PRICE $1.00

# Assembling and Using Your...

# Heathkit

## WILLIAMSON TYPE AMPLIFIER

**MODEL W4-AM**

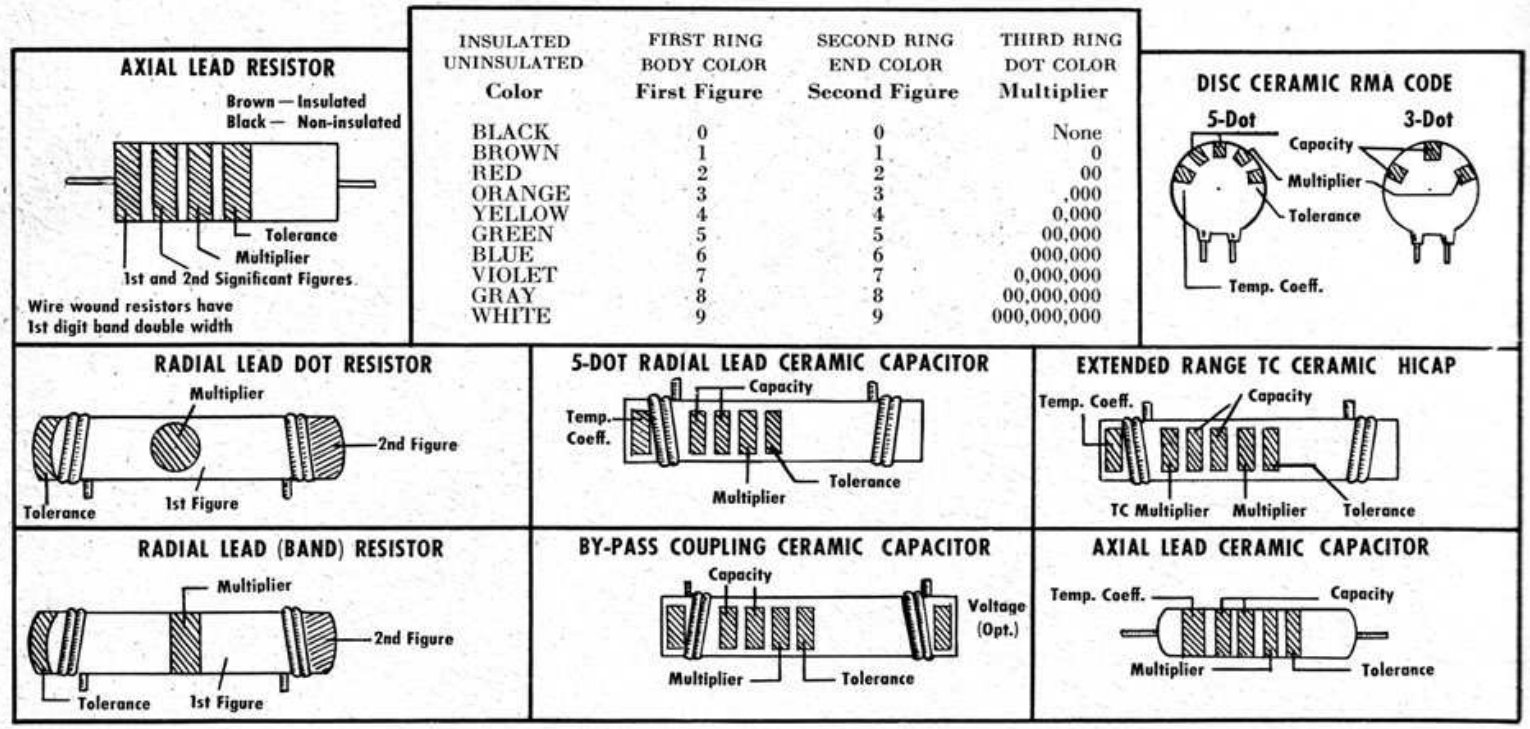
**HEATH COMPANY**

*A Subsidiary of Daystrom inc*

**BENTON HARBOR, MICHIGAN**

595-107

# STANDARD COLOR CODE — RESISTORS AND CAPACITORS

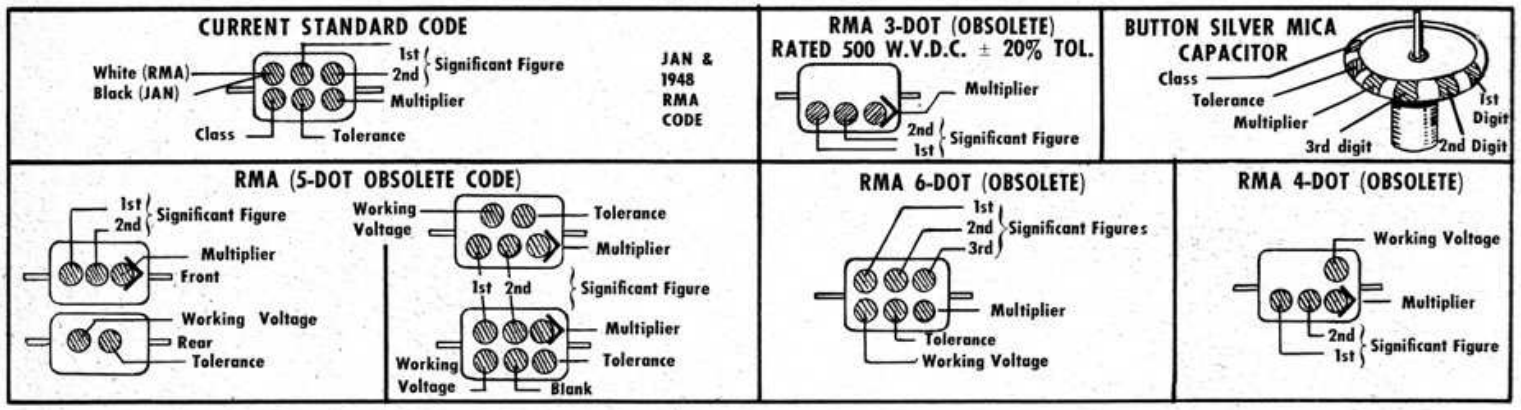



| INSULATED UNINSULATED Color | FIRST RING BODY COLOR First Figure | SECOND RING END COLOR Second Figure | THIRD RING DOT COLOR Multiplier |
|---|---|---|---|
| BLACK | 0 | 0 | None |
| BROWN | 1 | 1 | 0 |
| RED | 2 | 2 | 00 |
| ORANGE | 3 | 3 | ,000 |
| YELLOW | 4 | 4 | 0,000 |
| GREEN | 5 | 5 | 00,000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

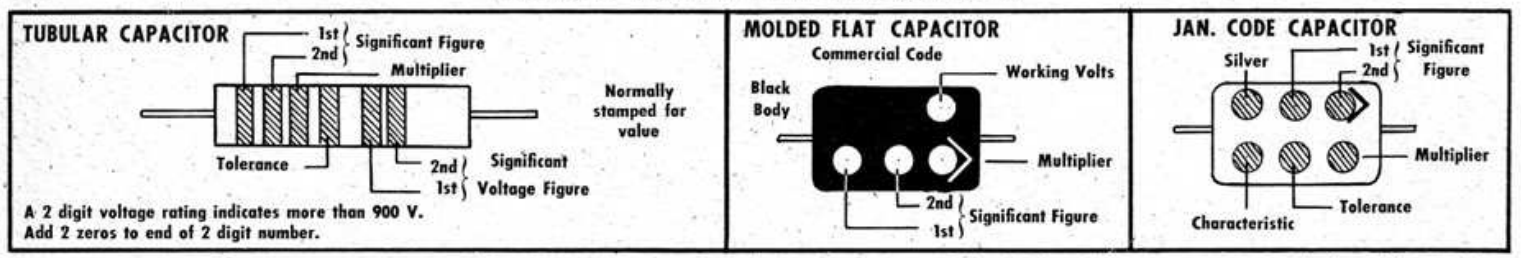
The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: 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




# MOLDED PAPER TYPE CAPACITORS




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.

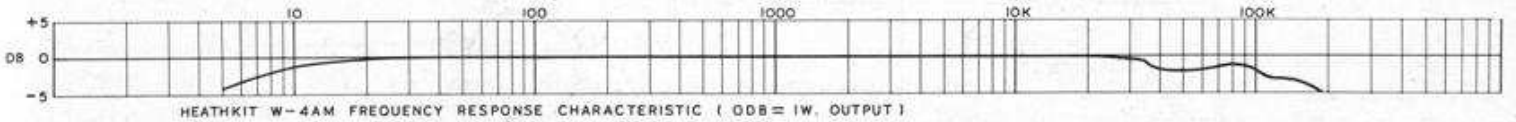
# HEATHKIT WILLIAMSON-TYPE AMPLIFIER

## MODEL W4-AM

### SPECIFICATIONS

Power Output: . . . . . 20 watts at 1,000 cycles with less than 1% total harmonic distortion.
Maximum output; 27 watts. Peak power output; 36 watts.

