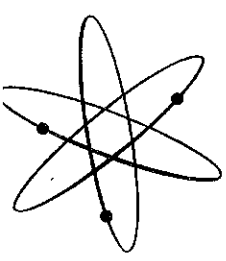
PRICE $2.00

W. H. GREENE

HEATHKIT®
ASSEMBLY MANUAL

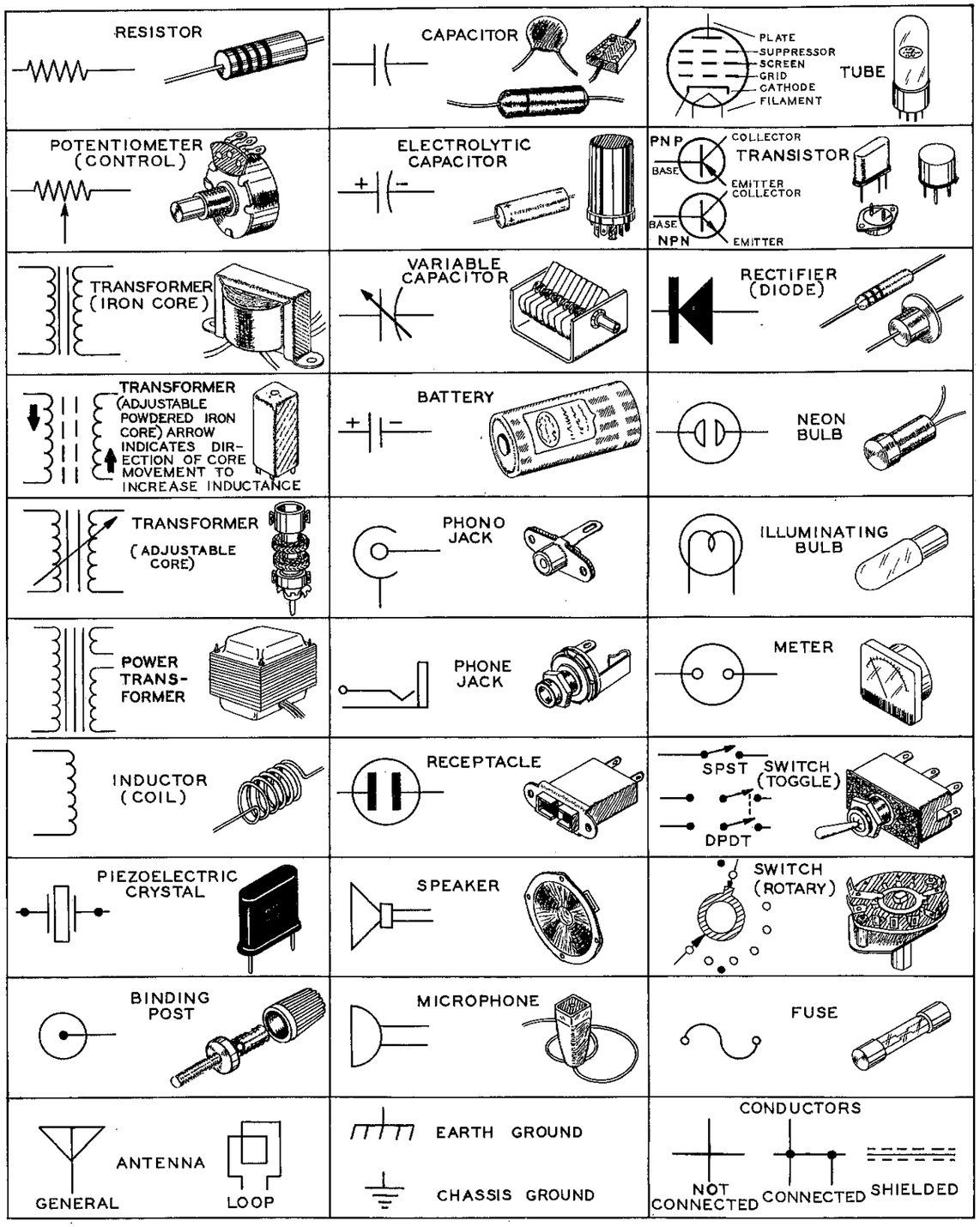


IMPEDANCE BRIDGE

MODEL IB-2A

TYPICAL COMPONENT TYPES

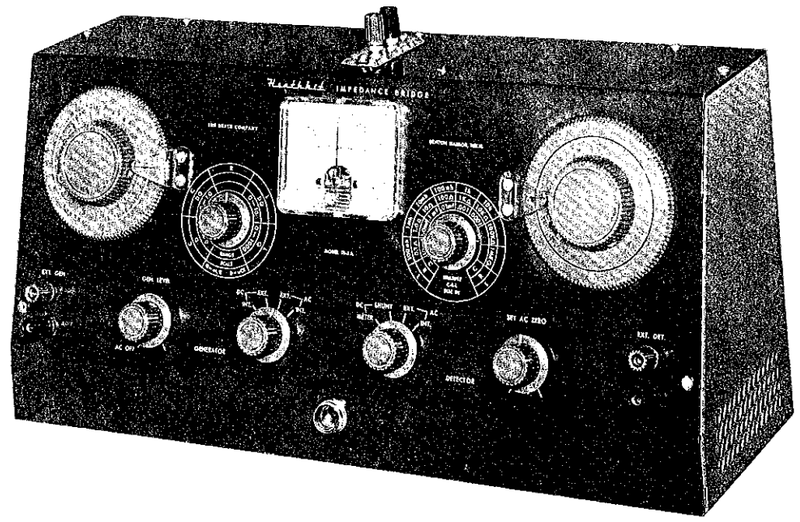
This chart is a guide to commonly used types of electronic components. The symbols and related illustrations should prove helpful in identifying most parts and reading the schematic diagrams.



ASSEMBLY AND OPERATION OF THE HEATHKIT IMPEDANCE BRIDGE

MODEL IB-2A

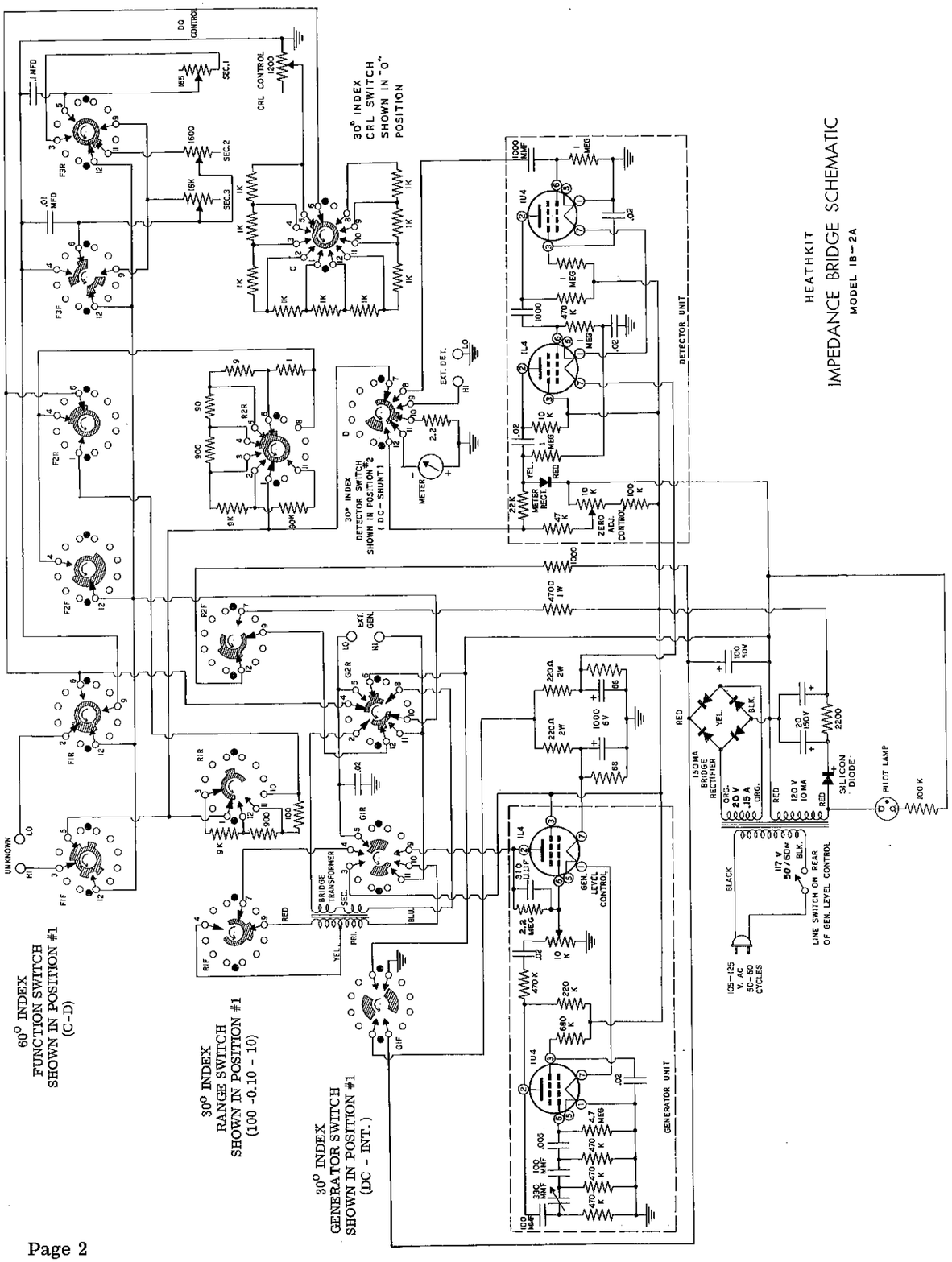
W. H. GREENE



SPECIFICATIONS

Circuit	4-arm impedance bridge.
DC Measurements	Built-in power supply operating directly from 110 V AC. Panel binding posts provide for use of external supply.
Meter	100-0-100 microampere meter.
AC Measurements	Built-in 1000 cycle vacuum tube oscillator. Terminals on panel provide for connecting an external generator for measurement at other frequencies.
Detector	Vacuum tube detector and rectifier make use of built-in meter. Panel binding posts provide for connection to external detector.
Resistance	0.1 Ω to 10 megohm.
Capacitance	100 μμfd to 100 μfd.
Inductance	0.1 mh to 100 h.
Dissipation Factor (D)	0.002 to 1.
Storage Factor (Q)	0.1 to 1000.
Accuracy	1/2 of 1% decade resistors used. 1/2 of 1% silver mica condensers used. Accuracy is limited more by interpretation of scales and workmanship of assembly. The following is normal: Resistance ±3% Capacitance ±3% Inductance ±10% Dissipation Factor (D = ω CR) ±20% Storage Factor (Q = ω L/R) ±20% Accuracy will fall off at extreme outer limits.
Power Requirements	105-125 volts, 50/60 cycles, 10 watt.
Tube Complement	2 - 1U4 and 2 - 1L4.
Power Supply	Power Transformer, silicon diode, and bridge rectifier.
Cabinet Size	8" high x 17" wide x 6" deep.
Shipping Weight	15 lbs.

11/26/65



GENERAL DESCRIPTION

The Heathkit model IB-2A Impedance Bridge is a self-contained, direct reading precision laboratory instrument designed for rapid and accurate measurement of resistance, capacitance, inductance, dissipation factors of condensers, and storage factors of inductors.

The Heathkit Impedance Bridge is a self-powered four-arm bridge of standard design for use in laboratories, service shops and schools. By use of switches, a number of basic bridge circuits are obtained.

Resistance is measured with an internal well filtered power supply operating directly from 105-120 volts AC, 50/60 cycles. This supply uses a transformer, silicon diode, and bridge rectifier.

A 100-0-100 microampere meter is used for determining balance. A 2.2 Ω resistor is shunted across the meter for protection. This may be cut out for final balance.

A built-in vacuum tube adjustable phase shift generator supplies 1000 cycles for alternating voltage measurements. A trimmer condenser provides for setting the frequency of the oscillator by means of a laboratory standard if desired. Binding posts are available for connecting to an external generator for measurements at frequencies other than 1 kc. Battery type tubes are used so that a warming up period is not required and also to eliminate change in operating characteristics due to thermal effect.

The built-in vacuum tube detector unit and meter rectifier make possible the use of the meter for AC measurements thus making unnecessary the usual headset or other device for such measurements. Provision is made for using an external detector when desirable.

THEORY

A bridge is an arrangement of impedances used for measuring various electrical properties. When used for direct current measurement of resistance, the bridge generally takes the form of the Wheatstone bridge with four resistance arms. This is the standard method for the accurate measurement of resistance.

For the measurement of circuit constants at audio frequencies, the alternating-current bridge is the most widely used device. Measurements of inductance and capacitance are made conveniently and accurately by this method. The type of AC bridge circuit used is determined by the measurement to be made. These circuits are all adaptations of the fundamental Wheatstone bridge circuit.

