PRICE $1.00

Assembling

and Using Your...

Heathkit

ELECTRONIC CROSSOVER

MODEL XO-1

HEATH COMPANY

A Subsidiary of Daystrom Inc.

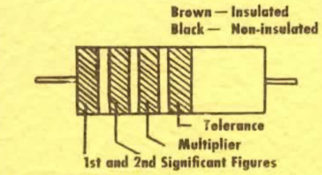
BENTON HARBOR, MICHIGAN

595-130

STANDARD COLOR CODE — RESISTORS AND CAPACITORS

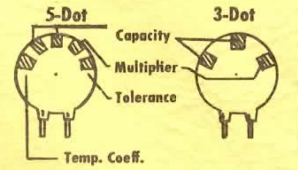
INSULATED UNINSULATED Color	FIRST RING BODY COLOR First Figure	SECOND RING END COLOR Second Figure	THIRD RING DOT COLOR Multiplier
BLACK	0	0	None
BROWN	1	1	0
RED	2	2	00
ORANGE	3	3	,000
YELLOW	4	4	0,000
GREEN	5	5	00,000
BLUE	6	6	000,000
VIOLET	7	7	0,000,000
GRAY	8	8	00,000,000
WHITE	9	9	000,000,000

AXIAL LEAD RESISTOR

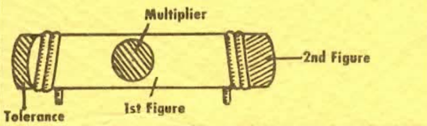


Wire wound resistors have 1st digit band double width

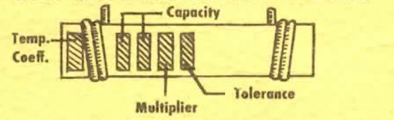
DISC CERAMIC RMA CODE



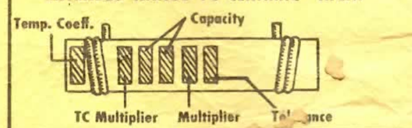
RADIAL LEAD DOT RESISTOR



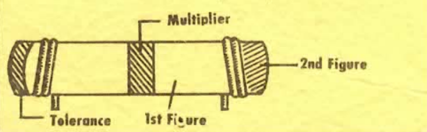
5-DOT RADIAL LEAD CERAMIC CAPACITOR



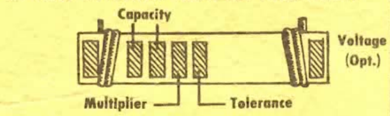
EXTENDED RANGE TC CERAMIC HICAP



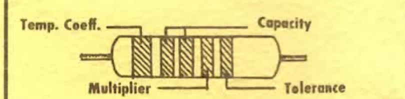
RADIAL LEAD (BAND) RESISTOR



BY-PASS COUPLING CERAMIC CAPACITOR



AXIAL LEAD CERAMIC CAPACITOR

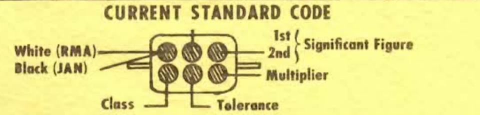


The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: Gold = 5%, silver = 10%. Absence of the fourth band indicates a 20% tolerance rating.

The physical size of carbon resistors is determined by their wattage rating. Carbon resistors most commonly used in Heathkits are ½ watt. Higher wattage rated resistors when specified are progressively larger in physical size. Small wire wound resistors ½ watt, 1 or 2 watt may be color coded but the first band will be double width.

MOLDED MICA TYPE CAPACITORS

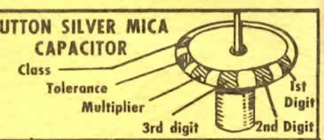
CURRENT STANDARD CODE



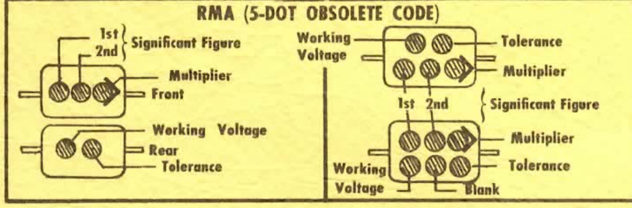
JAN & 1948 RMA CODE

RMA 3-DOT (OBSOLETE) RATED 500 W.V.D.C. ± 20% TOL.

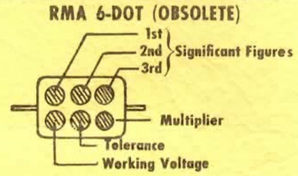
BUTTON SILVER MICA CAPACITOR



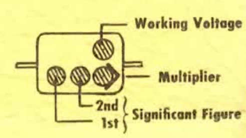
RMA (5-DOT OBSOLETE CODE)



RMA 6-DOT (OBSOLETE)

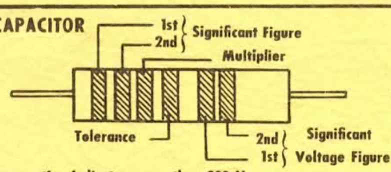


RMA 4-DOT (OBSOLETE)



MOLDED PAPER TYPE CAPACITORS

TUBULAR CAPACITOR

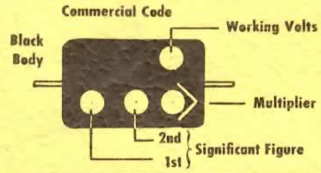


Normally stamped for value

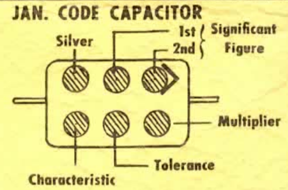
A 2 digit voltage rating indicates more than 900 V. Add 2 zeros to end of 2 digit number.

MOLDED FLAT CAPACITOR

Commercial Code



JAN. CODE CAPACITOR



The tolerance rating of capacitors is determined by the color code. For example: red = 2%, green = 5%, etc. The voltage rating of capacitors is obtained by multiplying the color value by 100. For example: orange = 3 × 100 or 300 volts. Blue = 6 × 100 or 600 volts.

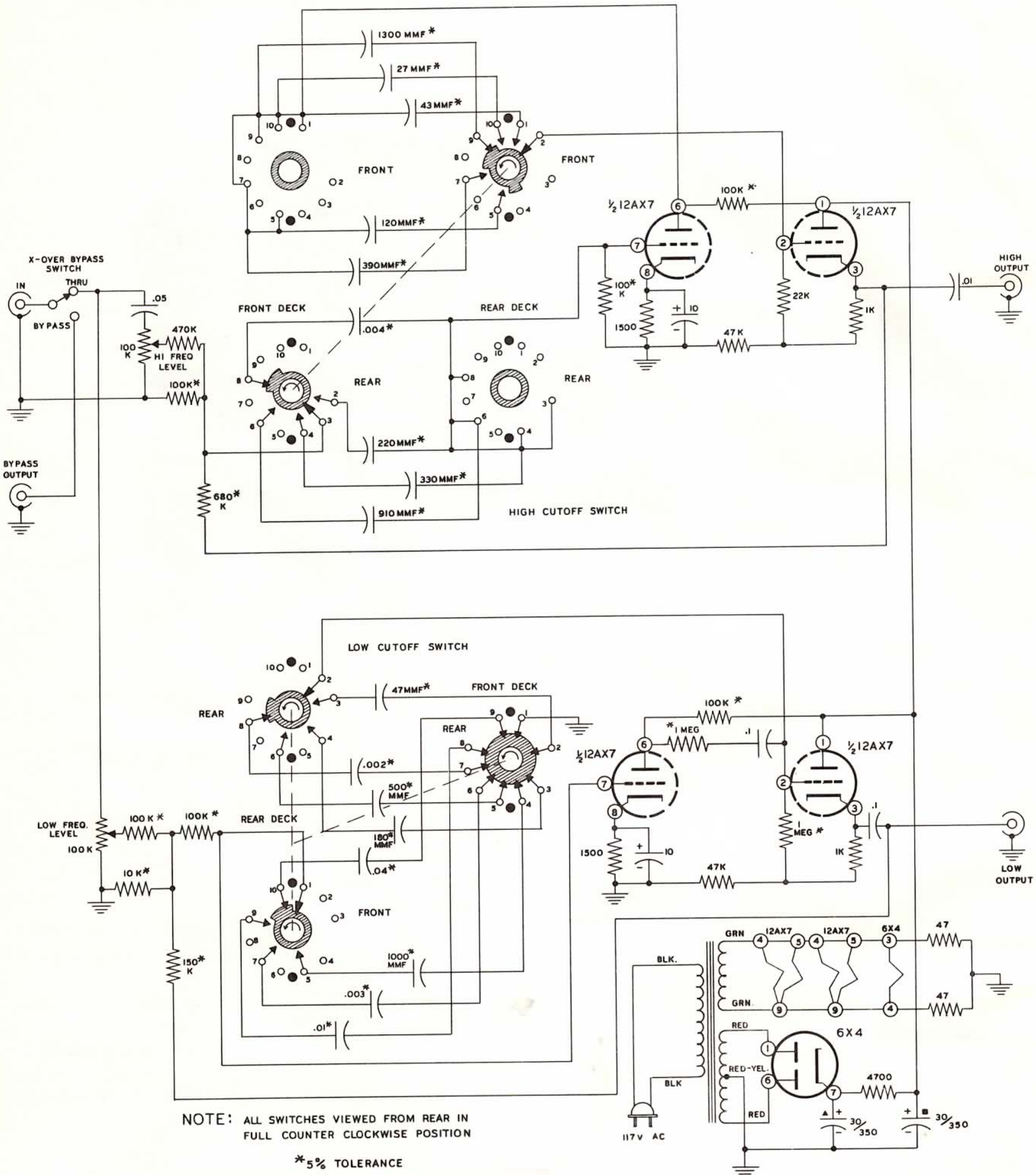
In the design of Heathkits, the temperature coefficient of ceramic or mica capacitors is not generally a critical factor and therefore Heathkit manuals avoid reference to temperature coefficient specifications.

Courtesy of Centralab

HEATHKIT ELECTRONIC CROSSOVER
MODEL XO-1

SPECIFICATIONS

Input:	High impedance.
Outputs:	(1). Low-frequency. (2). High-frequency. (3). By-pass. (Input signal may be transferred to this output jack by means of switch provided.) (Low and high-frequency outputs are low impedance from cathode-followers.)
Cutoff Frequencies:	100, 200, 400, 700, 1200, 2000 and 3500 cycles. The high and the low-frequency channels can be individually adjusted to any of these frequencies by means of two rotary switches.
Total Hum and Noise, Each Channel:	70 db below 1.5 volts out.
Tubes:	Two 12AX7. One 6X4 rectifier.
Dimensions:	9" wide, 5 3/4" high, 4 3/4" deep.
Power Requirements:	105 - 125 volts, 50-60 cycles AC. 5 watts.
Kit Shipping Weight:	6 lbs.



NOTE: ALL SWITCHES VIEWED FROM REAR IN FULL COUNTER CLOCKWISE POSITION

*5% TOLERANCE

ALL CAPACITORS MARKED IN MFD UNLESS OTHERWISE SPECIFIED

HEATHKIT ELECTRONIC CROSSOVER
MODEL XO-1

Maximum Gain of Each Channel: . . . . Unity.

Normal Operating Level: . . . . 2.0 volts rms or less.

Maximum Recommended Operating Level: . . . 5.0 volts rms.

Frequency Response:

Low-Frequency Channel: . . . . ±1.2 db from 10 cycles to cutoff frequency.

High-Frequency Channel: . . . . ±1.2 db from cutoff frequency to 20,000 cycles.

