PRICE $1.00

Assembling and Using Your...

Heathkit

TELEVISION ALIGNMENT GENERATOR

MODEL TS-4A

TV ALIGNMENT GENERATOR TS-4A

HEATH COMPANY

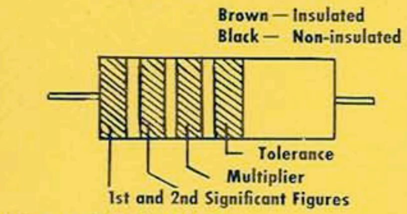
A Subsidiary of Daystrom Inc.

BENTON HARBOR, MICHIGAN

595-92

STANDARD COLOR CODE — RESISTORS AND CAPACITORS

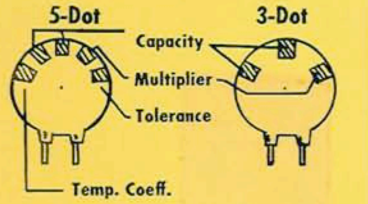
AXIAL LEAD RESISTOR



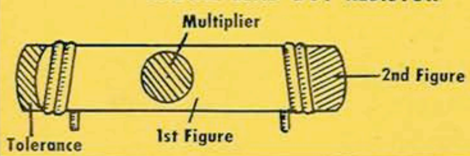
Wire wound resistors have 1st digit band double width

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

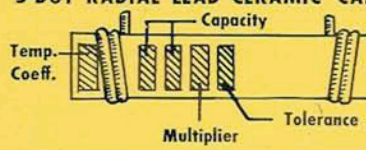
DISC CERAMIC RMA CODE



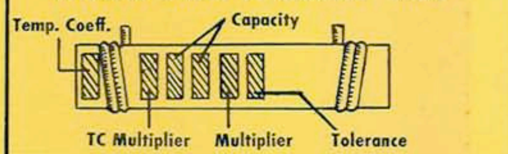
RADIAL LEAD DOT RESISTOR



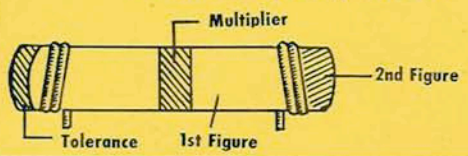
5-DOT RADIAL LEAD CERAMIC CAPACITOR



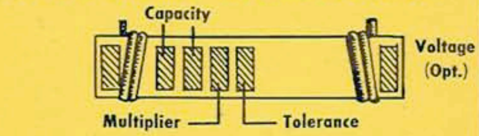
EXTENDED RANGE TC CERAMIC HICAP



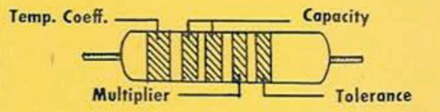
RADIAL LEAD (BAND) RESISTOR



BY-PASS COUPLING CERAMIC CAPACITOR



AXIAL LEAD CERAMIC CAPACITOR

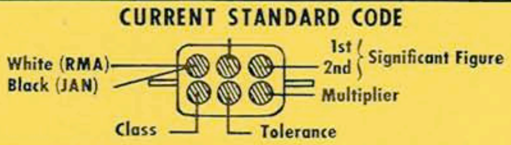


The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: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

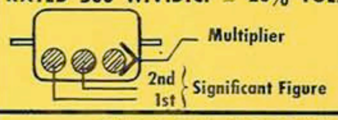
MOLDED MICA TYPE CAPACITORS

CURRENT STANDARD CODE

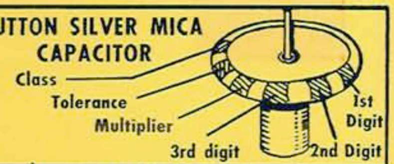


JAN & 1948 RMA CODE

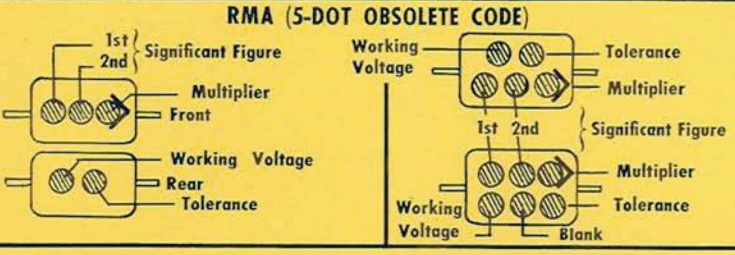
RMA 3-DOT (OBSOLETE) RATED 500 W.V.D.C. ± 20% TOL.



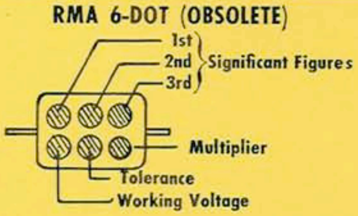
BUTTON SILVER MICA CAPACITOR



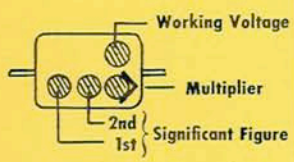
RMA (5-DOT OBSOLETE CODE)



RMA 6-DOT (OBSOLETE)

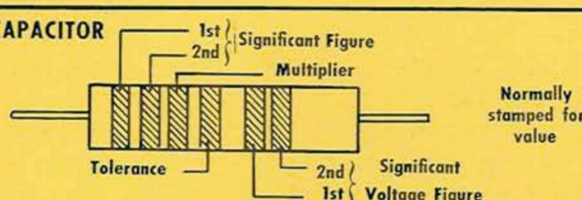


RMA 4-DOT (OBSOLETE)



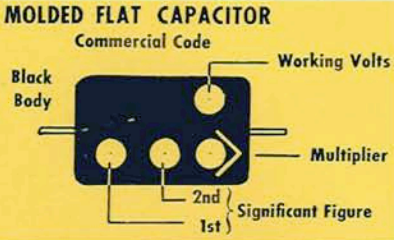
MOLDED PAPER TYPE CAPACITORS

TUBULAR CAPACITOR

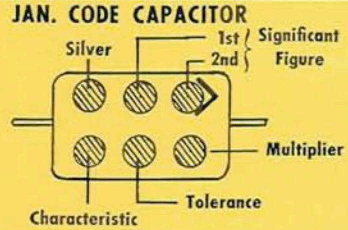


A 2 digit voltage rating indicates more than 900 V. Add 2 zeros to end of 2 digit number.

MOLDED FLAT CAPACITOR



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
TELEVISION ALIGNMENT GENERATOR
MODEL TS-4A

SPECIFICATIONS

Frequency Range and Output	Band A; 3.6 mc to 10 mc, output .23 volts RMS ±1/2 db Band B; 10 mc to 26 mc, output .22 volts RMS ±1/4 db Band C; 30 mc to 80 mc, output .11 volts RMS ±1/2 db Band D; 80 mc to 220 mc, output .08 volts RMS ±3/4 db

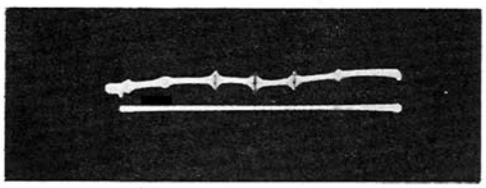
(Output measured with H-P 410B high frequency VTVM. Readings taken directly from scale without compensation for pulse nature of output. DB readings taken for worst deviation on each band at a fixed center frequency.)

Output Impedance	50 Ω, terminated at both ends of output cable.
Sweep Deviation	Continuously variable from 0-4 mc lowest maximum deviation, 0-42 mc highest maximum sweep, depending on frequency.
Fixed Frequency Marker	4.5 mc crystal, included with kit. Other frequency crystals may be quickly substituted if desired.
Variable Frequency Marker	19 mc to 60 mc on fundamentals, 57 mc to 180 mc on calibrated harmonics. Calibrated against furnished crystal which determines marker accuracy.
External Marker	Any RF frequency can be mixed with crystal and variable marker oscillators to provide as many as three marker pips on one trace. Marker energy can be taken out from external connector for separate applications.

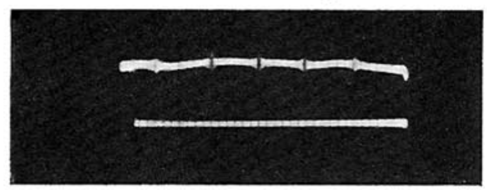
Attenuators	Step and "fine" controls for sweep oscillator, separate control for marker amplitude. Both sweep and marker output attenuated together by step switch to avoid marker overloading.
Blanking	2-way blanking incorporated to eliminate return trace.
Phasing	Narrow range phasing control to insure alignment accuracy.
Tube Complement	6BQ7A - sweep oscillator and buffer 12AT7 - variable and crystal marker oscillator 12AX7 - blanking and AGC amplifier 6CL6 - shunt regulator 6X4 - rectifier
Cables	Output cable, scope horizontal cable and compensated scope vertical cable provided. Convenient pod termination used on output cable.
Power Requirements	110 volt AC 50/60 cycle, 50 watts
Dimensions	13" wide x 8 1/2" high x 7" deep
Net Weight	11 lbs.
Shipping Weight	16 lbs.

FREQUENCY LINEARITY

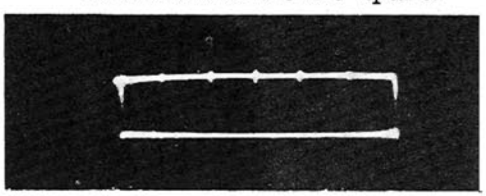
BAND A
Center frequency 6.5 mc, side markers 1 mc apart.



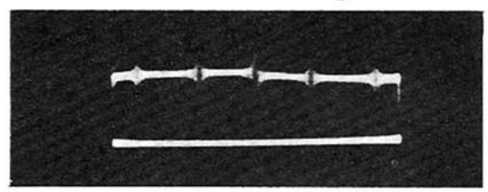
BAND B
Center frequency 16 mc, side markers 2 mc apart.



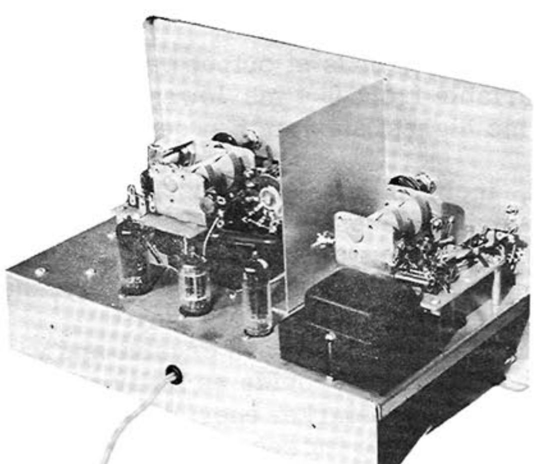
BAND C
Center frequency 50 mc, side markers 3 mc apart.

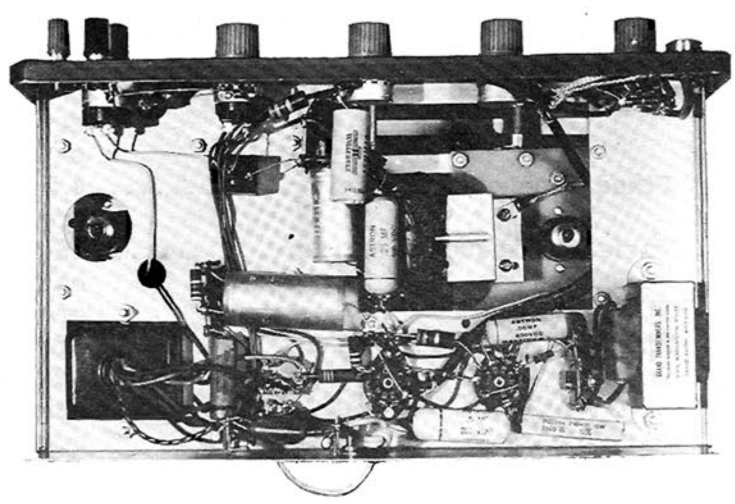


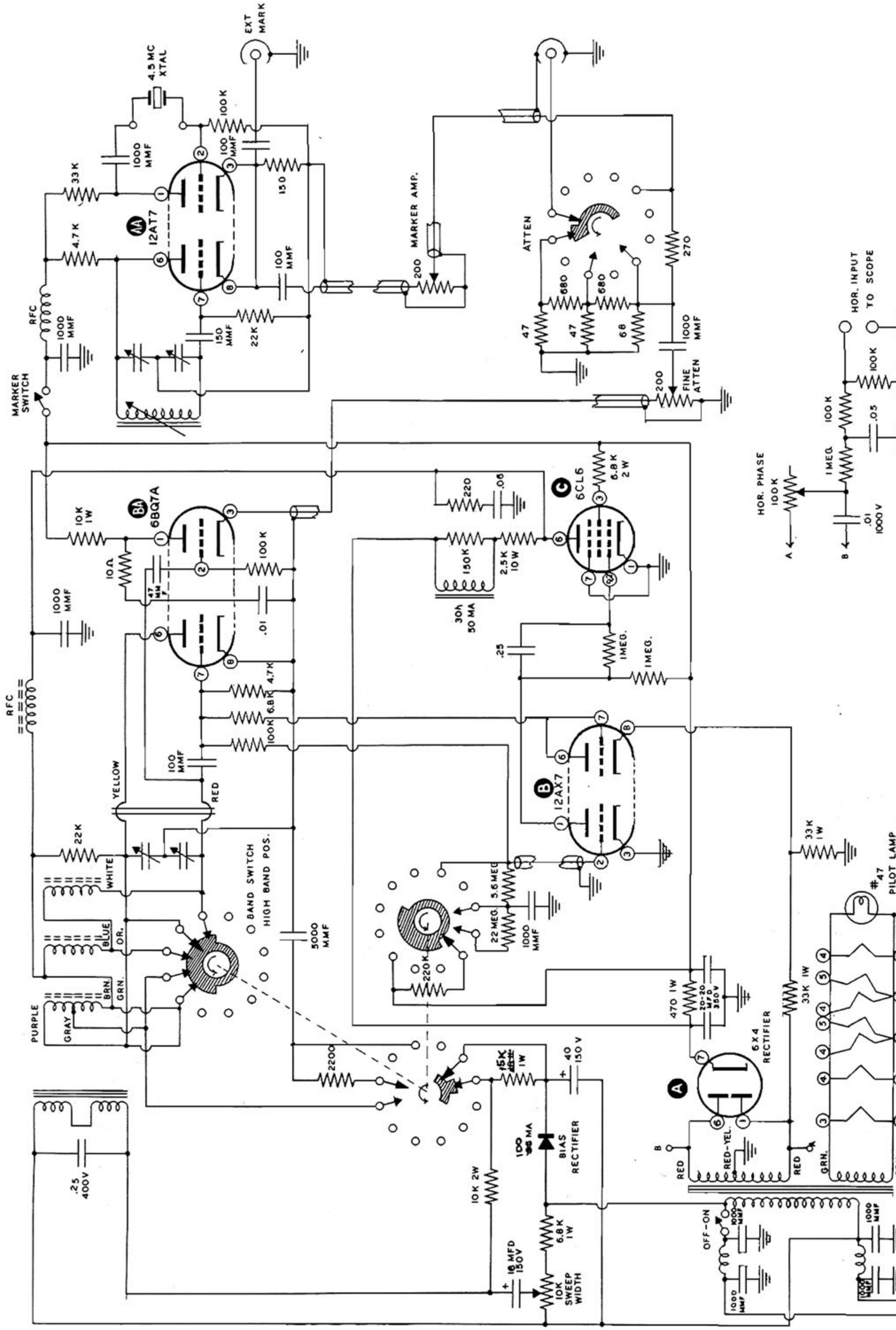
BAND D
Center frequency 140 mc, side markers 2 mc apart.