A characteristic of a coil or condenser which is of importance and which can be measured conveniently on an AC bridge, is the ratio of resistance to reactance. This ratio is defined as the dissipation factor D, and its reciprocal is called the storage factor Q. The defining equations are as follows:

$$D = \frac{1}{Q} = \frac{R}{X} \qquad Q = \frac{1}{D} = \frac{X}{R}$$

where R and X are the series resistance and reactance of the inductance or capacitance being measured.

Dissipation factor is directly proportional to the energy dissipated per cycle and storage factor is directly proportional to the energy stored per cycle. Dissipation factor is more commonly used for condensers because it varies with the loss, while storage factor is more commonly used for inductors since it indicates the voltage step-up in a tuned circuit.

In its basic form the bridge consists of four impedance arms A, B, C, D. The ratio of A and B is adjustable so that the variable arm D serves as a standard for measuring many values at C. The four impedances are connected in series-parallel to a source of potential E between the junctions of A and C. When the voltage drop across arm A is equal to the voltage drop across arm C, no current will flow through the detector and the bridge is in balance. This condition of balance may be indicated by the formula:

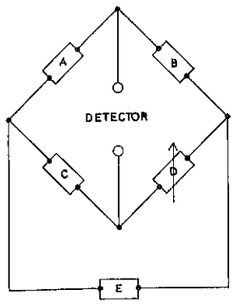


Figure 1

$$\frac{A}{C} = \frac{B}{D}$$

Two conditions are necessary for balance. Both the magnitudes of the impedances and the phase angles must be equal.

By the proper use of resistances, condensers, inductors or resistor-condenser combinations in series or parallel, the bridge may be used for measuring resistance, capacity, inductance, dissipation factor (D) and storage factor (Q).

In this bridge, selection of the various bridge combinations is made by setting the function switch to the proper position. The ratio arms of the bridge are controlled by the range switch. Balance is obtained by adjustment of the DQ and CRL dials.

RESISTANCE MEASUREMENTS

After over a century of use the Wheatstone bridge is still considered to be the fundamental circuit for the measurement of DC resistance. A Wheatstone bridge of four resistance arms, the fourth being the unknown, is used for resistance measurements. The basic equation of balance for the Wheatstone bridge is:

$$R_X = \frac{R_D R_A}{R_B}$$

R_D is read on the CRL control and the ratio R_A/R_B is read on the range dial. Thus the value of the unknown resistance is the product of the readings of the two dials.

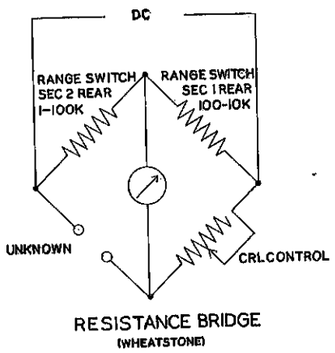


Figure 2

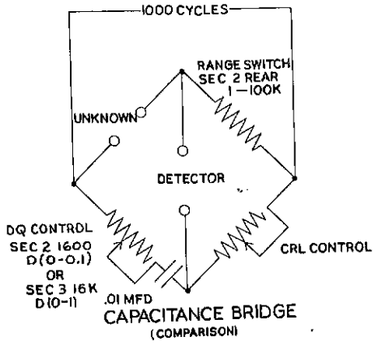


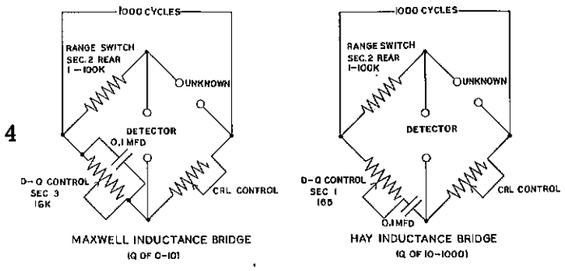
Figure 3

CAPACITY MEASUREMENTS

A Capacitance-Comparison bridge is used for the measurement of capacity. This circuit utilizes a standard condenser in series with a variable resistance. Dissipation factor is also measured with this circuit.

INDUCTANCE MEASUREMENTS

Figure 4



The Maxwell bridge is used for measuring inductances when the storage factor is below 10. In this bridge, inductance is measured in terms of capacitance. A condenser has some advantages as a standard as it gives practically no external field and is more compact.

For measuring inductances with storage factors between 10 and 1000, the Hay bridge is used. This is a modification of the Maxwell bridge. In the Hay bridge, the condenser is in series with the resistance, while in the Maxwell bridge, the condenser is in parallel with the resistance.

NOTES ON ASSEMBLY AND WIRING

The quality of parts and design of the Heathkit model IB-2A Impedance Bridge place it in the laboratory equipment class. When constructed in accordance with the instructions in this manual it will give many years of satisfactory service. We therefore urge you to take the necessary time to assemble and wire the kit carefully.

This manual is supplied to assist you in every way to complete the instrument with the least possible chance for error. We suggest you take a few minutes now and read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is started. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the completion of the kit. These diagrams are repeated in smaller form within the manual. We suggest you retain the manual in your files for future reference, both in the use of the instrument and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly.

ROSIN CORE SOLDER HAS BEEN SUPPLIED WITH THIS KIT. THIS TYPE OF SOLDER MUST BE USED FOR ALL SOLDERING IN THIS KIT. ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE EQUIPMENT IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. IF ADDITIONAL SOLDER IS NEEDED, BE SURE TO PURCHASE ROSIN CORE (60:40 or 50:50 TIN-LEAD CONTENT) RADIO TYPE SOLDER.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore, a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -20% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished instrument.

We strongly urge that you follow the wiring and parts layout shown in this manual. The position of wires and parts is quite critical in this instrument and changes may seriously affect the characteristics of the circuit.

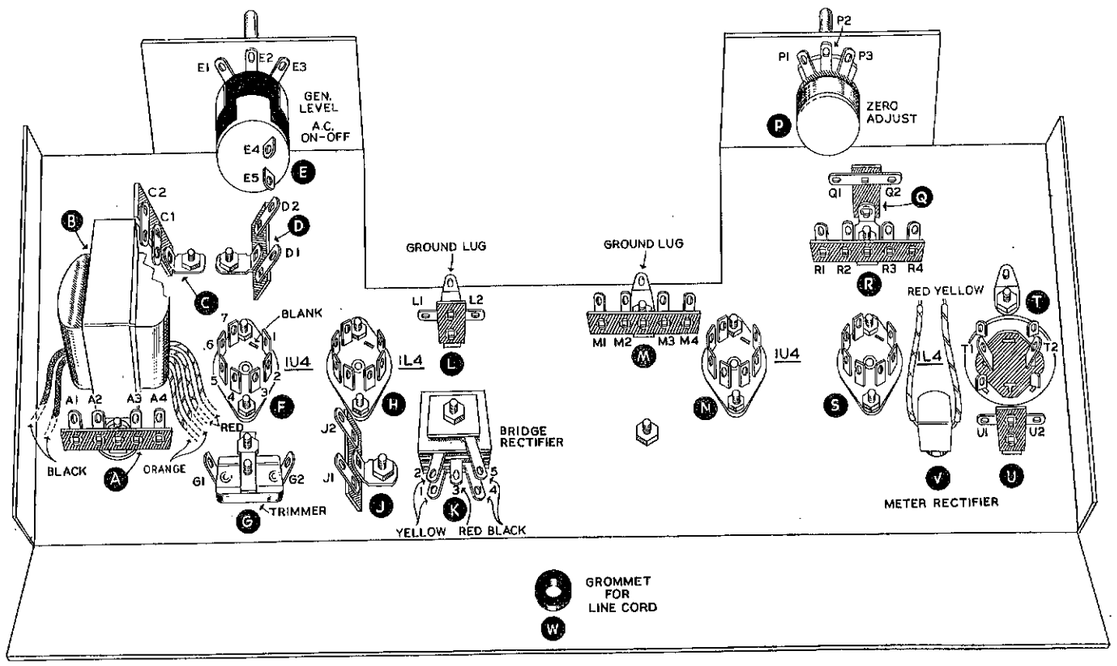
STEP-BY-STEP ASSEMBLY

The construction of the Heathkit Impedance Bridge is broken down into four parts: chassis parts mounting and wiring, panel parts mounting and wiring, wiring common to both chassis and panel, and test and calibration. If the step-by-step procedure is followed with the aid of the figures and the pictorials, little difficulty should be encountered in construction. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

We suggest that you do the following before any work is started:

1. Attach the large fold-in pictorials to the wall above your work bench.
2. Go through the entire assembly and wiring instructions. This is an excellent time to read the entire instructions through and familiarize yourself with the procedure.
3. Lay out all parts so that they are readily available.

MOUNTING OF PARTS ON CHASSIS

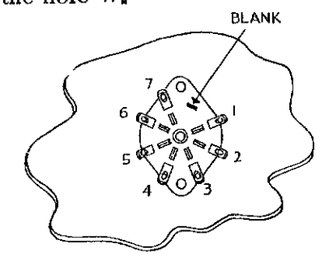


CHASSIS ASSEMBLY

Figure 5

( ) Install the 3/8" rubber grommet for the line cord through the hole W.

( ) Using 3-48 x 1/4 screws and nuts (no lockwashers) mount the four 7-pin tube sockets in positions F, H, N and S. Locate the blank spaces as shown in Figure 5 so as to have the sockets in the best position for wiring. See Figure 6.



NUMBERING ON 7-PIN TUBE SOCKET

Figure 6

( ) Using 6-32 screws, lockwashers and nuts, mount the condenser mounting wafer in position T. Under one of the nuts, in position U, mount a 1-lug terminal strip as shown. Under the other nut, mount a solder lug, positioning as shown.

( ) Mount the meter rectifier in position V, using a lockwasher and nut.

( ) In positions Q and R, mount a 1-lug and a 4-lug terminal strip using a 6-32 screw, lockwasher and nut.

( ) In the same manner, mount a 2-lug terminal strip in position J.

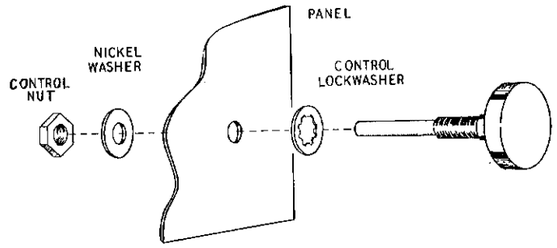
( ) In position D, mount a 2-lug terminal strip as shown.

( ) In position C, mount a 2-lug terminal strip (vertical) as shown.

( ) Mount the trimmer condenser in position G, using 6-32 screw, lockwasher and nut.

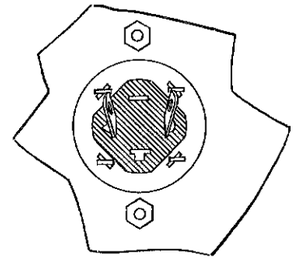
( ) Mount the power transformer in position B. The black leads should be on the side at the end of the chassis. Under the nut in position A, mount a 4-lug terminal strip using 6-32 x 3/8 screws.

( ) In position E, mount the 10 KΩ control (generator level control) with the switch on the rear. Use lockwasher and nut as shown in the diagram. Do not tighten this nut as it will be used later for attaching the chassis to the panel. See Figure 7.



HOW TO MOUNT CONTROLS & SWITCHES

Figure 7



CONDENSER MOUNTING

Figure 8

( ) In the same manner, in position P, mount the other 10 KΩ control (zero adjust control). Again do not tighten.

( ) Mount the 1000-1000 μfd condenser on the mounting wafer in position T. The manner of mounting is shown in Figure 8. Secure the condenser to the wafer by twisting each of the four mounting lugs about 1/8 turn with the pliers. Hold the condenser firmly against the wafer while twisting the lugs.

( ) Mount the bridge transformer on the top of the chassis in position BT, as shown in Figure 9. Use the #8 nickel washers under the heads of the screws. Under the nut in position L, mount a 1-lug terminal strip and a ground lug. Under the nut in position M, mount a 4-lug terminal strip and a ground lug. Use 6-32 x 3/8 screws. In position K, use a 6-32 x 1" screw and mount the bridge rectifier under the nut using a lockwasher.

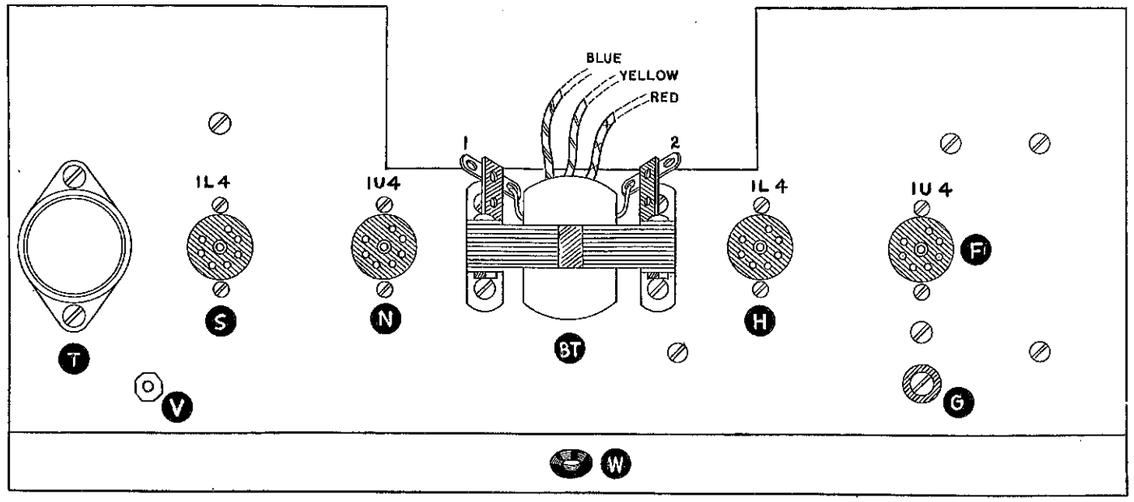


Figure 9

WIRING THE CHASSIS

Read the notes on the inside rear cover concerning wiring and soldering.