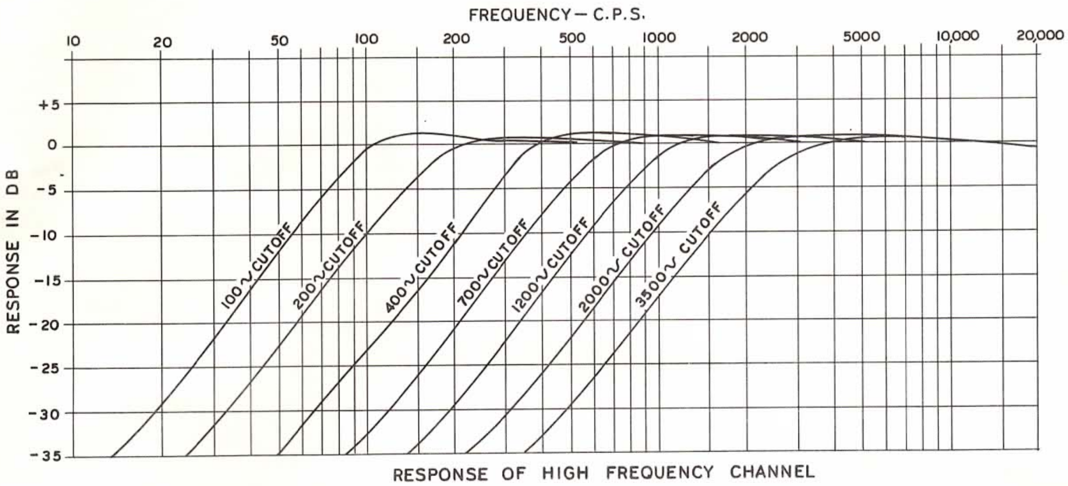


Figure 1

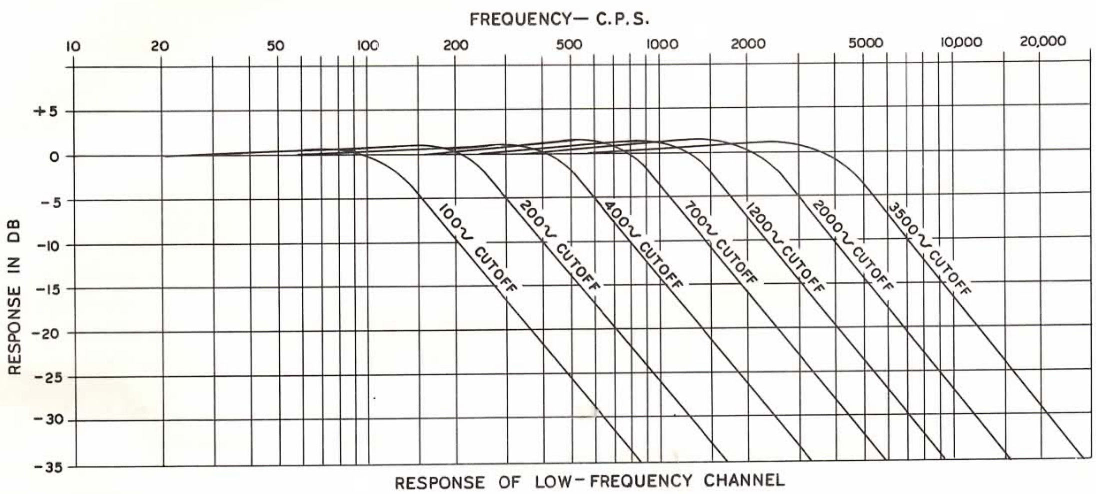


Figure 2

Distortion: Distortion introduced by the XO-1 is extremely low, and can be considered negligible. It was not possible to measure intermodulation distortion with laboratory equipment ordinarily available, owing to the frequency characteristics of the XO-1; distortion figures so obtained would not be valid. For this reason, harmonic distortion tests were relied upon to furnish information as to linearity of the XO-1 circuits.

Harmonic Distortion:

Low-Frequency Channel: . . . . Less than .1 of 1% at 2 volts out at any frequency up to approximately one-half the cutoff frequency. See curve (Figure 3) for further data on distortion vs. frequency.

High-Frequency Channel: . . . . Less than .25 of 1% when measured at the cutoff frequency; drops rapidly at higher frequencies, to less than .1 of 1% (see curve of Figure 4).

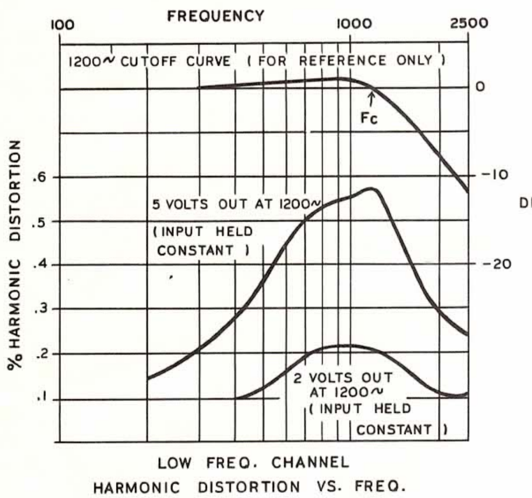


Figure 3

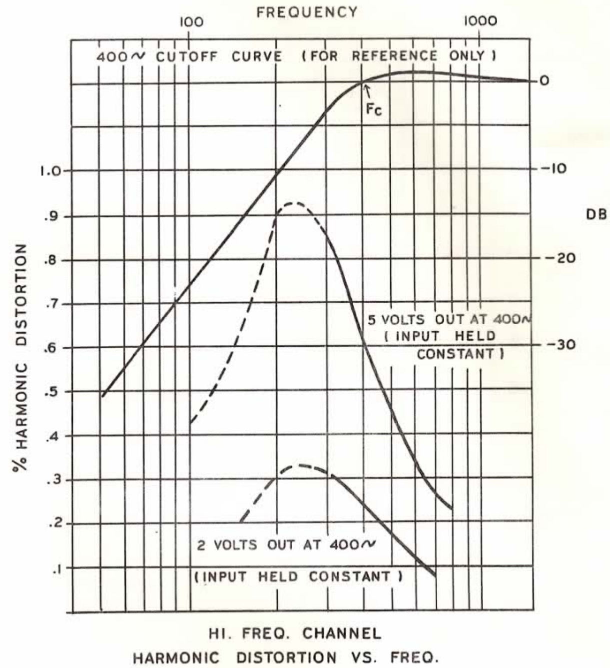


Figure 4

NOTE: The proper interpretation of these harmonic distortion vs. frequency curves is complicated by the fact that the response is far from flat. In other words, the relative levels of the fundamental frequency and the total harmonic content are upset by the inherent sloping response which is an essential characteristic of the XO-1. Thus, the harmonic content measured is not a true "percentage distortion" under the normal interpretation.

Nevertheless the curves indicate the relationship between harmonic content and the fundamental at various frequencies in the region of cutoff, which would hold under actual operating conditions; it is NOT a TRUE measure of distortion introduced by non-linearity of the XO-1 itself. Since the measurements were made by the method which shows "total harmonic content", it is difficult to accurately correct the curves in order to gain a true distortion figure for the XO-1. However, if this were done, it would be found that the distortion would not rise appreciably with decreasing frequency as appears to be the case in Figure 4. In Figure 3 the corrected distortion figure would be somewhat higher at frequencies close to Fc and would tend to level off above Fc instead of dropping. However, these corrected distortion figures are of little value anyway in the case of Figure 3 since harmonic products of frequencies approaching Fc are rapidly attenuated. From this it can be concluded that distortion introduced by the XO-1, at normal operating levels, can be considered negligible.

NOTE: The performance specifications given are based on careful measurements made on a typical unit, and kits constructed in exact accordance with the instructions can be expected to conform to these specifications to a reasonable degree. We cannot guarantee, however, that measurements made on completed kits will be in exact agreement with the specifications, owing to factors beyond our reasonable control. Such factors include placement of critical leads, normal variation of components and tube characteristics.

INTRODUCTION

It is generally appreciated that to satisfactorily reproduce the spectrum of audio frequencies from approximately 30 cycles to 15,000 cycles requires a relatively large speaker or "woofer" to reproduce the low frequencies, say from 30 to 1000 cycles and a comparitively small speaker or "tweeter" to reproduce the higher range, in this example, from 1000 to 15,000 cycles. Such a system requires an electrical dividing network or "crossover" to divide the total audio spectrum into the proper ranges, in order that only the high frequencies will be fed to the tweeter and only the low frequencies to the woofer. (Many 2-way speakers built as an integral unit with separate cones for the high and the low frequencies have a built-in or "mechanical" crossover and are not considered here. Best results and greatest flexibility are generally achieved by the use of a separate woofer and tweeter and an electrical, rather than a mechanical crossover.

Figure 5 shows, in block diagram form, the connection of a conventional electrical crossover unit of the type which has come into general use. Note that the crossover unit is connected between the output of the power amplifier and the speakers.

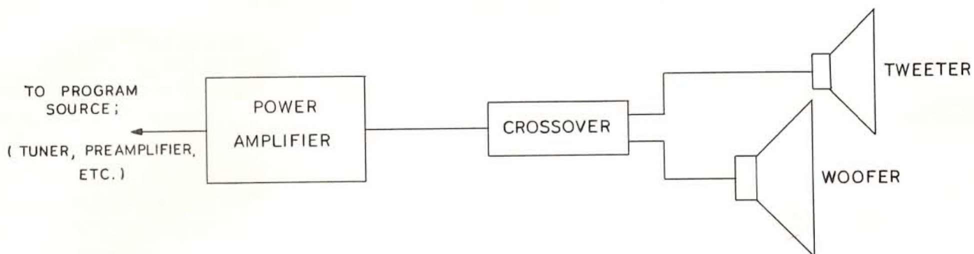


Figure 5

The Heathkit XO-1 Electronic Crossover is designed to operate in conjunction with a two-way speaker system where separate power amplifiers are used for the high and the low frequencies as shown in the block diagram of Figure 6. This has several important advantages over the conventional method of Figure 5.

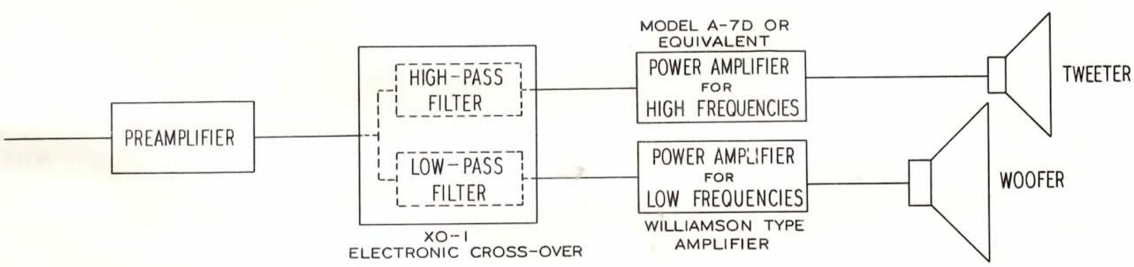


Figure 6

(1) Since the crossover unit operates at the input of the power amplifiers rather than at the output, no output power is dissipated and therefore wasted in the crossover unit itself. In contrast, it is to be noted that a conventional type crossover with an insertion loss of only 1 db would reduce the power capability of a 20 watt amplifier to 16 watts and a 50 watt amplifier to 40 watts.

(2) In an electronic crossover device, it is practical to vary the crossover frequency over a wide range to accommodate almost countless woofer-tweeter combinations and acoustic environments. Changing speakers in your hi-fi system will not obsolete the XO-1. Also, there are no complex impedance matching problems in assembling your own speaker crossover system.

(3) It is possible to achieve a near ideal crossover characteristic by means of electronic circuitry, without significant peaks or valleys in the overall response. Also, the response and crossover characteristics are unaffected by differences in speakers and enclosures.

(4) Amplifier damping factor is not altered by the crossover device.

(5) The possibility of intermodulation distortion (modulation of the high frequencies by high-amplitude low frequencies) in the amplifiers is reduced, particularly at high power levels.

(6) No reactive-load conditions, sometimes caused by conventional crossover units, are imposed on the power amplifier. Such load conditions can result in instability (oscillation) in amplifiers with heavy feedback.

It should be noted that while the above discussion is confined to two-way speaker systems, the XO-1 may be used to good advantage in three or four-way systems. A number of suggested arrangements are given in the section entitled "Installation and Operation".

CIRCUIT DESCRIPTION

The circuitry of the XO-1 is quite simple and straightforward. Refer to the Schematic. It consists basically of a high-frequency channel and a low-frequency channel. A 12AX7 dual triode is used in each channel. A 6X4 rectifier tube is used in a conventional full wave power supply with a two-section RC filter.

The high-frequency channel is actually a high-pass filter; it passes only those frequencies above the cutoff frequency, as shown in the curves of Figure 1. It will be noted that the cutoff frequency may be adjusted to 100, 200, 400, 700, 1200, 2000 or 3500 cycles by means of a rotary switch. Similarly, the low-frequency channel is a low-pass filter which will pass only frequencies below the cutoff frequency, as shown in Figure 2. The cutoff frequency of this channel is adjustable over the same range by means of another switch. The input signal is applied through the high and low-frequency LEVEL controls, through suitable isolating resistors to the input of both channels. The 12AX7 dual triode in each channel is utilized so that one section functions as a gain stage and the other as an output cathode follower. Each channel employs two RC networks in order to achieve a cutoff slope of 12 db per octave since each network contributes 6 db per octave. In each channel the 12AX7 gain stage serves to separate the two RC networks. Approximately 14 db negative feedback is applied around each channel from the cathode-follower output back to the grid of the gain stage. The function of this negative feedback is three-fold: (1) It modifies the shape of the response curves in the region near the cutoff frequency, so that a much sharper "knee" is imparted to the curve than if feedback were not used. This makes it possible to maintain essentially flat response up to and including the cutoff frequency, with as much as 12 db attenuation at twice and one-half this frequency for the low and high-frequency channel, respectively. (2) Any harmonic distortion developed is reduced by feedback, at frequencies within the passband of either channel. (3) The amount of feedback used reduces the overall gain to unity since gain is not required in the unit.