Frequency Response: . . Curve below was taken at 1 watt output:

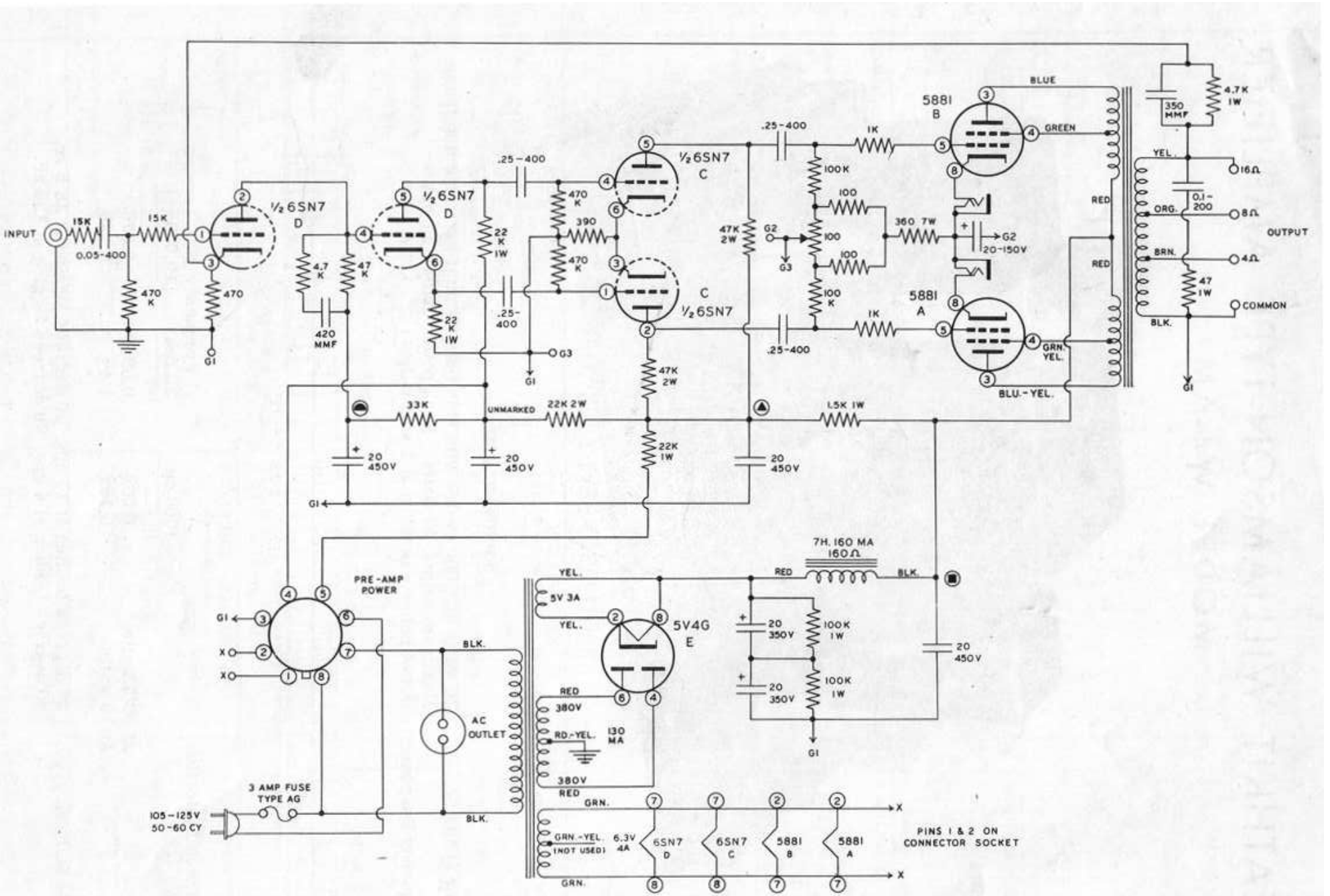



HEATHKIT W-4AM FREQUENCY RESPONSE CHARACTERISTIC ( 0DB = IW. OUTPUT )

Harmonic Distortion: . .

| | Test Frequency | | |
|---|---|---|---|
| | 1000 cps | 20 cps | 10,000 cps |
| At 0.25 watts: | 0.06% | 0.08% | 0.07% |
| At 20 watts: | 0.15% | 1.4% | 0.94% |

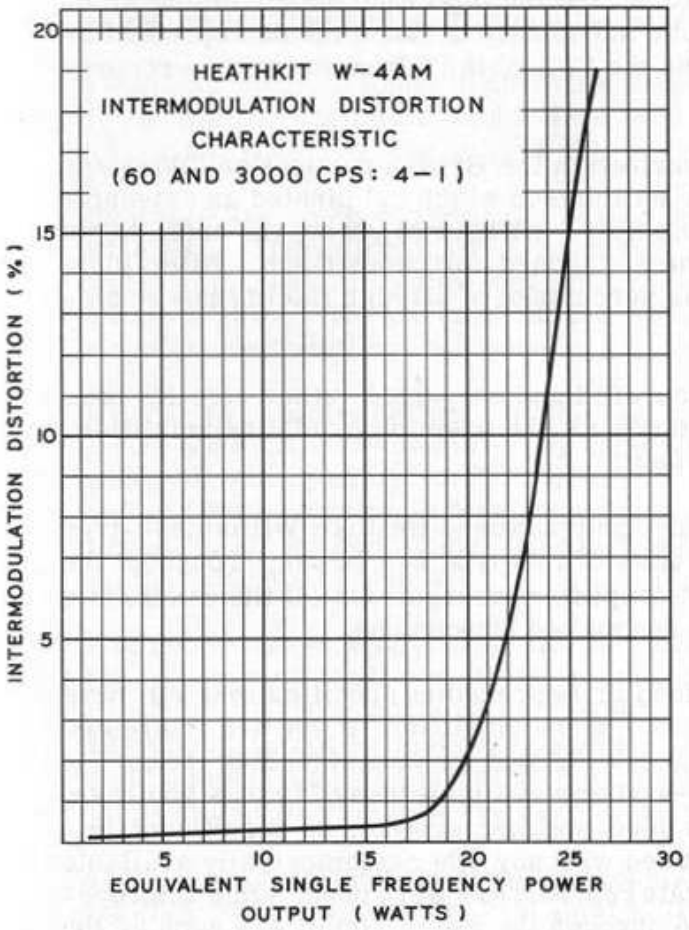
Phase Shift: . . . . . 30 degrees leading at 15 cps, 30 degrees lagging at 38.5 kc.
90 degrees leading at 4 cps, 90 degrees lagging at 136 kc.



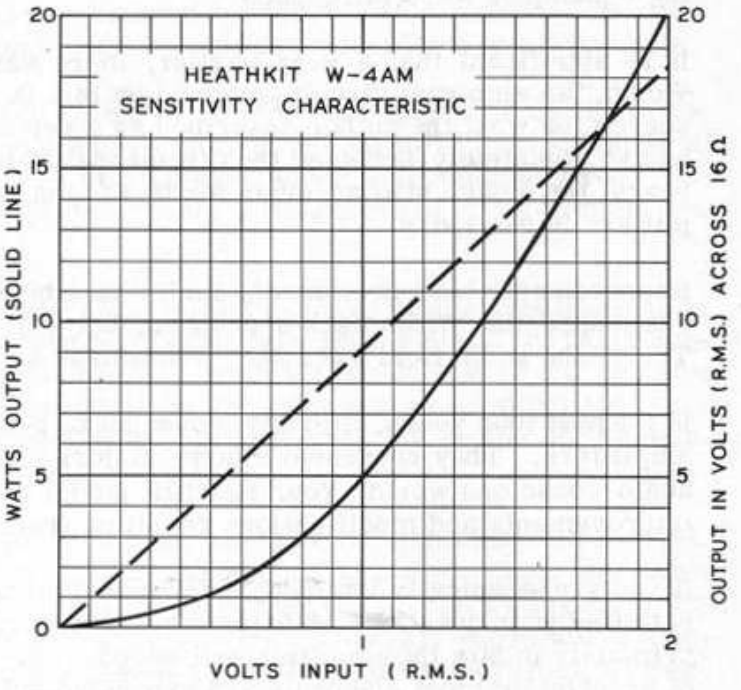

# HEATHKIT WILLIAMSON-TYPE AMPLIFIER

## MODEL W4-AM

Intermodulation Distortion: See curve below.




Sensitivity: See curve below.




Hum and Noise: ..... 76.2 db below 0.25 watts output.
95.2 db below 20 watts output.
Feedback Factor:..... Fixed; 22.6 db; independent of output impedance.
Damping Factor:..... Fixed; 28.5 to 1; independent of output impedance.
Output Impedances:..... 4, 8, and 16 ohms.
Input Requirements:.....105-125 volts, 50-60 cycles AC, 115 watts at 117 volts.
Dimensions:..... Single unit; 15 1/4" x 8 7/8" shelf space, 7" high.
Allow 1 1/2" x 15 1/4" additional shelf space for cables and connections.
Weight:..... Net: 23 1/4 lbs.
Shipping: 28 lbs.