All pictures taken with the oscillator dial approximately at the mid-range position. Sweep width adjusted to show only easily identifiable markers.







HEATHKIT
TELEVISION ALIGNMENT GENERATOR
MODEL TS-4A

INTRODUCTION

The Heathkit Television Alignment Generator, model TS-4 is designed to offer the maximum in performance, flexibility and utility at the lowest possible cost. To this end, several outstanding new features have been incorporated which are unusual in instruments in this price range.

A unique non-mechanical sweep oscillator system is used in the Heathkit TS-4 Generator. The heart of this system is the controllable inductor, which controls oscillator coil inductance as a function of excitation current flow in the primary windings of the unit. The main advantage of this circuit is that a large amount of sweep width can be obtained which is smoothly controllable, very linear and very stable. There is no mechanical vibration or hum and nothing to wear out or fatigue with age. Operation of the instrument is non-critical, for the large amount of sweep width available makes it easy to locate the band-pass trace even though the sweep generator or the TV set may be off frequency by a substantial amount. Once the waveform has been located, it is only necessary to adjust the frequency, sweep width and phasing a bit until the pattern fills the desired portion of the 'scope screen.

Additional features found in the sweep generator are an AGC circuit to keep the RF output constant over the swept range, positive action return trace blanking and an electronically regulated power supply to assure stable operation.

A multiple marker system is employed to make alignment easier. The built-in variable marker oscillator covers a range from 19 mc to 60 mc on fundamentals and 57 mc to 180 mc on calibrated harmonics. Higher order harmonics are also available when required. The fixed marker is a crystal controlled oscillator, which operates at 4.5 mc with the crystal furnished with the kit. This crystal mounts outside the front panel, making it easy to substitute any other crystal if needed. Both oscillators have a common output, controlled by one knob independently of the sweep circuit output. Since the fixed and variable oscillators have a common output, each frequency will be present, as well as the sum and difference frequencies. Marker pips spaced 4.5 mc apart are obtained by using the mixed outputs. If closer spaced markers are desired, a crystal of lower frequency can be used. Spacing of the markers is determined by the crystal frequency.

Another marker can be fed into the external marker connector for FM alignment or other work requiring frequencies not covered by the internal marker generator. Also, an external generator can be used to beat against the fixed or variable internal oscillators to give three or more simultaneous pips. Marker oscillator signal can be taken out of the external marker connector for separate application if needed.

CIRCUIT DESCRIPTION

The swept oscillator is basically a standard Colpitts oscillator, using half of a 6BQ7A tube. The coils are built into the controllable inductor and are series connected. When the low band is in use, all coils are in the circuit. As the band switch is set to higher bands, the coils are shorted out in succession until only the straps and switch which form the high frequency band coil are left. Ferrous material is used for the cores of the coils, which are made so that each core makes contact with the laminated pole pieces of the inductor. When no exciting current is applied to the primary circuit, the coils are operating at their nominal inductance and the oscillator is running at the lowest possible frequency for the particular setting of the tuning condenser. When current flows in the primary coil, a magnetic field is set up. This field completes itself through the oscillator coil cores, causing the cores to change characteristics to a degree dependent on the amount of excitation current and the subsequent magnetic field strength. In effect the coils lose inductance as the exciting current increases and the frequency of the oscillator increases proportionally. Highest possible deviation of frequency is obtained when the cores are saturated. In order to control the width of the sweep, a control is connected across the 110 volt line in series with a limiting resistor which prevents overloading of the controllable inductor. The Increductor unit is connected to one end and to the center of the control through a capacitor. Sweep width can be set to any level by rotating the control until the desired amount of sweep width is obtained.

Center frequency sweep is obtained by biasing the windings of the controllable inductor with DC current. The current is adjusted on each band so that at zero sweep width, the operating frequency is halfway between the no-current and the saturation point of the inductor. When the band switch is turned to a different band, it will change the amount of current, thus assuring good linearity at all frequencies. Bias current is obtained from the small selenium rectifier connected to one side of the AC line. The circuit is completed through an 18 KΩ resistor, a 10 KΩ resistor and the primary windings of the Increductor unit. A 40 μfd filter condenser is used to smooth out the current. Sweep is obtained by coupling AC through the 12 μfd isolating capacitor, which varies the primary current without changing the static or center current supplied by the rectifier. Changes in current for different bands are accomplished by switch shunting the 18 KΩ bleeder resistor. Oscillator operation is entirely on fundamentals, insuring adequate output on all bands and efficient attenuator action.

The second half of the 6BQ7A sweep oscillator is connected as a cathode follower. RF energy is coupled from the grid circuit of the oscillator to the grid of the cathode follower. A cathode follower is a high impedance input device, so loading effects on the oscillator are negligible. Output from the cathode follower is at low impedance and is connected to the attenuator network.

Blanking is required to eliminate the return trace encountered when the oscillator returns to the starting point. Without blanking, a double trace is present which is difficult to interpret. Elimination of the return trace is accomplished by cutting down the B+ voltage to the oscillator tube and at the same time driving the oscillator grid highly negative. B+ voltage is reduced due to a portion of the negative grid blanking voltage fed to the regulating amplifier. This causes the shunt regulator tube to conduct heavily during the blanking time. The subsequent large drop across the shunt regulator load resistor and choke effectively cuts off the high voltage to the sweep oscillator tube. Negative voltage at the oscillator grid is applied from one half of the 12AX7 blanking and regulator amplifier. The grid and plate are tied together and to the oscillator grid through a 6.8 KΩ isolating resistor. One side of the power transformer high voltage secondary is tied to the cathode of the blanking tube through a voltage dividing network of two 33 KΩ resistors. When the cathode swings in a positive direction, the plate is negative in respect to the cathode and no current can flow. At this time, the oscillator will be operating with its own 4.7 KΩ grid leak only. During the negative half of the cycle at the cathode of the blanking tube, the grid and plate become effectively positive in respect to the cathode and current will flow. The plate will follow the cathode causing a high negative voltage to be applied to the oscillator grid, cutting the tube off.

Regulation of the RF output voltage is accomplished by feeding a portion of the DC voltage developed at the oscillator grid through an isolating resistor to the control grid of the regulating amplifier. Any variations in oscillator output are amplified and fed through a resistor and capacitor to the grid of the 6CL6 shunt regulator. A unique direct coupling system is used at this point, which allows the shunt regulator to handle wide voltage swings without distortion. The oscillator plate is connected through an RF filter to the plate of the 6CL6. A resistor and choke are also connected to this plate. Any variation in current will cause a related increase or decrease of B+ voltage at this point and thus the oscillator high voltage is varied. If oscillator output increases, the negative voltage at the grid will also increase. A negative voltage at the grid of the regulator amplifier will be fed to the grid of the 6CL6 as a positive potential, causing an increase in plate current. This in turn is reflected in reduced plate voltage, which is reflected to the oscillator plate causing the output to drop. An opposite reaction occurs if the output of the oscillator should decrease.

Changes of oscillator efficiency on different bands are compensated for by switching bias voltage to the grid of the regulator amplifier. Efficiency on band "D" is low, and the voltage from the oscillator grid is fed straight though without compensation. Better efficiency is evident on band "C" and a slight amount of positive voltage is added through the switch to keep the regulator operating in its optimum range. Highest operating efficiency is obtained on bands "A" and "B" and the same higher positive potential is applied for both.

A 12AT7 dual triode tube is used in the multiple marker system. One half of the tube is employed as a Colpitts variable frequency oscillator, covering a fundamental range from 19 mc to 60 mc. Slug tuning is used in the coil so the oscillator can be trimmed and padded for perfect tracking over the entire frequency range. Output from the oscillator is taken from the cathode circuit at low impedance so that changes of control settings and loading will not affect stability. The second half of the 12AT7 is a Pierce crystal oscillator and the output of this section is taken from the same cathode load as the first. Mixing the output of the two oscillators in a common load causes the frequencies of both generators to be present, as well as the sum and difference of the frequencies and their harmonics. Therefore, a 4.5 mc crystal mixed with the variable oscillator at an example frequency of 25 mc will give markers at 25 mc, 29 1/2 mc, 20 1/2 mc, 34 mc, 16 mc, etc. and at 22 1/2 mc and 27 mc, which are direct harmonics of the crystal oscillator. Other frequency crystals can be substituted to obtain markers that are closer or further spaced, or to give direct frequency check points. Additional markers are obtained by connecting a signal generator to the EXT. MARK. connector.

RF energy from the cathode of the marker generator is taken out through a DC blocking capacitor to a control. Output from the control is connected to the input of the step attenuator network for the sweep oscillator. This causes the output of the marker to be attenuated proportionally in respect to the sweep signal, preventing excessive marker overloading, but still allowing a wide range of amplitude control to be maintained.

The power supply employs a 6X4 full wave rectifier with well filtered DC output. Plate voltage for the rectifier and filament voltage for all tubes is furnished by the power transformer, as well as voltage for the phasing and blanking circuits. Phasing is accomplished by connecting a condenser and variable resistor across the high voltage plate windings. Changing the amount of resistance changes the phase shift in the network, which is connected to the horizontal output terminals.

Calibration of the TS-4 Television Alignment Generator is easily accomplished, for an accurate reference is furnished with the kit, (the 4.5 mc crystal). Harmonics of the 4.5 mc crystal are used to calibrate the variable frequency marker oscillator at several points on the dial. Adjustment of pointer setting and slug tuning effectively trims and pads the oscillator so that it tracks over the entire dial range. The sweep oscillator dial needs only to be indexed with the condenser plates fully meshed, for accuracy is not required from the sweep portion of the instrument. The marker system is always considered to be the accurate reference, not the sweep system. Frequency markings on the sweep dial are for reference only.

NOTES ON ASSEMBLY AND WIRING

The Heathkit Television Alignment Generator model TS-4, when constructed in accordance with the instructions in the manual, is a high-quality instrument capable of many years of trouble-free service. We therefore urge you to take the necessary time to assemble and wire the kit carefully. Do not hurry the work and you will be rewarded with a greater sense of confidence, both in your instrument and your own ability.

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

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

CAUTION: The controllable inductor, the variable condensers and the crystal are quite delicate and should be handled with care. The tuning condensers should be kept fully meshed until construction is completed, to avoid bending the plates. The crystal can be damaged by a sharp blow of any kind, so it should be placed where it will not be disturbed or accidentally dropped. Many short leads come out of the controllable inductor unit which may be broken off if the unit is handled excessively. It is recommended that the unit be placed in a safe location until it is ready to be installed in the instrument.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and the terminal are free of wax, corrosion or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes such as Kester "Resin-Five," Ersin "Multicore" or similar types.

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.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -50% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished instrument.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 120 KΩ resistor has been supplied in place of a 100 KΩ as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion in checking the contents of your kit.

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

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

THE HEATHKIT TS-4 TELEVISION ALIGNMENT GENERATOR IS A COMPLEX INSTRUMENT CONTAINING SEVERAL SUB-ASSEMBLIES. WE VERY STRONGLY URGE THAT THE STEP-BY-STEP INSTRUCTIONS BE FOLLOWED EXACTLY, RATHER THAN WIRING FROM THE PICTORIALS AND SCHEMATIC EXCLUSIVELY. SPECIAL INSTRUCTIONS REGARDING SEQUENCE OF ASSEMBLY AND LEAD LENGTHS ARE GIVEN TO MAKE CONSTRUCTION OF THE KIT AS EASY AS POSSIBLE. WIRING AND MOUNTING OF PARTS IN IMPROPER ORDER MAY RESULT IN THE NECESSITY OF RE-DOING WORK PREVIOUSLY ACCOMPLISHED.