The cutoff frequency is varied by switching different values of capacity in both RC networks of each channel. Although this could be accomplished by switching resistors instead, the level in the "flat" region would vary appreciably with the cutoff frequency due to the finite values of resistance already in the circuit. A unique method of switching capacitors has been devised whereby each capacitor (with exceptions) serves for two successive cutoff frequencies. This greatly reduces the number of components required and is made possible by "staggering" the turnover frequencies of the two RC networks in each channel.

NOTES ON ASSEMBLY AND WIRING

A great deal of enginnering has gone into the design of your Heathkit Electronic Crossover to ensure highest performance and the components have been carefully selected for quality and long life. We urge you to proceed with the utmost care in construction, follow the instructions exactly and perform each step in the most workmanlike manner possible. By so doing you will protect your investment in time and money and be rewarded with the fine performance of which your Electronic Crossover is capable as well as the deep feeling of satisfaction that comes from a job well done.

This manual is supplied to assist you in every way to complete the instrument with the least possible chance for error. The detailed instructions are specifically written to allow either the experienced or inexperienced constructor to construct the unit with a minimum of difficulty. Only a very small percentage of Heathkit assemblers encounter any difficulty whatsoever in completing kits of this kind. The large fold-in pictorial diagrams included in this manual are intended to be attached to the wall above your work space, for convenient reference. The diagrams are repeated in smaller form within the manual proper.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. DO NOT DISCARD ANY PACKING MATERIAL UNTIL THIS HAS BEEN DONE. In so doing you will become acquainted with each part. Full size sketches of the various type parts will be found on Page 28 to help you identify any questionable components. If a parts shortage is found, please notify us promptly and return the inspection slip to us with your letter. Hardware items are counted by weight and if a few are missing, we suggest that to save time, you obtain them locally if at all possible.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Thus a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ and still be acceptable. Tolerances on electrolytic condensers may be even wider and commonly run from +100% to -50%. The parts furnished with your Heathkit have been specified so as to meet the performance specifications given. Refer to the color code information given on the inside front cover of this manual when in doubt as to the value or tolerance of a resistor or capacitor.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are very carefully checked before they are approved and the parts supplied will work satisfactorily in your kit. For example, if your kit is short a 15 KΩ resistor and an 18 KΩ resistor is furnished which is not on the parts list, you will understand that such a substitution has been made. This fact is mentioned here only to prevent any confusion in checking the contents of your kit.

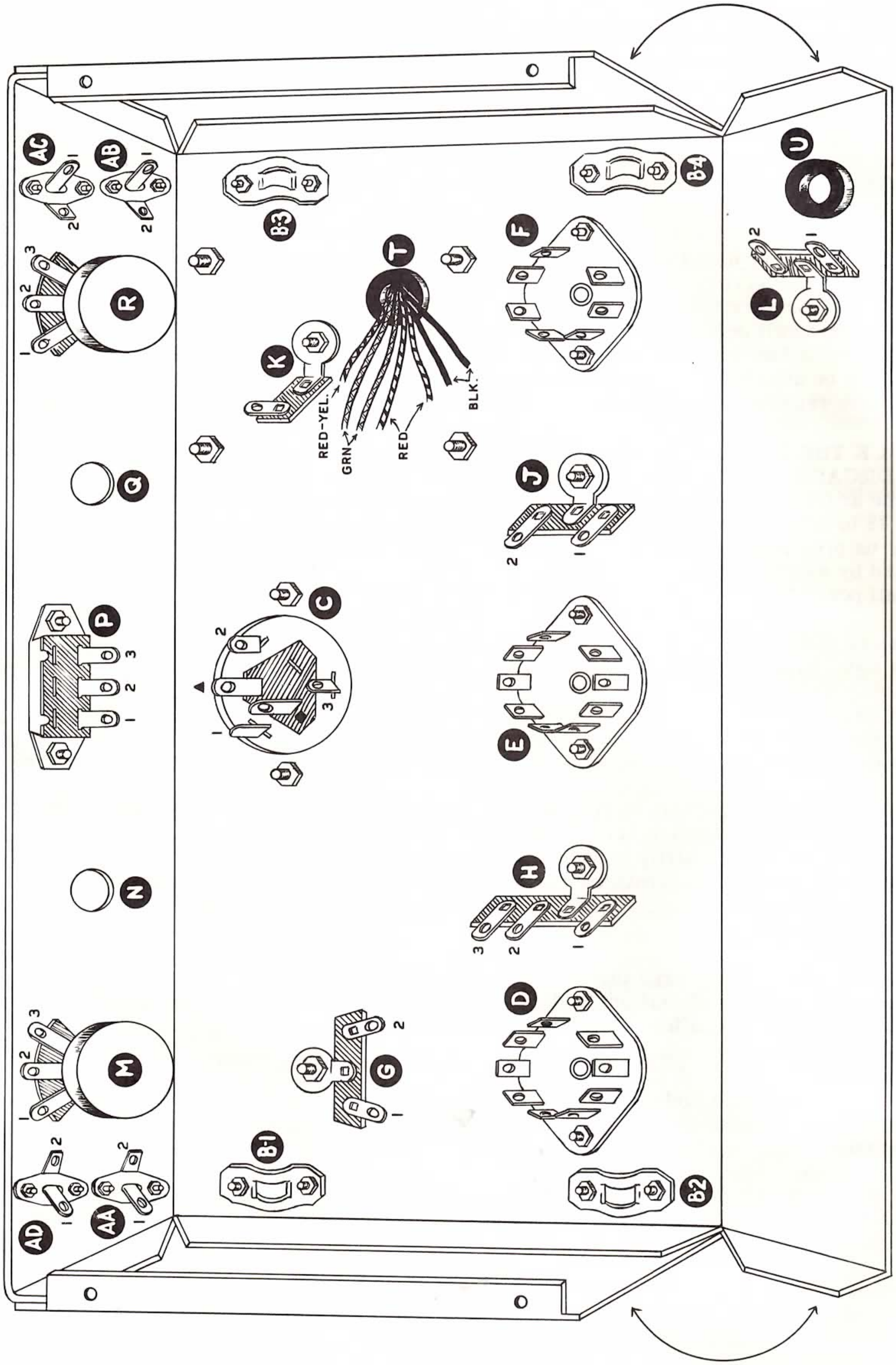
CAUTION: We strongly urge that you follow exactly the wiring and parts layout shown in this manual. The position of certain leads and components in this instrument is quite critical and changes may seriously affect the characteristics of the circuit.

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

First attach the large fold-in pictorials to the wall above your work space. Then we suggest that you carefully read through the entire assembly and wiring instructions. This will familiarize you with the construction procedure and will tend to prevent errors before they occur.

WE URGE YOU TO FOLLOW THE STEP-BY-STEP INSTRUCTIONS IN THE EXACT ORDER GIVEN. Read through each step carefully then perform the operation indicated. Place a check mark in the space provided ( ) as each step is completed.

In assembling the kit, use lockwashers under all nuts unless otherwise specified. Tube sockets are mounted inside the chassis; the filter condenser mounting wafer is mounted <u>on top</u> of the chassis. Other details of construction are included where pertinent in the instructions.



PICTORIAL 1

( ) Place the chassis with its open side up in front of you on your workbench. Be sure the front apron (with the lettering on the outside) is away from you. The chassis will then be in the position shown in Pictorial 1.

( ) Install a phono connector socket at location AA. Be sure lug 2 is away from the end of the chassis. Mount with two 6-32 screws through the chassis and the holes in the socket. Place a #6 lockwasher directly under each nut.

( ) In the same manner, install a phono connector socket at location AB. As before, be sure lug 2 is away from the end of the chassis.

( ) Likewise, install the two remaining phono connector sockets at AC and AD, observing lug orientation as before.

( ) Mount the four spring catch clips at B1, B2, B3 and B4. Secure each clip on the under side of the chassis, with two 4-40 pan head screws inserted from the top of the chassis. Use a #4 lockwasher under each nut.

( ) Install the fiber mounting wafer for the electrolytic filter condenser at C. IMPORTANT: Make sure this wafer is installed with the triangular hole positioned as shown in Pictorial 1. Secure with 6-32 hardware.

( ) Mount a 9-pin wafer tube socket at D. Be sure to observe lug orientation shown with the blank space (between lugs 1 and 9) to the right away from the end of the chassis. See Figure 7. Secure socket with two 3-48 screws and nuts. Lockwashers are not required with 3-48 hardware.

( ) Mount a 9-pin wafer tube socket at E observing the same lug orientation as before.

( ) Install the 7-pin wafer tube socket at F with the blank space (between lugs 1 and 7) to the right toward this end of the chassis.

( ) Mount a 2-lug terminal strip at G observing orientation shown in Pictorial 1. Use 6-32 hardware.

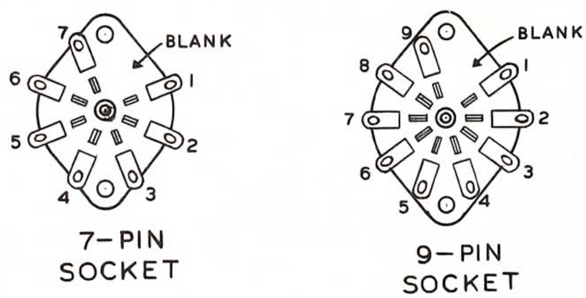


Figure 7

( ) In the same manner, mount a 3-lug terminal strip at H. Be sure terminal 1 is nearest the rear chassis apron.

( ) Install a 2-lug terminal strip at J.

( ) Mount a 1-lug terminal strip at K.

NOTE: The 2-lug terminal strip at L will be mounted later.

( ) Install a 100 KΩ control at M. Orient so that the lugs are toward the open side of the chassis. Refer to Figure 8 for control mounting details. Use a 3/8" lockwasher between the control and the chassis. Place a control washer under the 3/8"-32 nut used to secure the control.

( ) In the same manner install a 100 KΩ control at R.

( ) Using 6-32 hardware, mount the S. P. D. T. slide switch at P with the switch handle protruding through the rectangular opening in the front chassis apron. Observe orientation shown with the three lugs away from the open side of the chassis.

(✓) Install a 1/2" rubber grommet at T.

(✓) Install a 3/8" rubber grommet at U.

(✓) Install the power transformer on top of the chassis, by first pulling its seven leads through rubber grommet T all the way. Make sure no part of any lead remains coiled between the bottom of the transformer and the top of the chassis, which could result in a short circuit of serious consequences. Secure the transformer to the chassis by means of 8-32 hardware.

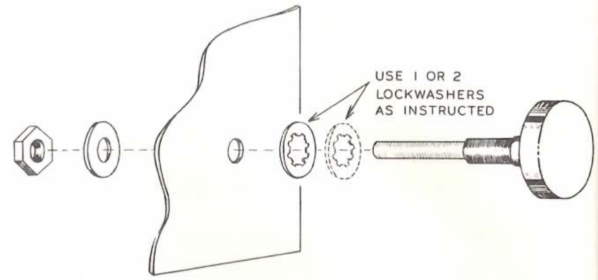


Figure 8

(✓) Install the electrolytic filter condenser on its mounting wafer which was previously mounted at C. Insert this condenser from the top of the chassis with the three metal tabs protruding through the three slots in the wafer. IMPORTANT: Be sure to orient the condenser as shown in Pictorial 1. Note that two of these metal tabs have holes through them, while one does not. The tab with no hole goes toward the upper left-hand corner of the chassis, when viewed as in Pictorial 1. With the condenser in this position and tight against the wafer, twist each of the mounting tabs 1/8 turn with a pair of pliers.

This completes preliminary assembly of parts on the chassis with the exception of the two rotary switches and terminal strip L, which will be mounted later. At this point we suggest that you carefully compare your work with Pictorial 1 and correct any errors in parts mounting before proceeding with the wiring. Any mistakes at this point are much more difficult to correct after wiring has been started.

PROPER SOLDERING PROCEDURE

Only a small percentage of Heathkit purchasers find it necessary to return an instrument for factory service. Of these, by far the largest proportion function improperly due to poor or improper soldering.