## TEST CONDITIONS

Measurements taken at 117 volts line, with WA-P2 preamplifier connected. Output impedance 16.02 Ω resistive. For harmonic distortion measurements; Krohn-Hite model 440-A generator (inherent distortion less than 0.1%), Hewlett-Packard 330-B distortion analyzer. For intermodulation distortion measurements; Measurements Corporation model 31 intermodulation meter. For frequency response measurement, Hewlett-Packard model 650-A test oscillator . For phase shift measurements, same oscillator with Tektronix 531 oscilloscope with 53-C preamplifier. For output power, voltage measurements across 16.02 Ω resistive load, taken with Hewlett-Packard model 400-D vacuum tube voltmeter.

Measurements given are those taken on a representative amplifier under conditions stated. Minor variations from these figures may be encountered in kit-assembled amplifiers because of tube characteristics, component variations and exact lead placement. In a highly stabilized amplifier such as the W-4AM, these variables may be disregarded from a performance point of view.

## INTRODUCTION

Most people are inclined to view the meteoric rise of the high fidelity craze as something which has taken place in the last two years. Actually, public acceptance of home music reproduction probably dates from the summer and fall of 1948 when the Columbia "LP" microgroove recording techniques were introduced.

It is significant that a year earlier, there was described in the British publication "Wireless World," an amplifier circuit designed by Mr. D. T. N. Williamson which culminated an extensive search for what the author described as a perfect amplifier. Within two years, the audio world had so completely accepted the circuit that it became a standard for comparison. After eight years, the design still accounts for by far the greater percentage of all high fidelity power amplifiers in use today.

Improvements have been made, faults have been discovered and corrected, other circuits have challenged the Williamson's position, but still it stands as the basic high fidelity amplifier. Truly, the audio field owes Mr. Williamson a great debt.

In the past four years, literally thousands of people have built and used Heathkit Williamson-type amplifiers. They represent a large majority of the units of this type now in use throughout the audio-conscious world. Your Heathkit model W-4AM Amplifier incorporates all the worthwhile improvements and modifications resulting from this unequalled background.

If you are technically inclined, the information contained in the preceding specifications will have satisfied your questions as to the measured performance of the amplifier. If you are interested primarily in how the amplifier will sound, your Heathkit W-4AM is capable of placing the burden of proof on the most elaborate and expensive speaker systems available today. Unless you have, or expect to have, more than $300.00 to spend for a loud-speaker system, no significant improvement would be audible if the W-4AM were replaced with any other commercially available power amplifier, regardless of price. If more elaborate reproducers were used, some improvement at extremely low frequencies might be expected through the use of amplifiers such as the Heathkit W-5M.

In this discussion, we have attempted to convince you that your investment in the W-4AM kit is worthy of extreme care in construction and installation. Hurried or careless construction can only lead to trouble, either initially or after some period of satisfactory performance. TAKE ENOUGH TIME TO DO THE JOB RIGHT THE FIRST TIME and you will be repaid many times in personal satisfaction and long, trouble-free service.

If you have built Heathkits before, you will note a change in the usual step-by-step procedure for assembling and wiring. The new "all-on-one-drawing" plan used in this manual has been developed to make your work even more enjoyable.

PLEASE READ THE MANUAL ALL THE WAY THROUGH BEFORE ANY WORK IS STARTED. Only a very small percentage of Heathkit assemblers encounter any difficulty whatsoever in completing kits of this kind. Large fold-in pictorial diagrams are included in the manual for your convenience and are quite helpful if attached to the wall above your work space. The diagrams are repeated in small form within the manual proper. We suggest that you retain the manual in your files for future reference in the use of the amplifier and for its maintenance.

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 and the chance of accidentally throwing away some part will be eliminated. Full size sketches of each of the parts categories appear on Page 16. Use this in checking against the parts list and in identifying any questionable components.

Components with wire pigtail leads can be conveniently sorted by inserting one of the leads into the corrugated edge of the shipping carton flap. It may be helpful to mark the value of the component on the flap so the part may be readily located when needed.

If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight. An occasional shortage occurs and if this is true in your kit, please obtain the missing parts locally if at all possible.

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 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.

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 in 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 the wiring and parts layout shown in this manual. The position of leads and parts is quite critical in the instrument and changes may seriously affect the characteristics of the circuit. We do not represent that the circuit or layout of the instrument cannot be improved; however the methods shown in this manual are the result of many experimental models and unless the constructor has access to full laboratory facilities, we recommend that they be followed very closely.

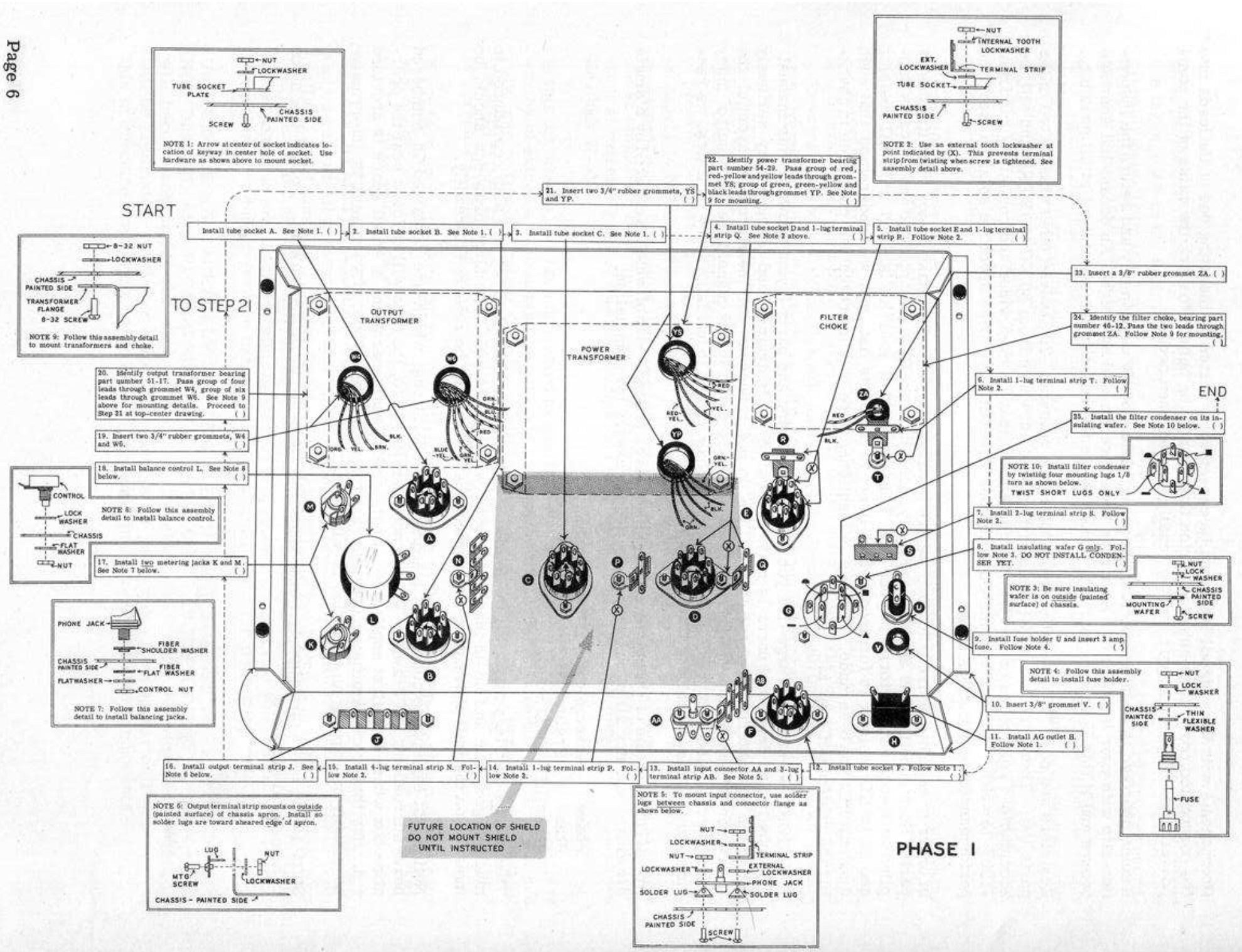
Actual construction of the amplifier consists of three phases, each of which is covered by a single drawing containing all pertinent information necessary for completion:

Phase I - Assembly of parts to chassis.
Phase II - Preliminary wiring.
Phase III - Final wiring.

These three drawings appear on the following pages of the manual. They are also reproduced in much larger form as fold-in inserts included with this manual. The large drawings should be mounted on the wall above your work space where they may be referred to readily.

Notice that each phase consists of a sequence of operations, which are contained in numbered boxes surrounding the drawing. When a note is referred to, the note will be found near the operation box where it is first applicable. At the end of each operation, a small space is provided ( ). Use this to check off each operation as it is completed. Then, if your work is interrupted, possibility of skipping an operation is minimized.