The leads on components such as transformers, resistors and condensers are frequently longer than necessary. When wiring these parts into the circuit, the leads should be cut to the proper length. Not only will this result in a neater looking instrument, but in many instances proper operation is impossible with long untrimmed lead wires in critical parts of the circuit.

Unless otherwise indicated, all wire used is insulated. Wherever there is a possibility of the bare leads on resistors and condensers shorting to other parts or to chassis, the leads should be covered with insulated sleeving. This is indicated in the instructions by the phrase, "use sleeving."

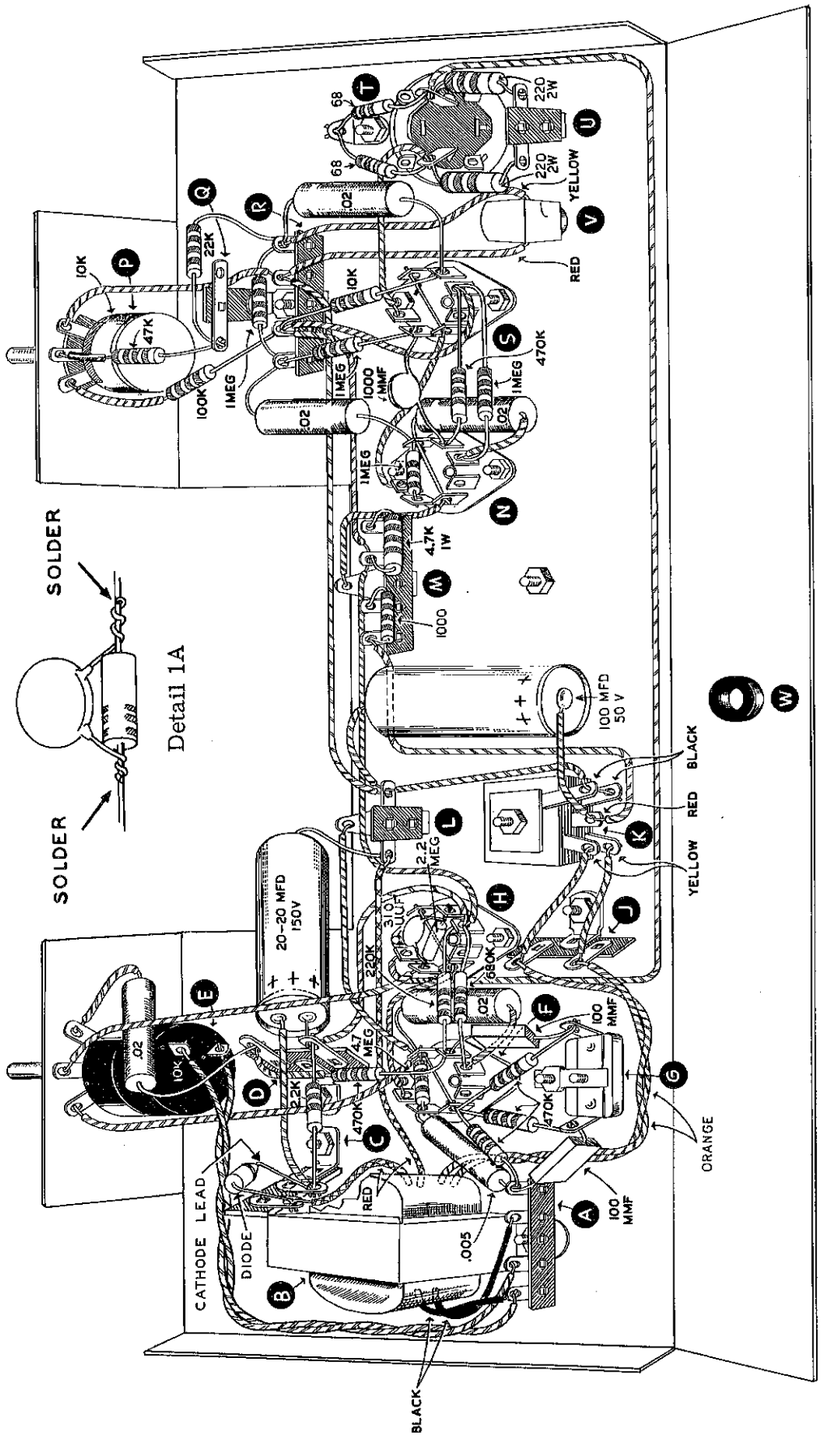
(S) means solder. (NS) means do not solder yet.

( ) Connect one of the black transformer leads to A1 (NS).

( ) Connect the other black lead to A3 (NS).

( ) Twist together the two orange leads of the power transformer. Connect one of them to J1 (NS) and the other one to J2 (NS).

( ) Connect the short red lead from the power transformer to C2 (NS).



Pictorial 1
Chassis Wiring

( ) Connect the long red lead of the power transformer to L1 (NS).

( ) Connect a short wire from J1 (S) to K1 (yellow) on the bridge rectifier (S). It may be convenient to remove the rectifier for easier wiring to the lugs.

( ) Connect another short wire from J2 (S) to the other yellow lug K2 of the bridge rectifier (S).

( ) Connect a wire from H7 (S) to T2 of the filter condenser (NS).
( ) Run a short piece of bare wire between H1 (S) and H5 (NS).

( ) Connect a wire from H5 (S) to F7 (S).
( ) Connect a wire from H3 (NS) to D1 (NS).

( ) Strip the insulation from 1" of the end of a piece of wire. Run the wire through F1 (NS) to F5 (NS). Connect the other end of the wire to the ground lug in position L (NS).

( ) Connect a wire from E1 (S) on the generator level control to F1 (NS).

( ) Connect one lead of a .02 μfd condenser to F1 (NS). Connect the other lead of this condenser to F3 (NS) (use sleeving). Any "outside foil" or "ground" markings on paper capacitors can be disregarded in wiring this circuit. They may be connected with either "polarity."

( ) Connect a 4.7 megohm resistor between F1 (S) and F6 (NS).

( ) Cut two wires about 8" long and twist them together. Connect one end of the twisted pair to E4 (S) and E5 (S), the connections to the switch on the rear of the generator level control. Connect the other ends of the twisted pair to A1 (S) and A2 (NS).

( ) Connect a wire from H3 (NS) to M3 (NS).

( ) Connect a wire from the red lug of the bridge rectifier, K3 (NS) to M1 (NS).

( ) Using a short piece of bare wire, connect the two black lugs, K4 and K5 of the bridge rectifier together (NS). (This may already be done in the rectifier in your kit.)

( ) Connect a wire from K5 (S) to L2 (NS).

( ) Connect the positive lead (marked +) of the 100 μfd condenser to the red lug of the bridge rectifier K3 (S) (use sleeving).

( ) Connect the other lead of this condenser to L2 (NS).

( ) The 20-20 μfd 150 volt condenser has two leads on the end marked positive (+). Connect one of these leads to D1 (NS). Connect the other lead from the same end to C1 (NS) and use sleeving on this lead.

( ) Connect the lead on the other end of this condenser to L1 (NS).

( ) Connect a 2.2 KΩ resistor (red-red-red) from C1 (NS) to D1 (S).

( ) Connect the cathode lead of a silicon diode to C1 (S) and the other lead to C2 (NS). The cathode end is marked with a color end, a color dot, or a color band.

( ) Connect one lead of a .02 μfd condenser to E3 (S). (Use sleeving.) Connect the other lead to D2 (NS).

( ) Connect a wire from E2 (S) to H6 (NS).

( ) Referring to Detail 1A, prepare a 2.2 megohm (red-red-green) 1/2 watt resistor and 310 μμf condenser combination.
( ) Connect this combination between H6 (S) and H2 (NS).
( ) Connect one lead of a 470 KΩ resistor (yellow-violet-yellow) to D2 (S) (use sleeving). Connect the other lead to F2 (NS).
( ) Connect the 220 KΩ resistor (red-red-yellow) from F2 (NS) to H3 (NS).
( ) Connect the 680 KΩ resistor (blue-gray-yellow) from F3 to H3 (S).
( ) Connect one of the 100 μμf (.001 μfd) condensers from F2 (S) to G2 (NS).

( ) Connect one of the 470 KΩ resistors (yellow-violet-yellow) between F5 (NS) and G2 (S).

( ) Connect another of the 470 KΩ resistors between F5 (NS) and G1 (NS).

( ) Connect a 470 KΩ resistor between F5 (S) and A4 (NS).

( ) Connect a .005 μfd condenser from F6 (S) to A4 (NS).

( ) Connect a 100 μμf (.0001 μfd) condenser between G1 (S) and A4 (S).

( ) Connect a wire from L2 (NS) to R3 (NS).

( ) Connect the red lead of the meter rectifier V to R3 (NS).

( ) Connect the yellow lead of the meter rectifier V to lug R4 (NS).

( ) Connect a short piece of bare wire between S1 (S) and S5 (NS).

( ) Connect a piece of wire from S5 (S) to N7 (S).

( ) Connect a wire from S3 (NS) to R2 (NS).

( ) Connect a wire from R2 (NS) to M3 (NS).

( ) Connect a short piece of bare wire between N1 (NS) and N5 (NS).

( ) Connect a piece of wire from N5 (S) to the ground lug at M (NS).

( ) Connect a wire from S7 (S) to T1 (NS).

( ) Connect a 220 Ω 2 watt resistor (red-red-brown) between T1 (NS) and U1 (S).

( ) Connect a 220 Ω 2 watt resistor between T2 (NS) and U2 (NS).

( ) Connect a 68 Ω resistor (blue-gray-black) between T1 (S) and the solder lug at T (NS).

( ) Connect another 68 Ω resistor between T2 (S) and the solder lug (NS).

( ) Connect a 22 KΩ resistor (red-red-orange) between R4 (NS) and Q1 (NS).

( ) Connect a wire from P3 (S) to R3 (S).

( ) Connect one lead of a 47 KΩ resistor (yellow-violet-orange) between P2 (S) (use sleeving) and Q1 (NS).

( ) Connect one lead of a 100 KΩ resistor (brown-black-yellow) from P1 (S) (use sleeving) to R2 (NS).

( ) Connect a .02 μfd condenser between R4 (NS) and S2 (NS).

( ) Connect a 10 KΩ resistor (brown-black-orange) between R2 (S) and S2 (S).

( ) Connect a 1 megohm resistor (brown-black-green) between R4 (S) and R1 (NS).

( ) Connect a 1 megohm (brown-black-green) resistor between N6 (NS) and N1 (NS).

( ) Connect a third 1 megohm resistor between R1 (NS) and S6 (NS).

( ) Connect one lead of a .02 μfd condenser to N1 (NS) and the other lead of this condenser to R1 (S).

( ) Connect a .02 μfd condenser between N1 (S) and N3 (NS).

( ) Connect a 1000 μμf (.001 μfd) condenser between S6 (S) and N2 (NS).

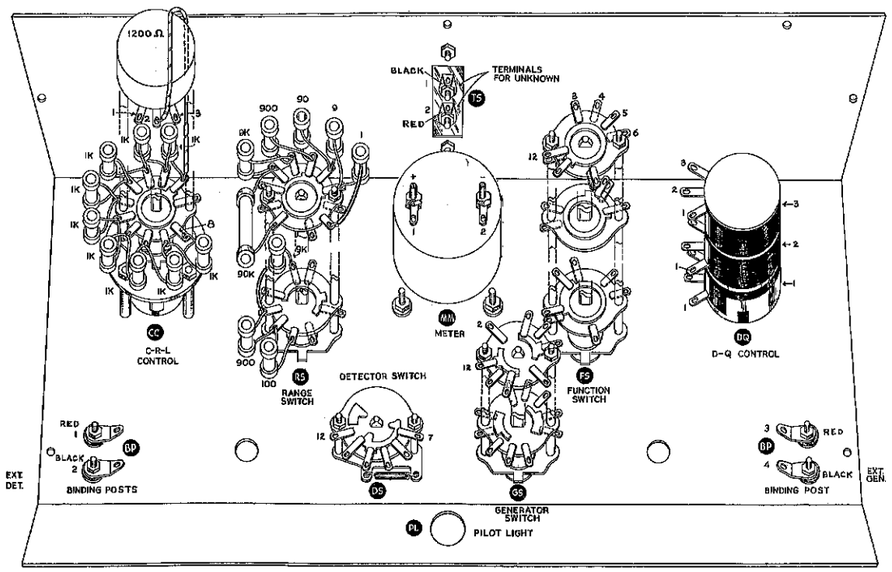
( ) Connect a 470 KΩ resistor (yellow-violet-yellow) between N2 (S) and S3 (NS).