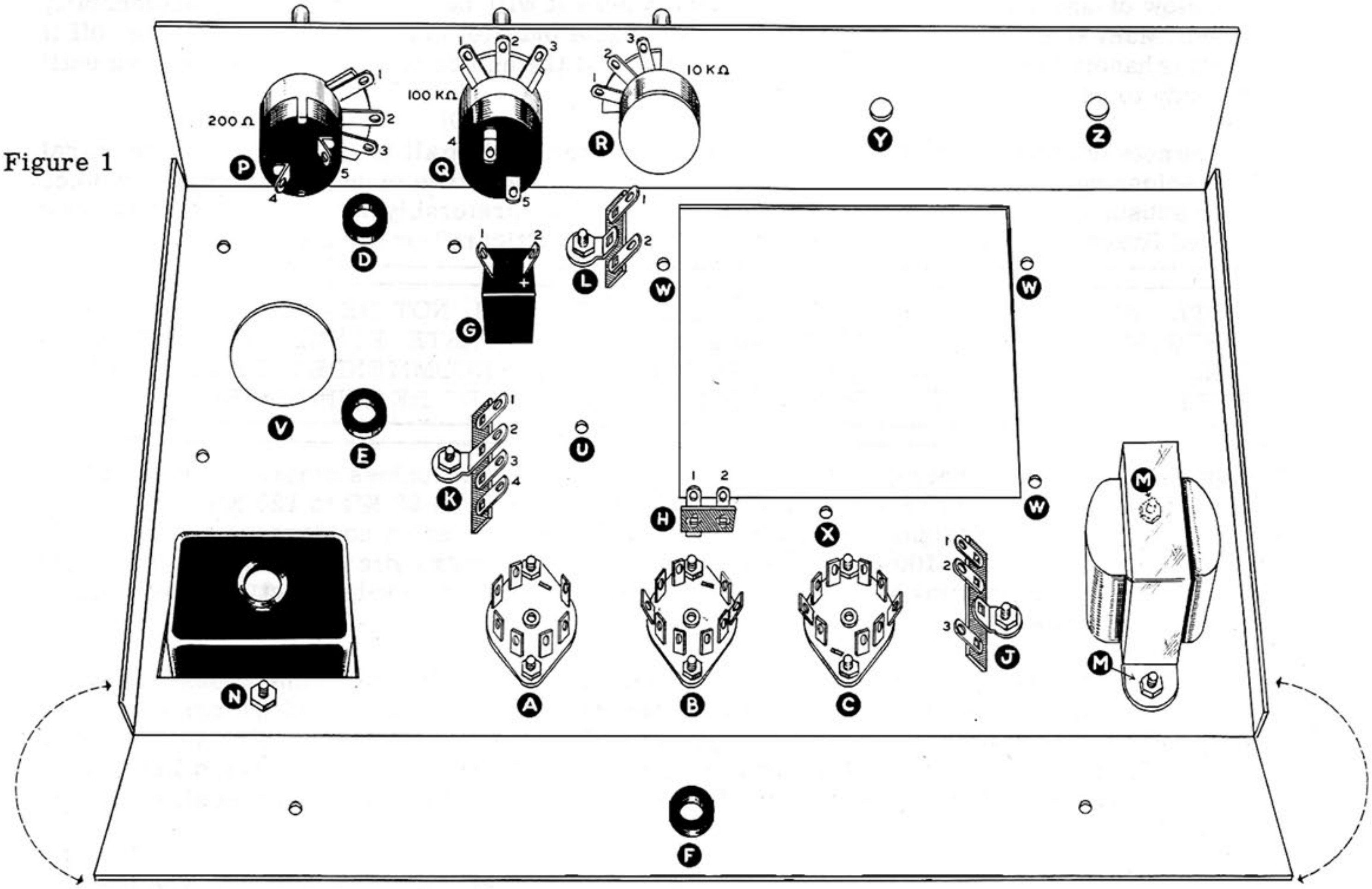
The following instructions are presented in a simple, logical, step-by-step sequence to enable you to complete your kit with the least possible confusion. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

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

1. Attach the large fold-in pictorials to the wall above your work bench.
2. Go through the entire assembly and wiring instructions. This is an excellent time to read the entire instruction section through and familiarize yourself with the procedure.
3. Lay out all parts so that they are readily available. Refer to the general information inside the front and back covers of this manual to help you identify components.

In assembling the kit, use lockwashers under all nuts except the 3-48 size. Tube sockets are mounted inside the chassis and sub-chassis. Other details of construction are included where pertinent in the instructions.

Figure 1



( ) 1. Place the chassis upside down on the bench. Note that one apron of the chassis has five identical holes symetrically located in it. Place this side away from you. The chassis will then be oriented correctly with the bottom chassis diagram, Figure 1.

( ) 2. Refer to Figure 2 and note that the contacts on the tube sockets are numbered consecutively in clockwise sequence when viewed from the bottom of the socket. Mount a 7-pin socket at hole A, locating the blank space between pins 1 and 7 as shown in Figure 1. Use 3-48 hardware. No lockwashers are used with 3-48 hardware only.

( ) 3. Mount a 9-pin socket at location B with the blank space between pins 1 and 9 toward the center of the chassis as shown. Use 3-48 hardware.

( ) 4. Install a 9-pin socket at hole C with 3-48 hardware. Note that the gap between pins 1 and 9 is toward the back chassis apron.

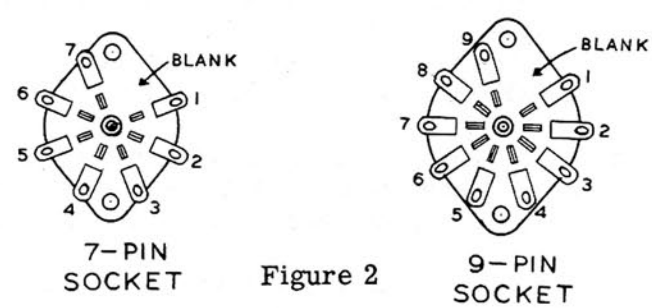


Figure 2

( ) 5. Mount a rubber grommet through hole D.

( ) 6. Place a rubber grommet through hole E.

( ) 7. Install a rubber grommet in hole F on the back chassis apron.

( ) 8. Mount the selenium rectifier at hole G, using a 6-32 nut and lockwasher on top of the chassis. The side marked positive (+) should be toward the large chassis cut-out.

( ) 9. Mount a 2-lug terminal strip (1 lug grounded) at hole H, using 6-32 hardware. Orient as shown in Figure 1. Mark lug numbers on chassis to aid wiring.

( ) 10. In a similar fashion, install a 3-lug terminal strip at location J.
( ) 11. Place a 4-lug terminal strip (1 lug grounded) at location K. Mount in a temporary manner for the marker sub-chassis bolt will hold the strip upon completion.
( ) 12. Temporarily mount a 2-lug insulated terminal strip at hole L.
( ) 13. Install the large iron-cored AF choke with 8-32 screws, nuts and lockwashers through holes M and M. The wire leads should be toward the center of the chassis.
( ) 14. Install the power transformer at location N. Secure with 8-32 nuts and lockwashers on the underside of the chassis. DO NOT remove the nuts holding the transformer shells together.

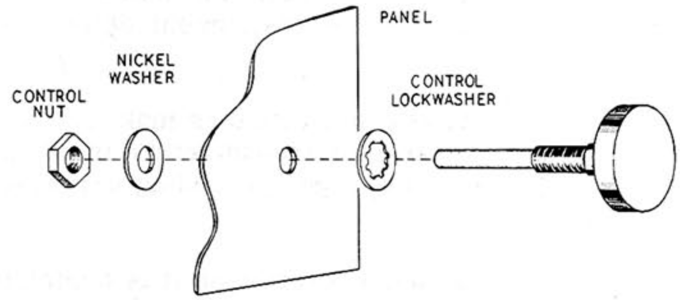


Figure 3

HOW TO MOUNT CONTROLS & SWITCHES.

( ) 15. Temporarily mount a 200 Ω potentiometer with switch at location P as shown in Figure 1. Use a lockwasher between the control and the chassis apron. See Figure 3.
( ) 16. In a similar fashion, mount a 100 KΩ control with switch at Q.
( ) 17. Install the 10 KΩ sweep width control at location R in the same manner.

The chassis is now ready to be wired.

WIRING OF THE TS-4 TELEVISION ALIGNMENT GENERATOR

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.

The figure on Page 11 is a pictorial representation of the completed main chassis wiring. All remaining connections will be made after the sub-chassis are wired and mounted. We again suggest that you use the large fold-in pictorials for reference as the work progresses. They are duplicates of the pictorials in the manual.

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

Refer to Pictorial 1. Note that each component part has been given a code designation which corresponds with the identification used during the assembly of the kit. In addition, each terminal on the part has also been assigned a number.

When the instructions read, "Connect one end of a 1 megohm resistor to B1 (NS)," it will be understood that the connection is to be made to contact pin 1 of tube socket B. The abbreviation "NS" indicates that the connection should not be soldered as yet, for other wires will be added. When the last wire is installed, the terminal should be soldered and the abbreviation "S" is used to indicate this.

Unless otherwise indicated, all wire used is insulated. Wherever there is a possibility of the bare leads on resistors and condenser shorting to other parts or to chassis, the leads should be covered with insulated sleeving. This is indicated in the instructions by the phrase, "use sleeving." Bare wire is used where the lead lengths are short and the possibility of short circuits non-existent.

Leads on resistors, condensers 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 instances the excessively long leads will actually interfere with proper 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 as shown, be followed exactly. 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 delivering a large amount of output with excellent linearity.

Please note particularly that the marker and sweep oscillators make no connections to chassis except at the output terminals. This use of insulated ground return is common practice in high frequency instruments and is very important. Improper grounding will result in instability and high radiation leakage from the cabinet.

Space has been provided for you to check off each operation as it is completed. This is particularly important in wiring and it may prevent omissions or errors, especially where your work is interrupted frequently as the wiring progresses. Some kit builders also have found it helpful to mark each lead in colored pencil on the pictorial as it is added.

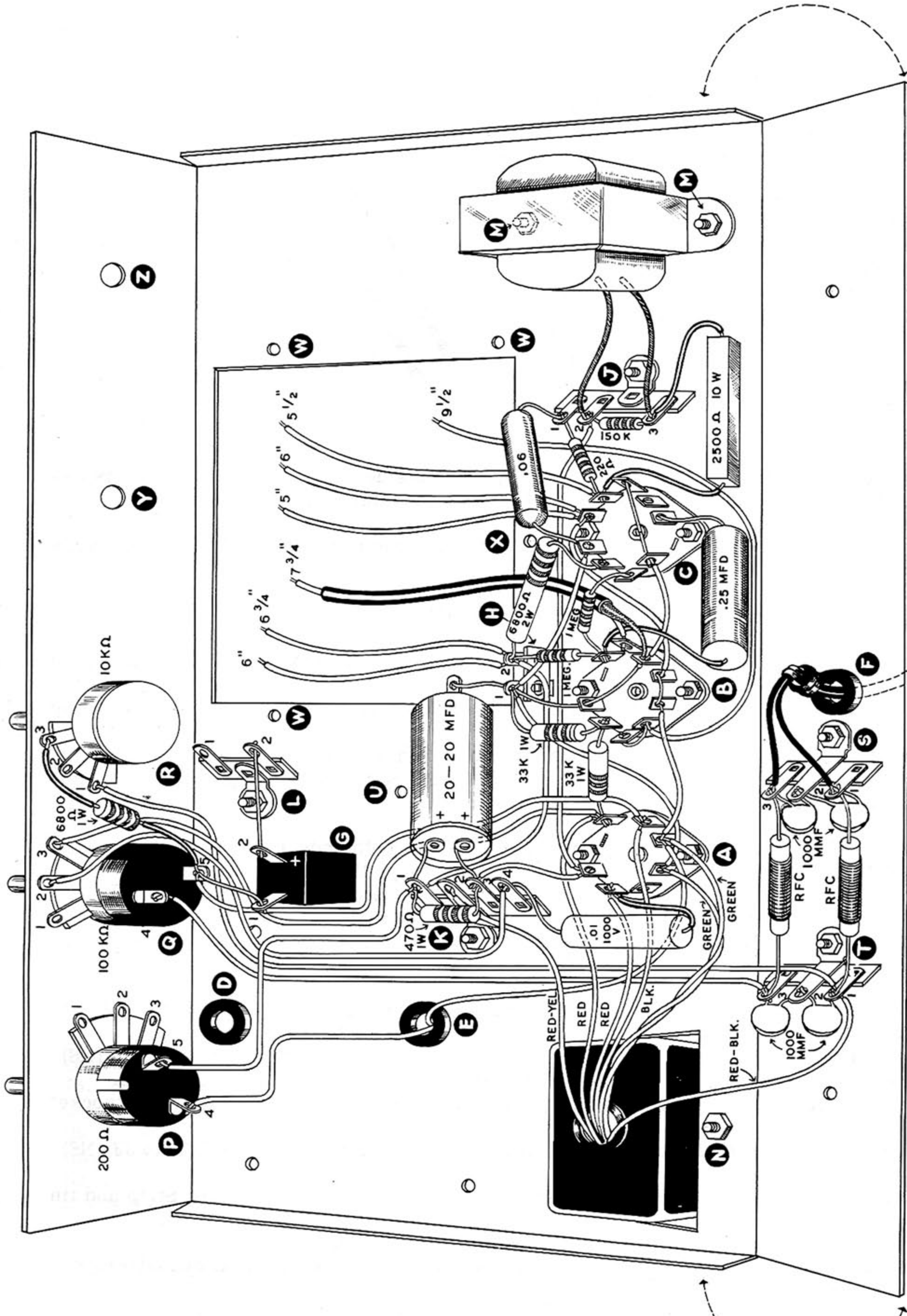
STEP-BY-STEP WIRING INSTRUCTIONS

( ) 18. Connect a wire from tube socket A4 (NS) to terminal strip H1 (NS).
( ) 19. Connect a bare wire from tube socket B3 (NS) through B9 (NS) to terminal strip H1 (NS). Now solder B9.
( ) 20. Connect a short piece of bare wire between tube socket B4 (NS) and B5 (NS).
( ) 21. Run a wire from socket A3 (NS) to socket B5 (S).

( ) 22. Connect a wire from socket B4 (S) to socket C5 (NS).
( ) 23. Run a wire from socket C4 (NS) to terminal strip H1 (NS).
( ) 24. Cut a wire to a length of 7 3/4". Strip and tin both ends and connect one end to socket A3 (NS). Run the other end through grommet E.
( ) 25. Connect one green wire from the power transformer to socket A4 (S).

( ) 26. Run the other green wire from the transformer to socket A3 (S).
( ) 27. Connect a wire from socket A1 (NS) to control Q3 (S).
( ) 28. Install a 33 KΩ 1 watt resistor (orange-orange-orange) from socket A1 (NS) to socket B8 (NS).
( ) 29. Connect a wire from socket A7 (NS) to terminal strip K3 (NS).
( ) 30. Run a wire from socket A7 (S) to terminal strip J2 (NS). Route this wire under the leads connected to terminal strip H.