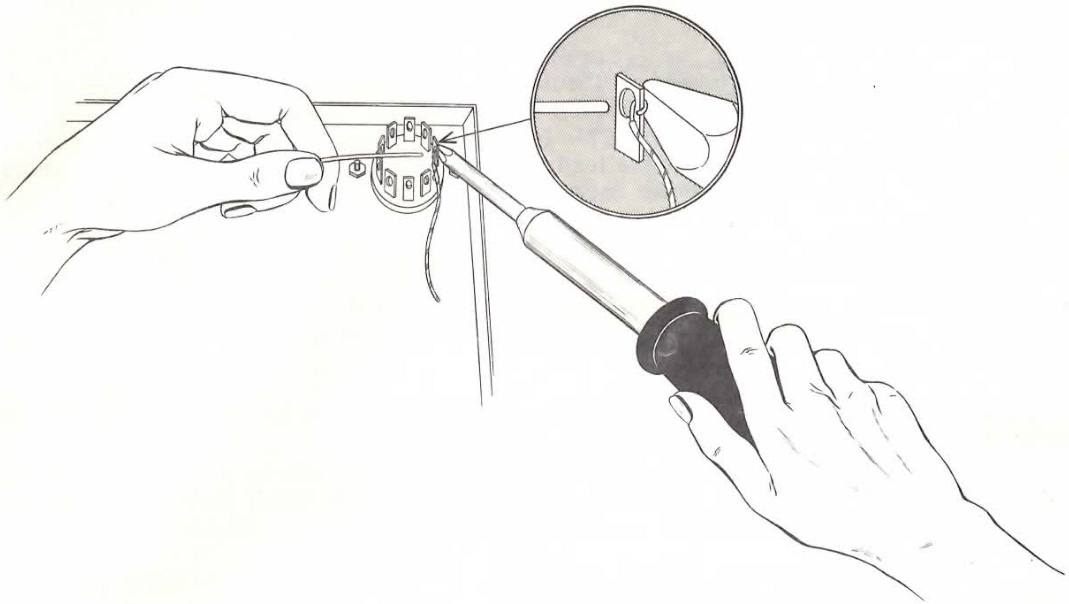
Correct soldering technique is extremely important. Good solder joints are essential if the performance engineered into the kit is to be fully realized. If you are a beginner with no experience in soldering, a half-hour's practice with odd lengths of wire and a tube socket will be a worthwhile investment.

High quality solder of the proper grade is most important. There are several different brands of solder on the market, each clearly marked "Rosin Core Radio Solder." Such solders consist of an alloy of tin and lead, usually in the proportion of 50:50. Minor variations exist in the mixture such as 40:60, 45:55, etc. with the first figure indicating the tin content. Radio solders are formed with one or more tubular holes through the center. These holes are filled with a rosin compound which acts as a flux or cleaning agent during the soldering operation.

NO SEPARATE FLUX OR PASTE OF ANY KIND SHOULD BE USED. We specifically caution against the use of so-called "non-corrosive" pastes. Such compounds, although not corrosive at room temperatures, will form residues when heated. The residue is deposited on surrounding surfaces and attracts moisture. The resulting compound is not only corrosive but actually destroys the insulation value of non-conductors. Dust and dirt will tend to accumulate on these "bridges" and eventually will create erratic or degraded performance of the instrument.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

If terminals are bright and clean and wires free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Crimp or otherwise secure the wire (or wires) to the terminal, so a good joint is made without relying on solder for physical strength. To make a good solder joint, the clean tip of the soldering iron should be placed against the joint to be soldered so that the terminal is heated sufficiently to melt solder. The solder is then placed against both the terminal and the tip of the iron and will immediately flow out over the joint. Refer to the sketch below. Use only enough solder to cover wires at the junction; it is not necessary to fill the entire hole in the terminal with solder. Excess solder may flow into tube socket contacts, ruining the socket, or it may creep into switch contacts and destroy their spring action. Position the work so that gravity tends to keep the solder where you want it.



A poor solder joint will usually be indicated by its appearance. The solder will stand up in a blob on top of the connection, with no evidence of flowing out caused by actual "wetting" of the contact. A crystalline or grainy texture on the solder surface, caused by movement of the joint before it solidified is another evidence of a "cold" connection. In either event, reheat the joint until the solder flows smoothly over the entire junction, cooling to a smooth, bright appearance. Photographs in the adjoining picture clearly indicate these two characteristics.

A good, clean well-tinned soldering iron is also important to obtain consistently perfect connections. For most wiring, a 60 or 100 watt iron, or the equivalent in a soldering gun, is very satisfactory. Smaller irons generally will not heat the connections enough to flow the solder smoothly over the joint and are recommended only for light work, such as on etched circuit boards, tec. Keep the iron tip clean and bright. A pad of steel wool may be used to wipe the tip occasionally during use.

Take these precautions and use reasonable care during assembly of the kit. This will insure the wonderful satisfaction of having the instrument operate perfectly the first time it is turned on.

Pictorial 2 represents a wired XO-1 crossover unit (complete except for parts to be installed later, as indicated in Pictorial 3.) We again suggest that you attach the large fold-in versions of these pictorials to the wall above your work space for a ready reference during wiring.

Note that the letter designations of parts in Pictorial 1 have been retained in Pictorial 2 and that the terminals on each component are numbered.

When the instructions read, "Connect one end of a .1 μf capacitor to D3 (NS).", it will be understood that the connection is to be made to pin 3 of tube socket D. The abbreviation (NS) indicates that the connection should not be soldered as yet as other leads will be added to the same terminal later. When the last wire is connected, the terminal should be soldered and the abbreviation (S) is used to indicate this.

Unless otherwise indicated, all wire used is insulated. Whenever there is a possibility of the bare leads on resistors and condensers shorting to other parts or to the chassis, the leads should be covered with insulated sleeving. This is indicated in the instructions by the phrase (use sleeving). Bare wire is used where the lead lengths are short and the possibility of short circuits non-existent. Use small diameter bare wire except where otherwise specified.

If a wire-stripping tool is not at hand, we suggest the following method of stripping insulation from the end of hook-up wire: Crush about 1/4" of insulation at the end of the wire by squeezing with longnose pliers. The wire should be placed as far back in the jaws as possible for maximum leverage. The insulation thus broken away may then be trimmed off close with diagonal cutters.

Leads on capacitors, resistors, and transformers are generally much longer than they need to be to make the indicated connections. In these cases, the excess leads should be cut off before the part is added to the chassis. In general, the leads should be just long enough to reach their terminating points. Not only does this make the wiring much neater but in many cases excessively long leads will actually impair the operation of the instrument.

The pictorials indicate actual chassis wiring, designate values of the component parts and show color coding of leads where pertinent. We very strongly urge that the chassis layout, lead placement and grounding connections be followed exactly as shown. While the arrangement shown is probably not the only satisfactory layout, it is the result of considerable experimentation and trial. If followed carefully it will result in a stable instrument operating at a high degree of dependability.

(√) Twist together the two green leads coming from grommet T. Connect the longer of these two leads to F3 (NS) and the shorter lead to F4 (NS).

(√) Twist together the two red leads coming from the same grommet. Connect the longer red lead to F1 (S) and the shorter red lead to F6 (S).

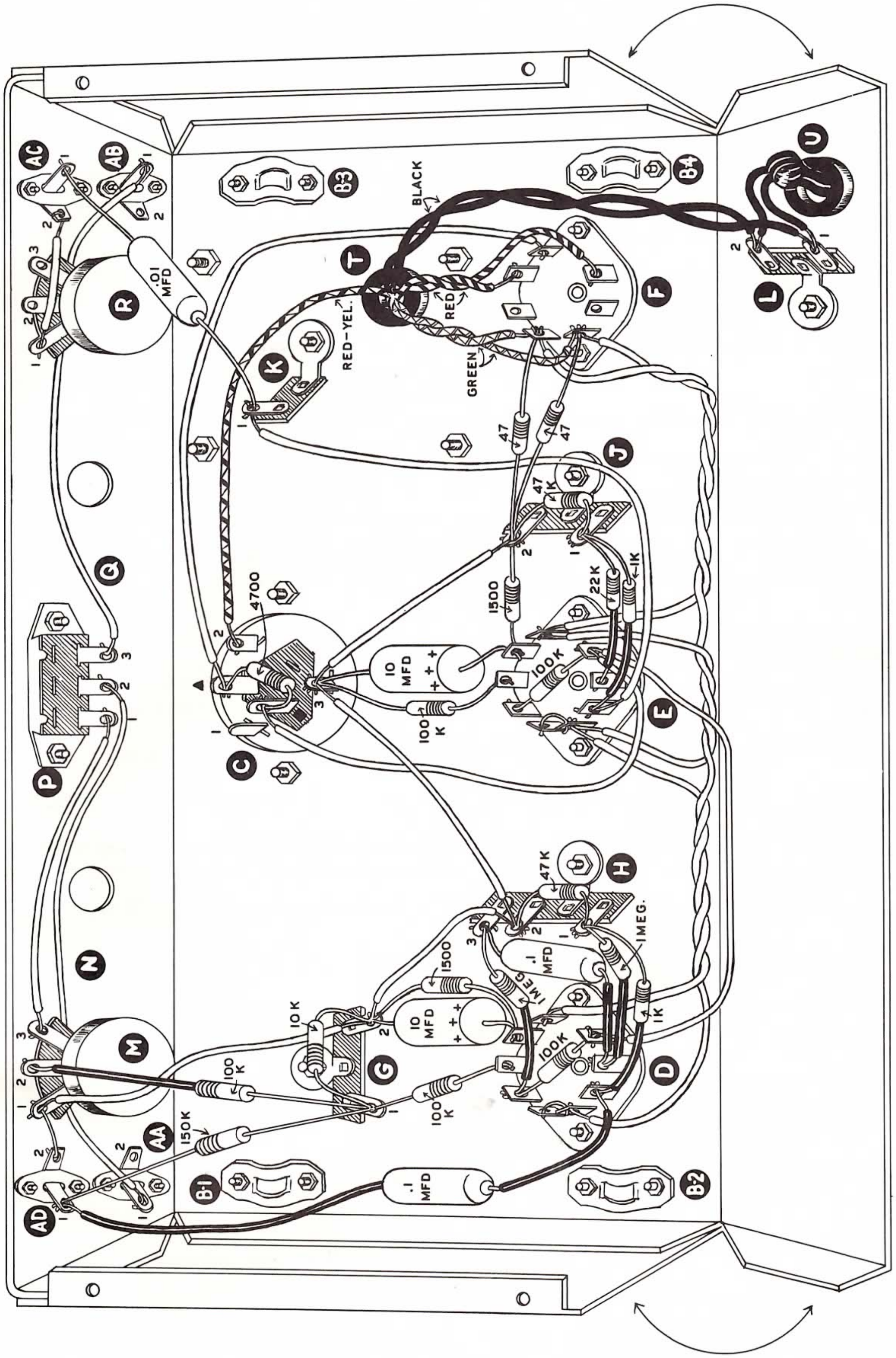
(√) Connect the red and yellow striped wire coming from the same grommet to C2 (S) (twisted mounting tab of the electrolytic capacitor). Run this wire between terminal strip K and the front apron of the chassis.

(√) Connect a 47 Ω resistor (yellow-violet-black) between F3 (NS) and J2 (NS).

(√) Connect another 47 Ω resistor between F4 (NS) and J2 (NS).

(√) Cut a wire to a length of 5 1/4". Strip approximately 1/4" of insulation from each end and connect one end to F3 (S). Leave the other end free temporarily.

(√) Cut another length of wire 4 1/2" long. Strip both ends as before and connect one end to F4 (S).


BLACK
RED-YEL.
RED
GREEN
.01 MFD
4700
1500
10 MFD
100 K
22K
IK
47 K
.1 MFD
IMEG.
150K
10 K

PICTORIAL 2

( ) Run this wire under the two 47 Ω resistors and twist it together with the wire coming from F3. Twist up to 1 1/4" from the end of the shorter wire. Connect the shorter wire to E9 (NS). Dress the twisted pair of wires snugly along the bend at the rear of the chassis. Leave the longer wire unconnected for now.

( ) Cut a wire to a length of 6" and after stripping both ends connect one end to E9 (S). Run this wire toward the rear of the chassis along beside the wire previously connected to E9. At the rear bend of the chassis twist this wire with the unconnected wire coming from the twisted pair previously installed. Twist for a length of 1", then connect the shorter wire to E4 (NS).

( ) Cut a wire 5 1/4" long and strip 1/2" of insulation from both ends. Pass one end through E4 and connect to E5 (S). Now solder E4. Run this wire toward the rear of the chassis along with the other wire connected to E4. At the rear bend of the chassis run this wire to the left and twist with the wire coming from the pair previously twisted. Twist for a length of 2 1/4".

( ) Connect the shorter end to D9 (S).

( ) Pass the longer end through D4 and connect to D5 (S). Now solder D4. Dress these twisted wires snugly in the rear bend of the chassis. Be sure all of these wires clear the unused socket terminals.

( ) Prepare an 8" length of wire and connect one end to F7 (S). Connect the other end to the terminal marked ▲ on the electrolytic capacitor C (NS). Route this wire as shown in Pictorial 2.

( ) Run a 3" length of wire between J2 (NS) and C3 (NS).

( ) Run a 3 1/2" length of wire between C3 (NS) and H2 (NS).

( ) Connect a 3 1/2" length of wire between H2 (NS) and G2 (NS).

( ) Dress the three preceeding wires close to chassis.

( ) Bend the ground lug 2 of phono connector socket AA down against the front apron of the chassis.

( ) Do the same on socket AB.

( ) Prepare a wire 5 1/2" long and connect one end to AA1 (S). Run this wire over the mounting bushing of control M and connect the other end to P2 (S). Dress this wire close to the front chassis apron. Be sure this wire is at least 1/4" above hole N (viewed in the wiring position) so it will not interfere with the installation of the switch that mounts in this hole.

