diode	1N538			532,008
D204	Diode	1N538			532,008
D205	Diode	1N538			532,008
D206	Diode	1N538			532,008
D207	Diode	1N538			532,008
D208	Diode	1N538			532,008
F201	Fuse (234V ac models)	0.6A, 250V Buss MDL 0.6			545,512
F201	Fuse (117V ac models)	1.2A, 125V Buss MDL 1.2			545,509
I201	Lamp	6V, No. 47			545,101
J201	Socket	12 Pin			474,106
L201	Choke	7 H			440,001
P201	Connector	Line Cord			568,101
P202	Connector	Plug			477,137
R201	Resistor	10KΩ	5%	1/2W	301,111
R202	Resistor	3.5KΩ	5%	10 W	312,102
R203	Resistor	22Ω	5%	2 W	303,622
S201	Switch	SPST Toggle			465,105

T202	Transformer, Power				446,038
*T201	Transformer, Power				446,026
*T202	Transformer, Power				446,020
V201	Tube	6BW4			526,6BW4
V202	Tube	OA2			526,OA2
V203	Tube	OA2			526,OA2

Oscillator Emitter-Follower Section

C101	Capacitor	Variable, 2 Sec. 10-410 pF/sec.			275,131
C102	Capacitor	0.022 μF at 400V			234,033
C103	Capacitor	22 pF 5% Ceramic			220,113
C104	Capacitor	Trimmer 4.5-25 pF Ceramic			281,000
C105	Capacitor	0.056 μF at 200V			236,006
C106	Capacitor	0.01 μF at 400V			234,021
C107	Capacitor	0.5 μF at 100V			234,034
C108	Capacitor	8 μF at 350V			283,126
C109	Capacitor	0.056 μF at 200V			236,006
C110	Capacitor	0.056 μF at 200V			236,006
C111	Capacitor	68 pF 5%			200,031
C112	Capacitor	1.0 μF at 100V			236,007
C113	Capacitor	100 μF at 25V			283,105
J101	Connector	Plug			477,166
J102	Connector	Coaxial			479,123
P101	Connector	Receptacle			477,145
P102	Connector	Coaxial			477,121
Q101	Transistor	2N404A			528,002
Q102	Transistor	2N404A			528,002
Q103	Transistor	2N1605A			528,005
Q104	Transistor	2N1046			528,010
R101	Resistor	7.87KΩ	0.5%		321,278
R102	Resistor	78.7KΩ	0.5%		321,277
R103	Resistor	7.87KΩ	0.5%		321,278
R104	Resistor	78.7KΩ	0.5%		321,277
R105	Resistor	1.5KΩ	5%	1/2W	301,091
R106	Resistor	47KΩ	5%	1/2W	301,127
R107	Resistor, Var.	25KΩ		2 W	311,155
R108	Resistor	10KΩ	5%	1/2W	301,111
R109	Resistor	330Ω	5%	1/4W	300,070
R110	Resistor	330Ω	5%	1/2W	301,075
R111	Resistor	300KΩ	5%	1/2W	301,146
R112	Resistor	1 MegΩ	5%	1/4W	300,154
R113	Resistor	1 KΩ	5%	1/2W	301,087

* Used only on serial numbers below 634.

R114	Resistor	39KΩ	5%	1/4W	300,120
R115	Resistor	4.7KΩ	5%	1/4W	300,098
R116	Resistor	2.7KΩ	5%	1/4W	300,092
R117	Resistor	10KΩ	5%	1/4W	300,106
R118	Resistor	10KΩ	5%	1/4W	300,106
R119	Resistor	330Ω	5%	2 W	303,626
R120	Resistor	47Ω	5%	1/2W	301,055
R121	Resistor	10Ω	5%	2 W	303,614
R122	Resistor	50Ω		10 W	312,117
R123	Resistor	1KΩ	5%	1/2W	301,087
S101	Switch	4PDT			466,128
TH101	Thermistor	65A1			325,001
V101	Tube	12AT7			526,12AT7