Start Phase I with operation 1, in the upper left hand corner of the drawing. Follow the steps in numerical sequence.


START
TO STEP 21
END
NUT
LOCKWASHER
TUBE SOCKET PLATE
SCREW
CHASSIS PAINTED SIDE
NOTE 1: Arrow at center of socket indicates location of keyway in center hole of socket. Use hardware as shown above to mount socket.
INTERNAL TOOTH LOCKWASHER
EXT. LOCKWASHER
TERMINAL STRIP
TUBE SOCKET
NOTE 2: Use an external tooth lockwasher at point indicated by (X). This prevents terminal strip from twisting when screw is tightened. See assembly detail above.
8-32 NUT
TRANSFORMER FLANGE
8-32 SCREW
NOTE 9: Follow this assembly detail to mount transformers and choke.
Install tube socket A. See Note 1. ( )
2. Install tube socket B. See Note 1. ( )
3. Install tube socket C. See Note 1. ( )
4. Install tube socket D and 1-lug terminal strip Q. See Note 2 above. ( )
5. Install tube socket E and 1-lug terminal strip R. Follow Note 2. ( )
21. Insert two 3/4" rubber grommets, YS and YP. ( )
22. Identify power transformer bearing part number 54-29. Pass group of red, red-yellow and yellow leads through grommet YS; group of green, green-yellow and black leads through grommet YP. See Note 9 for mounting. ( )
33. Insert a 3/8" rubber grommet ZA. ( )
24. Identify the filter choke, bearing part number 46-12. Pass the two leads through grommet ZA. Follow Note 9 for mounting. ( )
6. Install 1-lug terminal strip T. Follow Note 2. ( )
25. Install the filter condenser on its insulating wafer. See Note 10 below. ( )
OUTPUT TRANSFORMER
POWER TRANSFORMER
FILTER CHOKE
20. Identify output transformer bearing part number 51-17. Pass group of four leads through grommet W4, group of six leads through grommet W8. See Note 9 above for mounting details. Proceed to Step 21 at top-center drawing. ( )
19. Insert two 3/4" rubber grommets, W4 and W8. ( )
18. Install balance control L. See Note 8 below. ( )
CONTROL
LOCK WASHER
CHASSIS
FLAT WASHER
NUT
NOTE 8: Follow this assembly detail to install balance control.
17. Install two metering jacks K and M. See Note 7 below. ( )
PHONE JACK
FIBER SHOULDER WASHER
CHASSIS PAINTED SIDE
FIBER FLAT WASHER
FLATWASHER
CONTROL NUT
NOTE 7: Follow this assembly detail to install balancing jacks.
NOTE 10: Install filter condenser by twisting four mounting lugs 1/8 turn as shown below.
TWIST SHORT LUGS ONLY
7. Install 2-lug terminal strip S. Follow Note 2. ( )
8. Install insulating wafer G only. Follow Note 3. DO NOT INSTALL CONDENSER YET. ( )
NOTE 3: Be sure insulating wafer is on outside (painted surface) of chassis.
MOUNTING WAFER
9. Install fuse holder U and insert 3 amp fuse. Follow Note 4. ( )
NOTE 4: Follow this assembly detail to install fuse holder.
THIN FLEXIBLE WASHER
FUSE
10. Insert 3/8" grommet V. ( )
11. Install AG outlet H. Follow Note 1. ( )
16. Install output terminal strip J. See Note 6 below. ( )
15. Install 4-lug terminal strip N. Follow Note 2. ( )
14. Install 1-lug terminal strip P. Follow Note 3. ( )
13. Install input connector AA and 3-lug terminal strip AB. See Note 5. ( )
12. Install tube socket F. Follow Note 1. ( )
NOTE 6: Output terminal strip mounts on outside (painted surface) of chassis apron. Install so solder lugs are toward sheared edge of apron.
LUG
NUT
MTG SCREW
LOCKWASHER
CHASSIS - PAINTED SIDE
FUTURE LOCATION OF SHIELD
DO NOT MOUNT SHIELD
UNTIL INSTRUCTED
NOTE 5: To mount input connector, use solder lugs between chassis and connector flange as shown below.
TERMINAL STRIP
EXTERNAL LOCKWASHER
PHONE JACK
SOLDER LUG
SCREW
PHASE I

## NOTES ON WIRING

Before proceeding with actual wiring of your W-4AM kit, the following notes should be read carefully.

1. Notice that on the Phase II drawing, each contact of the terminal strips and other parts has been identified by a number. No numbering is shown for tube sockets since markings are molded on each socket, as shown in the sketch under Step 1.

   This system of numbering terminals is used to simplify wiring instructions. For example, when an instruction reads, "Connect yellow lead to J1 (NS)," it will be understood that the yellow lead is to be connected to terminal number 1 on terminal strip J.

2. The abbreviation (NS) is used to indicate that other connections will be made to that terminal later and the connection should not be soldered yet. When the last connection has been made to a terminal, the abbreviation $\overline{(S)}$ in inserted indicating that the connection should be soldered.

3. The term "dress" appears several times in the instructions. This means to place the cable or lead so that it reaches to and remains near the terminal indicated. It may be necessary to form or bend the cable slightly so that it stays in position without undue strain on the connections.

4. "Strip and tin" means that the insulation on the lead should be removed, usually for a distance of 3/8" or so. Then twist the exposed bare strands of wire together and coat with hot solder so the wire may be easily pushed through terminal holes without fraying out.

5. To avoid possibility of error, each color coded component is described quite completely in the wiring instructions. On most resistors, a gold or silver band will be found in addition to the three colors called out. This fourth color may be disregarded, since it indicates only the resistance tolerance.

6. On electrolytic condensers of the tubular type, one of the leads will be marked "positive" by means of a + sign or other method. The instructions plainly indicate to which terminal the positive lead is to be connected. It is very important that the condenser be connected exactly as called out, otherwise it will be destroyed and may possibly damage other components as well.

7. On paper dielectric condensers, usually of the molded paper type, a band or other marking sometimes appears to designate the outside foil of the condenser. Such markings are not significant in the W-4AM and may be disregarded entirely.

8. Before doing any soldering, read the note on the inside rear cover of this manual.

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.

9. Unless otherwise indicated, all wire used is insulated. Wherever there is a possibility of bare leads on components shorting to other metallic objects, the leads should be protected by use of insulated sleeving. This is indicated in the instructions by the term "use sleeving."

10. Leads on most components are longer than they need to be. Excess lead length should be cut off before the part is wired in place. This will not only give a neater appearance to the job, but actually improve the operation of the equipment.

START

1. Twist these four leads together, dress cable to terminal strip J. Cut yellow lead to length to reach J1. Strip and tin. Connect yellow lead to J1 (NS). In the same way, connect orange lead to J2 (S), brown to J3 (S), black to J4 (NS). ( )

2. Twist together blue-yellow and green-yellow leads, dress to socket A. As in Step 1, connect blue-yellow lead to A3 (S), green-yellow lead to A4 (S). ( )

3. Twist together blue and green leads, dress to socket B. Connect blue lead to B3 (S), green lead to B4 (S). ( )

4. Twist together two red leads; dress to terminal strip H. Connect both leads to H1 (S). ( )

5. Twist together two green leads; dress to socket A. Connect one green lead to A2 (NS), other to A7 (NS). ( )

6. Cut green-yellow lead to 4" length. Fold remaining end back and tape to lead. (See manual Page 13.) ( )

7. Twist together two black leads; dress to AC outlet H. Connect either lead to H1 (NS); other to H2 (NS). ( )

8. Connect red-yellow lead to G1 (NS). ( )

9. Twist together two yellow leads; dress to socket E. Connect either lead to E2 (S); other to E8 (NS). ( )

10. Twist together two red leads; dress to socket E. Connect either lead to E4 (S); other to E6 (S). ( )

11. Connect black lead to R2 (NS). ( )

12. Connect red lead to E8 (NS). ( )

13. Connect positive lead of 20 µfd 350 volt condenser to X1 (NS). Connect other lead to T1 (NS).

14. Connect 100 KΩ 1 watt resistor (medium body, brown-black-yellow) from X1 (NS) to T1 (S). ( )

15. Connect positive lead of 20 µfd 350 volt condenser to T2 (NS). Connect other lead to X2 (NS). ( )

16. Connect 100 KΩ 1 watt resistor (medium body, brown-black-yellow) from X2 (NS) to T2 (S). ( )

17. Connect a wire from R2 (S) to G ■ (NS). ( )

18. Use bare wire and sleeving to connect E8 (S) to X1 (S). ( )

19. Use bare wire and sleeving to connect X2 (S) to G2 (S). ( )

20. Connect 1.5 KΩ 1 watt resistor (medium body, brown-green-red) from G ■ (S) to G ▲ (NS). ( )

21. Connect a lead from G ▲ (NS) to N3 (NS). ( )

22. Connect a 22 KΩ 1 watt resistor (medium body, red-red-orange) from G ▲ (NS) to F5 (S). ( )

23. Insert stripped end of line cord through grommet V. Tie knot in cord 3" from end. Connect either lead of line cord to U2 (S). Connect other lead to F6 (S). ( )