( ) In a similar manner, prepare a wire 5 1/4" long and connect one end to AB1 (S). Run this wire over the mounting bushing of control R and connect the other end to P3 (S). Be sure the wire clears hole Q.

( ) Connect a 2 1/4" length of wire between G2 (NS) and M1 (NS). Dress this wire close to the rear cover of the control.

( ) Connect a short bare wire between M1 (S) and AD2 (NS).

( ) Run a 2 3/4" length of wire between M3 (S) and P1 (NS).

( ) Connect one end of a 5 1/2" length of wire to C■ (NS). Run this wire between socket E and terminal strip H around to E1 (NS). Dress close to chassis.

(✓) Connect a 4 3/4" length of wire between E1 (NS) and D1 (NS).

(✓) Connect one end of an 8" length of wire to K1 (NS). Run this wire between terminal strip J and socket F and connect to E3 (NS). Dress this wire close to chassis.

(✓) Connect a 1500 Ω resistor (brown-green-red) between J2 (NS) and E8 (NS).

(✓) Connect a 10 μf tubular electrolytic capacitor between C3 (NS) and E8 (S). IMPORTANT: Be sure the positive (+) end of this capacitor connects to E8. Before soldering, rotate this capacitor so that the positive lead goes straight to E8 and avoids E7.

(✓) Connect a 100 K 5% resistor (brown-black-yellow-gold) between C3 (S) and E7 (NS). Let the resistor rest lightly against the 10 μf electrolytic capacitor.

(✓) Connect another 10 μf tubular electrolytic capacitor between G2 (NS) and D8 (NS). Observe polarity as before with the positive (+) lead going to D8.

(✓) Connect a 1500 Ω resistor (brown-green-red) between G2 (NS) and D8 (S).

(✓) Connect a 100 K 5% resistor (brown-black-yellow-gold) between G1 (NS) and D7 (NS).

(✓) Install a 10 K 5% resistor (brown-black-orange-gold) between G2 (S) and G1 (NS).

(✓) Connect a 150 K 5% resistor (brown-green-yellow-gold) between G1 (NS) and AD1 (NS).

(✓) Connect a 100 K 5% resistor (brown-black-yellow-gold) between G1 (S) and M2 (S) (use sleeving on the end going to M2).

(✓) Install a 4700 Ω resistor (yellow-violet-red) between C▲ (S) and C■ (S). Note the position of this resistor in the pictorial.

(✓) Install a 100 K 5% resistor (brown-black-yellow-gold) between D1 (S) and D6 (NS).

(✓) Install a 100 K 5% resistor between E1 (S) and E6 (NS).

(✓) Slip a 1 3/8" length of insulated sleeving on each lead of a .1 μf capacitor and connect the capacitor between AD1 (S) and D3 (NS). Dress this capacitor close to the chassis end plate.

SEE NOTE (✓) ~~Connect a .01 μf capacitor from K1 (NS) to AC1 (S)~~. Note: Do not use capacitor marked "5%" here.

(✓) Connect a 1 1/2" length of wire from AC2 (S) to R1 (NS).

(✓) Install a 47 K resistor (yellow-violet-orange) from J1 (NS) to J2 (S).

(✓) Install another 47 K resistor from H1 (NS) to H2 (S).

(✓) Install a .1 μf capacitor between H3 (NS) and D2 (NS). Position this capacitor as shown in the pictorial and cover the lead going to D2 with a 1" length of insulated sleeving.

(✓) Connect a 1 megohm 5% resistor (brown-black-green-gold) between H3 (S) and D6 (S). Use a 3/4" length of sleeving on the lead to D6 and position as shown.

(✓) Connect a 1 megohm 5% resistor (brown-black-green-gold) between H1 (NS) and D2 (NS) (use sleeving on the lead to D2).

(✓) Install a 1 K resistor (brown-black-red) between H1 (S) and D3 (S) (use 1/2" of sleeving on the lead to D3).

(✓) Connect a 22 K resistor from J1 (NS) to E2 (NS) (use 3/8" of sleeving on the lead to E2).

(√) Connect a 1 K resistor (brown-black-red) between J1 (S) and E3 (S) (use 1/2" of sleeving on the lead to E3.

(√) Now mount a 2-lug terminal strip at L. Use 6-32 hardware.

(√) Twist together the two black leads coming from rubber grommet T. Connect the shorter black lead to L2 (NS) and the longer one to L1 (NS). Dress these twisted leads as near as possible to the chassis end plate.

(√) Bring the end of the line cord in through rubber grommet U. Tie a knot in the line cord inside the chassis for strain relief. Leave about 1" between the knot and the end of the cord. Connect one line cord wire to L2 (S) and the other to L1 (S).

Lay the chassis aside temporarily.

WIRING OF THE ROTARY-SELECTOR SWITCHES

You are now ready to mount the capacitors on the two rotary-selector switches, after which these switches will be mounted on the chassis. Only two of these capacitors are of the molded-paper type (the .04 μf and the .01 μf). The rest are of the molded-mica type; the values may be printed directly on these capacitors or may be in the form of color code, depending on the manufacturer. Values printed on may be in micro-farads (μf) whereas the values referred to in the step-by-step instructions are in micro-micro-farads, for the molded-mica capacitors. To convert from μf to $\mu\mu$f, move the decimal point six places to the right. Thus, a capacitor marked .00039 μf is the same value as one marked 390 $\mu\mu$f. If the mica capacitors in your kit are color-coded, refer to Figure 9, which shows the coding system currently in use. In the following step-by-step instructions, the colors given for a particular capacitor are given in this order: 1st significant figure, 2nd significant figure, multiplier.

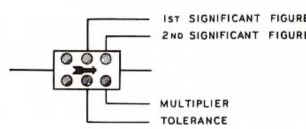


Figure 9

(√) Identify the low-frequency cutoff selector switch which has nine contact lugs on the front deck and ten lugs on the rear deck. This switch is shown in Figure 10 with the capacitors installed. Each lug on the front deck, as well as each lug on the rear deck, has been assigned an identifying number. Carefully compare the switch with Figure 10 so that you will have no difficulty in identifying any of the lugs. Remember that any mistakes made in wiring the capacitors to the switch will be quite difficult to correct after the connections have been soldered. The capacitors in the Figure are shown widely separated for clarity. On the actual switch, all leads should be perfectly straight and no longer than necessary to make the connections. Otherwise, it may be difficult to place the completed switch in the chassis. The capacitors should be positioned as shown in Figure 11 like the spokes of a wheel. In addition, they should be approximately centered between the front and rear switch decks.

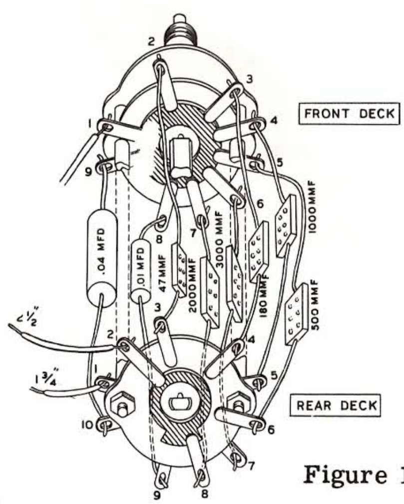


Figure 10

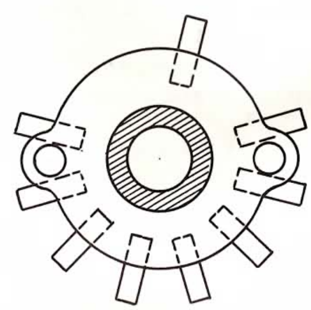


Figure 11

(✓) Connect a 47 $\mu\mu$f mica capacitor (yellow-violet-black) between lug 2 (S) on the front deck and lug 3 (S) on the rear deck.

(✓) Connect a 180 $\mu\mu$f mica capacitor (brown-gray-brown) between lug 3 (S) on the front deck and lug 4 (S) on the rear deck.

(✓) Connect a 1000 $\mu\mu$f mica capacitor (brown-black-red) between lug 4 (S) on the front deck and lug 5 (S) on the rear deck.

(✓) Connect a 500 $\mu\mu$f mica capacitor (green-black-brown) between lug 5 (S) on the front deck and lug 6 (S) on the rear deck.

(✓) Connect a 3000 $\mu\mu$f mica capacitor (orange-black-red) between lug 6 (S) on the front deck and lug 7 (S) on the rear deck.

(✓) Connect a 2000 $\mu\mu$f mica capacitor (red-black-red) between lug 7 (S) on the front deck and lug 8 (S) on the rear deck.

(✓) Connect a .01 μf 5% molded tubular paper capacitor between lug 8 (S) on the front deck and lug 9 (S) on the rear deck.

(✓) Connect a .04 μf 5% molded paper tubular capacitor between lug 9 (S) on the front deck and lug 10 (S) on the rear deck.

(✓) Connect one end of a 2 1/2" length of wire to lug 1 (S) on the front deck. Leave the other end free.

(✓) Connect one end of a 1 3/4" length of wire to lug 1 (S) on the rear deck.

(✓) Connect one end of a 2 1/2" length of wire to lug 2 (S) on the rear deck.

Lay this switch aside temporarily.

The high-frequency cutoff switch will now be prepared in the same manner. This switch is shown in Figure 12.

(✓) Connect a 43 $\mu\mu$f mica capacitor (yellow-orange-black) between lug 1 (NS) on the front deck and lug 1 (S) on the rear deck.

(✓) Connect a 220 $\mu\mu$f mica capacitor (red-red-brown) between lug 2 (S) on the front deck and lug 3 (NS) on the rear deck.

(✓) Connect a 330 $\mu\mu$f mica capacitor (orange-orange-brown) between lug 4 (S) on the front deck and lug 4 (NS) on the rear deck.

(✓) Connect a 120 $\mu\mu$f mica capacitor (brown-red-brown) between lug 5 (NS) on the front deck and lug 5 (S) on the rear deck.

(✓) Connect a 910 $\mu\mu$f mica capacitor (white-brown-brown) between lug 6 (S) on the front deck and lug 6 (NS) on the rear deck.

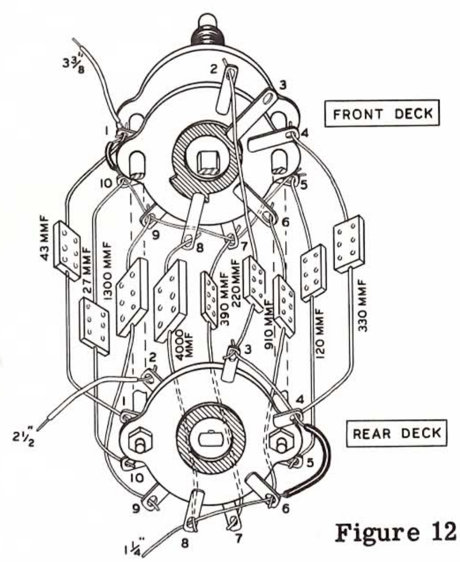


Figure 12

(✓) Connect a 390 $\mu\mu$f mica capacitor (orange-white-brown) between lug 7 (NS) on the front deck and lug 7 (S) on the rear deck.

(√) Connect a 4000 $\mu\mu$f mica capacitor (yellow-black-red) between lug 8 (S) on the front deck and lug 8 (NS) on the rear deck.

(√) Connect a 1300 $\mu\mu$f mica capacitor (brown-orange-red) between lug 9 (NS) on the front deck and lug 9 (S) on the rear deck.

(√) Connect a 27 $\mu\mu$f mica capacitor (red-violet-black) between lug 10 (NS) on the front deck and lug 10 (S) on the rear deck.

(√) On the front deck connect lugs 5, 7, 9, 10 and 1 together with a single length of bare wire. (These are the five dummy lugs on the front side of this deck or the side toward the threaded mounting bushing). Solder the bare wire at lugs 5, 7, 9 and 10. Use a 5/16" length of sleeving on the wire between lugs 10 and 1.

(√) Connect one end of a 3 3/8" length of wire to lug 1 (S) on the front deck. Leave the other end free.

(√) Connect lugs 3, 4, 6 and 8 on the rear deck together with a length of bare wire. (These are the four dummy lugs on the rear side of this deck). Leave 1 1/4" of bare wire protruding from lug 8. Use sleeving on the wire between lugs 4 and 6. Solder the connections on these four lugs.

(√) Connect one end of a 2 1/2" length of wire to lug 2 (S) on the rear deck. Leave the other end free.

This completes the installation of capacitors on the switches and they are ready to be mounted on the chassis.

(√) Install the low-frequency cutoff switch in chassis hole N of Pictorial 1. Use a 3/8" lock-washer inside the chassis and a control washer under the nut as shown in Figure 8. IMPORTANT: Before tightening the nut, orient the switch as shown in Pictorial 3. The two switch posts should lie horizontally. Note that lugs 1 and 10 are to the left. Refer to Pictorial 3 in making the following connections.