( ) 31. Connect one red wire from the power transformer to socket A1 (S).
( ) 32. Connect the other red wire to socket A6 (NS).
( ) 33. Install a .01 μfd 1000 volt tubular condenser from socket A6 (S) to terminal strip K4 (NS) (use sleeving). Any "outside foil" or "ground" markings on paper capacitors may be disregarded in wiring this circuit. They may be connected with either "polarity."
( ) 34. Connect the red-yellow lead from the transformer to terminal strip ground lug K2 (S).
( ) 35. Run a wire from terminal strip K4 (S) to control Q2 (NS).
( ) 36. Connect a wire from terminal strip K1 (NS) to terminal strip H2 (NS).
( ) 37. Connect a wire from terminal strip K1 (NS) to control switch P5 (S).
( ) 38. Run a wire from socket A2 (NS) to control switch Q5 (NS).
( ) 39. Install a 6.8 KΩ 1 watt resistor (blue-gray-red) from control switch Q5 (NS) to control R3 (S). (Use sleeving.)
( ) 40. Run a bare wire from control switch Q5 (S) to selenium rectifier G1 (S).
( ) 41. Connect a bare wire from rectifier G2 (S) to terminal strip L2 (NS). G2 is the positive (+) side of the rectifier.


10 KΩ
100 KΩ
200 Ω
6800 Ω 1W
20-20 MFD
.25 MFD
.06
150 K
2500 Ω 10 W
220 Ω
6800 Ω 2W
1 MEG.
MEG.
33K 1W
33 K 1W
470 Ω 1W
.01 1000 V
GREEN
RED-YEL
RED
RED
BLK.
RED-BLK.
RFC
RFC
1000 MMF
1000 MMF
6"
6 3/4"
7 3/4"
5"
6"
5 1/2"
9 1/2"

PICTORIAL 1

( ) 42. Install a 33 KΩ 1 watt resistor (orange-orange-orange) from socket B8 (S) to terminal strip H1 (NS).

( ) 43. Connect a short piece of bare wire from socket B6 (NS) to B7 (S).

( ) 44. Cut a piece of wire to a length of 9 1/2". Strip and tin both ends and connect one end to socket B6 (S). Dress the other end around socket C and place it through the large chassis cut-out as shown in Pictorial 1.

( ) 45. Cut a piece of insulated coaxial cable to a length of 7 3/4". At one end, cut away 1 3/4" of rubber outside insulation as shown in Figure 4. Push the braid back until a bulge develops near the end of the outside insulation. Bend the wire over double at the bulge point, separate the braid strands and pull the inner conductor through the hole. Cut away the braid at the end of the outside rubber insulation and strip and tin the end of the center conductor.

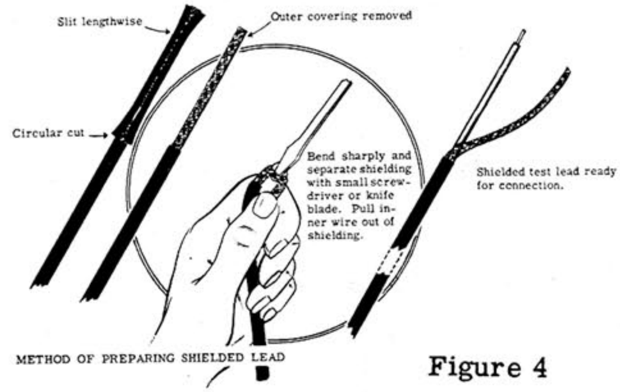


Figure 4

( ) 46. At the opposite end of the cable, cut away 3/4" of outside insulation and prepare as before, except do not cut off the braid. Strip and tin the center conductor as before. Twist the braid to form a pigtail lead.

( ) 47. Connect the center conductor at the braid end of the cable to socket B2 (S). Make sure the braid is toward B3.

( ) 48. Connect a bare wire from socket C1 (NS) to C7 (S).

( ) 49. Connect a wire from socket C1 (S) to socket B3 (NS).

( ) 50. Connect the braid of the shielded cable to socket B3 (S). Dress the opposite end of the cable through the large cut-out.

( ) 51. Install a 1 megohm resistor (brown-black-green) from socket B1 (NS) to terminal strip H2 (NS).

( ) 52. Mount a 1 megohm resistor (brown-black-green) from socket B1 (NS) to socket C2 (S).

( ) 53. Connect a .25 μfd 400 volt tubular capacitor from B1 (S) to C9 (S). (Use sleeving.) (The 6CL6 has an internal jumper between pins 2 and 9.)

( ) 54. Cut a piece of wire to a length of 5". Strip and tin both ends and connect one end to socket C5 (NS). Dress the opposite end of the wire through the large cut-out.

( ) 55. In a similar fashion, cut a wire 6" long and connect one end to socket C5 (S).

( ) 56. In the same manner, prepare a wire 5 1/2" long. Connect one end to socket C6 (NS).

( ) 57. Prepare a wire 6 1/2" in length as before and connect one end to terminal strip H2 (NS).

( ) 58. Likewise, cut a wire to a length of 6 3/4" and connect one end to terminal strip H2 (NS).

( ) 59. Install a 2500 Ω 10 watt resistor (a large square or tubular unit) from socket C6 (NS) to terminal strip J3 (NS). (Use sleeving.)

( ) 60. Connect a 220 Ω resistor (red-red-brown) from socket C6 (S) to terminal strip J1 (NS).

( ) 61. Connect a .06 μfd 400 volt condenser from terminal strip J1 (S) to socket C4 (S).

( ) 62. Install a 6800 Ω 2 watt resistor (blue-gray-red) from terminal strip H2 (S) to socket C3 (S).

( ) 63. Mount a 150 KΩ resistor (brown-green-yellow) from terminal strip J2 (NS) to J3 (NS).

( ) 64. Cut one of the wires of choke M to length sufficient to reach terminal J3. Strip and tin the wire and connect it to J3 (S).

( ) 65. In like fashion, connect the other wire of choke M to J2 (S).

( ) 66. Mount a 3-lug terminal strip (center grounded) at location S on the rear chassis apron. Use 6-32 hardware.

( ) 67. Similarly, mount a 3-lug terminal strip at location T.

( ) 68. Run a wire from terminal strip T3 (NS) to control switch Q4 (S).

( ) 69. Connect a wire from terminal strip T1 (NS) to control R1 (NS).

( ) 70. Mount a 1000 $\mu\mu$f condenser from terminal strip S1 (NS) to S2 (NS). (This condenser is sometimes marked .001.)

( ) 71. Likewise, install a 1000 $\mu\mu$f condenser from S3 (NS) to S2 (S).

( ) 72. In similar fashion, install a 1000 $\mu\mu$f condenser from terminal T1 (NS) to T2 (NS).

( ) 73. In the same fashion, connect a 1000 $\mu\mu$f condenser from T3 (NS) to T2 (S).

( ) 74. Connect a line filter choke (one of two chokes using heavier gauge wire) between terminal strips S3 (NS) and T3 (S).

( ) 75. Install the other line filter choke between terminal S1 (NS) and T1 (NS).

( ) 76. Connect either the black or the red-black lead from the power transformer N to tube socket A2 (S). Do not secure this wire too tightly, for it may be necessary to exchange the transformer primary leads when the instrument is tested.

( ) 77. Run the remaining black or red-black wire from the transformer to terminal strip T1 (S) in the same manner.

( ) 78. Connect a 470 Ω 1 watt resistor (yellow-violet-brown) from terminal strip K1 (NS) to K3 (NS). Mount the unit in such a manner that the strip mounting nut is accessable.

( ) 79. Connect the positive red marked lead (if any) of a 20-20 μfd electrolytic filter condenser to terminal K3 (S). Mount the condenser close to the terminal strip. Be sure to leave access to hole U.

( ) 80. Connect the other positive lead to terminal K1 (S).

( ) 81. Connect the negative lead of the condenser to terminal strip H1 (S).

( ) 82. Pass the AC line cord through grommet F and tie a knot approximately 1" from the end for strain relief. Connect the end of one of the wires to terminal strip S3 (S). Connect the adjacent end to S1 (S).

( ) 83. Cut a wire to a length of 8". Strip and tin both ends. Connect one end to control switch P4 (S) and pass the other end through grommet E.

Wiring of the main chassis is now complete. The marker and sweep oscillator circuits will be wired next. It is extremely important that all resistors, condensers, chokes and wires be mounted so that the leads are just long enough to reach their terminating points. Excessive lead length will contribute to difficulty in calibration and stability.

ASSEMBLY OF THE MARKER OSCILLATOR

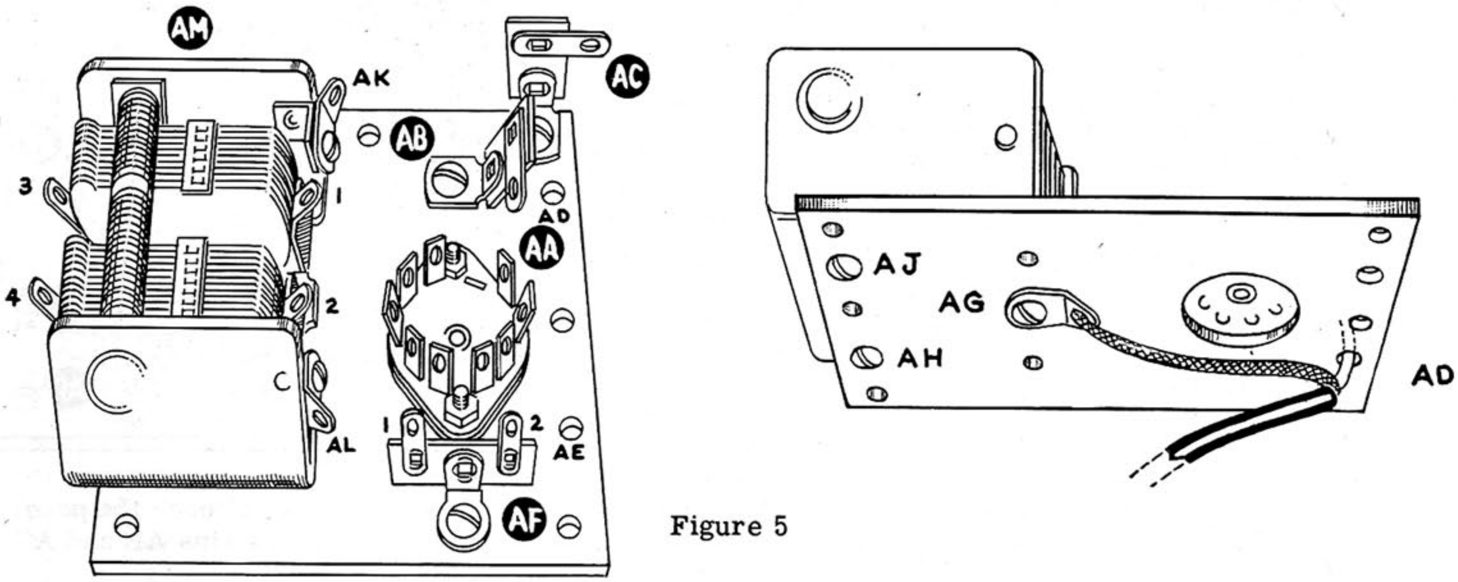


Figure 5

( ) 84. Place an insulated chassis board so that the large hole is to the right, as shown in Figure 5. The edge with the three small irregularly spaced holes should be nearest you. Make sure the chassis board is properly oriented, for it will be impossible to complete the assembly of the instrument if the parts are improperly mounted on the board.

( ) 85. Mount a 9-pin socket at hole AA with the blank space between pins 1 and 9 toward hole AB. Use 3-48 hardware.

( ) 86. Install an offset 1-lug terminal strip at location AB. Use a 6-32 screw, lockwasher and nut. Make sure that the strip is oriented as shown.

( ) 87. In a similar manner, mount an offset 1-lug terminal strip at location AC. Do not secure too tightly, for it will be necessary to remove the screw later.

( ) 88. Install a 2-lug terminal strip at location AF.

( ) 89. Mount a tuning condenser with 6-32 x 3/8 screws through holes AG-AH and AJ. Use lockwashers under the screw heads at AH and AJ and a solder lug under AG. The solder lug should point toward hole AB. Keep the condenser plates fully meshed to avoid possible damage to the unit.

( ) 90. Install a solder lug on tuning condenser frame clip AK, which is nearest terminal strip AB. Secure with a 6-32 x 3/16 screw. The lug should point toward the front of the tuning condenser.

( ) 91. In a similar manner, install a solder lug on the tuning condenser frame clip AL, so that it points toward the back of the condenser. Use a 6-32 x 3/16 screw.

WIRING THE MARKER OSCILLATOR

(✓) 92. Connect a short piece of bare wire from AA4 (NS) to AA5 (S).

(✓) 93. Run a bare wire from socket AA3 (NS) across the socket to AA8 (NS).

(✓) 94. Connect a bare wire from socket AA9 (NS) to solder lug AK (NS).

(✓) 95. Cut the leads of a 22 KΩ resistor (red-red-orange) to a length sufficient to reach and connect the resistor from socket AA7 (NS) to AA9 (NS). Dress the resistor close to the chassis.

( ) 96. Prepare a 150 $\mu\mu f$ condenser (same as .00015 μfd) as before and install it from socket AA7 (S) to tuning condenser lug AM1 (S).

( ) 97. Trim the leads of a 150 Ω resistor (brown-green-brown) and connect it from socket AA8 (NS) to solder lug AK (S).

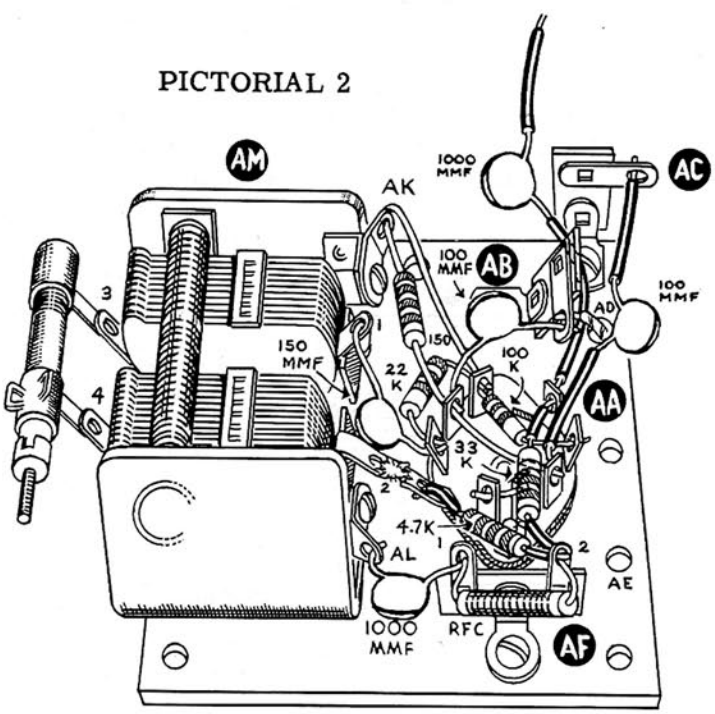
( ) 98. Prepare a 100 KΩ resistor (brown-black-yellow) as before and install it from socket AA2 (NS) to AA9 (S).