( ) Connect a 1 megohm resistor (brown-black-green) between N3 (S) and S3 (S).

( ) Connect a 1000 Ω resistor (brown-black-red) between M1 (NS) and M2 (NS).

( ) Connect a 4700 Ω 1 watt resistor (yellow-violet-red) between M3 (NS) and M4 (NS).

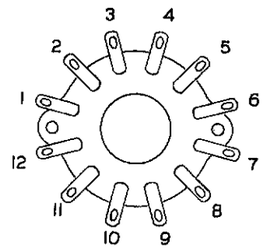
MOUNTING OF PARTS ON PANEL



PANEL ASSEMBLY

Figure 10

Before mounting the parts on the panel, the switch on the CRL control, #19-36 should have the resistors mounted. The resistors should also be mounted on the range switch, #63-62. It is important that the switch be in the proper position before soldering the resistors in place. Refer to Figure 10 and to Figure 11 showing the numbering of the contacts on the switch.



SWITCH NUMBERING

As seen from rear when mounted as in Figure 10

Figure 11

WIRING OF CRL SWITCH

( ) There are nine 1 KΩ precision resistors. Connect one lead of a 1 KΩ resistor to lug 8 of the switch on the CRL control, #19-36 (S).

( ) Connect the other lead to lug 9 of the switch (NS).

( ) Connect a 1 KΩ resistor between lug 9 (S) and lug 10 (NS).

( ) Connect a 1 KΩ resistor between lug 10 (S) and lug 11 (NS).

( ) Connect a 1 KΩ resistor between lug 11 (S) and lug 12 (NS).

( ) Connect a 1 KΩ resistor between lug 12 (S) and lug 1 (NS).

( ) Connect a 1 KΩ resistor between lug 1 (S) and lug 2 (NS).

( ) Connect a 1 KΩ resistor between lug 2 (S) and lug 3 (NS).

( ) Connect a 1 KΩ resistor between lug 3 (S) and lug 4 (NS).

( ) Connect a 1 KΩ resistor between lug 4 (S) and lug 5 (NS).

( ) Connect a wire between lug 5 of the switch (S) and the center lug of the 1200 Ω control on the rear of the switch (S). See Figure 10.

This completes the preliminary wiring of the CRL switch.

WIRING OF RESISTORS ON RANGE SWITCH

( ) Connect one lead of a 9 KΩ precision resistor to R1R3 (S). (Be sure the switch is in the proper position.) R1R3 means range switch, first deck (counting from panel out), rear of deck, contact #3.

( ) Connect the other lead to R1R12 (NS). (Use sleeving.)

( ) Connect a 900 Ω precision resistor between R1R12 (S) and R1R11 (NS).

( ) Connect one lead of a 100 Ω precision resistor to R1R11 (S).

( ) Connect the other lead to R1R10 (NS).

( ) Connect a 1 Ω precision resistor between R2R8 (NS) (use sleeving) and R2R6 (NS).

( ) Connect a 9 Ω precision resistor between R2R6 (S) and R2R5 (NS).

( ) Connect a 90 Ω precision resistor between R2R5 (S) and R2R4 (NS).

( ) Connect a 900 Ω precision resistor between R2R4 (S) and R2R3 (NS).

( ) Connect a 9 KΩ precision resistor between R2R3 (S) and R2R2 (NS).

( ) Connect a 90 KΩ precision resistor between R2R2 (S) and R2R11 (S).

This completes the preliminary wiring of the range switch.

( ) Mount the binding posts on the terminal board insulator as shown in Figure 12.

( ) Using 6-32 screws, lockwashers and nuts, mount the terminal board insulator on the top of the panel in position TS.

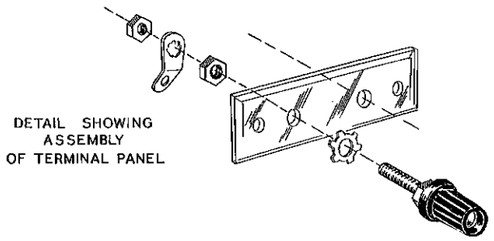


Figure 12

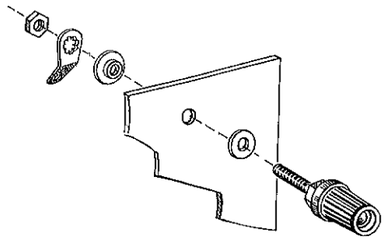


Figure 13

( ) Referring to Figure 13, mount the binding posts in positions BP-1, 2, 3, 4.

( ) Using 6-32 x 3/4" screws and 1/2" spacers, mount the CRL mounting bracket on the panel in position CC.

( ) Mount the CRL control on the CRL mounting bracket.

( ) Mount the range switch, #63-62, in position RS.

( ) Mount the function switch, #63-63, in position FS.

( ) Mount the DQ control in position DC. This is the 3-gang control.

( ) Mount the generator switch, #63-61, in position GS.

( ) Mount the detector switch, #63-60, in position DS.

( ) Mount the 100-0-100 microampere meter in position MM using the washers and nuts provided with the meter. Use the #8 solder lugs on the meter terminals.

WIRING OF THE PANEL

The accuracy of the bridge is dependent on the wiring. Heavy bus wire is provided for wiring the switches. The resistance of the wiring is held to a minimum by the large bus wire. The capacity of the wiring is held to a minimum by using an open, rigid style of wiring as shown in the pictorial. Notice carefully the proper positions of the switches on the panel. Also the proper numbering of the contacts on the switches. The switches are shown in the schematic in the same positions as they appear on the panel. Check with this as well as with the pictorial. Make a good mechanical and electrical joint of each connection. Poor connections will impair the accuracy of the bridge.

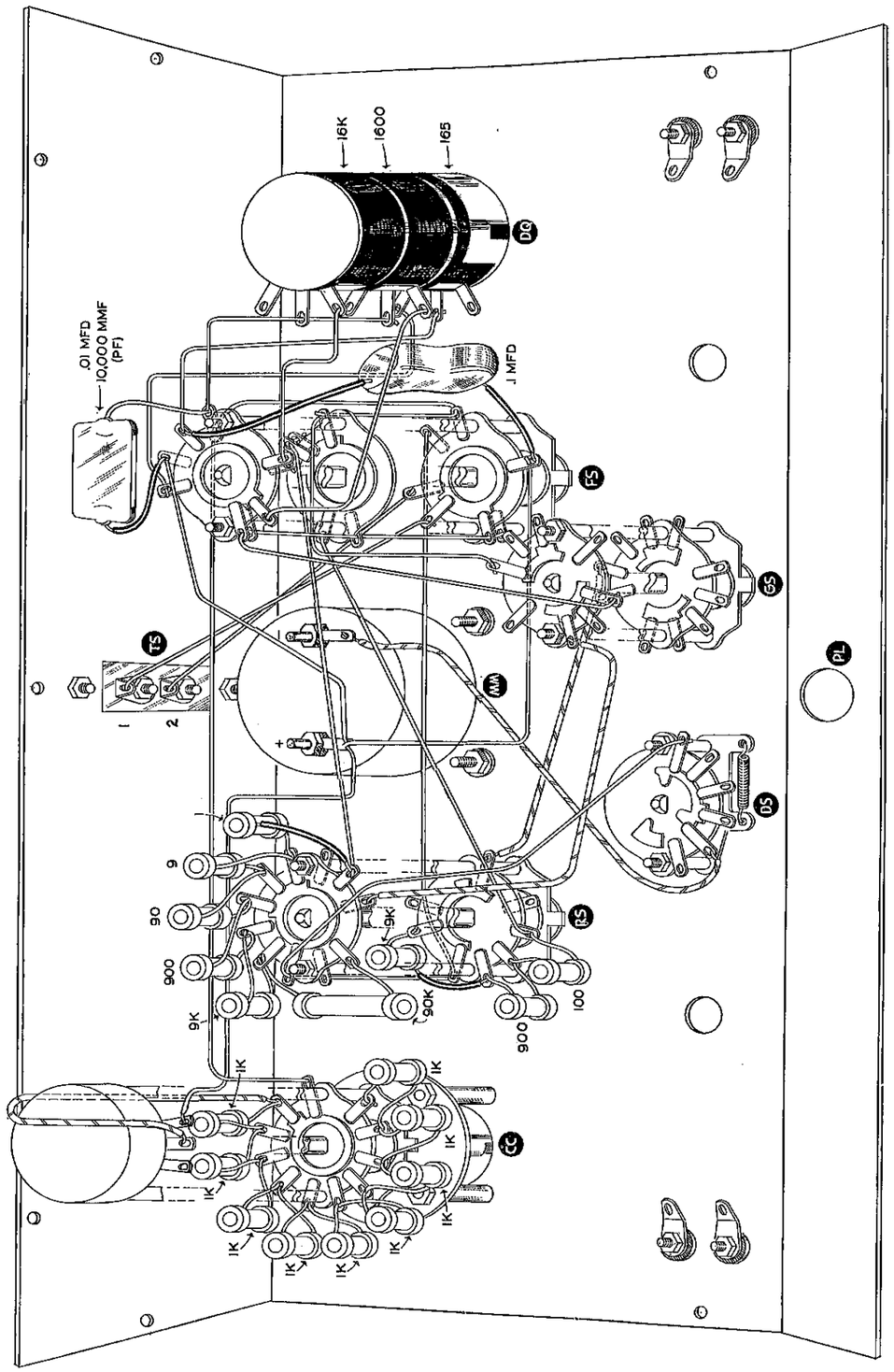
Before wiring the panel, place one end of the bus wire in a vise and pull the other end with a pair of pliers. Pull until the wire stretches. This will remove any kinks and will stiffen the wire resulting in a better and neater job of wiring.

Proceed carefully, as once the switches are wired, it is very difficult to change the connections to correct an error.

( ) Run a piece of bus (heavy solid wire) from CC6 (S) through F1R6 (NS) to F2R6 (NS). Now solder F1R6.

( ) Connect F1F5 (S) to R1R1 (S) and R2R1 (NS). Use bus.

( ) Connect F1F3 (S) to TS2 (S). Use bus.



Pictorial 2
Panel Wiring

( ) Connect F1R2 (S) to TS1 (S). Use bus.

( ) Run one end of a piece of bus wire through F2F4 (NS) to F2R4 (S). Now solder F2F4.

( ) Connect the other end to R2R8 (S).

( ) Run a piece of bus wire through F3R12, F3F12, F2F12, F1R12 to F1F12. Now solder all but F3R12.

( ) Run a bus wire from F2R1 (S) to R1R10 (S).

( ) Using insulated hookup wire, connect R1F7 (S) to G1R4 (S).

( ) Again using insulated wire, connect R2F9 (S) to G2R12 (S).

( ) Run a bus wire from R2R1 (S) to D7 (S).

( ) Using insulated wire, connect MM2 (S) (negative terminal of the meter) to D11 (S).

( ) Connect a bus wire from F2R6 (S) to G2R4 (S).

( ) Run a bus wire from CRL3 (S) through MM1 (NS) to F1R9 (NS). Now solder MM1.

( ) Connect one lead of a .1 μfd precision condenser to F1R9 (S). (Use sleeving.)

( ) Connect the other lead to F3R5 (NS). (Use sleeving.)

( ) Run a bus wire from F3R5 (S) to lug 2 of DQ1 (S).

( ) Run a bus wire from F3R3 (S) to lug 3 of DQ1 (S).

( ) Run a bus wire from F3F6 (NS) through lug 2 of DQ3 (NS) to lug 2 of DQ2 (S). Now solder DQ3.

( ) Run a bus wire from F3F9 (S) through F3R9 (S) to lug 1 of DQ3 (S).

( ) Run a bus wire from F3R11 (S) to lug 1 on DQ2 (S).

( ) Run a bus wire from F3R12 (S) to G2R10 (S).

( ) Connect one lead of a .01 μfd (10,000 $\mu\mu$f) precision condenser to F3F6 (S) (use sleeving).

( ) Connect the other lead to F3F4 (NS). (Use sleeving.)

( ) Run a bus wire from F3F4 (S) to MM1 (S). The connection to MM1 is best made by wrapping the wire from F3F4 around the wire from MM1 near the solder lug.

( ) The panel is now mounted on the chassis by removing the nuts on the two controls mounted on the chassis. The panel is put in place and the nickel washers and nuts put on the controls. It may be necessary to omit the lockwashers on these two controls because of the extra thickness of the panel and chassis.

WIRING COMMON TO PANEL AND CHASSIS

NOTE: Use insulated hook-up wire unless otherwise specified. Numbers refer to Pictorial 3.

⑨ ( ) Connect the yellow lead of the bridge coupling transformer to R1F4 (S).