Pre-Amplifier Section

C401	Capacitor	0.22 μF 100V			236,005
C402	Capacitor	10 μF 6V			283,130
C403	Capacitor	0.1 μF 200V			230,116
C404	Capacitor	0.1 μF 200V			230,116
C405	Capacitor	0.005 μF 200V			230,121
J401	Connector				477,167
P401	Connector				479,168
R401	Resistor	22 MegΩ	5%	1/2W	301,191
R402	Resistor	22 MegΩ	5%	1/2W	301,191
R403	Resistor	2.2KΩ	5%	1/4W	300,090
R404	Resistor	470KΩ	5%	1/4W	300,146
R405	Resistor	220KΩ	5%	1/4W	300,138
V401	Tube	6AK5W			525,004

Tuned Detector Section

C501	Capacitor, Var.	2 sec 10/410 pF/sec.	275,131
C502	Capacitor	Trimmer 7-45 pF	275,114
C503	Capacitor	Trimmer 7-45 pF	275,114
C504	Capacitor	Trimmer 5.5-18 pF	281,001
C506	Capacitor	0.1 μF 200V	230,116
C507	Capacitor	0.01 μF 200V	234,027
C508	Capacitor	10 μF 6V	283,130
C509	Capacitor	0.1 μF 200V	230,116
C510	Capacitor	0.1 μF 200V	230,116
C511	Capacitor	8 μF 350V	283,126