( ) 99. Connect a 100 $\mu\mu f$ condenser (same as .0001 μfd) from socket AA8 (S) to terminal lug AB (NS). Use sleeving if necessary to avoid short circuits.

( ) 100. Connect a 4700 Ω resistor (yellow-violet-red) from terminal strip AF2 (NS) to socket AA6 (NS).

( ) 101. Bend tuning condenser stator lug AM2 over toward tube socket pin AA6 carefully. At the same time, bend AA6 back until it rests underneath the tuning condenser lug. Solder the lug, resistor and socket pin securely together.

PICTORIAL 2



( ) 102. Connect one end of a 1000 $\mu\mu f$ condenser (same as .001 μfd condenser) to socket AA1 (NS). Do not cut off any wire on this component for the other end must reach the panel when installed. (Use sleeving.) Place the condenser between terminal strips AB and AC as shown.

( ) 103. Install a 33 KΩ resistor (orange-orange-orange) from terminal strip AF2 (NS) to socket AA1 (S). (Use sleeving)

( ) 104. Connect a 100 $\mu\mu f$ condenser (same as .0001 μfd) from socket AA3 (S) to terminal strip AC (NS). (Use sleeving).

( ) 105. Install an RF choke (a form wound with fine wire) from terminal strip AF1 (NS) to AF2 (S).

( ) 106. Connect a 1000 $\mu\mu$f condenser (same as .001 μfd) from terminal AF-1 (NS) to tuning condenser frame solder lug AL (S).

( ) 107. Bend the tuning condenser stator lugs on the side away from the tube socket down carefully until they are both approximately straight out. Tin both lugs, AM3 and AM4.

( ) 108. Likewise, tin the appropriate lugs on the marker oscillator coil. (The coil with a slug tuning screw.) The lugs to be used are those to which the coil wires are attached.

( ) 109. Hold the coil lugs underneath the tuning condenser stator lugs AM3 and AM4. Heat a stator lug with the soldering iron until the solder flows smoothly over the connection. Let cool and repeat the operation at the opposite end of the coil. Make sure the coil adjustment screw is toward the back of the condenser frame.

( ) 110. Cut a piece of insulated coaxial cable to a length of 6 1/4". Cut away 2 1/4" of rubber outside insulation as shown in Figure 4. Prepare as illustrated, pulling the center conductor through a hole made in the braid close to the end of the insulation.

( ) 111. At the opposite end of the cable, cut away 1 1/8" of outside insulation and prepare as before.

( ) 112. Place the long exposed inner wire through hole AD from the bottom, pulling the wire up until the end of the shielded portion of the wire rests against the bottom of the chassis. Cut the wire to length sufficient to reach terminal strip AB. Strip and tin the wire and connect it to AB (S). Make sure the braid points toward solder lug AG underneath.

( ) 113. Connect the braid to solder lug AG (S) beneath the chassis.

This completes the wiring of the marker oscillator. Set it aside carefully.

ASSEMBLY OF THE SWEEP OSCILLATOR

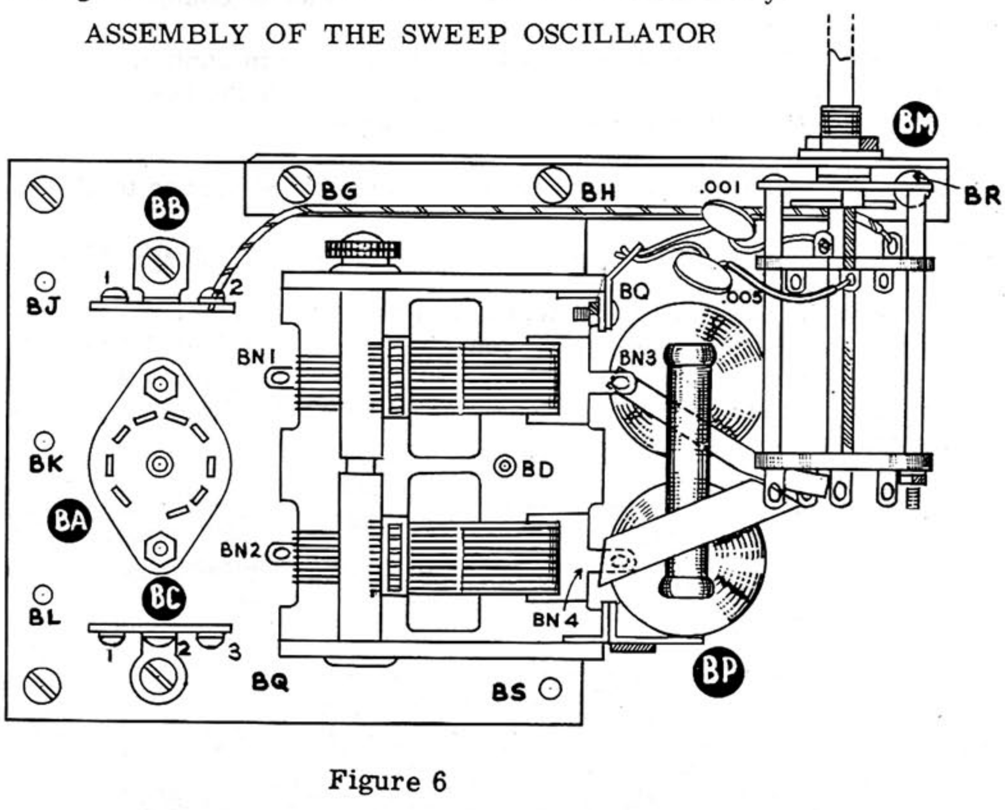


Figure 6

( ) 114. Orient the insulated chassis board so that the tube socket hole is at the left, with the three small irregularly spaced holes nearest you. Check with Figure 6.

( ) 115. Mount a 9-pin socket at location BA with the blank space between pins 1 and 9 toward hole BC. Use 3-48 hardware.

( ) 116. Install a 2-lug terminal strip as shown in location BB. Use 6-32 hardware.

( ) 117. Install a 3-lug terminal strip at location BC.

( ) 118. The switch mounting bracket is installed next, using 6-32 hardware through holes BG and BH.

( ) 119. Install the tuning condenser, securing it with a 6-32 x 3/8 screw through hole BD. Use a lockwasher under the bolt head. Do not place bolts through BE and BF yet.

( ) 120. Install a solder lug on tuning condenser frame clip BQ, using a 6-32 x 3/16 screw.

( ) 121. The front section of the band switch should be wired before the switch is mounted. Refer to Figure 7 and note that lug 6 is the first long clip to the right of the switch wafer mounting post, looking at the switch from the rear. Connect a 2200 Ω (red-red-red) resistor between switch contact 6 (S) and contact 8 (NS).

( ) 122. Cut one lead of a .005 μfd ceramic condenser (same as 5000 μμf) to a length of 3/4" and connect this end to contact 8 (S). (Use sleeving.) Leave the other end free.

( ) 123. Install a 5.6 megohm resistor (green-blue-green) from contact 11 (NS) to contact 12 (NS). These contacts are on the front side of the front wafer.

( ) 124. Cut a wire to a length of 4 3/4". Strip and tin both ends and connect one end to contact 11 (S). Leave the other end free.

( ) 125. Connect a 22 megohm resistor (red-red-blue) from contact 12 (NS) to contact 13 (S).

( ) 126. Cut one lead of a 1000 μμf condenser (same as .001 μfd) to a length of 3/8". Connect this lead to contact 12 (S). Leave the other end free.

( ) 127. Install a 220 KΩ resistor (red-red-yellow) from contact 14 (S) to contact 7 (NS). Place the insulated body of the resistor against the wafer mounting post as shown.

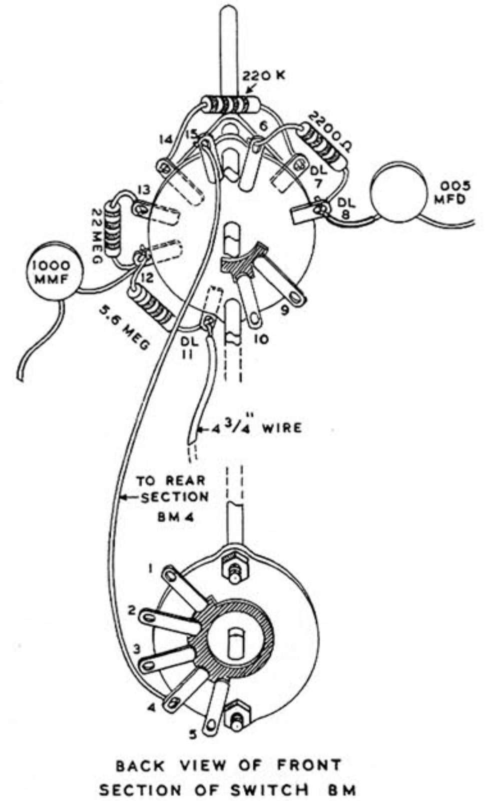


Figure 7

( ) 128. Connect a bare wire from switch contact 15 (S) across to the rearmost wafer contact 4 (NS).

( ) 129. Place a 6-32 x 1 1/2" screw through bracket hole BR, which is beneath the switch mounting hole BM.

( ) 130. Mount the band switch through hole BM in the bracket. The lockwasher will mount between the nut and the bracket. Orient the switch with lugs 1 and 2 pointing toward the tuning condenser as in Figure 8. Leave the switch loosely mounted and place the wire and two condensers connected to the front section of the switch between the tuning condenser and the switch bracket.

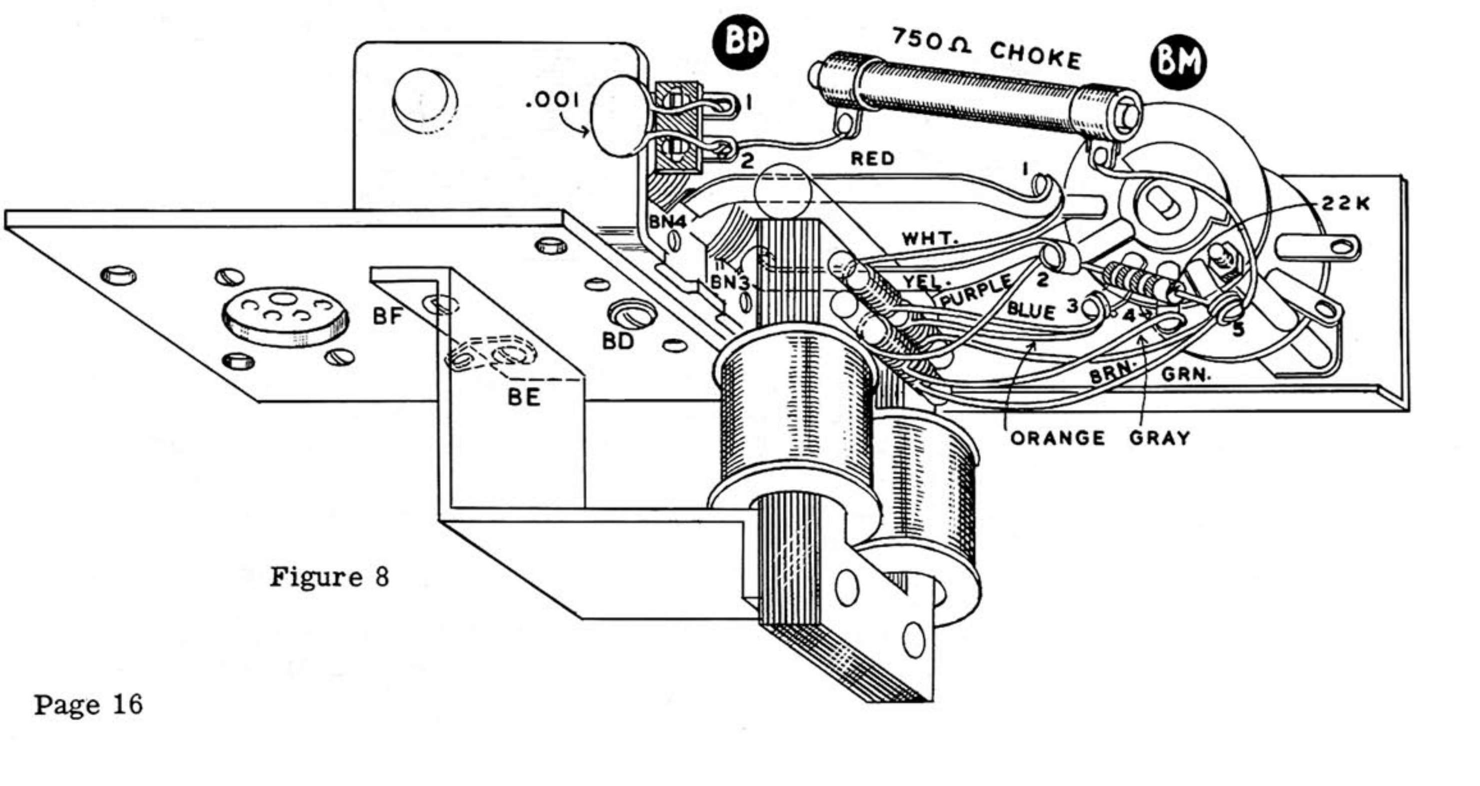


Figure 8

( ) 131. Bend the tuning condenser stator lugs BN3 and BN4 out toward the band switch carefully until they are approximately horizontal.