(√) Connect the wire coming from lug 1 on the front deck to AD2 (S). Run this wire between control M and the front chassis apron and dress close to apron.

(√) Connect the wire from lug 1 on the rear deck to D7 (S).

(√) Connect the wire from lug 2 on the rear deck to D2 (S).

(√) Install the high-frequency cutoff switch in hole Q, using a 3/8" lockwasher, control washer and nut as before. The switch posts should lie horizontally and lugs 1 and 10 should be to the left.

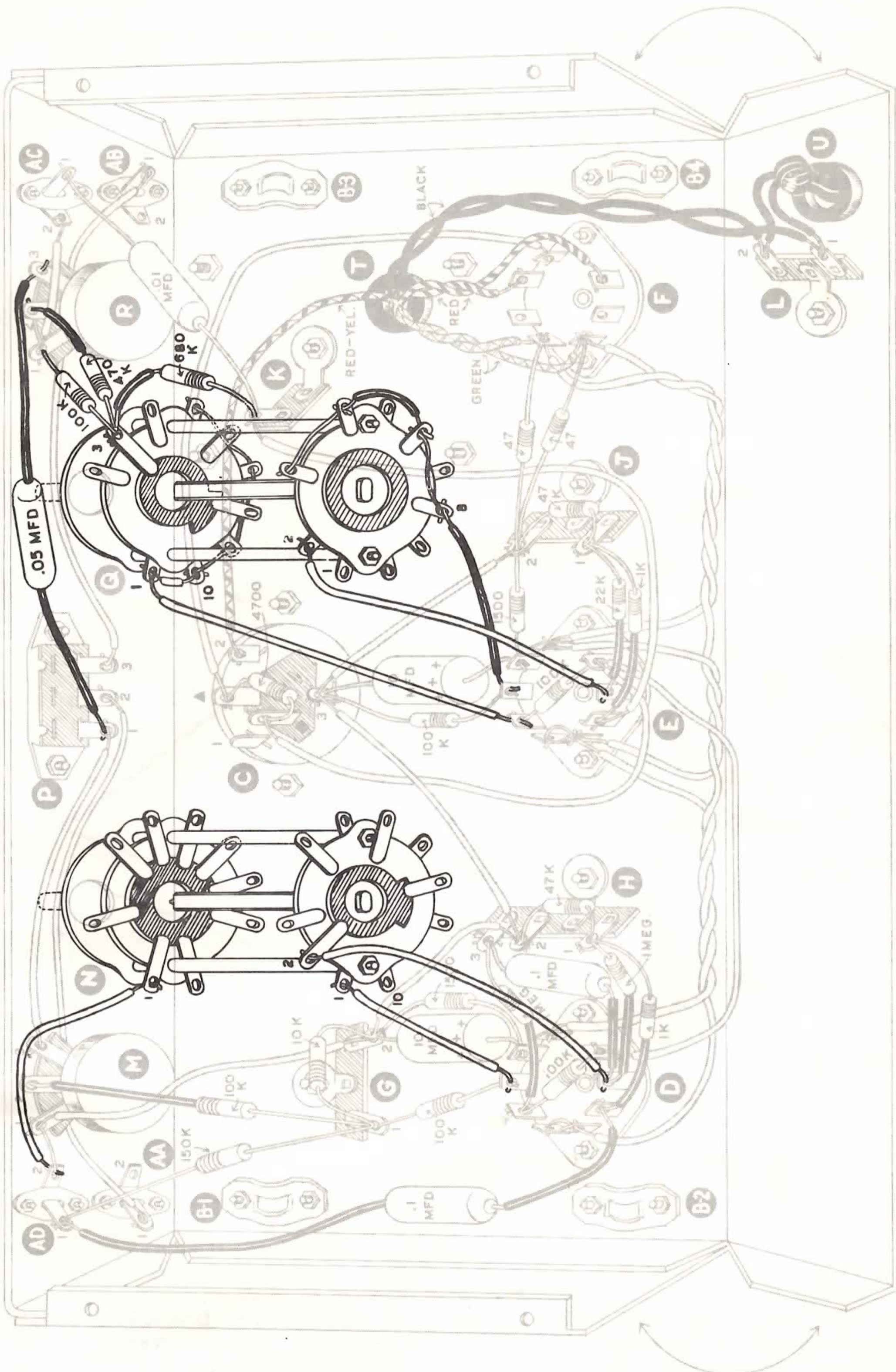
(√) Connect the wire coming from lug 1 on the front deck to E6 (S). Dress this wire as shown.

(√) Connect the wire from lug 2 on the rear deck to E2 (S).

(√) Slip a 1" length of sleeving on the bare wire coming from lug 8 on the rear deck and connect to E7 (S).

SEE NOTE 2 (√) ~~Install a 680 K 5% resistor (blue-gray-yellow-gold) between lug 3 on the front deck (NS) and K1 (S) (use sleeving on the lead to switch lug 3).~~

(√) Connect a 100 K 5% resistor (brown-black-yellow-gold) from lug 3 on the front deck (NS) to R1 (S).



PICTORIAL 3

( ) Connect a 470 K resistor (yellow-violet-yellow) from lug 3 on the front deck (S) to R2 (S) (use sleeving on the lead to R2).

( ) Install a .05 μf capacitor between P1 (S) and R3 (S) (use sleeving on both leads and dress the capacitor close to the front chassis apron).

This completes the wiring of your instrument. At this point check your work carefully until satisfied that no errors exist. Shake out any drops of solder and wire trimmings that may have accumulated.

( ) Prepare the perforated metal cover by installing the four spring catch pins as shown in Figure 13. Secure each pin with a #6 lockwasher and a 6-32 nut.

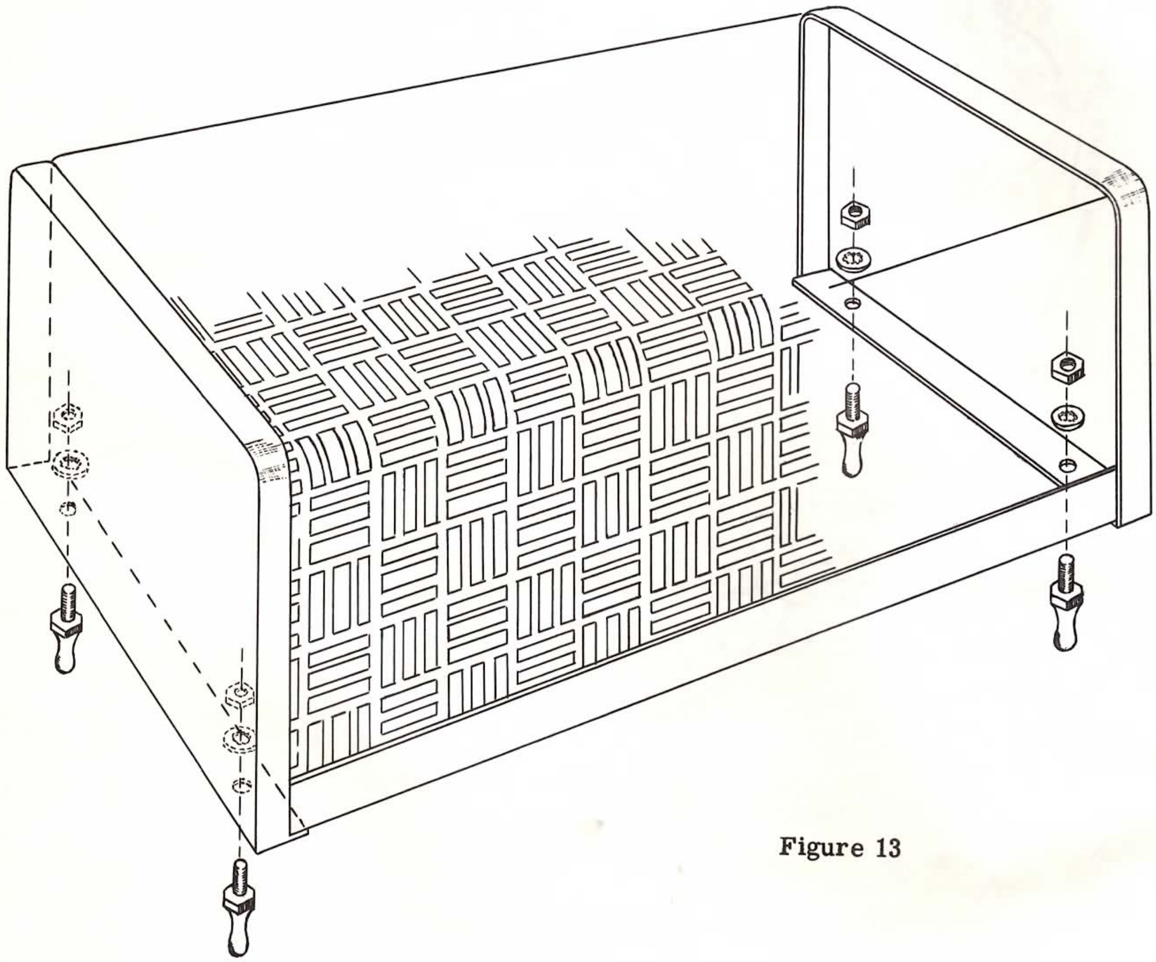


Figure 13

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.

(✓) Insert tubes in the sockets as follows:
Socket F - type 6X4.
Sockets D and E - type 12AX7.

( ) Install the perforated metal cover on top of the chassis. Position the cover so that the four spring catch pins match the mating spring catch clips at B1, B2, B3 and B4 and the front and rear sides of the cover are flush with the front and rear chassis aprons. Push the cover down securely. The pins should snap into the spring clips.

WARNING: Do not attempt to carry the completed unit by the perforated cover. The catch pins and spring clips are designed to hold the cover in place and provide easy access to the tubes but not to support the weight of the chassis.

(✓) Prepare the bottom cover by installing the four rubber feet in the holes provided. The feet should be pushed in with a rotary motion. See Figure 14.

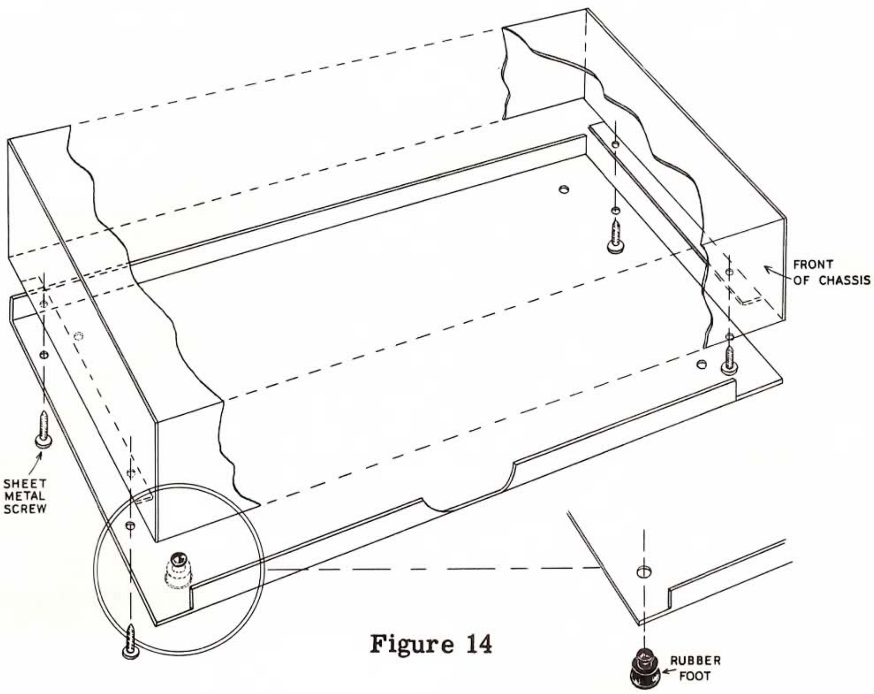


Figure 14

(✓) Install the bottom cover on the open side of the chassis, using four #6 sheet metal screws. Refer to Figure 14 and note that the edge with the notches goes toward the front of the chassis.

(✓) Install the two large knobs on the HIGH and LOW frequency CUTOFF switch shafts. Orient both knobs so that the white marker is at the 100 cycle mark when the switch is in the maximum counterclockwise position. Tighten the set screws.

(✓) Install the two smaller knobs on the HIGH and LOW frequency LEVEL control shafts. Orient these knobs so that the marker is at the extreme counterclockwise panel mark when shaft is in this position and tighten the set screws.

(✓) Prepare two 4' lengths of shielded audio cable as shown in Figure 15. Use a phono pin plug on the end of each cable. These cables will be used to connect the HIGH-OUT and LOW-OUT to the two power amplifier inputs.