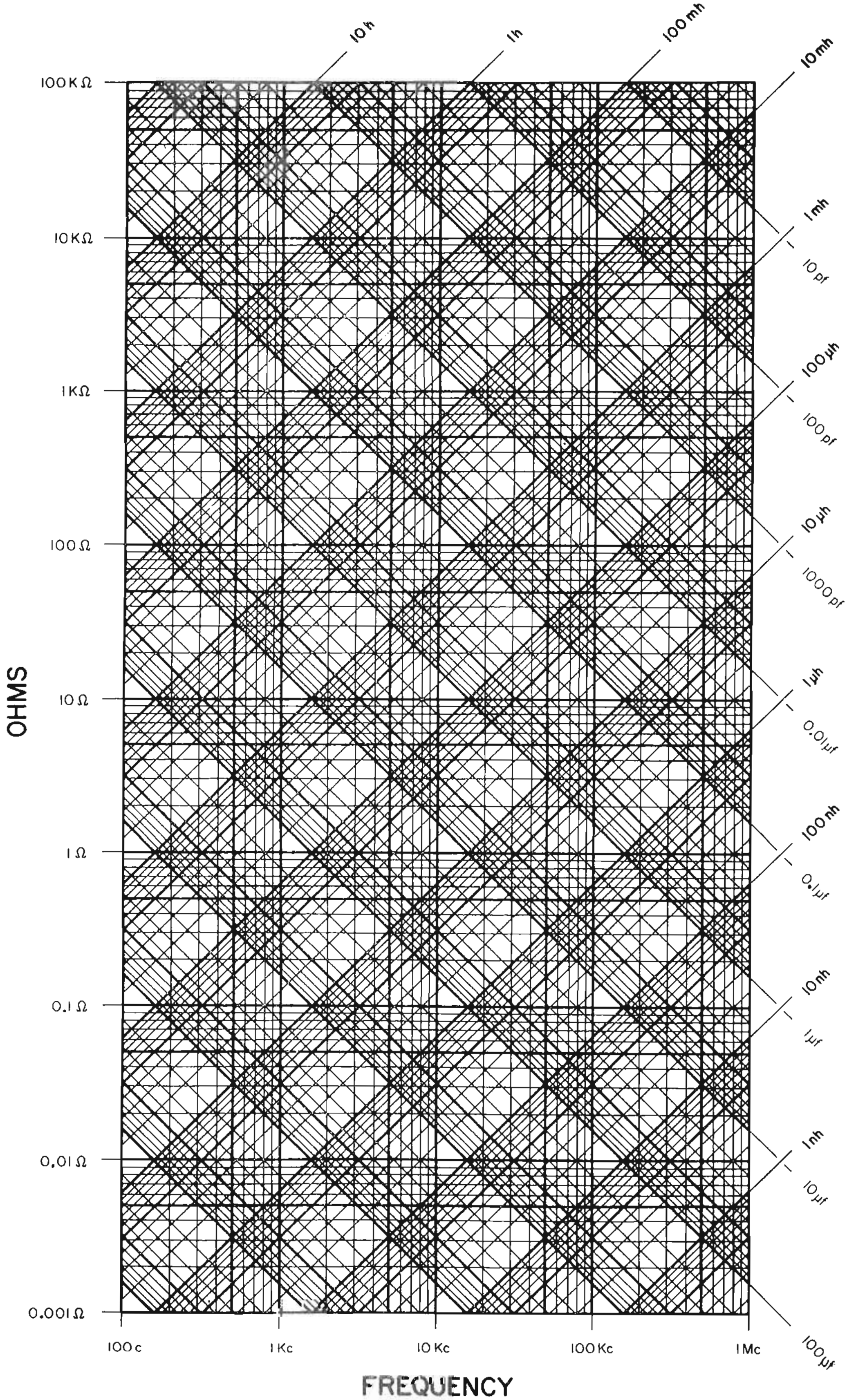
J501	Connector	Coaxial			479,123
J502	Connector	Coaxial			477,166
J503	Connector	Coaxial			479,123
P501	Connector	Coaxial			477,121
P502	Connector	Coaxial			477,145
P503	Connector	Coaxial			477,121
R501	Resistor	7.87KΩ	0.5%		312,278
R502	Resistor	78.7KΩ	0.5%		321,277
R503	Resistor	7.87KΩ	0.5%		321,278
R504	Resistor	78.7KΩ	0.5%		321,277
R505	Resistor	47Ω	5%		301,055
R506	Resistor	8.25KΩ	1%	1/2W	306,350
R507	Resistor	15KΩ	5%	1/2W	301,115
R508	Resistor	10KΩ	5%	1/2W	301,111
R509	Resistor	150Ω	5%	1/2W	301,067
R510	Resistor	1 MegΩ	5%	1/2W	301,159
R511	Resistor	24KΩ	5%	1/2W	301,120
R512	Resistor	16.5KΩ	1%	1/2W	306,385
R513	Resistor, Var.	5KΩ		1/10W	311,169
R514	Resistor, Var.	5KΩ		1/10W	311,169
R515	Resistor	1KΩ	5%	1/2W	301,087
R516	Resistor	100KΩ	5%	1/4W	300,130
S501	Switch	4PDT			466,128
V501	Tube	6U8			526,6U8