NOTE: The controllable inductor is quite fragile and should be handled with care. Do not handle the coil leads any more than necessary to connect them to the switch. The Heath Company does not guarantee parts that have been damaged due to neglect or abuse. We strongly urge that the unit be checked carefully with an ohmmeter <u>before</u> it is installed, for it is extremely difficult to remove the unit once it is wired into the instrument. All coils except the high band straps should show continuity. It may be necessary to scrape the terminal lugs in order to check continuity of the primary coils. Low resistance continuity or short circuits must not exist between any of the coils or straps and the frame of the unit. High resistance will be encountered frequently but will not affect the performance.

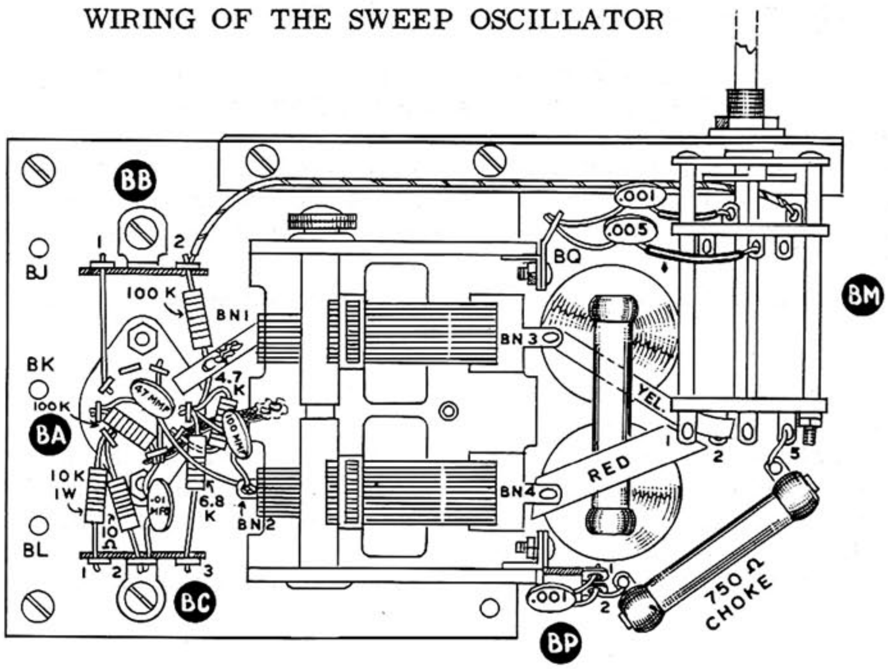
( ) 132. Install the controllable inductor, checking Figures 6 and 8. The ends of the red and yellow high frequency flat straps that are close together should fit between lugs 1 and 2 on switch BM. The opposite ends of the straps should be over stator lugs BN3 and BN4 on the tuning condenser. When everything is properly lined up, secure the unit in place with 6-32 screws through the inductor mounting bracket and holes BE and BF. These same screws hold the tuning condenser. Use a lockwasher under the head of screw BF and a solder lug under the head of screw BE. The solder lug should be toward hole BJ.

( ) 133. Tighten the nut holding band switch BM to the bracket.

( ) 134. Mount a 2-lug (1 lug grounded) terminal strip on the rear right hand clip of the tuning condenser at location BP. Use a 6-32 x 3/16 screw with a lockwasher under the head.

WIRING OF THE SWEEP OSCILLATOR

PICTORIAL 3



Lead dress of wires and components is even more critical in the sweep oscillator than in the marker oscillator due to the wider range of frequencies covered. Extreme care should be exercised to keep all leads as short as possible. Painstaking work will be rewarded with reliable performance.

( ) 135. To begin wiring, bend lugs 1 through 5 on band switch BM until they point straight back at 90° to the wafer. Connect a white coded wire to the top left contact BM1 (NS) on the band switch. See Pictorial 3 and Figure 8.

( ) 136. Wrap the red coded strap end nearest the band switch around switch clip BM1 (S). Make sure solder flows smoothly over the entire connection.

( ) 137. Connect a 22 KΩ resistor (red-red-orange) from contact BM2 (NS) to contact BM5 (NS). The resistor leads should be straight back from the contacts so that it will be possible to wrap the yellow coded strap around BM2 without interference. Keep leads short.

( ) 138. Connect the purple lead from the bottom coil to switch BM2 (NS).

( ) 139. Wrap the nearby end of the yellow high frequency strap around switch BM2 (S). Make sure that the connection is secure.

( ) 140. Connect the blue lead of the middle core to switch BM3 (NS).

( ) 141. Connect the orange lead of the middle core to switch BM3 (S).

( ) 142. Connect the gray lead of the bottom coil to BM4 (S).

( ) 143. Connect the brown lead of the middle core to switch BM5 (NS).

( ) 144. Connect the green lead of the bottom coil to switch BM5 (NS).

( ) 145. Install an RF choke (the 750 Ω 10 watt tubular resistor with a ferrite core cemented through the center) from terminal strip BP2 (NS) to band switch BM5 (S). Check all wires to the switch to be sure that no short circuits exist. Redress the leads slightly if necessary.

( ) 146. Mount a 1000 $\mu\mu$f condenser (same as .001 μfd) between terminal strip BP2 (NS) and grounded terminal BP1 (S).

( ) 147. Wrap the end of the red strap around the adjacent condenser stator lug BN4 (S).

( ) 148. In the same manner, connect the yellow strap to condenser stator lug BN3 (S).

( ) 149. Connect a short piece of bare wire from tube socket BA5 (S) to BA9 (NS).

( ) 150. Cut a piece of wire braid to a length of approximately 1". Solder one end to the tuning condenser frame between the two stators near socket BA7. Dress the opposite end along BA8 (NS) and BA9 (NS). The flat edge should rest against these pins near the socket, exposing the top holes.

( ) 151. Connect a 100 KΩ resistor (brown-black-yellow) from socket BA2 (NS) across the socket to BA9 (NS). Keep the leads as short as possible.

( ) 152. Mount a .01 μfd disc condenser (same as 10,000 $\mu\mu$f) from terminal strip BC2 (NS) to socket BA9 (S). When soldering BA9, make sure that the braid is securely connected.

( ) 153. Connect a 4700 Ω resistor (yellow-violet-red) from socket BA7 (NS) to BA8 (S). Again make sure that BA8 and the braid are securely bonded together.

( ) 154. Install a 100 KΩ resistor (brown-black-yellow) from socket BA7 (NS) to terminal strip BB2 (NS).

( ) 155. Connect a 6800 Ω resistor (blue-gray-red) from socket BA7 (NS) to terminal strip BC3 (NS).

( ) 156. Connect a 100 $\mu\mu$f condenser (same as .0001 μfd) from socket BA7 (S) to condenser stator lug BN2 (NS).

( ) 157. Connect the free end of the wire attached to band switch BM11 to terminal strip BB2 (NS). Dress the wire along the sub-chassis and switch bracket.

( ) 158. Run the free end of the .005 μfd condenser connected to switch BM8 to solder lug BQ (NS) on the tuning condenser frame.

( ) 159. Connect the free end of the 1000 $\mu\mu$f condenser attached to switch BM12 to solder lug BQ (S).

( ) 160. Bend the condenser stator lug BN1 near socket BA6 down carefully, at the same time bending pin BA6 back until the pin is held securely under lug BN1. Solder the two lugs together securely.

( ) 161. Install a 47 $\mu\mu$f condenser (same as .000047 μfd) from condenser stator lug BN2 (S) to socket BA2 (S).

( ) 162. Place a 10 KΩ 1 watt resistor (brown-black-orange) from socket BA1 (NS) to terminal strip BC1 (NS).

( ) 163. Connect a 10 Ω resistor (brown-black-black) from socket BA1 (S) to terminal BC2 (S).

( ) 164. Connect a bare wire from socket BA3 (S) to terminal strip BB1 (NS).

This completes the wiring of the sweep oscillator chassis.

ASSEMBLY OF SUB-CHASSIS TO MAIN CHASSIS

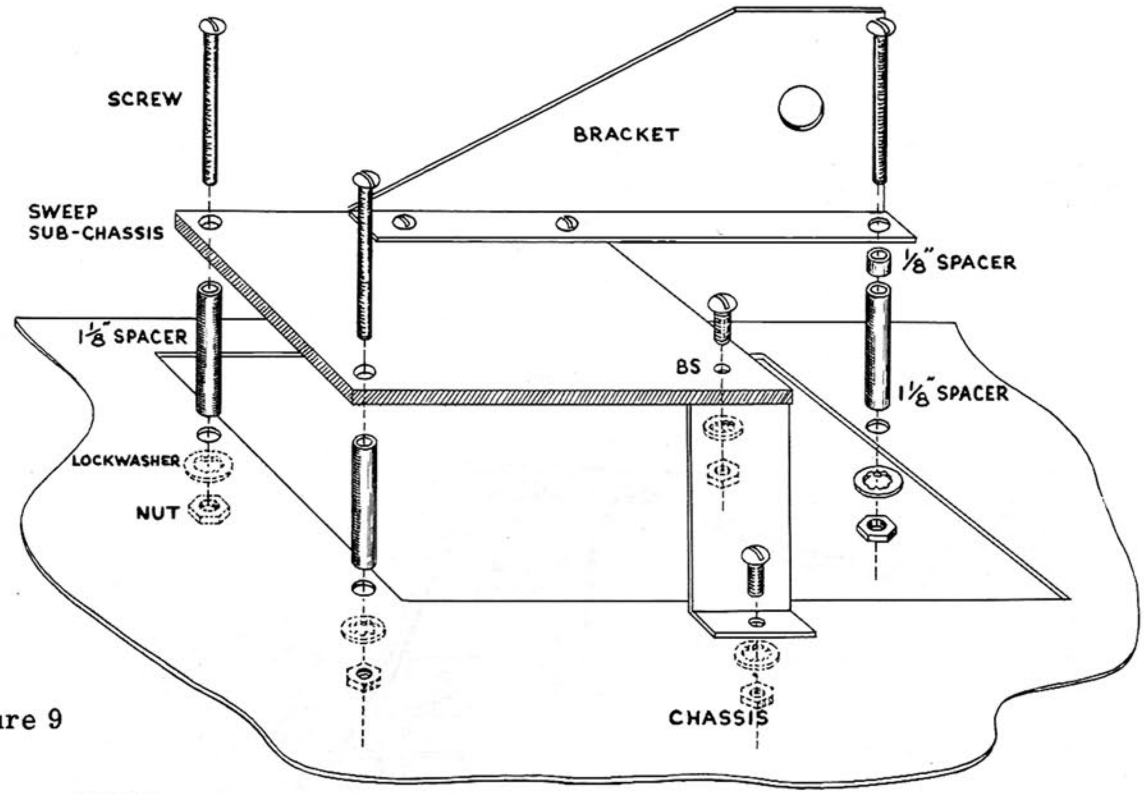


Figure 9

NOTE: FOUR POSTS ARE USED TO MOUNT THE MARKER SUB-CHASSIS

( ) 165. Remove the screw holding terminal strip AC in place on the marker oscillator chassis and insert a 6-32 x 1 1/2" screw in its place. Place 6-32 x 1 1/2" screws through the other three corner holes. Do not install nuts on these screws. See Figure 9.

( ) 166. Remove the screw holding terminal strip K in place on the main chassis.

( ) 167. Slip a 1 1/8" spacer over each screw and mount the assembly by placing the screw ends through the four evenly spaced holes around hole V on the main chassis. Make sure the tuning condenser shaft is toward the front of the main chassis. Hold the assembly securely and fasten in place with 6-32 nuts and lockwashers under the main chassis. Place the coaxial lead through grommet D.

( ) 168. Mount the S-shaped bracket at location BS, using 6-32 hardware. See Figure 9.

( ) 169. Insert 6-32 x 1 1/2" screws through the two corner holes near holes BJ and BL on the sweep oscillator chassis. Do not install nuts on these screws. Slip 1 1/8" spacers over these two screws. Place a 1/8" spacer and a 1 1/8" spacer on the screw at hole BR on the switch bracket installed earlier.

( ) 170. Mount the sweep oscillator chassis in the same manner as the marker chassis, with the switch and condenser shafts toward the front. The three screws are placed through the holes labelled "W" and secured with 6-32 nuts and lockwashers.

( ) 171. Secure bracket BS in place with 6-32 hardware through the hole in the bracket and hole X on the main chassis.

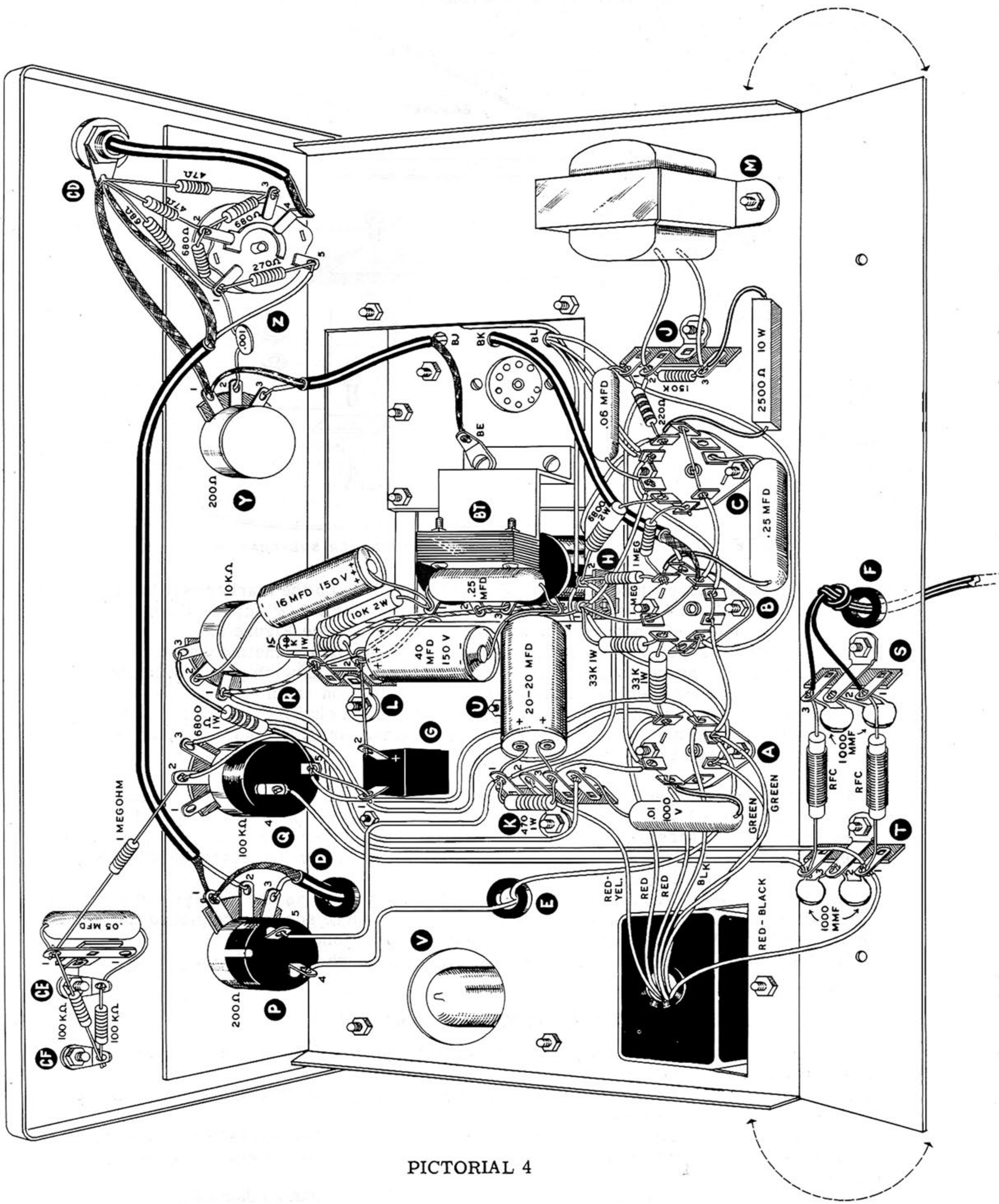
WIRING OF CHASSIS ASSEMBLY

( ) 172. Run the wire from control switch P4 through grommet E up through hole AE in the marker chassis and connect it to terminal strip AF1 (S).