24. Connect a wire from U1 (S) to H2 (NS). ( )

25. Connect a wire from H2 (S) to F8 (S). ( )

26. Connect a wire from H1 (S) to F7 (S). ( )

27. Connect a 22 KΩ 2 watt resistor (large body, red-red-orange) from G ▲ (S) to G ▬ (NS). ( )

28. Connect a wire from F4 (S) to G ▬ (NS). ( )

29. Connect a wire from AA4 (NS) to F3 (S). ( )

30. Connect a wire from AA4 (S) to G1 (S). ( )

31. Cut two lengths of wire about 5" long. Strip all four ends. Twist the leads together to form a twisted pair. At one end of this pair, connect either lead to F1 (S); connect adjacent lead to F2 (S). At other end, connect either lead to D7 (NS); connect adjacent lead to D8 (NS). ( )

32. In same way, using 5" leads, form a twisted pair. At one end, connect the pair to D7 (S) and D8 (S). At other end, connect to C7 (NS) and C8 (NS). ( )

33. In same way, using 5" leads, form a twisted pair. At one end, connect the pair to C7 (S) and C8 (S). At other end, connect to A2 (NS) and A7 (NS). ( )

34. Connect a wire from AA3 (NS) to J4 (NS). ( )

35. Connect a wire from AB2 (NS) to J1 (NS). ( )

36. Connect a 47 Ω 1 watt resistor (medium body, yellow-violet-black) from J4 (S) to B6 (NS). ( )

37. Connect a 0.1 µfd 200 volt condenser from J1 (S) to B6 (S). ( )

38. Connect a wire from K3 (S) to B8 (S). ( )

39. Cut a lead 3 1/2" long. Strip both ends to expose 1/2" of bare wire. Slip one end through K1 (NS) to K2 (S). Slip other end through M2 (NS) to M1 (S). ( )

40. Connect the positive lead of a 20 µfd 150 volt condenser to K1 (S). Connect the other lead (use sleeving) to L2 (NS). ( )

41. Connect a 360 Ω 7 watt resistor (rectangular ceramic body) from M2 (S) to N2 (NS). ( )

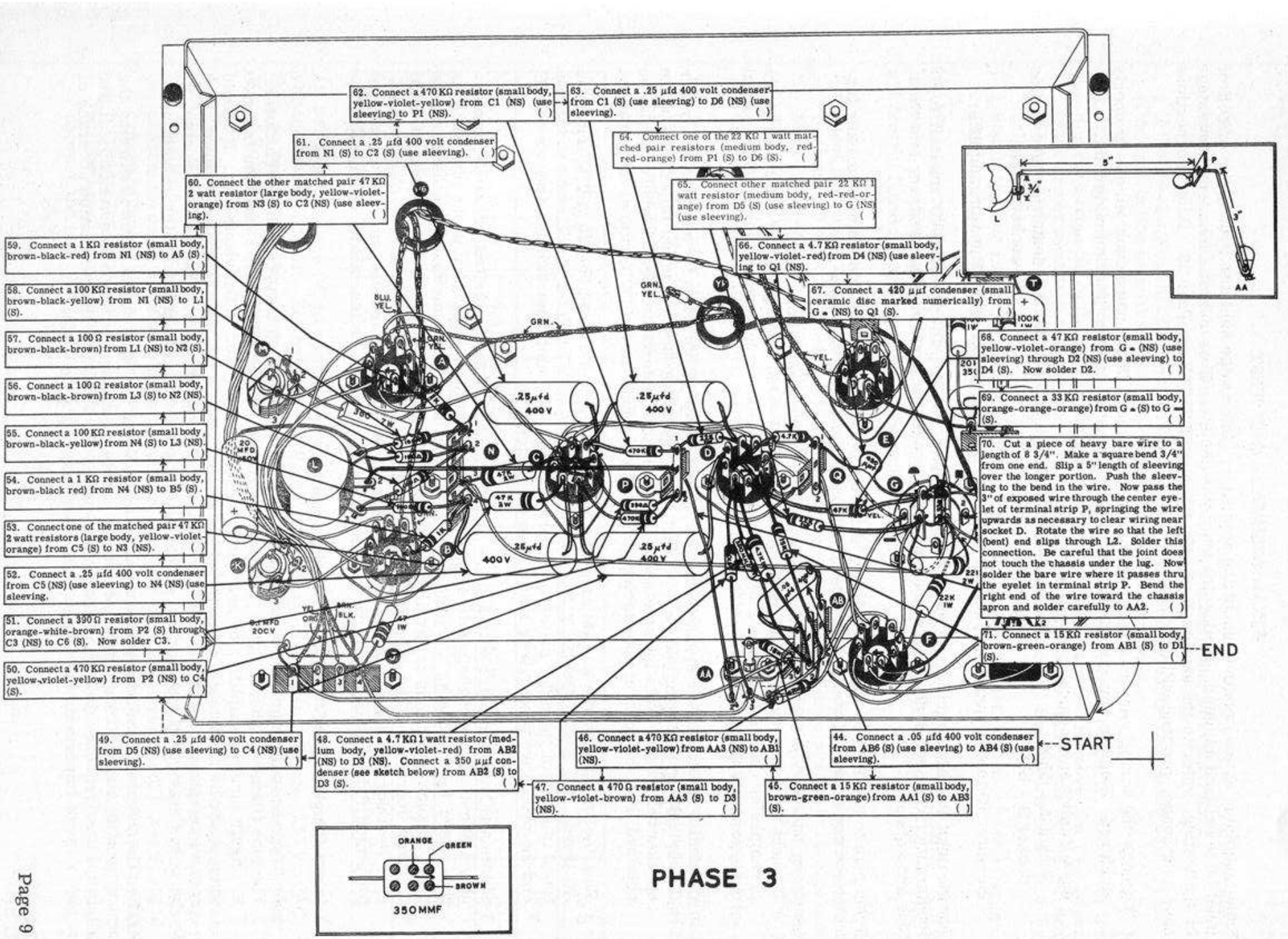
42. Connect a lead from M3 (S) to A8 (S). ( )

43. As in Step 31, using 6" leads, form a twisted pair. At one end, connect the pair to A2 (S) and A7 (S). At other end, connect the pair to B2 (S) and B7 (S). ( )

END

OCTAL SOCKET NUMBERING

PHASE 2


62. Connect a 470 KΩ resistor (small body, yellow-violet-yellow) from C1 (NS) (use sleeving) to P1 (NS). ( )
63. Connect a .25 µfd 400 volt condenser from C1 (S) (use sleeving) to D6 (NS) (use sleeving). ( )
61. Connect a .25 µfd 400 volt condenser from N1 (S) to C2 (S) (use sleeving). ( )
64. Connect one of the 22 KΩ 1 watt matched pair resistors (medium body, red-red-orange) from P1 (S) to D6 (S). ( )
60. Connect the other matched pair 47 KΩ 2 watt resistor (large body, yellow-violet-orange) from N3 (S) to C2 (NS) (use sleeving). ( )
65. Connect other matched pair 22 KΩ 1 watt resistor (medium body, red-red-orange) from D5 (S) (use sleeving) to G (NS) (use sleeving). ( )
59. Connect a 1 KΩ resistor (small body, brown-black-red) from N1 (NS) to A5 (S). ( )
66. Connect a 4.7 KΩ resistor (small body, yellow-violet-red) from D4 (NS) (use sleeving to Q1 (NS). ( )
58. Connect a 100 KΩ resistor (small body, brown-black-yellow) from N1 (NS) to L1 (S). ( )
67. Connect a 420 µµf condenser (small ceramic disc marked numerically) from G (NS) to Q1 (S). ( )
57. Connect a 100 Ω resistor (small body, brown-black-brown) from L1 (NS) to N2 (S). ( )
68. Connect a 47 KΩ resistor (small body, yellow-violet-orange) from G (NS) (use sleeving) through D2 (NS) (use sleeving) to D4 (S). Now solder D2. ( )
56. Connect a 100 Ω resistor (small body, brown-black-brown) from L3 (S) to N2 (NS). ( )
69. Connect a 33 KΩ resistor (small body, orange-orange-orange) from G (S) to G (S). ( )
55. Connect a 100 KΩ resistor (small body, brown-black-yellow) from N4 (S) to L3 (NS). ( )
70. Cut a piece of heavy bare wire to a length of 8 3/4". Make a square bend 3/4" from one end. Slip a 5" length of sleeving over the longer portion. Push the sleeving to the bend in the wire. Now pass the 3" of exposed wire through the center eyelet of terminal strip P, springing the wire upwards as necessary to clear wiring near socket D. Rotate the wire so that the left (bent) end slips through L2. Solder this connection. Be careful that the joint does not touch the chassis under the lug. Now solder the bare wire where it passes thru the eyelet in terminal strip P. Bend the right end of the wire toward the chassis apron and solder carefully to AA2. ( )
54. Connect a 1 KΩ resistor (small body, brown-black red) from N4 (NS) to B5 (S). ( )
53. Connect one of the matched pair 47 KΩ 2 watt resistors (large body, yellow-violet-orange) from C5 (S) to N3 (NS). ( )
52. Connect a .25 µfd 400 volt condenser from C5 (NS) (use sleeving) to N4 (NS) (use sleeving. ( )
51. Connect a 390 Ω resistor (small body, orange-white-brown) from P2 (S) through C3 (NS) to C6 (S). Now solder C3. ( )
71. Connect a 15 KΩ resistor (small body, brown-green-orange) from AB1 (S) to D1 (S). ( )
END
50. Connect a 470 KΩ resistor (small body, yellow-violet-yellow) from P2 (NS) to C4 (S). ( )
49. Connect a .25 µfd 400 volt condenser from D5 (NS) (use sleeving) to C4 (NS) (use sleeving). ( )
48. Connect a 4.7 KΩ 1 watt resistor (medium body, yellow-violet-red) from AB2 (NS) to D3 (NS). Connect a 350 µµf condenser (see sketch below) from AB2 (S) to D3 (S). ( )
46. Connect a 470 KΩ resistor (small body, yellow-violet-yellow) from AA3 (NS) to AB1 (NS). ( )
44. Connect a .05 µfd 400 volt condenser from AB6 (S) (use sleeving) to AB4 (S) (use sleeving). ( )
START
47. Connect a 470 Ω resistor (small body, yellow-violet-brown) from AA3 (S) to D3 (NS). ( )
45. Connect a 15 KΩ resistor (small body, brown-green-orange) from AA1 (S) to AB3 (S). ( )
ORANGE
GREEN
BROWN
350 MMF
PHASE 3