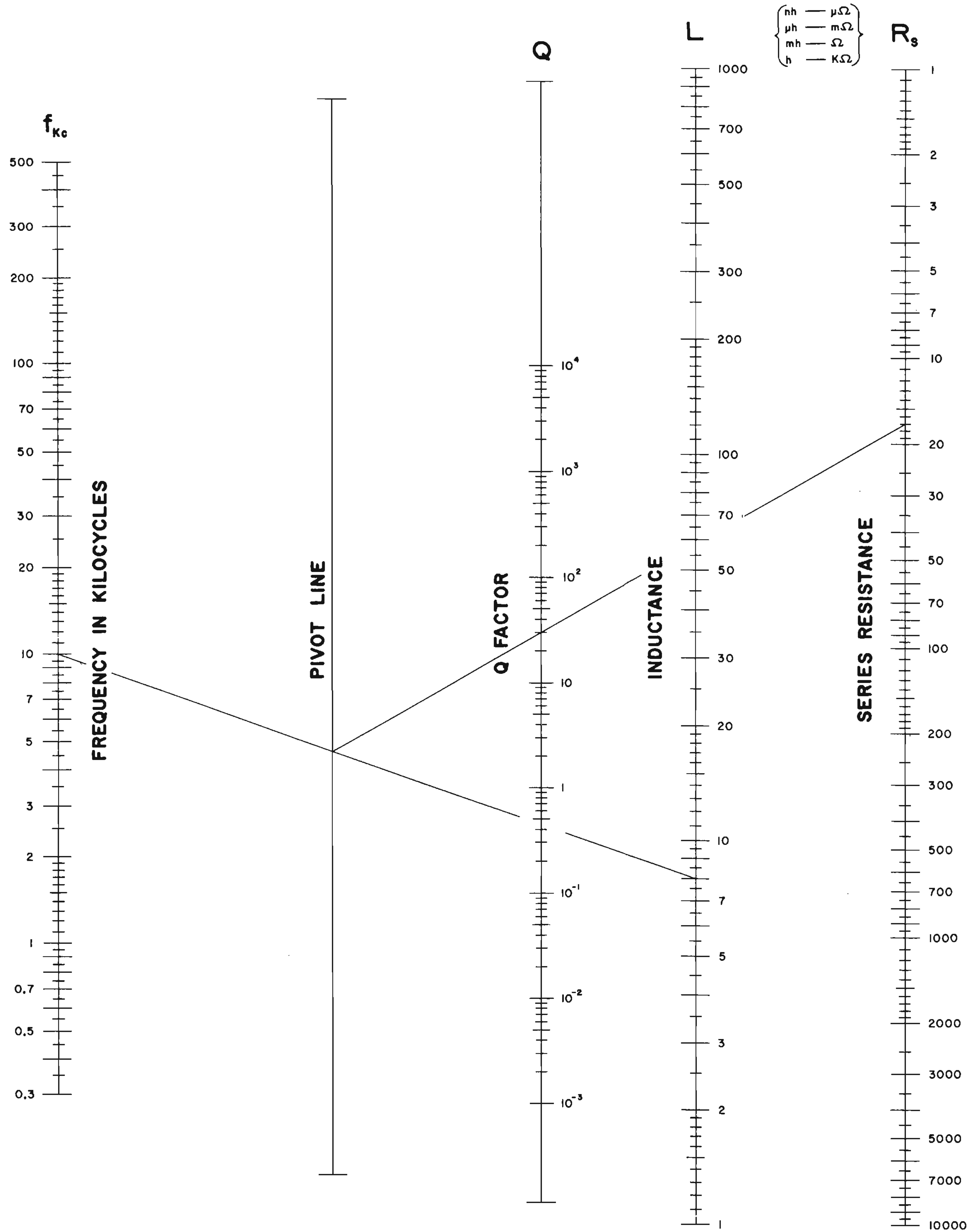
Wide Band Amplifier

C601	Capacitor	1000 pF	201,117
C602	Capacitor	1000 pF	201,117
C603	Capacitor	50 μF 6V	283,145
C604	Capacitor	0.1 μF 200V	230,116
C605	Capacitor	8 μF 350V	283,126
C606	Capacitor	0.1 μF 400V	236,001
C607	Capacitor	1000 pF	201,117
C608	Capacitor	0.1 μF 400V	236,001
C609	Capacitor	10 μF 6V	283,130
C610	Capacitor	0.1 μF 400V	236,001
C611	Capacitor	0.1 μF 200V	230,116
C612	Capacitor	0.1 μF 400V	236,001
C613	Capacitor	0.1 μF 400V	236,001
D601	Diode	1N58A	530,021
D602	Diode	SG-3113	530,009
J601	Connector	Coaxial	479,123
J602	Connector		477,166
J603	Jack		479,114

L601	Coil	2.5 mH			400,014
M601	Meter	0-50 μA			554,140
P601	Connector	Coaxial			477,121
R601	Resistor	470KΩ	5%	1/2W	301,151
R602	Resistor	2.2 MegΩ	5%	1/2W	301,167
R603	Resistor	470KΩ	5%	1/2W	301,151
R604	Resistor	1 KΩ	5%	1/2W	301,087
R605	Resistor	18 KΩ	5%	1/2W	301,117
R606	Resistor	47 KΩ	5%	1/2W	301,127
R607	Resistor	330Ω	5%	1/2W	301,075
R608	Resistor	470Ω	5%	1/2W	301,151
R609	Resistor, Var.	2.5 KΩ		1/10W	311,128
R610	Resistor	470KΩ	5%	1/2W	301,151
R611	Resistor	470KΩ	5%	1/2W	301,151
R612	Resistor, Var.	5KΩ		2 W	311,200
R613	Resistor	1 MegΩ	5%	1/2W	301,159
R614	Resistor	22KΩ	5%	1 W	302,133
R615	Resistor	100KΩ	5%	1/2W	301,135
R616	Resistor	470KΩ	5%	1/2W	301,151
R617	Resistor	47KΩ	5%	1/2W	301,127
R618	Resistor	47KΩ	5%	1/2W	301,127
R619	Resistor, Var.	50KΩ		1/10W	311,120