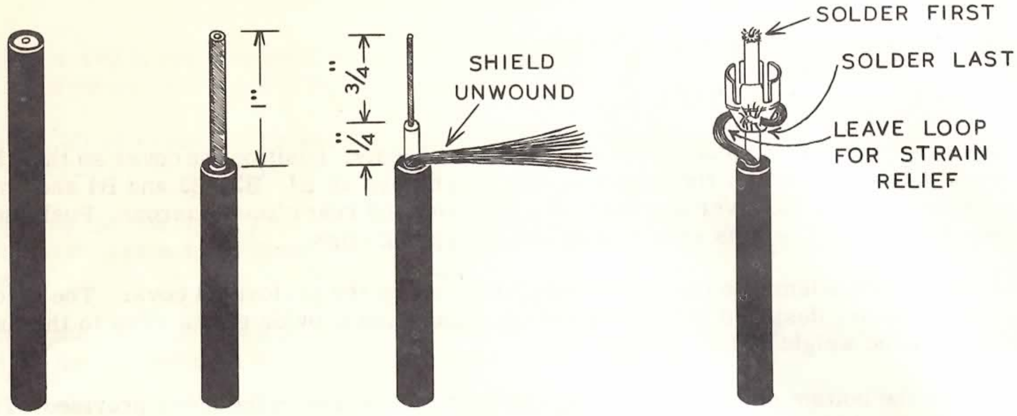


Figure 15

INSTALLATION AND OPERATION OF THE XO-1

All terminal and control designations pertinent to operation of the XO-1 are on the front chassis apron.

Connect a shielded cable from the output of your preamplifier (or tuner or other program source) to the input jack (marked IN) of the XO-1. Connect a similar cable between the jack marked HIGH-OUT and the input of the power amplifier for the tweeter. Connect another cable between the jack marked LOW-OUT and the input of the power amplifier for the woofer. Set the slide-switch to the "THRU" position. Set the HIGH and LOW frequency LEVEL controls to their maximum clockwise positions. Set the HIGH and LOW frequency CUTOFF switches to the approximate crossover frequency desired, depending upon the particular speakers used. For more detailed information see below.

NOTE: The XO-1 does not incorporate a power switch since it is intended to be plugged into a "switched" auxiliary power outlet on one of the amplifiers. Some tuners also have such AC outlets.

CAUTION: DO NOT CONNECT THIS INSTRUMENT TO A DC (DIRECT CURRENT) LINE. SERIOUS DAMAGE TO THE POWER TRANSFORMER WILL RESULT. Do not attempt to operate the amplifier on a 25 cycle source, for it will not operate and the transformer will be damaged.

When plugged in, the three tube filaments should light. If they fail to light, check the steps outlined under "IN CASE OF DIFFICULTY".

Use the volume control on the preamplifier to set volume at the preferred level. Adjust the HIGH and LOW frequency LEVEL controls for the desired balance between high and low frequencies.

THRU-BYPASS switch: If desired, a single amplifier-speaker system may be operated from the BY-PASS OUT jack by placing the switch in the "BY-PASS" position. This feeds the input directly to this jack, by-passing the XO-1 filter circuits.

Setting of CUTOFF switches: Settings of these switches depend primarily upon the particular woofer and tweeter used. The best guide is the crossover frequency recommended by the speaker manufacturer. Alternatively, the crossover frequency to use may be determined roughly by knowing the response limits of the woofer and tweeter. For example, assume a tweeter having a rated response of "700 to 16,000 cycles". Immediately, we may assume that the response of this tweeter does not extend below approximately 700 cycles; this sets the limit on the lowest cutoff frequency that may be used for the high-frequency channel. It also implies that the response of the woofer should extend as high as 700 cycles, not a difficult requirement for most woofers.

This example should serve in a general way to illustrate the relationship between the low-frequency limit of the tweeter, the high-frequency limit of the woofer and the crossover frequency used. It implies that the high and the low-frequency cutoffs should be equal (700 cycles), but this is not necessarily true. If, in our example, the treble response of the woofer happened to extend smoothly beyond 700 cycles, say to 2000 cycles, then the cutoff of the low-frequency channel could be increased to 2000 cycles, while the cutoff of the high-frequency channel remained at 700 cycles. This would represent an "overlap" in the overall response; both speakers would reproduce the range from 700 to 2000 cycles. The cutoff of the high-frequency channel could be advanced to 2000 cycles, too, whereupon there would be no overlap and we would have a simple crossover at 2000 cycles instead of 700. These are mentioned merely as examples of the many combinations of settings possible with the XO-1. With a given woofer-tweeter combination, there is generally a considerable latitude of permissible settings, and the setting which sounds best can only be determined by experimentation under existing room acoustic conditions. The fact that different cutoff frequencies may be used for the two channels is often an advantage. An overlapping crossover, as mentioned above, tends to give a smoother transition from woofer to tweeter, in the frequency region near crossover. This is particularly true where there is appreciable physical separation between woofer and tweeter. It also tends to accentuate those frequencies in the range of overlap, an effect which may be desirable under certain conditions or as a matter of personal preference.

It is also possible to so adjust the two cutoff frequencies as to produce a "gap" or "hole" at some point in the overall response. While this is not generally recommended, it could conceivably correct for a peak in the response of one of the speakers. Figure 16 illustrates these effects.

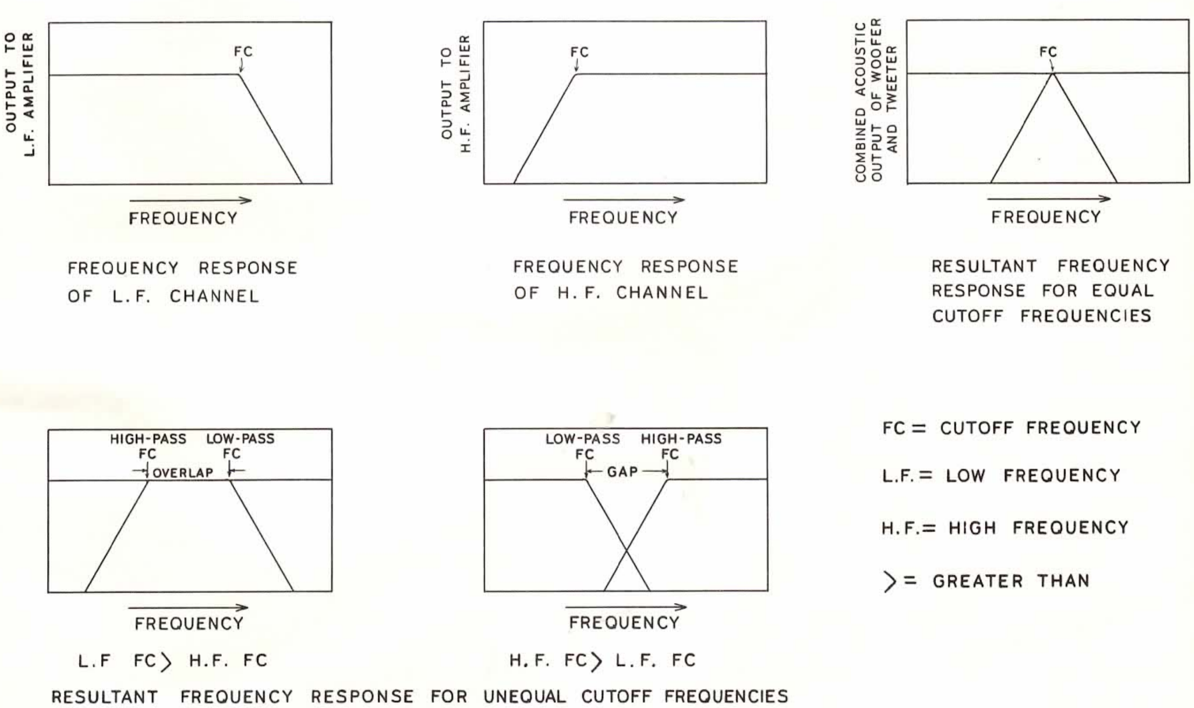


Figure 16

USE OF THE XO-1 IN THREE OR FOUR-WAY SYSTEMS: Figure 17 illustrates three suggested arrangements, in addition to the recommended connection in the case of the Heathkit SS-1 and SS-1B Speaker System. Note that in many cases the additional crossover device required can take the form of a simple capacitor; the XO-1 still performs the principal crossover function, thus retaining the advantages of electronic crossover.

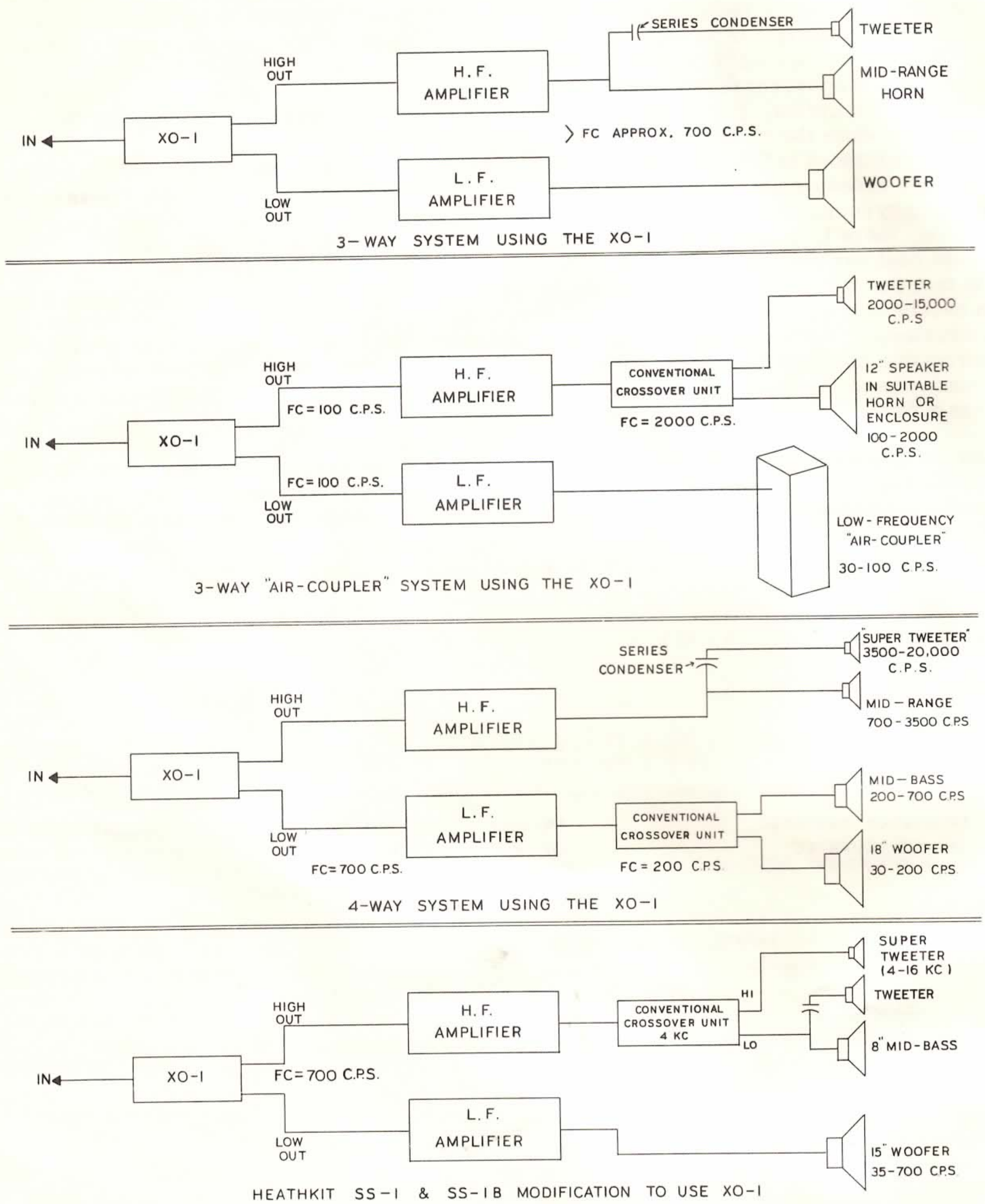


Figure 17

IN CASE OF DIFFICULTY

Recheck the wiring. Trace each lead in colored pencil on the pictorial as it is checked in the unit. Most cases of difficulty result from wrong connections. Often having a friend check the wiring will reveal a mistake consistently overlooked.

If possible, compare the tube socket voltages with those given in the voltage chart below. Readings within 20% of those shown may be considered normal. If a discrepancy is noted, check the associated circuits carefully. Any component in those circuits should be suspected until proven satisfactory.

If only one of the channels in the XO-1 is defective, i. e., noisy or inoperative, reversing the two 12AX7 tubes in their sockets will indicate whether or not one of these tubes is at fault.

VOLTAGE CHART

SOCKET	TUBE TYPE	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9
D	12AX7	310	25*	67	Fil.	Fil.	220	0	1.5	Fil.
E	12AX7	310	65*	67	Fil.	Fil.	220	0	1.5	Fil.
F	6X4	260 A. C.		Fil.	Fil.		260 A. C.	325		

Filter Condenser ▲335 ■310

All voltages positive DC to chassis, measured with a Heathkit V-7 VTVM with 11 megohm input resistance.