④ ( ) Connect the red lead of the transformer to R1F9 (S).

⑧ ( ) Connect a wire from R2F7 (S) to M4 (S).

⑦ ( ) Connect a wire from R2F12 (S) to M2 (S).

② ( ) Connect a wire from D9 (S) to BP1 (S).

① ( ) Connect a wire from BP2 (S) to the solder lug at T (S).

⑳ ( ) Connect a short piece of bus wire from the ground lug at M (NS) to the bus wire on the positive terminal of the meter M1 (S). The last connection is made by looping the end of the short wire securely around the wire from the meter so as to make a good mechanical connection.

㉓ ( ) Connect a .02 μfd condenser from G2R5 (NS) to ground lug at L (NS).

⑤ ( ) Connect a 2.2 Ω resistor (red-red-gold) between D10 (S) and the ground lug at M (S).

⑥ ( ) Connect a 1000 $\mu\mu$f (.001 μfd) condenser from N6 (S) (use sleeving) to D8 (S).

③ ( ) Connect a wire from Q1 (S) to D12 (S).

⑪ ( ) Connect the blue lead of the bridge transformer to G1R10 (S).

⑲ ( ) Strip 1" of insulation from one end of a piece of wire. Pass this through G1R5 (NS) to G2R5 (S). Now solder G1R5.

( ) Connect the other end of the wire to BP4 (S).

⑱ ( ) Again strip 1" of the insulation from a piece of wire. Pass it through G2R6 (NS) to G1F6 (S). Now solder G2R6.

( ) Connect the other end to L1 (S).

⑭ ( ) Connect a wire from G1R3 (S) to M3 (S).

㉑ ( ) Run a piece of bus wire from G2R2 (S) to BT1 (S).

⑬ ( ) Run a wire from G1F1 (S) to U2 (S).

⑫ ( ) Run a wire from G1F12 (S) to M1 (S).

⑮ ( ) Strip 1" of insulation from one end of a piece of wire. Pass this through G1R11 (NS) to G2R11 (S). Now solder G1R11.

( ) Connect the other end to BP3 (S).

㉒ ( ) Run a piece of bus wire from G2R8 (S) to BT2 (S).

⑰ ( ) Connect a wire from G1F7 (S) to the ground lug at L (S).

⑯ ( ) Connect a wire from G1R9 (S) to H2 (S).

( ) Mount the pilot light in position PL. Refer to Figure 14.

㉔ ( ) Connect a 100 K resistor (brown-black-yellow) between PL2 (S) and L2 (S).

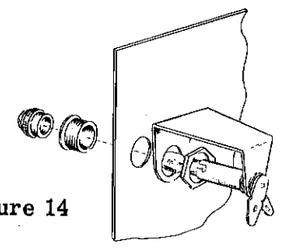
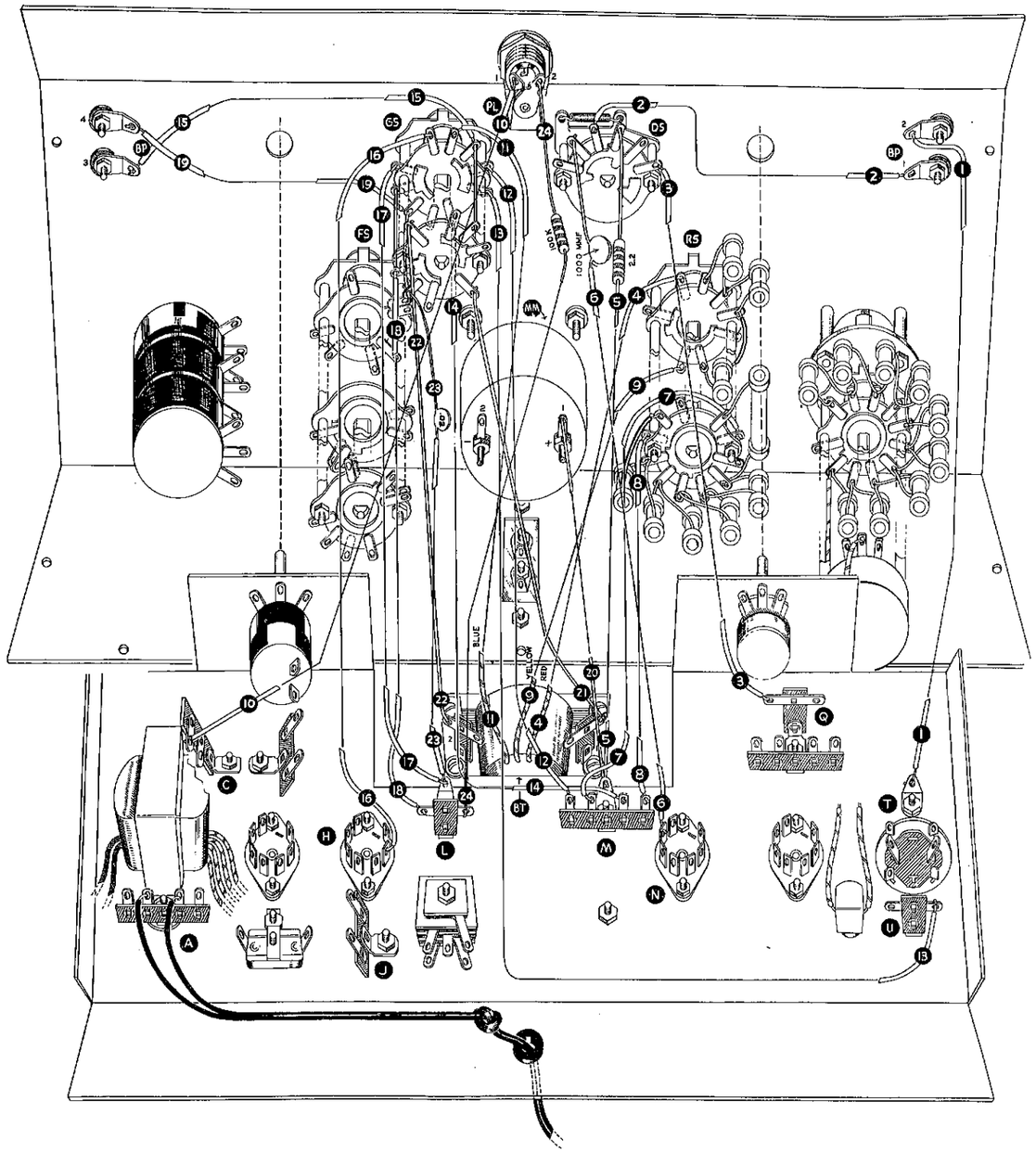


Figure 14



Pictorial 3

Chassis and Panel Wiring

(10)( ) Connect a wire from PL1 (S) to C2 (S).

( ) Run the line cord through the rubber grommet W in the rear of the chassis and tie a knot inside the chassis to keep the cord from being pulled out. Allow sufficient length inside the chassis for the cord to reach terminal strip A.

( ) Connect one lead to A2 (S) and the other lead to A3 (S).

( ) Install the knobs, making sure that the pointer positions check with the panel markings. Use 8-32 set screws for holding the knobs.

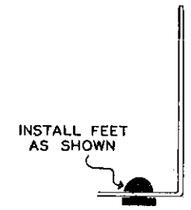
( ) Install the DQ knob. A reasonable degree of accuracy may be obtained by simply setting the knob at zero at the extreme end of rotation of the control. If maximum accuracy is desired, do not tighten the DQ knob setscrew securely at this time. Calibration instructions will appear later.

( ) Install the CRL control ring and knob.

( ) Using #6 self tapping screws, mount the two stationary pointers for the DQ and CRL controls.

( ) Adjust the ring of the CRL control so the numbers line up with the stationary pointer. The knob will be adjusted later.

Figure 15



( ) Install the rubber feet in the bottom of the cabinet as shown in Figure 15.

( ) Install the 1L4 and 1U4 tubes in their proper sockets. See Figure 9.

IMPORTANT WARNING

MINIATURE TUBES CAN BE EASILY DAMAGED WHEN PLUGGING THEM INTO THEIR SOCKETS. THEREFORE, USE EXTREME CARE WHEN INSTALLING THEM. WE DO NOT GUARANTEE OR REPLACE MINIATURE TUBES BROKEN DURING INSTALLATION.

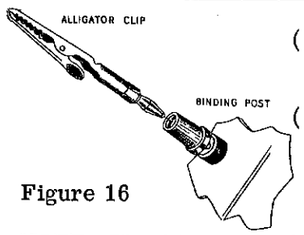


Figure 16

( ) Two alligator clips with banana plugs are provided as test leads. These plug into the terminals of the bridge as shown in Figure 16. The unknown may then be clipped between them.

( ) After making the initial adjustments, install the instrument in the cabinet and fasten with two #6 self tapping screws through the rear into the chassis, and with seven #6 screws through the panel into the cabinet.

NOTE: The blue and white identification label shows the Model Number and Production Series Number of your kit. Refer to these numbers in any communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

( ) Install the identification label in the following manner:

1. Select a location for the label where it can easily be seen when needed, but will not show when the unit is in operation. This location might be on the rear panel or the top of the chassis, or on the rear or bottom of the cabinet.
2. Carefully peel away the backing paper. Then press the label into position.

INITIAL ADJUSTMENTS

Plug the line cord into a 105-125 volt 50/60 cycle AC outlet only. SERIOUS DAMAGE TO THE TRANSFORMER WILL RESULT IF PLUGGED INTO A DC SUPPLY. Turn on the power switch on the GENERATOR LEVEL control.

The oscillator circuit is designed to operate somewhere between 800 and 1200 cps. The actual frequency will depend on the components. A trimmer condenser is provided so that the frequency may be set at approximately 1 kc by use of an audio generator. The most convenient method is to use an oscilloscope. Set the audio generator at 1 kc and connect it to one set of plates of the oscilloscope. Connect the terminals on top of the bridge to the other set of plates of the oscilloscope. Set the GENERATOR switch at AC INTERNAL, the DETECTOR switch at AC INTERNAL, the GENERATOR LEVEL control clockwise, the FUNCTION switch at L-DQ and the RANGE switch a 1h. Adjust the trimmer until a circle or ellipse appears on the oscilloscope. The bridge generator frequency is then equal to the frequency of the audio generator.

If an oscilloscope is not available, headphones may be used. The output of the audio generator and the bridge oscillator may be fed into the earphones and the trimmer adjusted until zero beat is heard. The frequency of the bridge oscillator will then equal the frequency of the audio oscillator. The bridge may still be used even if an audio oscillator is not available. Tighten the trimmer condenser by turning the screw clockwise. Then turn the screw 1/2 turn counterclockwise. This will set the oscillator at approximately 1 kc. Later adjustment may be made when additional equipment is available.

The CRL control is set as follows. Check the zero setting of the galvanometer. Set the FUNCTION switch to R. Set the GENERATOR switch to DC INTERNAL and the DETECTOR switch to DC SHUNT. Set the RANGE switch to 100 Ω on the R scale. Set the ring of the CRL control to 5. Connect the 550 Ω precision resistor supplied for calibration across the terminals on the top of the bridge. Rotate the knob of the CRL control until the galvanometer does not move when the DETECTOR switch is moved to DC METER position. The switch is spring loaded in this position so it will return to DC SHUNT position when released. Now loosen the CRL control knob and rotate it until it reads .5 on the stationary pointer. The CRL dial now will read 5.5. Tighten the CRL control knob and again check to see that the meter does not move when the DETECTOR switch is moved to DC METER position. Repeat the adjustment until the meter does not move. The CRL control is now set and ready for use.

If greater accuracy of the DQ control calibration is desired (more than that obtainable by simply zero-setting the knob), proceed in the following manner:

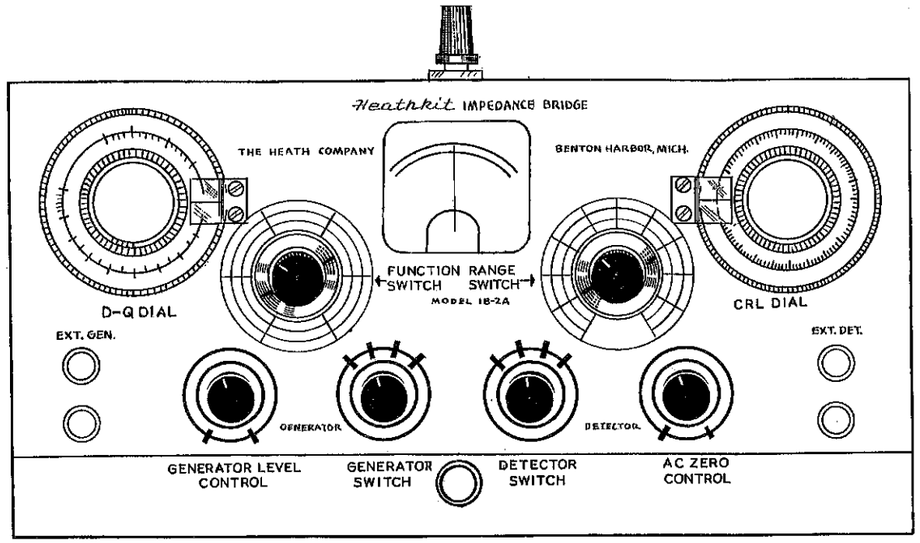
1. Set up the controls as outlined for the CRL calibration. Remove the 550 Ω precision resistor from the terminals on top of the bridge.