INDUCTANCE BRIDGE REACTANCE CHART





Q Nomograph for INDUCTANCE BRIDGES

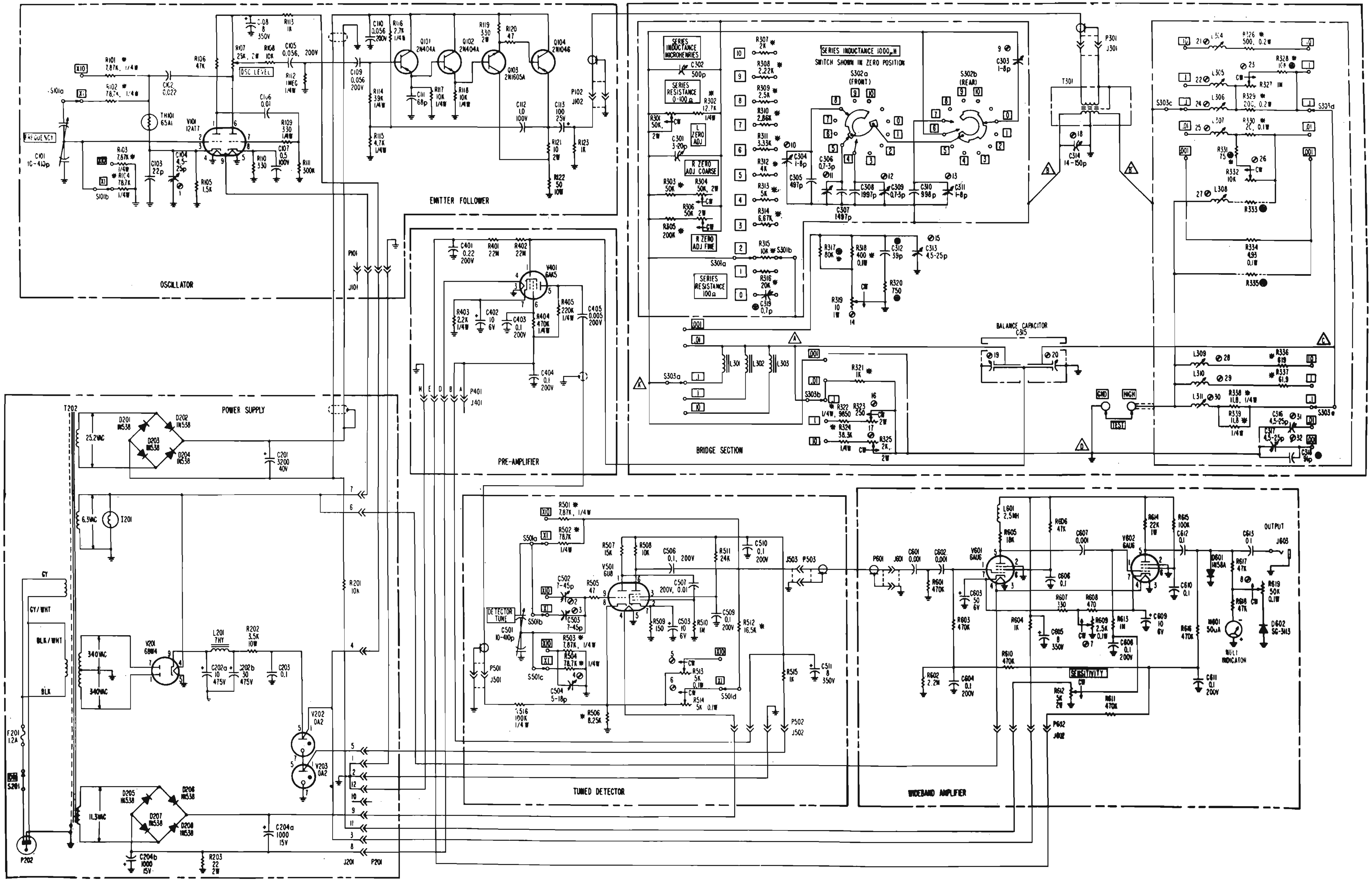
L WHEN INDUCTANCE SCALE IS IN	R_s USE RESISTANCE SCALE IN
NANOHENRIES, nh	MICROHMS, μΩ
MICROHENRIES, μh	MILLIOHMS, mΩ
MILLIHENRIES, mh	OHMS, Ω
HENRIES, h	KILOHMS, KΩ