## FINAL ASSEMBLY AND TEST

This completes actual construction of the amplifier. Before the shield is added, the amplifier must be tested and adjusted. Follow the procedure below. (If trouble is indicated at any stage of the testing, refer to the section IN CASE OF DIFFICULTY on Page 11. After corrections have been made, proceed with the tests.)

( ) Check the wiring very carefully against the drawings. Make sure each wire is properly soldered. Remove any wire clippings, solder splashes or other foreign materials.

( ) Install tubes in the sockets as follows:

| | | |
|---|---|---|
| Socket A - 5881 | Socket C - 6SN7GT | Socket E - Install no tube in this socket as yet. |
| Socket B - 5881 | Socket D - 6SN7GT | |

Be sure NO tube is installed in socket F since this is the power outlet for a preamplifier.

The Heathkit W-4AM Amplifier is specifically designed for use with the Heathkit model WA-P2 Preamplifier or other high-quality preamplifiers containing controls for program selection, tone and volume.

If you plan to use the WA-P2 preamplifier, it should be constructed at this time before any further tests are made. If some other preamplifier is to be used, see Page 14.

Assuming that the WA-P2 preamplifier is available, proceed as follows:

( ) Connect the power cable of the preamplifier to the W-4AM by plugging the octal plug on the preamplifier cable into socket F on the W-4AM chassis. Do not connect the shielded signal cable to the W-4AM at this time.

( ) Connect a speaker to the speaker terminal strip, using "C" terminal for one lead and either the "4," "8" or "16" terminal for the other lead, depending on the nominal impedance of the speaker being used. This information is generally available on the speaker label or it may be obtained from the speaker manufacturer. In case of doubt, use the "8" terminal temporarily.

( ) Plug the line cord of the W-4AM amplifier into an outlet delivering 105-125 volt 50-60 cycle AC power. DO NOT CONNECT TO A DC (DIRECT CURRENT) OUTLET, such as may be found in some of the older districts of large cities. The amplifier will not operate on DC and the protective fuse will be blown if so connected.

( ) Obtain a DC milliammeter with a range of not less than 75 milliamperes full scale, preferably 100 ma. Connect the positive terminal (+) to the tip of a standard phone plug such as those used for headsets. Connect the negative terminal of the meter to the sleeve of the plug. If such a meter is not available, it probably can be borrowed from a friend, a local amateur operator or the adjustments can be made in ten minutes by a radio serviceman. (The Heathkit Handitester model M-1 is ideal for this purpose and also would be convenient for a multitude of other applications, should the constructor be technically inclined.)

( ) Insert the phone plug in either of the phone jacks.

( ) Apply power to the amplifier by turning TREBLE tone control on the preamplifier clockwise. The tube filaments should light. Now turn the power off and insert the 5V4G tube in socket E. Again turn the amplifier on and watch the meter connected to the phone plug. It should swing upward to indicate a current of from 40 to 75 milliamperes. Note the reading, then remove the phone plug and insert it in the other phone jack. Adjust the balance control L, between the two 5881 tube sockets so that exactly equal currents are indicated at both jacks.

NOTE: The procedure just completed assures that each of the 5881 output tubes is drawing the same amount of current from the power supply. This balancing operation is quite critical and affects the low-frequency distortion characteristics of the W-4AM. The calibration accuracy of the meter is not important, so long as both tubes draw equal currents.

( ) Now connect the shielded signal cable to input connector AA. A loud "pop" should be heard in the speaker as this is done and a low hum or rumbling sound will be evident.

( ) If the WA-P2 Preamplifier has not been tested, this work should be completed now. Follow the instruction manual for the WA-P2 for detailed instructions.

( ) Assuming that both power amplifier and preamplifier are behaving properly, disconnect the line cord from the outlet and attach the shield below the chassis. Remove the two power transformer mounting screws nearest the center of the chassis. Mount the shield so that it covers sockets C and D, using the two transformer screws. See Figure on Page 6 for orientation of the shield.

( ) Install the four rubber mounting feet in the larger holes in each corner of the chassis flanges. The flat side of the foot should support the weight of the chassis.

Your Heathkit W-4AM Amplifier is now complete and ready for permanent installation. Since there are no operating controls on the amplifier itself, no operation instructions are required. All control functions are supplied by the preamplifier.

## IN CASE OF DIFFICULTY

If the test procedure above indicates that things are not normal, follow the plan given below:

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

2. Check the tubes. Most radio service shops will do this at no charge or for a nominal fee.

3. If possible, check tube socket voltages against the chart below. Agreement within 20% can be expected. If a discrepancy is apparent, check the wiring and components associated with the circuit under suspicion.

### VOLTAGE CHART

| SOCKET TUBE TYPE | Pin 1 | Pin 2 | Pin 3 | Pin 4 | Pin 5 | Pin 6 | Pin 7 | Pin 8 |
|---|---|---|---|---|---|---|---|---|
| A or B 5881 | NC | H | 370 v | 375 v | NS | NS | H | 38 v |
| C 6SN7GT | NS | 135 v | 4.0 v | NS | 135 v | 4.0 v | H | H |
| D 6SN7GT | NS | 54 v | 1.2 v | 54 v | 200 | 60 v | H | H |
| E 5V4G | NC | 440 v* | NC | 380 vac | NC | 380 vac | NC | 440 v* |
| F Preamplifier Power | H | H | 0 | 250 v | 275 v | See Table, Page 13 | | |

All voltages positive DC to chassis, measured with Heathkit V-7 VTVM (11 megohm input). Voltages measured with Heathkit WA-P2 Preamplifier connected. Line voltage, 117 volt AC. NC - no connection. NS - reading not significant. H - voltage between points marked, 6.3 volts AC. *Voltage between points marked, 5.0 volts AC.

4. If difficulty still persists, touch socket terminal A5 with one lead of a .01 μfd paper condenser, holding the condenser by its other lead. (CAUTION: Do not touch chassis or any other metallic body with your other hand while making this test. Dangerously high voltages are present throughout the amplifier circuit and due care should be exercised.) A decided increase in hum at the speaker should be noted. If terminal A5 is "hot" as indicated by hum increase, try terminals B5, C2, C5, D5, D2 and D1. At some point in this sequence, no hum will be heard; thus localizing the difficulty to that circuit which appears dead. All circuits between the last "hot" point and the speaker may be considered normal.

## UNUSUAL TROUBLES AND CORRECTIVE PROCEDURES

Certain difficulties often appear to originate in the power amplifier but actually have their source in associated equipment. Some of these are outlined below.

1. High hum level at the loudspeaker may be caused by several external effects. Assuming that the W-4AM is used with a WA-P2 preamplifier, a very decided reduction in hum will be noticed upon proper setting of the "HUM" control on the preamplifier. This will take place at nearly the center of rotation. To check hum level, adjust the volume control for slightly higher than normal room volume. Then lift the pickup arm from the record or turn off power to the tuner being used for a program source. The hum level at the loudspeaker should just barely be audible at a distance of three feet or so from the speaker. A louder hum indicates abnormal conditions which can generally be corrected. Try the following:

   (a) Reverse the line cord in its outlet for minimum hum.

   (b) Try disconnecting the shield of the signal cable at the power-amplifier end where it connects to the shell of the phono plug. This will prevent a "ground loop" through the shield of the cable which might actually induce hum rather than eliminate it.

   (c) Try eliminating possible "ground loops" between various program sources (phono pickups, tuners, recorders, etc.) and the preamplifier by opening the shield grounds at one end or the other.