Line Voltage: 117 volts AC.

Fil.: Voltage between points so designated, 6.3 volts AC.

*Will vary depending on impedance of voltmeter used.

PHYSICAL LOCATION OF THE XO-1

This crossover unit should preferably be located near the power amplifiers. It may be located in an out-of-the-way place since its controls do not require adjustment once they have been set. Since very little heat is generated in the unit, there is no ventilation problem.

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 type and model number of kit in which it is used.
C. Mention the order number and 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 facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $3.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES 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.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. Factory repair service is available for a period of one year from the date of purchase or you may contact the Engineering Consultation Department by mail. For information regarding possible modification of existing kits, 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 any electronic outlet store. 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.

SPECIFICATIONS

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

The Heath Company limits its warranty of parts supplied with any kit to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility or liability for any damages or injuries sustained in the assembly of the device or in the operation of the completed instrument.

HEATH COMPANY
Benton Harbor, Michigan

PARTS LIST

Resistors

PART No.	PARTS Per Kit	DESCRIPTION
1-1	2	47 Ω
1-9	2	1000 Ω
1-11	2	1500 Ω
1-16	1	4700 Ω
1-22	1	22 KΩ
1-25	2	47 KΩ
1-33	1	470 KΩ
1-101	2	1 megohm 5%
1-104	6	100 KΩ 5%
1-105	1	10 KΩ 5%
1-106	1	680 KΩ 5%
1-107	1	150 KΩ 5%

Capacitors

PART No.	PARTS Per Kit	DESCRIPTION
20-35	1	910 $\mu\mu$f 5% mica
20-61	1	27 $\mu\mu$f 5% mica
20-62	1	43 $\mu\mu$f 5% mica
20-63	1	47 $\mu\mu$f 5% mica
20-64	1	120 $\mu\mu$f 5% mica
20-65	1	180 $\mu\mu$f 5% mica
20-66	1	220 $\mu\mu$f 5% mica
20-67	1	330 $\mu\mu$f 5% mica
20-68	1	390 $\mu\mu$f 5% mica
20-69	1	500 $\mu\mu$f 5% mica
20-70	1	1000 $\mu\mu$f 5% mica
20-71	1	1300 $\mu\mu$f 5% mica
20-72	1	2000 $\mu\mu$f 5% mica
20-73	1	3000 $\mu\mu$f 5% mica
20-74	1	4000 $\mu\mu$f 5% mica
~~23-3~~	~~1~~	~~.01 $\mu\mu$f plastic molded paper~~
23-28	~~2~~ 3	.1 μf plastic molded paper
23-59	1	.05 μf plastic molded paper
23-73	1	.01 μf 5% plastic molded paper
23-74	1	.04 μf 5% plastic molded paper
25-4	2	10 μf tubular electrolytic
25-42	1	30-30 μf 350 volt electrolytic

Controls-Switches

PART No.	PARTS Per Kit	DESCRIPTION
10-46	2	100 K controls
60-4	1	SPDT slide switch
63-116	1	Rotary switch HIGH CUTOFF
63-117	1	Rotary switch LOW CUTOFF

Transformer

PART No.	PARTS Per Kit	DESCRIPTION
54-40	1	Power transformer

Connectors-Insulators-Sockets

PART No.	PARTS Per Kit	DESCRIPTION
73-1	1	3/8" rubber grommet
73-3	1	1/2" rubber grommet
431-2	3	2-lug terminal strip
431-3	1	3-lug terminal strip
431-15	1	1-lug terminal strip
434-15	1	7-pin tube socket
434-16	2	9-pin tube socket
434-42	4	Phono connector socket
438-4	4	Phono plug
481-4	1	Electrolytic capacitor mounting wafer

Tubes

PART No.	PARTS Per Kit	DESCRIPTION
411-26	2	Type 12AX7
411-64	1	Type 6X4

Sheet Metal Parts

PART No.	PARTS Per Kit	DESCRIPTION
200-M102-F125	1	Chassis
205-M52F	1	Bottom plate
90-47	1	Perforated cover

Wire-Sleeving

PART No.	PARTS Per Kit	DESCRIPTION
344-1	1	Length hookup wire
340-2	1	Length bare wire
89-1	1	Line cord
346-1	1	Length insulated sleeving
343-3	1	Length shielded cable

Hardware

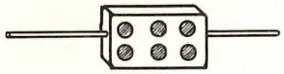
PART No.	PARTS Per Kit	DESCRIPTION
250-2	6	3-48 screw
250-8	4	#6 sheet metal screw
250-9	17	6-32 screw
250-17	4	8-32 screw
250-52	8	4-40 pan head screw
252-1	6	3-48 nut
252-2	8	4-40 nut
252-3	21	6-32 nut
252-4	4	8-32 nut
252-7	4	3/8" control nut
253-10	4	Control washer
254-1	21	#6 lockwasher
254-2	4	#8 lockwasher
254-4	4	Control lockwasher
254-9	8	#4 lockwasher
260-11	4	Spring catch clip
262-4	4	Spring catch pin

Miscellaneous

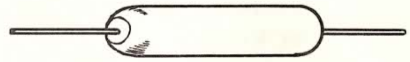
PART No.	PARTS Per Kit	DESCRIPTION
261-4	4	Rubber feet
462-19	2	Skirt knobs
462-38	2	Knobs
595-130	1	Manual

CAPACITORS

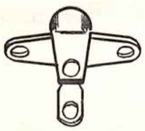
$^1/_2$W RESISTOR



MICA



MOLDED TUBULAR



PHONO SOCKET

SPRING CATCH CLIP

SPRING CATCH PIN

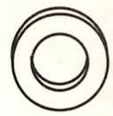
LOCKWASHERS

#4

#6

#8

CONTROL



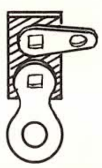
CONTROL FLAT WASHER

GROMMETS

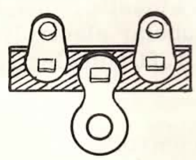
3/8

1/2

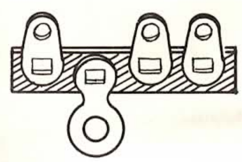
TERMINAL STRIPS



1 LUG



2 LUG



3 LUG

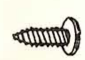
SCREWS

3-48

4-40 PAN HEAD

6-32

8-32



SHEET METAL

HELPFUL KIT BUILDING INFORMATION

Before attempting actual kit construction read the construction manual through thoroughly to familiarize yourself with the general procedure. Note the relative location of pictorials and pictorial inserts in respect to the progress of the assembly procedure outlined.

This information is offered primarily for the convenience of novice kit builders and will be of definite assistance to those lacking thorough knowledge of good construction practices. Even the advanced electronics enthusiast may benefit by a brief review of this material before proceeding with kit construction. In the majority of cases, failure to observe basic instruction fundamentals is responsible for inability to obtain desired level of performance.

RECOMMENDED TOOLS

The successful construction of Heathkits does not require the use of specialized equipment and only basic tools are required. A good quality electric soldering iron is essential. The preferred size would be a 100 watt iron with a small tip. The use of long nose pliers and diagonal or side cutting pliers is recommended. A small screw driver will prove adequate and several additional assorted screw drivers will be helpful. Be sure to obtain a good supply of rosin core type radio solder. Never use separate fluxes, paste or acid solder in electronic work.

ASSEMBLY

In the actual mechanical assembly of components to the chassis and panel, it is important that the procedure shown in the manual be carefully followed. Make sure that tube sockets are properly mounted in respect to keyway or pin numbering location. The same applies to transformer mountings so that the correct transformer color coded wires will be available at the proper chassis opening.

Make it a standard practice to use lock washers under all 6-32 and 8-32 nuts. The only exception being in the use of solder lugs—the necessary locking feature is already incorporated in the design of the solder lugs. A control lock washer should always be used between the control and the chassis to prevent undesirable rotation in the panel. To improve instrument appearance and to prevent possible panel marring use a control flat nickel washer under each control nut.

When installing binding posts that require the use of fiber insulating washers, it is good practice to slip the shoulder washer over the binding post mounting stud before installing the mounting stud in the panel hole provided. Next, install a flat fiber washer and a solder lug under the mounting nut. Be sure that the shoulder washer is properly centered in the panel to prevent possible shorting of the binding post.

WIRING

When following wiring procedure make the leads as short and direct as possible. In filament wiring requiring the use of a twisted pair of wires allow sufficient slack in the wiring that will permit the twisted pair to be pushed against the chassis as closely as possible thereby affording relative isolation from adjacent parts and wiring.

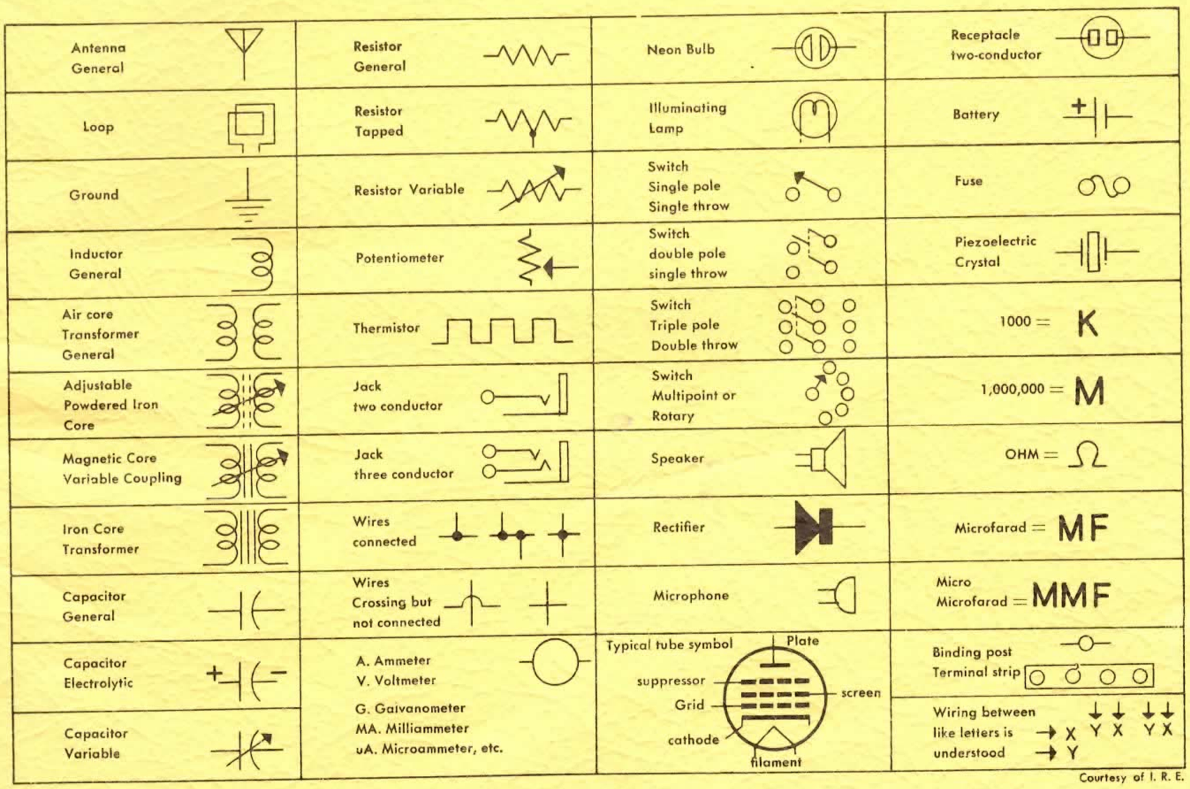
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown baked enamel coating. After the transformer leads have been trimmed to a suitable length, it is necessary to scrape the enamel coating in order to expose the bright copper wire before making a terminal or soldered connection.

In mounting parts such as resistors or condensers, trim off all excess lead lengths so that the parts may be installed in a direct point-to-point manner. When necessary use spaghetti or insulated sleeving over exposed wires that might short to nearby wiring.

It is urgently recommended that the wiring dress and parts layout as shown in the construction manual be faithfully followed. In every instance, the desirability of this arrangement was carefully determined through the construction of a series of laboratory models.

SOLDERING

Much of the performance of the kit instrument, particularly in respect to accuracy and stability, depends upon the degree of workmanship used in making soldered connections. Proper soldered connections are not at all difficult to make but it would be advisable to observe a few precautions. First of all before a connection is to be soldered, the connection itself should be clean and mechanically strong. Do not depend on solder alone to hold a connection together. The tip of the soldering iron should be bright, clean and free of excess solder. Use enough heat to thoroughly flow the solder smoothly into the joint. Avoid excessive use of solder and do not allow a flux flooding condition to occur which could conceivably cause a leakage path between adjacent terminals on switch assemblies and tube sockets. This is particularly important in instruments such as the VTVM, oscilloscope and generator kits. Excessive heat will also burn or damage the insulating material used in the manufacture of switch assemblies. Be sure to use only good quality rosin core radio type solder.



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