2. Disconnect the end of the wire connecting lug 2 of the rear section of the DQ control to lug 6 on the rear deck of function switch FS at the switch.

3. Temporarily connect a jumper wire (clip-leads will suffice, if available) between lug 1 of the rear section of the DQ control and lug 1 of terminal strip TS on top of the bridge. Connect another lead between lug 2 of the same rear section and lug 2 of the binding post strip (the red post). Turn on the power. Set the CRL controls to read 160 Ω and adjust the DQ control to bring the meter to zero (this will occur near the 0.1 mark on the DQ knob). Verify this adjustment by turning the DETECTOR switch to DC METER. No pointer movement is noticeable at exact zero. The adjustment is critical, so use care.

   When the bridge has been balanced, note the position of the 0.1 mark on the DQ dial with respect to the pointer. Correct the knob setting to read exactly 0.1 and rebalance the bridge to check. A double check may be made by turning the RANGE switch to 1000 Ω. The bridge should balance at 1.0 on the DQ dial.

   When calibration is complete, remove the jumpers and reconnect the proper leads to the control and the switch FS.



FRONT PANEL SHOWING CONTROLS

Figure 17

DC Resistance Measurements

1. Plug in the cord and turn on the switch mounted on the GENERATOR LEVEL control.
2. Check the zero setting of the galvanometer.
3. Connect the unknown resistance to the terminals on top of the bridge.
4. Set the FUNCTION switch to R.
5. Set the GENERATOR switch to DC INTERNAL.
6. Set the DETECTOR switch to DC SHUNT.
7. Set the CRL DIAL to zero.

For greater indicating accuracy of DC resistance measurements, external batteries may be used as follows:

Provided the CRL dial is not turned below 1, the following external battery voltages in series with additional resistance may be used:

On multipliers	not more than	in series with
0.1 Ω, 1.0 Ω, 10 Ω, 100 Ω	67 1/2 V	not less than 1500 ohms.
1 KΩ	135 V	not less than 4000 ohms.
10 KΩ, 100 KΩ, 1 Megohm ...	202 1/2 V	not less than 6500 ohms.

(over) to #8

8. Set the RANGE switch (CRL multiplier dial) to the setting that results in minimum deflection of the galvanometer. Choose the setting that gives a reading to the left of the zero mark.
9. Turn the rim of the CRL control for approximate balance, then continue with the center knob for further balance.
10. For final balance, turn the DETECTOR switch to DC METER.
11. Multiply CRL reading by multiplier setting of the RANGE switch to find the resistance. For resistance measurements below 1 Ω, it is recommended that an external galvanometer of greater sensitivity be used.

Low resistance measurements are subject to errors due to the internal resistance of the bridge and resistances of the contacts and leads. The internal resistance of the bridge can be measured by shorting the unknown terminals with a piece of heavy wire and balancing the bridge in the usual manner. It will probably be of the order of .02 Ω. The lead resistance can be partially eliminated by connecting the resistance directly to the binding post. Cleaning the leads will also help to minimize errors in lead resistance. When measuring low resistances, the internal resistance of the bridge should be subtracted from the measured value of resistance to give the corrected value.

Inductance Measurements at 1000 Cycles

1. Connect the unknown inductor to the terminals on top of the bridge.
2. Set the GENERATOR switch to AC INTERNAL.
3. Set the DETECTOR switch to AC INTERNAL.
4. Set the FUNCTION switch to L-DQ. Set the DQ dial at 50%.
5. Set the AC ZERO control so that the meter reads 100 microamperes counterclockwise. The GENERATOR LEVEL control should be in counterclockwise while this is done.
6. Set the GENERATOR LEVEL control so that the meter will move about half scale.
7. Set the RANGE switch so that the meter will read maximum counterclockwise.
8. Alternately adjust the CRL and DQ dials until the meter reads maximum counterclockwise. Move the GENERATOR LEVEL control clockwise as balance is approached so that at final balance it will be in maximum clockwise position. If the DQ setting tends to go above 10, set the FUNCTION switch to L-Q and again balance as above.
9. Multiply the CRL reading by the multiplier setting of the RANGE switch to find L. Q is read directly from the DQ or Q scale.

Inductance measurements at other frequencies may be made by using an external generator. Set the GENERATOR switch to EXTERNAL GENERATOR and measure as outlined for 1000 cycles.

Capacitance Measurements at 1000 cycles

1. Connect the unknown capacitance to the terminals on top of the bridge.
2. Set the GENERATOR switch to AC INTERNAL.
3. Set the DETECTOR switch to AC INTERNAL.
4. Set the FUNCTION switch to C-DQ. Set the DQ dial to zero.
5. Set the AC ZERO control so that the meter reads 100 microamperes counterclockwise. The GENERATOR LEVEL control should be in counterclockwise position while this is done.
6. Set the GENERATOR LEVEL control so the meter will read about half scale.
7. Set the RANGE switch so that the meter will read maximum counterclockwise.
8. Adjust the CRL and DQ dials until the meter reads maximum counterclockwise. The GENERATOR LEVEL control should be moved clockwise as balance is approached so that at final balance it is in maximum clockwise position. If the DQ setting tends to go below one, set the FUNCTION switch to CD and again balance as above.
9. Multiply the CRL reading by the multiplier setting on the RANGE switch to find C. Read D directly on the DQ dial.

Capacitance measurements at frequencies other than 1000 cycles may be made by using an external generator and following the method outlined above.

The CRL reading is independent of frequency. Dissipation factor and storage factor both depend upon frequency, however, so a correction factor must be applied to the D-Q readings. For 1 kc, the D and Q readings are direct. For frequencies other than 1 kc, the dissipation factor D is obtained by multiplying the observed value of D by the frequency in kilocycles. Storage factor Q at any frequency is the observed value on the DQ dial multiplied by the frequency in kilocycles or the observed value on the Q dial divided by the frequency in kilocycles.

IN CASE OF DIFFICULTY

1. Check the wiring by following each wire on the pictorial and in the instrument, inspecting the soldered connections on each end and then checking off that wire on the pictorial with a colored pencil. This will reveal mistakes and omissions in wiring, which is the most frequent cause of difficulties. Often having a friend check the wiring will reveal a mistake consistently overlooked.
2. Check the position of the switches on the panel and be sure they are in the proper position.
3. Check the tubes.
4. Check the voltages between tube socket terminals and chassis. The readings should come reasonably close to the values tabulated below, if a vacuum tube voltmeter with 11 megohm input resistance is used. Other type meters may give considerably lower readings. If a voltage reading fails to check with the tabulation, investigate the portion of the circuit involved by checking the resistors and condensers.

VOLTAGE CHART

SOCKET	TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7
GENERATOR F	1U4	0	50-55	45-50	NC	0	.3-.35*	1.4-1.45
H	1L4	1.4-1.45	95-105	100-110	NC	1.4-1.45	NS	2.4-2.6
DETECTOR N	1U4	0	40-45	35-40	NC	0	.3-.35*	1.4-1.45
S	1L4	1.4-1.45	70-75	100-110	NC	1.4-1.45	22-23*	2.4-2.6

* - Negative with respect to chassis.
NC - No connection.
NS - Not significant.
All measurements made with GENERATOR LEVEL control set at maximum, GENERATOR switch at AC INTERNAL, DETECTOR switch at AC INTERNAL, FUNCTION and RANGE switches in maximum clockwise position.
Unless otherwise indicated, all voltages are positive and measured to chassis.
Line voltage - 115 volts, 60 cycles.

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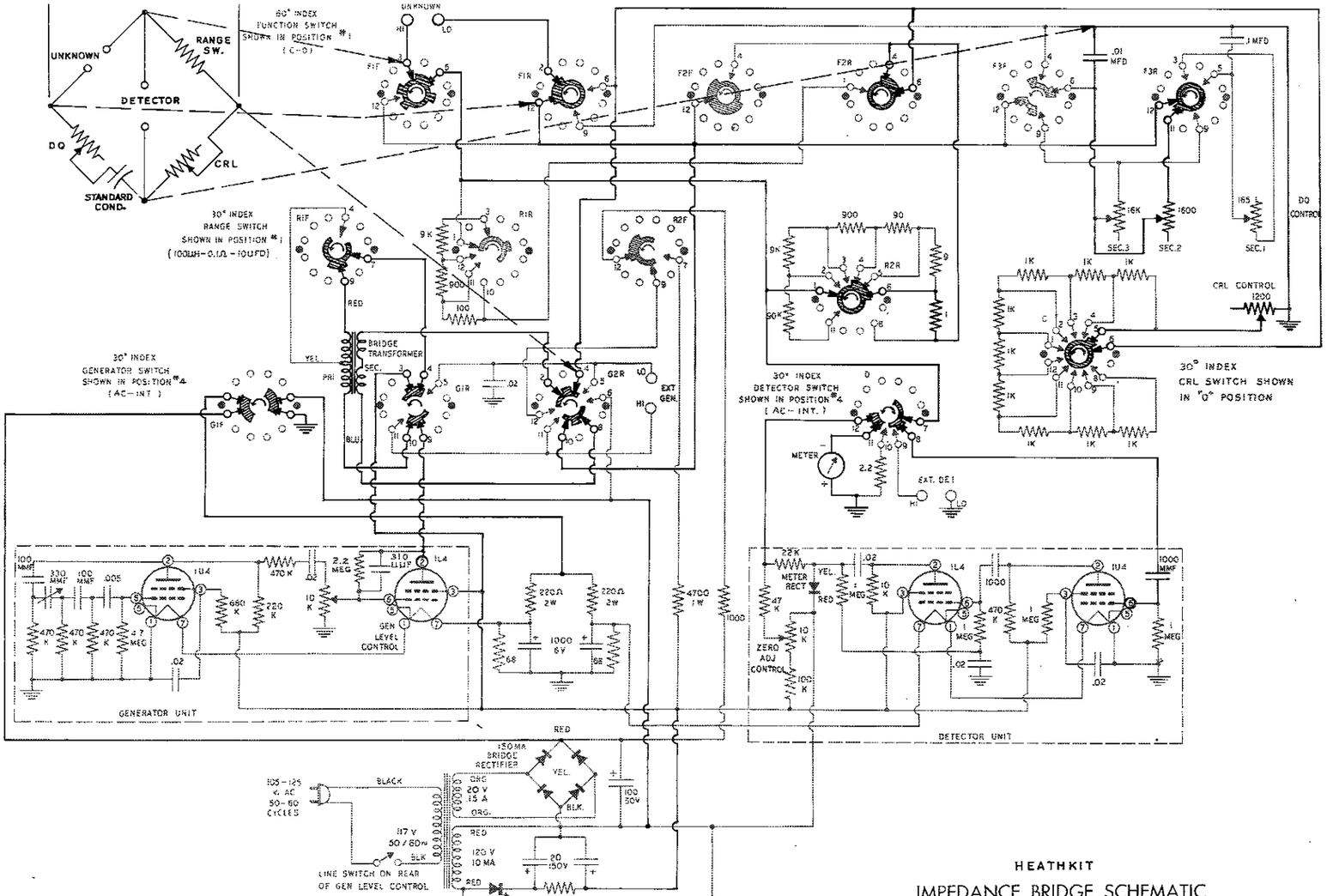