   (d) Try disconnecting each program source from the preamplifier and determine if the hum level is affected in any way. Even idle tuners or phono pickups will occasionally develop into hum sources because of leakage in power circuits.

   (e) As a last resort, try connecting the frame or chassis of each component to a good ground such as a cold water pipe or driven ground.

2. "Motor boating" is a term used to describe a low-frequency (2 to 5 cps) oscillation of an amplifier system. It is generally caused by inadequate amplifier loading at low frequencies. For example, a speaker with a nominal impedance of 16 Ω may actually look like 150 to 200 Ω at frequencies near speaker system resonance. Sufficient low frequency stability is included in the W-4AM to prevent this difficulty in the vast majority of cases. However, all-inclusive safety margins are quite expensive. In general, the better speaker systems are less likely to cause trouble in this way.

   Under no conditions should shielded speaker leads be used and every attempt should be made to keep the capacity across speaker lines to a minimum. Other less frequent causes of motor boating are:

   (a) Unbalanced output tubes. Recheck balance settings.
   (b) Defective filter condenser sections, either in the power amplifier or preamplifier.
   (c) Feedback factor too high. Feedback is controlled by the 4.7 KΩ 1 watt resistor from AB2 to D3. In rare cases, it may be necessary to increase the value of this resistor to eliminate motorboating. A change to 6.8 KΩ will generally correct a persistent case, with very slight degradation to performance in other respects.
   (d) Low frequency oscillation may sometimes be triggered or touched off because of oscillation of the amplifier at a supersonic frequency around 100 kc. This type of difficulty will cause the amplifier to sound strained or muddy. It may be readily identified by connecting an oscilloscope across the speaker terminals. If oscillation is present, it will be evidenced by a steady high frequency output voltage with a highly distorted wave form. This output voltage will exist even in the absence of input signals. The condition may be caused by an improper or defective condenser across the feedback resistor or by improper components in the phase correction network, the 4.7 KΩ resistor and 420 $\mu\mu$f condensers connected to D4 and G .

3. Output tubes will not balance. First, try interchanging the tubes in sockets A and B. If the unbalanced effect is also interchanged, one of the tubes is probably defective. If not, carefully check the wiring associated with the cathode circuits of the output tubes. Be sure neither of the jacks is shorting to the chassis; they should be completely free of metallic contact to chassis except through the 360 Ω bias resistor and the balancing network. Check voltages carefully against the voltage chart if unbalance still persists. Do not attempt to balance tubes while program material is being reproduced.

## INSTALLATION

When the amplifier is completely tested, it should be permanently installed in the system. Since no operating controls are associated with the W-4AM, it may be installed wherever convenient with the following precautions:

(a) Allow sufficient ventilation to prevent overheating. Bear in mind that while in operation, the unit will develop about as much heat as a 150 watt lamp bulb.
(b) Provide access room for connecting cables, occasional balancing of the output tubes and tube replacement.
(c) Protect the amplifier from dampness or physical damage. Since the tubes run very hot, the unit should be installed where it cannot be tampered with by small children.

An AC outlet is provided on control apron of the amplifier. It may be used to supply power to a tuner, phonograph record changer or other accessory. If used for a record changer, be sure the unit is allowed to pass completely thru its change cycle so it shuts itself off. Otherwise, idlers in the changer may be left in contact with other parts causing flats to develop and ruining the idlers.

A complete discussion of how to install the high fidelity system is too lengthy to carry in this manual. We suggest a review of current issues of "High Fidelity" and "Music at Home." These magazines carry specific sections on installation. This type of information also appears frequently in other periodicals on home building and decorating.

## USING THE W-4AM AMPLIFIER WITH OTHER PREAMPLIFIERS

As previously stated, the W-4AM is designed specifically for use with the Heathkit model WA-P2 Preamplifier. It may, however, be used with other preamplifiers or AM-FM tuners which incorporate the necessary control functions.

Sufficient power is available from the W-4AM to operate both filament and plate circuits of the usual preamplifier where independent power supplies are not included in the preamplifier itself. The following circuits are available at socket F:

| | |
|---|---|
| 6.3 volts AC at 1 ampere | Socket contacts F1 and F2. |
| Ground and B - | Socket contact F3. |
| 250 volts DC at 10 ma | Socket contact F4. |
| 275 volts DC at 10 ma | Socket contact F5. |
| 117 volts AC, switched and fused | Socket contacts F7 and F8. |
| 117 volts AC, not switched and fused | Socket contacts F6 and F8. |
| Line switch, to control amplifier | Socket contacts F6 and F7. |

It is suggested that an adapter cable be made up to supply power and/or switching circuits to preamplifiers other than the WA-P2. This cable should terminate in a standard octal plug, with cap, similar to Amphenol's type 86-PM8, and may be wired in accordance with the above information. The cable may then be connected to the W-4AM using socket F.

DO NOT, UNDER ANY CIRCUMSTANCE, EXCEED THE POWER RATINGS GIVEN ABOVE FOR ADDITIONAL FILAMENT AND PLATE SUPPLY. To do so may seriously damage power supply components in your W-4AM amplifier. If the preamplifier used has no provision for hum balancing through an adjustable resistor across the filament line, it will be necessary to ground the center tap of the filament winding of the W-4AM power transformer. This can be done by connecting to chassis the green-yellow lead passed through grommet YP. This may be done by soldering the lead to terminal strip P1.

## 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. Mention the order number and date of purchase.
C. Identify the type and model number of kit in which it is used.
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 $6.00, plus the price 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 to you or you may contact the Technical 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.

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.

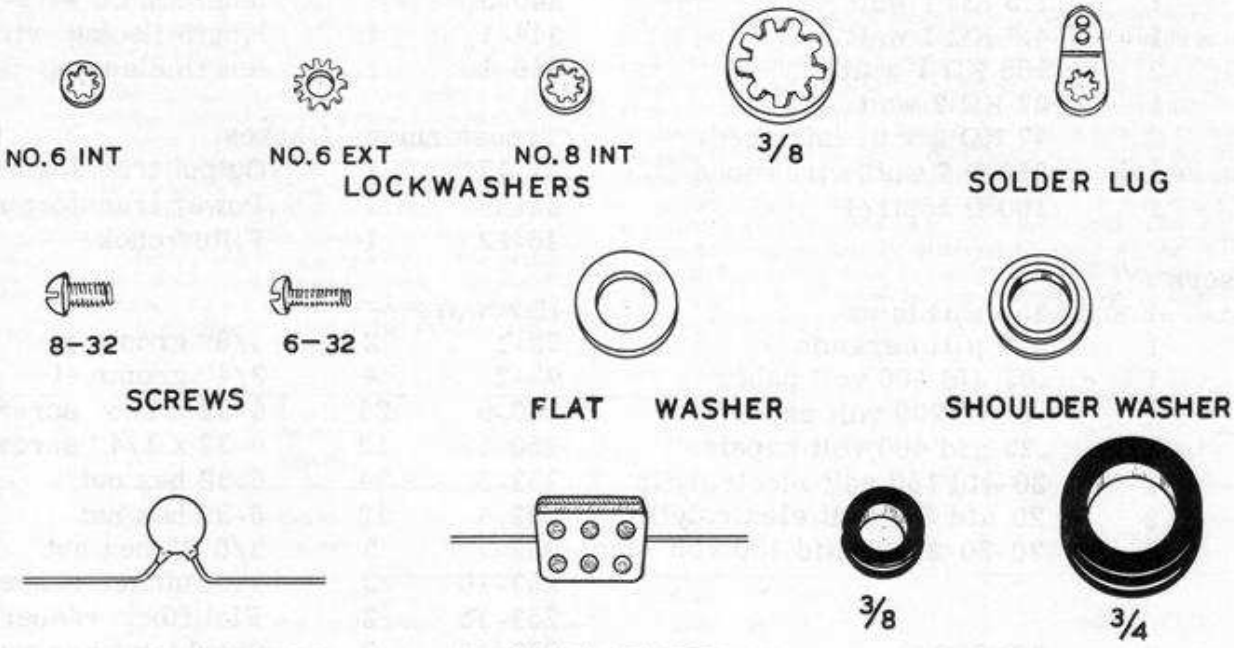
# WARRANTY

Heath Company warrants that for a period of three months from the date of shipment, all Heathkit parts shall be free of defects in materials and workmanship under normal use and service and that in fulfillment of any breach of such warranty, Heath Company shall replace such defective parts upon the return of the same to its factory. 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.

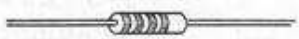
NOTE: The foregoing warranty is completely void and we will not replace, repair or service instruments or parts thereof in which acid core solder or paste fluxes have been used.

HEATH COMPANY

Use the outline drawings below to assist in identifying any parts which need clarification.