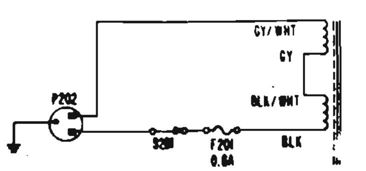
EXAMPLE:

f = 10 Kc
L = 8 mh
R = 17 Ω

CONNECT STRAIGHT EDGE BETWEEN 10 Kc AND MEASURED INDUCTANCE OF 8 mh. NOTE REFERENCE POINT ON PIVOT LINE. CONNECT STRAIGHT EDGE BETWEEN REFERENCE POINT AND MEASURED SERIES RESISTANCE OF 17 Ω. READ Q AS 30.

IN A FEW CASES A MULTIPLYING FACTOR FOR R_s, OTHER THAN THAT GIVEN IN THE ABOVE TABLE, WILL BE NEEDED. THIS MAY BE DONE PROVIDED THE Q IS DIVIDED BY THE RATIO OF THE MULTIPLIER USED, TO THAT SUGGESTED IN THE TABLE. EXAMPLE: f = 100 Kc, L = 159 μh, and R_s = 50 Ω. USE THE L SCALE IN MICROHENRIES AND THE R_s SCALE IN OHMS, INSTEAD OF MILLIOHMS. THE RATIO OF OHMS TO MILLIOHMS IS 10^3 AND THE INDICATED Q OF 2×10^3 MUST BE DIVIDED BY THIS FACTOR, OR, Q = 2.





PRIMARY WIRING FOR 234V MODELS

NOTES

RESISTANCE VALUES IN OHMS AND 1/2 WATT UNLESS OTHERWISE SPECIFIED.

$K = 10^3$

$M = 10^6$

✱ PRECISION RESISTORS.

CAPACITANCE IN μF & 400V UNLESS OTHERWISE SPECIFIED

⊘ CALIBRATION CONTROL.

● FACTORY SELECTED VALUE.

LAST NUMBER USED:

R123	C115
R203	C204b
R339	C319
R405	C405
R516	C511
R619	C613

Schematic Diagram Model 63H

Drawing No. 830183F

(Serial number 634 and above)

Warranty

Boonton Electronics warrants its devices against defects in material and workmanship for a period of one (1) year from date of shipment provided they are used under normal operating conditions as specified in Boonton Electronics installation and maintenance instructions. This warranty shall not apply to any item which shall have been repaired or altered by anyone, not authorized by the Seller, in any way so as, in the judgment of the Seller, to affect its stability and reliability. This warranty applies to all components, assemblies and material, except vacuum tubes, panel lamps, fuses, batteries, and sealed assemblies which have been opened. This warranty is made to the original Purchaser only. In the event of any breach of this warranty, the Purchaser shall give immediate notice thereof to the Seller, stating in what manner an item is defective, and reasonable time shall be given to the Seller to send a competent person to the Purchaser's premises to remedy the difficulty or to remedy the difficulty at the Seller's premises. Failure to give such notice shall be conclusive evidence of due fulfillment of the warranty on the part of the Seller and that an item is satisfactory to the Purchaser, and in such event the Seller shall be released from all liability under the warranty.

SHIPPING INSTRUCTIONS

If it becomes necessary to ship the instrument, the following steps should be followed:

a. Wrap the instrument with heavy wrapping paper and seal the seams with gummed tape. Place in fibreboard carton large enough to permit three inches of soft packing material between instrument and sides of box.

   IMPORTANT NOTICE

   Be sure to remove the shorting bar from the test terminals before packing. Packing the instrument with the shorting bar in place can result in severe damage to the test terminal assembly during shipment.

b. Alternatively Boonton Electronics will provide an appropriate shipping container and packing materials at nominal cost. These may be obtained by writing to the Sales Department, Boonton Electronics Corporation, Route 287 at Smith Road, Parsippany, New Jersey 07054.