( ) 173. Run the other wire appearing through grommet E (from socket A3) up through hole AE and connect it to socket AA4 (S).

( ) 174. On the sweep oscillator chassis, run the shorter wire from socket C5 up through hole BL and connect it to socket BA4 (S). Curve the wire around so it will clear the tube when installed.

( ) 175. Connect the wire from socket C6 to terminal BP2 (S) near the band switch.



PICTORIAL 4

( ) 176. Run the wire from socket B6 up through hole BL and connect it to terminal strip BC3 (S). Dress this wire close to the sub-chassis, underneath the leads going to BC.

( ) 177. Route the shorter wire from terminal strip H2 along the edge of the chassis cut-out and up through hole BL with the other two wires. Connect this lead to terminal strip BC1 (S).

( ) 178. Connect the other lead from terminal H2 to band switch front wafer clip BM7 (S). Dress the wire along the chassis cut-out edge and up to the switch terminal. A 220 KΩ resistor is already connected to BM7.

( ) 179. Place the center conductor of the shielded lead connected to socket B2 up through hole BK and connect it to terminal strip BB2 (S). Dress the lead so it will clear the tube when installed.

( ) 180. Connect a wire from terminal strip L1 (NS) to band switch BM10 (S).

( ) 181. Run a wire from terminal strip L2 (NS) to band switch BM9 (S).

( ) 182. Install an 18 KΩ 1 watt resistor (brown-gray-orange) from terminal L1 (NS) to L2 (NS).

NOTE: Some model controllable inductors will have two primary lugs while others will have four. These units are electrically identical and the performance will be the same regardless of the model used. If the two-lug model is used, disregard the following step and number the lugs 1 and 4, the number 1 lug being closest to the front of the chassis. The described jumper connection is made internally.

( ) 183. Connect a bare wire jumper from controllable inductor BT2 (S) to BT3 (S).

( ) 184. Install a .25 μfd 400 volt tubular condenser from inductor BT1 (NS) to BT4 (NS).

( ) 185. Mount a 40 μfd 150 volt electrolytic capacitor from inductor BT4 (NS) to terminal strip L2 (S). The positive end (+) must be connected to L2.

( ) 186. Run a wire from control R1 (S) to inductor BT4 (S).

( ) 187. Connect a 10 KΩ 2 watt resistor (brown-black-orange) from terminal strip L1 (S) to inductor BT1 (NS).

( ) 188. Install a 16 μfd 150 volt electrolytic tubular condenser from control R2 (S) to inductor BT1 (S). The positive end (+) must be connected to BT1.

PREPARATION OF THE FRONT PANEL AND FINAL ASSEMBLY

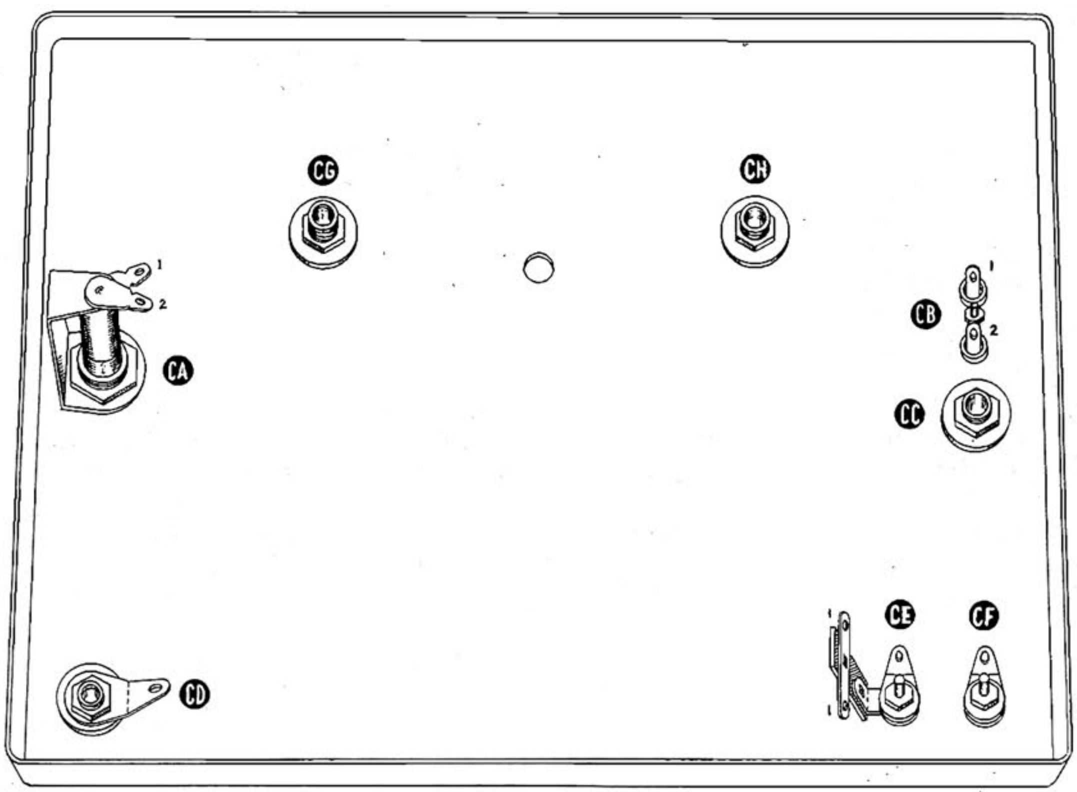


Figure 10

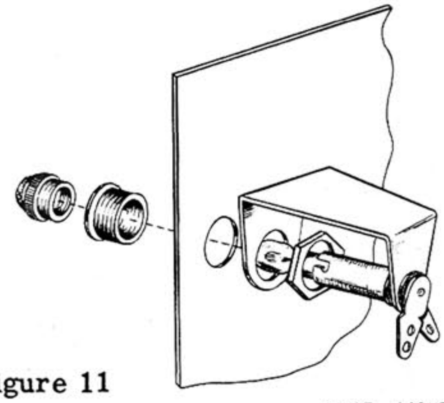


Figure 11

PILOT LIGHT ASSEMBLY

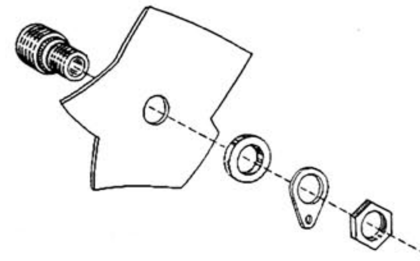


Figure 12

( ) 189. Mount the pilot light socket at location CA as shown. Place the large bushing through the panel from the front. Slip the socket assembly over the bushing and secure it with a large nut. See Figure 11.

( ) 190. Install the crystal socket at location CB, using a 4-40 x 1/2 screw and nut.

( ) 191. At location CC, mount a coaxial connector. Remove the large solder lug for it will not be used. A large thick washer is installed between the panel and nut. See Figure 12.

( ) 192. In a similar manner, mount a coaxial connector at location CD, this time using the large solder lug between the nut and washer. The solder lug should be toward holes CE and CF.

( ) 193. Insert a binding post base through a flat fiber washer, hole CE in the panel, a single lug terminal strip and a solder lug. Secure with a 6-32 nut. Orient the parts as shown in Figure 10.

( ) 194. Install a binding post base at location CF as shown in Figure 13. The base goes through a fiber shoulder washer, the panel, a flat fiber washer, a solder lug and a 6-32 nut. Make sure the washers are properly seated before tightening the nut.

( ) 195. Mount a shaft bushing at location CG. No washer is used between the bushing shoulder and the front side of the panel. Place a control lockwasher between the panel and control nut and tighten securely.

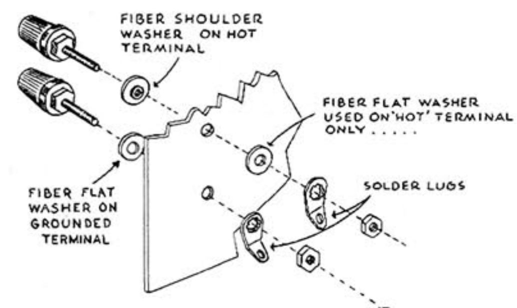


Figure 13

( ) 196. In the same fashion, install a bushing at location CH.

( ) 197. Place a flexible insulating coupling on the end of the sweep oscillator and marker oscillator tuning condenser control shaft, securing each one by tightening the set screw provided.

( ) 198. Remove the nuts holding controls P, Q, and R in place on the main chassis. Slip the panel in position over the control bushings and secure by re-installing the nuts with flat control washers underneath on controls P, Q, and R. Do not tighten the nuts until all controls are installed.

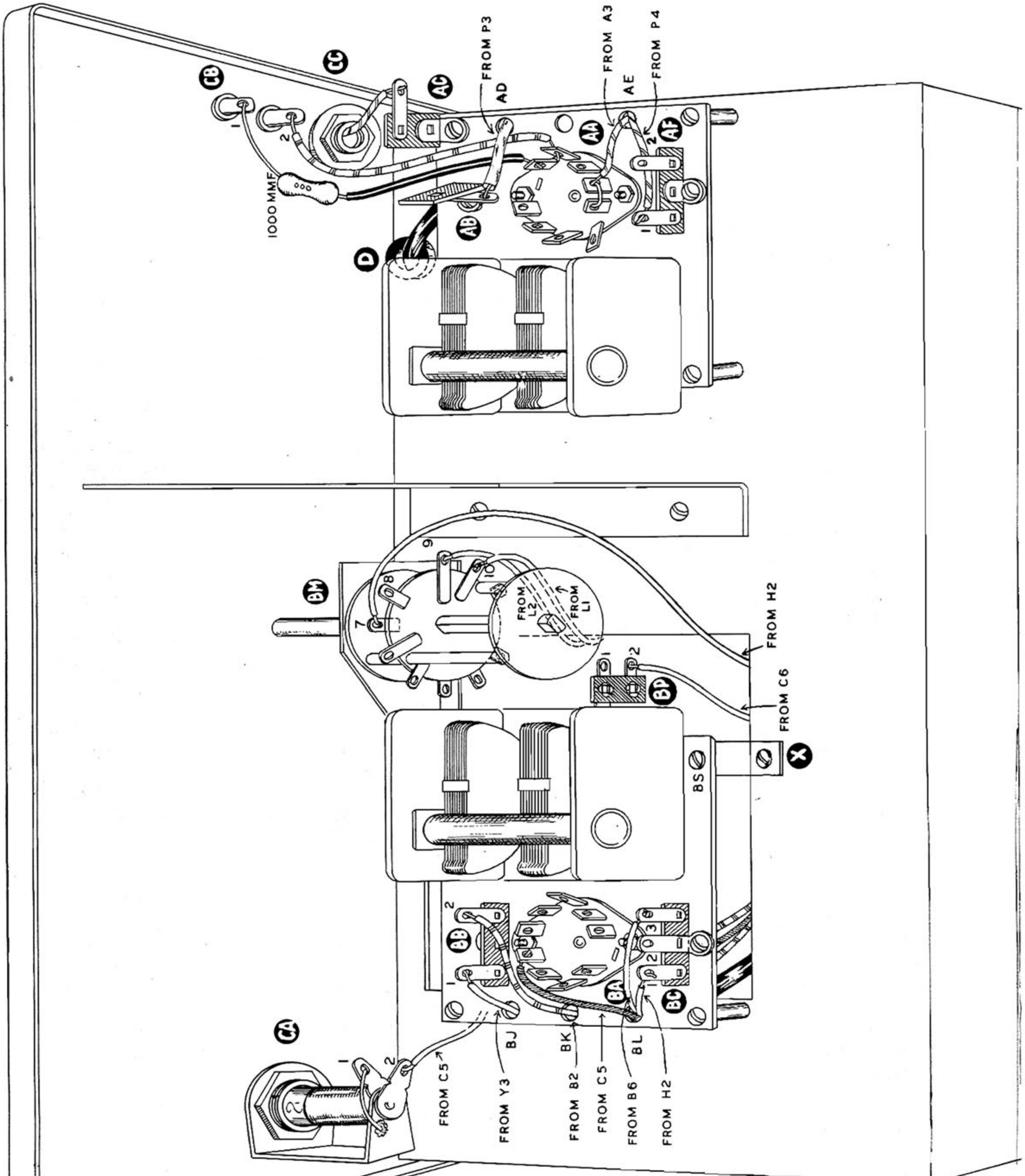
( ) 199. Install a 200 Ω control at location Y, using a lockwasher, flat washer and control nut.