## RESISTORS

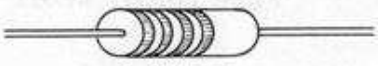


1/2 WATT

1/2 watt resistors (small body)
100 Ω, brown-black-brown
390 Ω, orange-white-brown
470 Ω, yellow-violet-brown
1 KΩ, brown-black-red
4.7 KΩ, yellow-violet-red
15 KΩ, brown-green-orange
22 KΩ, red-red-orange
33 KΩ, orange-orange-orange
47 KΩ, yellow-violet-orange
100 KΩ, brown-black-yellow
470 KΩ, yellow-violet-yellow

1 WATT

1 watt resistors (medium body)
47 Ω, yellow-violet-black
1.5 KΩ, brown-green-red
4.7 KΩ, yellow-violet-red
22 KΩ, red-red-orange
100 KΩ, brown-black-yellow



2 WATT

2 watt resistors (large body)
22 KΩ, red-red-orange
47 KΩ, yellow-violet-orange

Fourth band, if present, may be disregarded.

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Resistors** | | |
| 1-3 | 2 | 100 Ω 1/2 watt |
| 1-48 | 1 | 390 Ω 1/2 watt |
| 1-5A | 1 | 22 KΩ 1 watt |
| 1-6 | 1 | 470 Ω 1/2 watt |
| 1-9 | 2 | 1 KΩ 1/2 watt |
| 1-16 | 1 | 4.7 KΩ 1/2 watt |
| 1-21 | 2 | 15 KΩ 1/2 watt |
| 1-24 | 1 | 33 KΩ 1/2 watt |
| 1-25 | 1 | 47 KΩ 1/2 watt |
| 1-26 | 2 | 100 KΩ 1/2 watt |
| 1-33 | 3 | 470 KΩ 1/2 watt |
| 1-5A | 2 | 22 KΩ 1 watt (matched) |
| 1-15A | 1 | 47 Ω 1 watt |
| 1-22A | 1 | 1.5 KΩ 1 watt |
| 1-48A | 1 | 4.7 KΩ 1 watt |
| 1-28A | 2 | 100 KΩ 1 watt |
| 1-11B | 1 | 22 KΩ 2 watt |
| 1-10B | 2 | 47 KΩ 2 watt (matched) |
| 3-7G | 1 | 360 Ω 7 watt wirewound |
| 11-1 | 1 | 100 Ω control |
| **Condensers** | | |
| 20-34 | 1 | 350 μμf mica |
| 21-23 | 1 | 420 μμf ceramic |
| 23-61 | 1 | .05 μfd 400 volt paper |
| 23-28 | 1 | .1 μfd 200 volt paper |
| 23-63 | 4 | .25 μfd 400 volt paper |
| 25-19 | 1 | 20 μfd 150 volt electrolytic |
| 25-16 | 2 | 20 μfd 350 volt electrolytic |
| 25-21 | 1 | 20-20-20-20 μfd 450 volt elec. |
| **Tubes** | | |
| 411-15 | 2 | 6SN7GT |
| 411-35 | 1 | 5V4G |
| 411-45 | 2 | 5881 |
| **Sockets-Jacks-Plugs-Fuse** | | |
| 434-42 | 1 | Phono input socket |
| 434-20 | 1 | AC power socket |
| 434-58 | 6 | Octal tube socket |
| 436-4 | 2 | Phone jack |
| 438-4 | 1 | Phono plug |
| 421-2 | 1 | Fuse |
| A423-2 | 1 | Fuse holder short |

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Terminal Strips-Wafer** | | |
| 431-1 | 4 | 1-lug terminal strip |
| 431-2 | 1 | 2-lug terminal strip |
| 431-4 | 1 | 3-lug terminal strip |
| 431-5 | 1 | 4-lug terminal strip |
| 431-13 | 1 | 4-screw terminal strip |
| 481-3 | 1 | Condenser mounting wafer |
| **Sheet Metal Parts** | | |
| 200-M86F101 | 1 | Chassis |
| 206-M22 | 1 | Shield |
| **Wire** | | |
| 89-1 | 1 | Line cord |
| 340-3 | 1 | length Solid wire |
| 344-1 | 1 | length Hookup wire |
| 346-1 | 1 | length Sleeving |
| **Transformers-Chokes** | | |
| 51-17 | 1 | Output transformer |
| 54-29 | 1 | Power transformer |
| 46-12 | 1 | Filter choke |
| **Hardware** | | |
| 73-1 | 2 | 3/8" grommet |
| 73-2 | 4 | 3/4" grommet |
| 250-9 | 24 | 6-32 x 3/8" screw |
| 250-17 | 12 | 8-32 x 1/4" screw |
| 252-3 | 24 | 6-32 hex nut |
| 252-4 | 12 | 8-32 hex nut |
| 252-7 | 3 | 3/8-32 hex nut |
| 253-10 | 3 | Flat nickel washer |
| 253-15 | 2 | Flat fiber washer |
| 253-16 | 2 | Shoulder fiber washer |
| 254-1 | 24 | #6 lockwasher, internal |
| 254-6 | 7 | #6 lockwasher, external |
| 254-2 | 12 | #8 lockwasher |
| 254-4 | 1 | 3/8" lockwasher |
| 259-1 | 2 | #6 solder lug |
| 261-1 | 4 | Rubber feet |
| 595-107 | 1 | Instruction manual |

# 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 with 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.

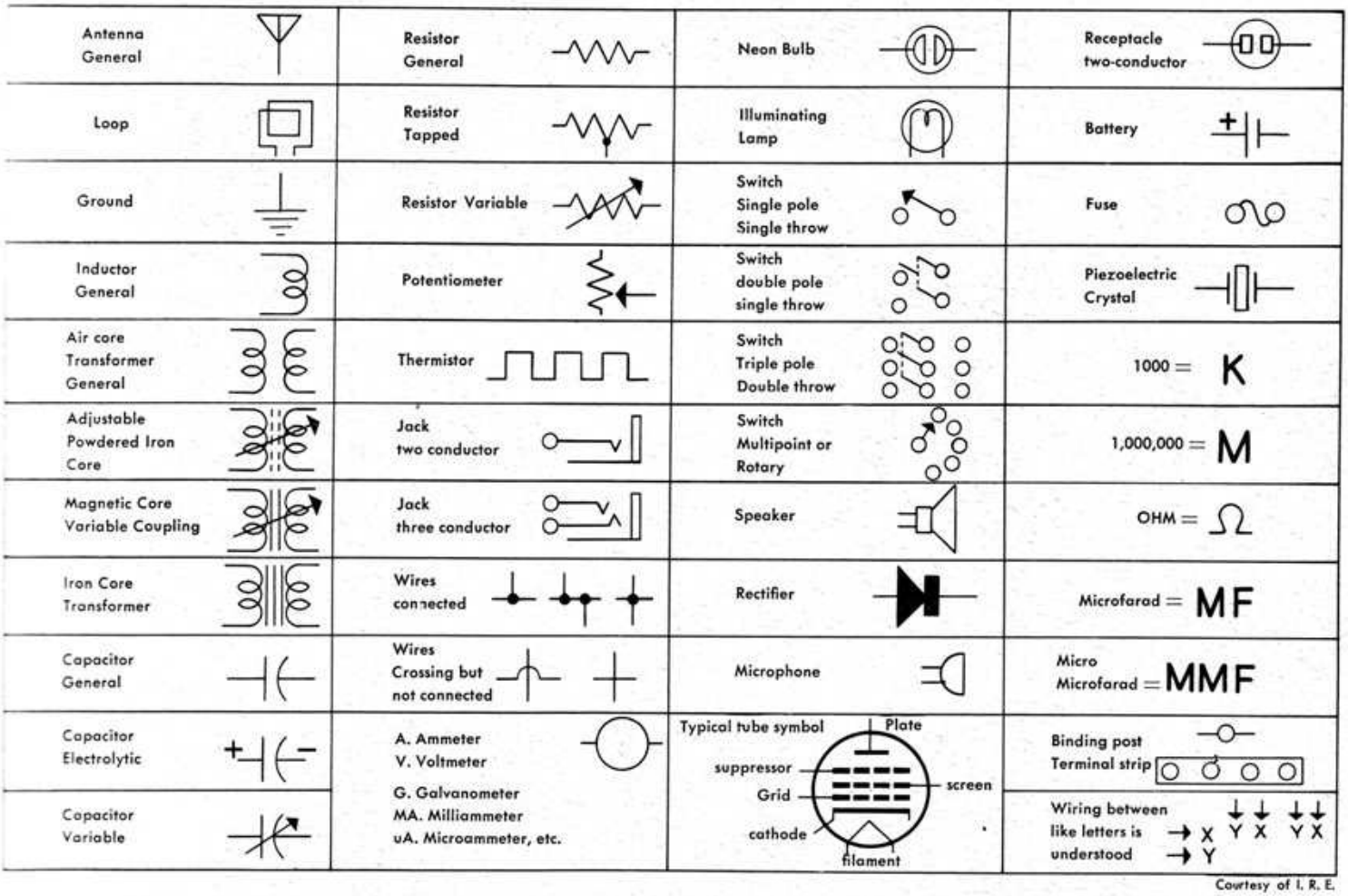
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown 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.




Courtesy of I. R. E.