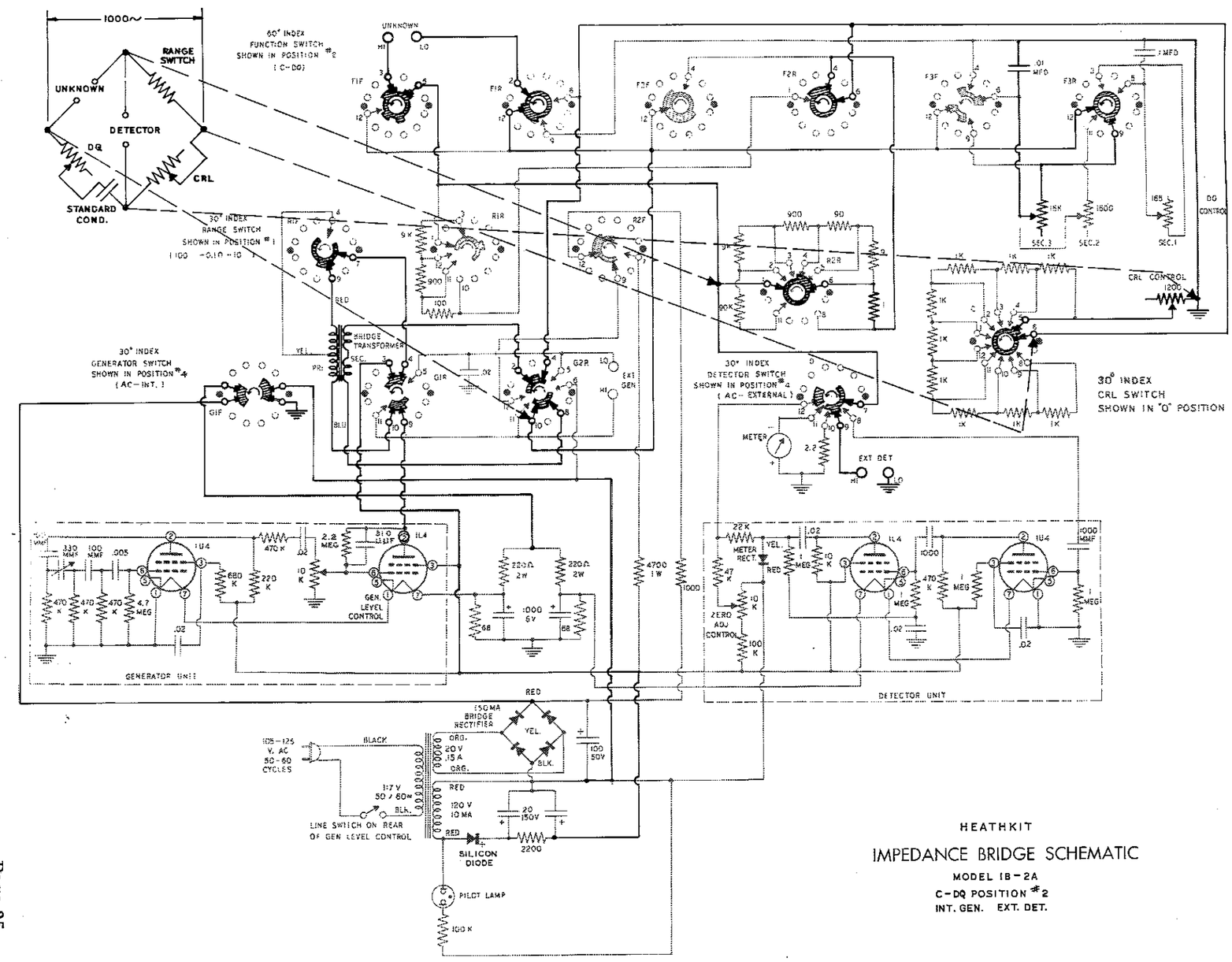
HEATHKIT

IMPEDANCE BRIDGE SCHEMATIC

MODEL IB-2A

C-D POSITION #1

INT. GEN. INT. DET.



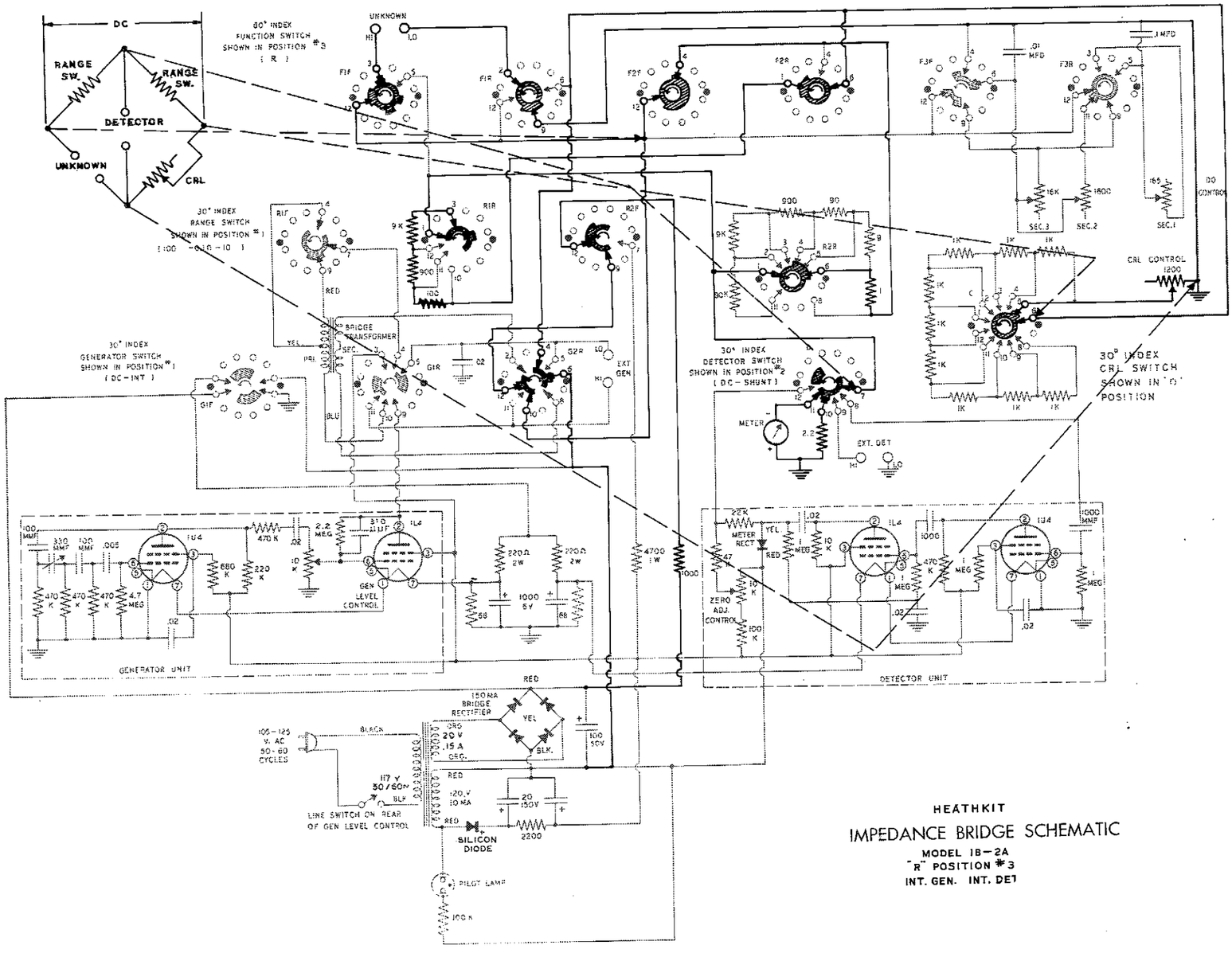
HEATHKIT

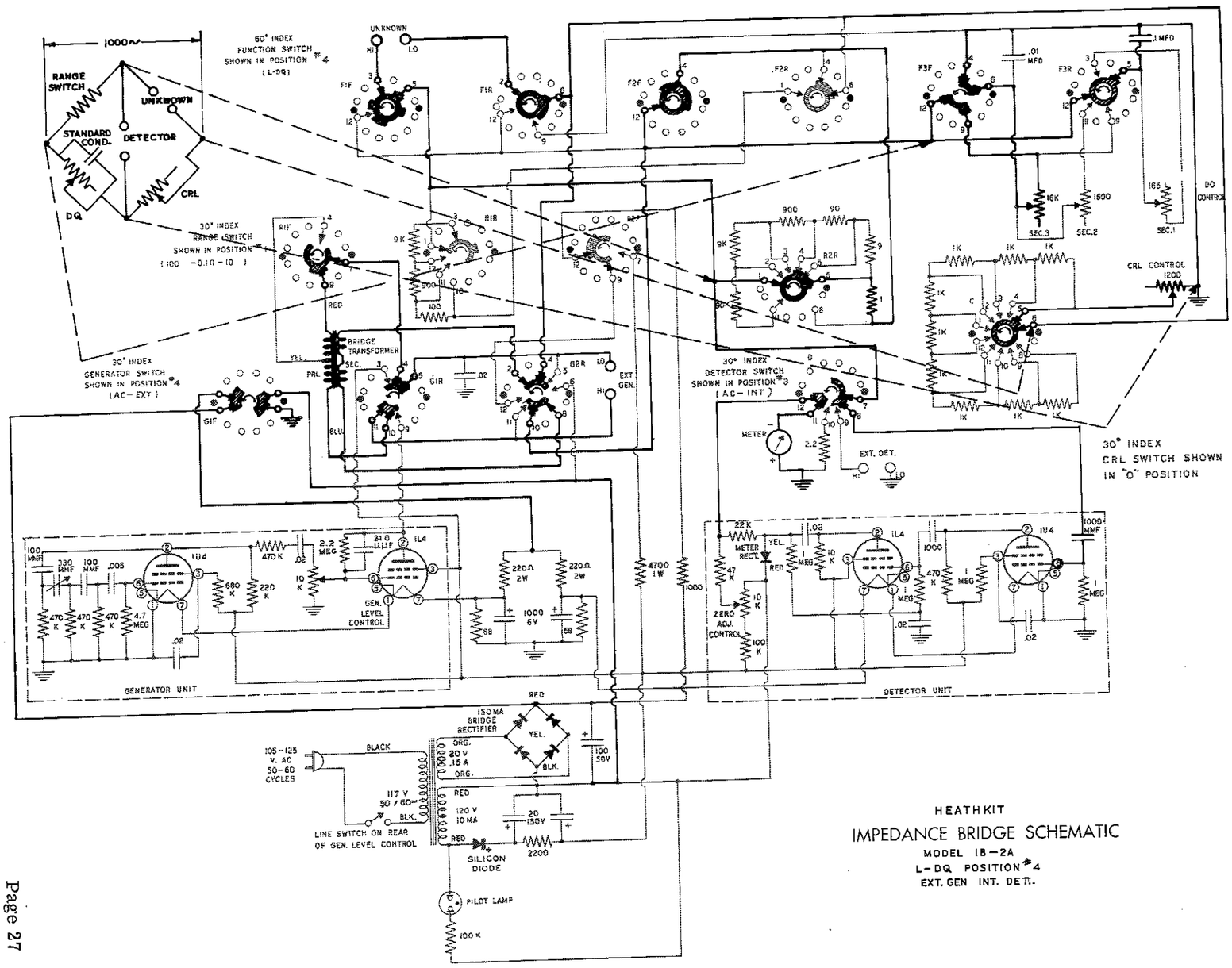
IMPEDANCE BRIDGE SCHEMATIC

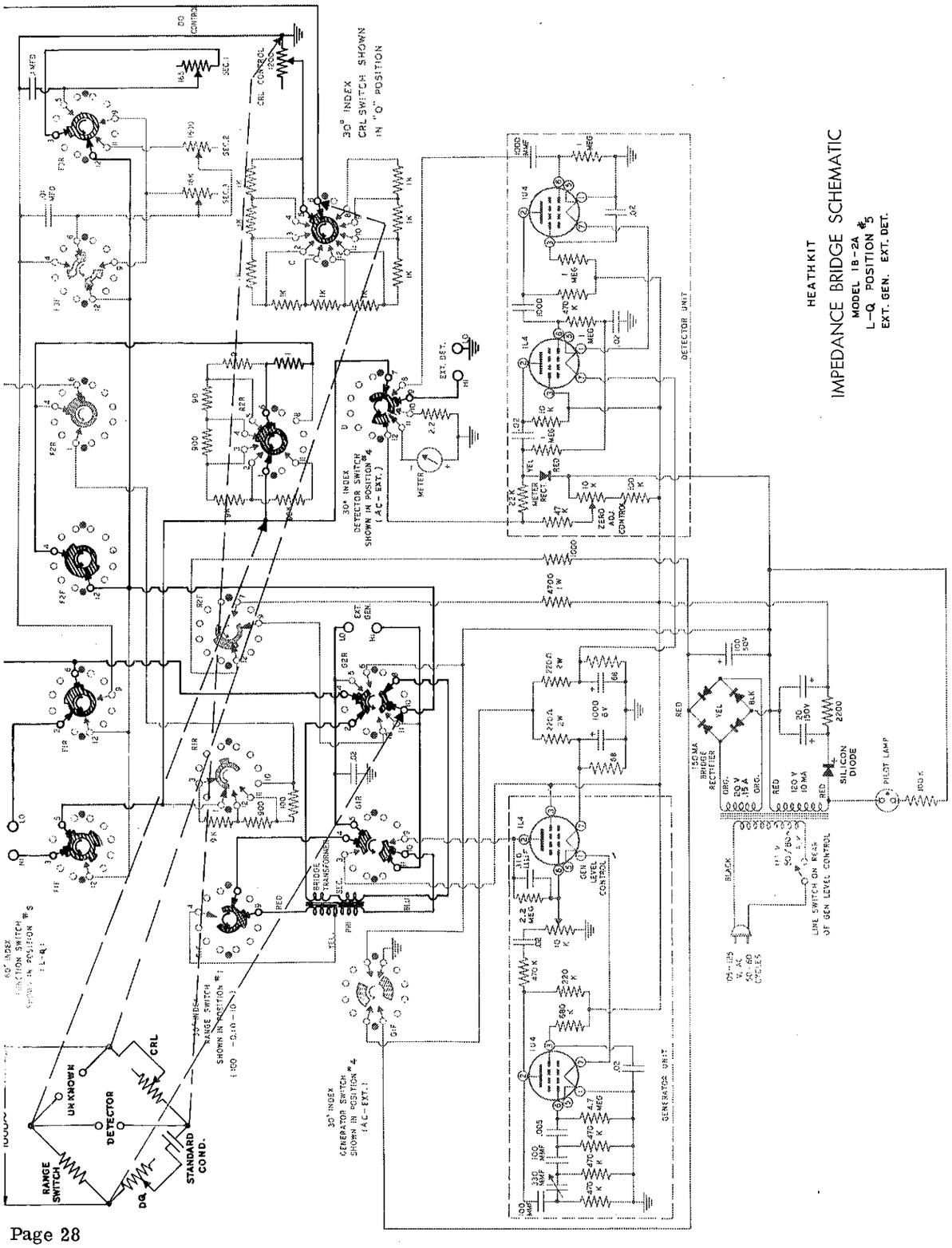
MODEL IB-2A

C-DQ POSITION #2

INT. GEN. EXT. DET.


DC
RANGE SW.
RANGE SW.
DETECTOR
UNKNOWN
CRL
30° INDEX FUNCTION SWITCH SHOWN IN POSITION #3 (R)
30° INDEX RANGE SWITCH SHOWN IN POSITION #1 (100 - 0.10 - 10)
30° INDEX GENERATOR SWITCH SHOWN IN POSITION #1 (DC - INT)
30° INDEX DETECTOR SWITCH SHOWN IN POSITION #2 (DC - SHUNT)
30° INDEX CRL SWITCH SHOWN IN "0" POSITION
BRIDGE TRANSFORMER
METER
EXT. DET
GENERATOR UNIT
DETECTOR UNIT
GEN LEVEL CONTROL
ZERO ADJ. CONTROL
CRL CONTROL
DQ CONTROL
150MA BRIDGE RECTIFIER
105-125 V. AC 50-60 CYCLES
LINE SWITCH ON REAR OF GEN LEVEL CONTROL
SILICON DIODE
PILOT LAMP
HEATHKIT
IMPEDANCE BRIDGE SCHEMATIC
MODEL IB-2A
"R" POSITION #3
INT. GEN. INT. DET


1000~
RANGE SWITCH
UNKNOWN
STANDARD COND.
DETECTOR
DQ
CRL
60° INDEX FUNCTION SWITCH SHOWN IN POSITION #4 (L-DQ)
30° INDEX RANGE SWITCH SHOWN IN POSITION #1 (100 - 0.10 - 10)
30° INDEX GENERATOR SWITCH SHOWN IN POSITION #4 (AC - EXT)
30° INDEX DETECTOR SWITCH SHOWN IN POSITION #3 (AC - INT)
30° INDEX CRL SWITCH SHOWN IN "0" POSITION
BRIDGE TRANSFORMER
METER
EXT. DET.
GENERATOR UNIT
DETECTOR UNIT
GEN. LEVEL CONTROL
ZERO ADJ. CONTROL
CRL CONTROL
DQ CONTROL
150MA BRIDGE RECTIFIER
105-125 V. AC 50-60 CYCLES
LINE SWITCH ON REAR OF GEN. LEVEL CONTROL
SILICON DIODE
PILOT LAMP
HEATHKIT
IMPEDANCE BRIDGE SCHEMATIC
MODEL IB-2A
L-DQ POSITION #4
EXT. GEN INT. DET.



REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the kit Model Number and Series Number.
C. Mention date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. The facilities of our Service Department are at your disposal, and your instrument may be returned for inspection and repair. You will be charged a minimal fee plus the price of any additional parts or material that may be required.

The services of our Technical Consultation Department are also available to you, without charge. Our technical consultants are thoroughly familiar with every instrument and can usually localize the trouble from a suitable description of the difficulty encountered.

It is necessary that you provide full and complete information concerning your problem when writing to our Technical Consultation Department for assistance, or when returning your instrument for Factory Repair Service. For instance, clearly identify the kit involved, giving the purchase date and, if possible, the invoice number; describe in detail the difficulty that you have encountered, state what you have attempted to do to rectify the trouble, what results have been achieved, and include any information or clues that you feel could possibly be of value to the consultant who handles your problem.

Local Service by Authorized HEATHKIT Service Centers is also available in some areas and often will be your fastest, most efficient method of obtaining service. HEATHKIT Service Centers will honor the regular 90 day HEATHKIT Parts Warranty on all kits, whether purchased through a dealer or directly from the Heath Company; however, it will be necessary that you verify the purchase date of your kit.

Under the conditions specified in the Warranty, replacement parts are supplied without charge; however, if your local dealer assists you in locating a defective part (or parts) in your Heathkit, or installs a replacement part for you, he may charge you for this service.

Heathkits purchased locally and returned to Heath Company for service must be accompanied by your copy of the dated sales receipt from your authorized Heathkit dealer in order to be eligible for parts replacement under the terms of the Warranty.

THESE SERVICE POLICIES APPLY ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned NOT repaired.

For information regarding modifications of Heathkits for special applications, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at most electronic outlet stores. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discretion of the kit builder, according to information which will be much more readily available from some local source.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted.

ATTACH A TAG TO THE INSTRUMENT GIVING NAME, ADDRESS AND TROUBLE EXPERIENCED.

Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

Heath Company warrants that all Heathkit parts shall be free of all defects in materials and workmanship under normal use and service, and in fulfillment of such warranty Heath Company will, for a period of three months from the date of shipment, replace any part upon verification that it is defective.

The foregoing warranty shall apply only to the original buyer, and is and shall be in lieu of all other warranties, whether express or implied and of all other obligations or liabilities on the part of Heath Company and in no event shall Heath Company be liable for any anticipated profits, consequential damages, loss of time or other losses incurred by the buyer in connection with the purchase, assembly or operation of Heathkits or components thereof. No replacement shall be made of parts damaged by the buyer in the course of handling or assembling Heathkit equipment.

The foregoing warranty is completely void if corrosive solder or fluxes have been used in wiring the equipment. Heath Company will not replace or repair any equipment in which corrosive solder or fluxes have been used.

This warranty applies only to Heath equipment sold and shipped within the continental United States including APO and FPO shipments. Warranty replacement for Heathkit equipment outside the United States is on an f.o.b. factory basis. Contact the Heathkit authorized distributor in your country or write: Heath Company, International Division, Benton Harbor, Michigan, U.S.A.

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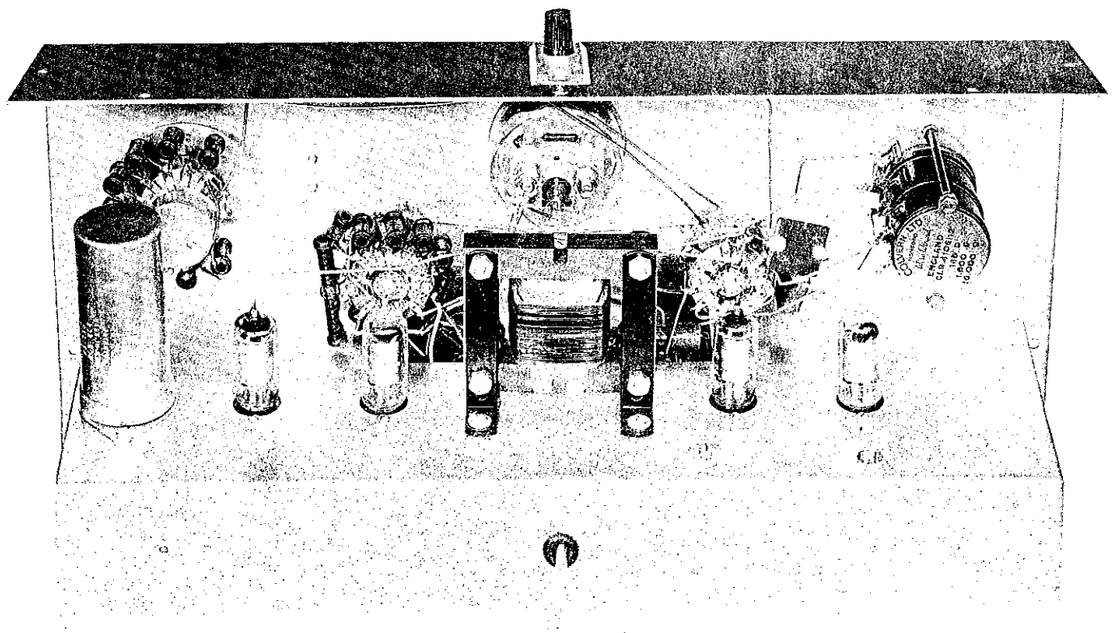
PARTS LIST

PART No.	PARTS Per Kit	DESCRIPTION
Composition Resistors		
1-72	1	2.2 Ω 1/2 watt
1-2	2	68 Ω 1/2 watt
1-9	1	1 KΩ 1/2 watt
1-44	1	2.2 KΩ 1/2 watt
1-20	1	10 KΩ 1/2 watt
1-22	1	22 KΩ 1/2 watt
1-25	1	47 KΩ 1/2 watt
1-26	2	100 KΩ 1/2 watt
1-29	1	220 KΩ 1/2 watt
1-33	5	470 KΩ 1/2 watt
1-34	1	680 KΩ 1/2 watt
1-35	4	1 megohm 1/2 watt
1-37	1	2.2 megohm 1/2 watt
1-71	1	4.7 megohm 1/2 watt
1A-24	1	4700 Ω 1 watt
1B-13	2	220 Ω 2 watt
Precision Resistors		
2-1	1	1 Ω 1/2%
2-2	1	9 Ω 1/2%
2-3	1	90 Ω 1/2%
2-4	1	100 Ω 1/2%
2-59	1	550 Ω 1/2%
2-5	2	900 Ω 1/2%
2-6	9	1 KΩ 1/2%
2-7	2	9 KΩ 1/2%
2-10	1	90 KΩ 1/2%
Condensers		
31-9	1	300-450 μμf trimmer
20-11	2	100 μμf (.0001 μfd)
21-14	2	.001 μfd (1000 μμf)
23-2	1	.005 μfd (5000 μμf)
20-27	1	.01 μfd precision mica
23-8	6	.02 μfd
20-28	1	.1 μfd precision mica
20-112	1	310 μμf 500 v mica
25-7	1	20-20 μfd 150 v
25-28	1	100 μfd 50 v
25-26	1	1000-1000 μfd 6 v
Controls-Switches		
10-8	1	10 KΩ control
63-60	1	4-pos. detector switch
63-61	1	4-pos. 2 sec. gen. switch
63-62	1	8-pos. 2 sec. range switch
63-63	1	5-pos. 3 sec. function switch
13-2	1	165-1600-16 KΩ control
19-36	1	1200 Ω control w/10-pos. switch
19-2	1	10 KΩ control w/switch

PART No.	PARTS Per Kit	DESCRIPTION
Meters-Tubes-Lamps		
407-4	1	100-0-100 microampere meter
411-56	2	1U4 tube
411-57	2	1L4 tube
412-3	1	NE-51 pilot lamp
Transformers-Rectifiers		
51-16	1	Bridge transformer
54-56	1	Power transformer
57-27	1	Silicon diode
57-6	1	Meter rectifier
57-12	1	Bridge rectifier
Sockets-Terminal Strips-Knobs		
434-15	4	7-pin miniature socket
434-69	1	Pilot light socket
75-6	1	Terminal board insulator
431-1	3	1-lug terminal strip
431-2	2	2-lug terminal strip
431-51	1	2-lug terminal strip (vertical)
431-5	3	4-lug terminal strip
462-19	6	Indicator knob
462-20	1	DQ knob
462-21	1	CRL knob
462-22	1	CRL ring
463-5	2	Stationary pointer
Hardware		
250-2	8	3-48 x 1/4 machine screw
250-8	13	#6 x 3/8 sheet metal screw
250-9	14	6-32 x 3/8 machine screw
250-13	1	6-32 x 1" machine screw
250-29	3	6-32 x 3/4 RHMS
252-1	8	3-48 nut
252-3	26	6-32 nut
252-7	8	Control nut
253-1	4	#6 flat fiber washer
253-2	4	#6 fiber shoulder washer
253-9	4	#8 washer
253-10	7	Control nickel washer
254-1	16	#6 lockwasher
254-6	2	#6 external lockwasher
254-4	8	Control lockwasher
255-15	3	#6 x 1/2" spacer
259-1	9	#6 solder lug
259-2	2	#8 solder lug

PART No.	PARTS Per Kit	DESCRIPTION
Sheet Metal Parts		
200-M53	1	Chassis
203-M54F154	1	Panel
204-M52	1	CRL mounting bracket
90-18	1	Cabinet
Wire		
340-3	1	roll #16 bus wire
344-59	1	roll Hookup wire
346-1	1	length Spaghetti (sleeving)
89-1	1	Line cord

PART No.	PARTS Per Kit	DESCRIPTION
Miscellaneous		
73-1	1	3/8 rubber grommet
100-M16B	3	Binding post cap, black
100-M16R	3	Binding post cap, red
261-1	4	Rubber feet
427-2	6	Binding post base
438-14	2	Banana clip
481-1	1	Condenser mounting wafer
331-6		Solder
595-156	1	Manual



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THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

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595-156...