( ) 200. In like fashion, install the attenuator switch at location Z. The lugs holding the switch wafer in place should be straight up and down with the dummy lug toward control Y. See Pictorial 4.

( ) 201. Place the shorter of the two pieces of 1/4" insulated rod through bushing CH and into the nearby flexible coupling. Tighten the set screw to secure the assembly.

( ) 202. In the same manner, install the longer insulated rod through bushing CG.

NOTE: If serious misalignment is evident, try shifting the panel in respect to the chassis, the bushings in respect to the panel and either or both sub-chassis in respect to the main chassis. This can be accomplished by loosening the bushing or sub-chassis mounting nuts and re-tightening them after proper alignment is achieved.


CB
CC
AC
FROM P3
AD
FROM A3
AE
FROM P4
AA
AF
AB
1000 MMF
D
BM
FROM L2
FROM L1
FROM H2
BP
FROM C6
X
BS
CA
FROM C5
BB
BA
BC
BJ
BK
BL
FROM Y3
FROM B2
FROM C5
FROM B6
FROM H2

PICTORIAL 5

( ) 203. Tighten all control nuts.

( ) 204. Remove the screw holding terminal strip L in place on the main chassis and place the large baffle plate in position so that its mounting holes line up with holes L and U on the chassis. See Pictorial 5. Secure in place with 6-32 bolts through holes L and U.

FINAL WIRING

( ) 205. Connect the remaining wire from socket C5 to pilot lamp socket CA2 (S). Dress the wire along the top of the chassis.

( ) 206. Connect a bare wire from pilot lamp socket CA1 (S) to the frame of the socket (S) as shown in Pictorial 5.

( ) 207. Connect a 100 KΩ resistor (brown-black-yellow) from binding post solder lug CE (NS) to solder lug CF (NS).

( ) 208. Install a .05 μfd 200 volt tubular condenser from panel terminal strip CE1 (NS) to solder lug CE (S).

( ) 209. Mount a 100 KΩ resistor (brown-black-yellow) from terminal strip CE1 (NS) to solder lug CF (S).

( ) 210. Connect a 1 megohm resistor (brown-black-green) from terminal strip CE1 (S) to control Q2 (S).

( ) 211. Cut a piece of coaxial cable to a length of 5". Cut away 1 5/8" of rubber outside insulation. Pull the inner conductor through the side of the braid near the end of the outside insulation as before.

( ) 212. At the opposite end, cut away 1" of outside insulation and pull the inner conductor through the side of the braid.

( ) 213. Place the long exposed inner conductor up through hole BJ in the sweep sub-chassis. With the braid snug against the bottom side of the sub-chassis, cut the inner wire to length sufficient to reach terminal strip BB1 and connect it to BB1 (S).

( ) 214. Connect the braid at this end to solder lug BE (S) on the mounting frame of the controllable inductor.

( ) 215. At the opposite end, connect the center wire to control Y3 (S).

( ) 216. Connect the adjacent end of the braid to control Y1 (NS).

( ) 217. Install a 680 Ω resistor (blue-gray-brown) from attenuator switch Z1 (NS) to Z2 (NS).

( ) 218. Connect a 680 Ω resistor from switch Z2 (NS) to Z3 (NS).

( ) 219. Connect a 270 Ω resistor (red-violet-brown) from switch Z1 (NS) to dummy lug Z5 (NS).

( ) 220. Connect a 68 Ω resistor (blue-gray-black) from switch Z1 (NS) to solder lug CD (NS).

( ) 221. Install a 47 Ω resistor (yellow-violet-black) from switch Z2 (S) to solder lug CD (NS).

( ) 222. Connect a 47 Ω resistor from switch Z3 (S) to solder lug CD (NS).

( ) 223. Connect a 1000 μμf condenser (same as .001 μfd) from control Y2 (S) to switch Z1 (S). Keep these leads as short as possible.

( ) 224. Run a piece of flat braid from control Y1 (S) to solder lug CD (NS).

( ) 225. Twist one end of a piece of flat braid until it will fit into the center contact hole of coaxial connector CD. Push the braid into the hole until it protrudes slightly and solder the connection from the front. Allow the solder to build up a smooth connecting surface.

( ) 226. Slip large sleeving over the braid, making sure that it goes well into the connector to prevent shorts. Connect the opposite end of the braid to Z4 (S). Keep this lead as short as possible.

( ) 227. Cut a piece of coaxial cable to a length of 10 3/4". Cut away 2" of outer insulation and pull through the center conductor as previously described.

( ) 228. Prepare the opposite end by cutting away 1" of outer insulation and pulling the center wire through a hole in the braid.

( ) 229. Connect the long exposed inner conductor to switch Z5 (S).

( ) 230. Connect the adjacent braid end to solder lug CD (S).

( ) 231. Connect the center conductor of the cable appearing through grommet D to control P3 (S).

( ) 232. Connect the braid of this cable to control P1 (NS).
( ) 233. Connect the center wire of the cable from switch Z5 to control P2 (S).
( ) 234. Run the adjacent end of the braid to control P1 (S).
( ) 235. On top of the chassis, connect a wire from marker chassis terminal strip AC (S) to the center contact of coaxial connector CC (S).
( ) 236. Run a wire from marker socket AA2 (S) to crystal socket CB2 (S).
( ) 237. Connect the lead of the 1000 $\mu\mu$f condenser from socket AA1 to crystal socket CB1 (S).

This completes the wiring of your Heathkit model TS-4 Television Alignment Generator. Carefully recheck each operation for accuracy. Remove any solder splashes, wire clippings or other foreign material. Inspect the wiring to be sure all components and wires are dressed to avoid shorts to each other or to chassis. Once sure that everything is correct, the group of wires running from back to front of the chassis, past the selenium rectifier, may be cabled together with string or insulating tape if desired. Doing this will reinforce the wiring and improve the appearance of the unit. Likewise, the wires going to sweep chassis hole BL may be cabled since they carry only AC and DC power.

( ) 238. Place the knobs on the control shafts with the indicator lines at the left hand panel marks when the controls are rotated fully counterclockwise. Whenever necessary, install set screws in the knobs and secure in place.
( ) 239. The indicator knobs for the marker and sweep oscillator sections should be indexed at the right hand indexing mark with the condenser plates fully meshed.
( ) 240. Install the #47 bulb in the pilot lamp socket and turn the jewel in place.
( ) 241. Install the binding post caps, with the red cap on the outside edge.

IMPORTANT WARNING: MINIATURE TUBES CAN BE EASILY DAMAGED WHEN INSTALLING THEM IN THEIR SOCKETS. THEREFORE, USE EXTREME CARE WHEN INSTALLING THESE TUBES. WE DO NOT GUARANTEE OR REPLACE MINIATURE TUBES BROKEN DURING INSTALLATION.

( ) 242. Insert the 12AX7 tube in socket B, the 6CL6 in socket C, the 12AT7 up through hole V to marker chassis socket AA and the 6BQ7A in sweep chassis socket BA. DO NOT install the 6X4 rectifier yet.
( ) 243. Install the handle on the instrument cabinet, using 10-24 hardware.
( ) 244. Mount the rubber feet in the bottom of the cabinet by pushing the small end through the hole in the cabinet and rotating until they lock in place.

WIRING OF TEST LEADS

( ) 245. Cut away 3/4" of outer insulation on a 3' length of coaxial cable. Pull the center conductor through the side of the braid as before. Strip off 1/4" of insulation from the center conductor and tin the exposed wire.
( ) 246. Prepare the output connector by mounting two binding posts on the terminal half shell with the binding posts going through the shell, #6 solder lugs and 6-32 nuts.
( ) 247. Install a red binding post cap on one base and a black binding post cap on the other as shown in Figure 14.

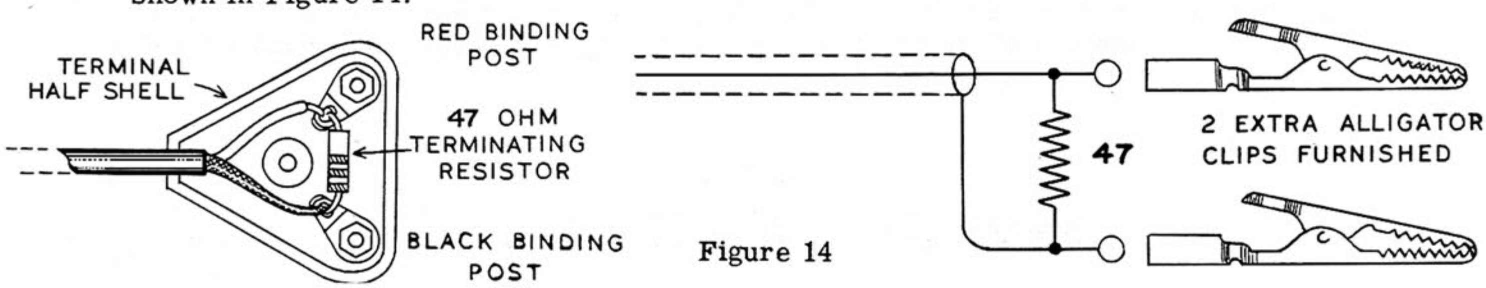


Figure 14

( ) 248. Connect the center conductor of the cable just prepared to the solder lug (NS) on the red binding post.
( ) 249. Twist the braid to form a small pigtail and connect it to the solder lug (NS) on the black binding post.

( ) 250. Install a 47 Ω resistor (yellow-violet-black) between the two solder lugs.(S). Avoid touching the shell with the soldering iron.

( ) 251. Install the other terminal half shell with a long 6-32 screw and nut. Make sure the cable is properly clamped with a little slack between the clamping point and the solder lugs.

( ) 252. Prepare the opposite end of the cable by cutting off 1/2" of outer insulation and pulling through the center conductor. Remove the spring from the coaxial connector and slip the large end over the outer insulation. Bend the braid back over the small end of the spring. Strip about 1/4" of insulation from the center wire, tin the end and push it through the center hole of the connector (S). Tighten the set screw to hold the spring and braid in place. Figure 15 shows assembly detail of this connector.

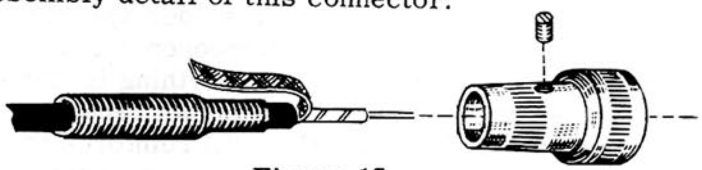


Figure 15

( ) 253. The compensated isolating 'scope lead is prepared by cutting away 2 3/4" of outer insulation from a 3' length of cable. Pull the center wire through the braid as before. Cut the center lead to a length of 1 1/4" and strip the end. Cut one lead of a 56 KΩ resistor (green-blue-orange) to a length of 1/2" and connect this end to the end of the center conductor (NS). Cut one lead of a 1000 $\mu\mu$f condenser (same as .001 μfd) to a length of 7/8" and connect this lead to the juncture of the resistor and center wire (S). Dress the condenser wire along the center wire insulation and wrap the other lead around the braid at the end of the outer insulation (S). Cut a piece of large sleeving 2" long and slip it over the resistor and center wire until it rests against the body of the condenser. Solder an alligator clip to the end of the braid and another clip to the end of the resistor as shown in Figure 16.

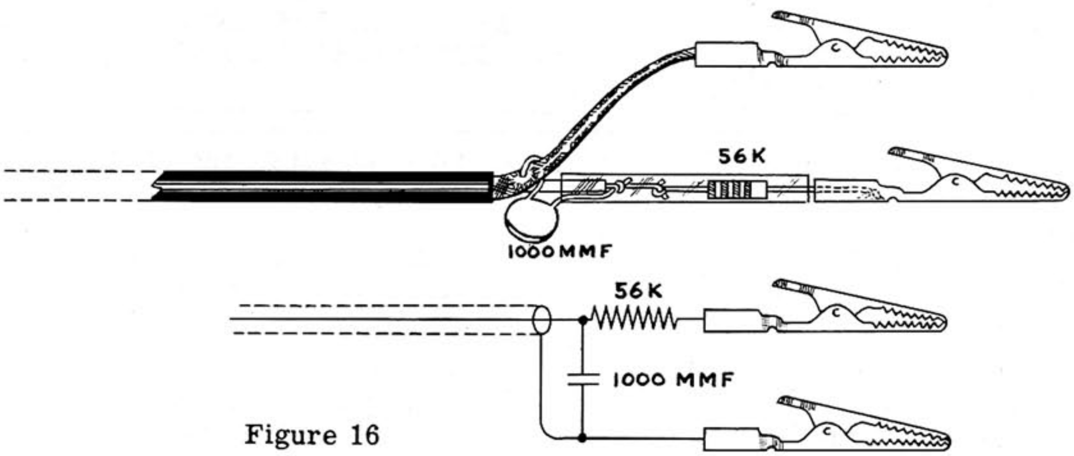


Figure 16

( ) 254. At the opposite end of the cable, strip away 1 1/2" of outer insulation and pull the center conductor through the side of the braid. Strip about 1/4" of insulation from the center conductor and tin the exposed wire. Slip a red sleeve over a banana plug so that the holes line up and push the wire in as far as it will go. Secure the assembly with a small 4-40 screw. Twist the end of the braid tightly, tin the end and secure to a banana plug with a black sleeve in the same manner. See Figure 17.

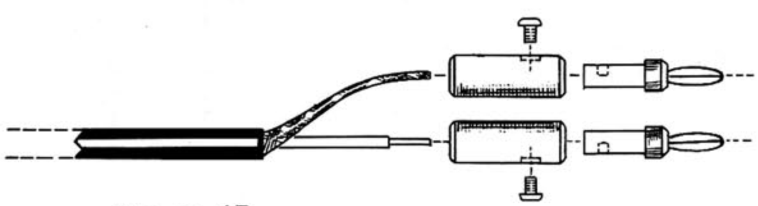


Figure 17

( ) 255. In the same fashion as above, prepare the 'scope horizontal drive cable, installing banana plugs on both ends.

TESTING THE COMPLETED INSTRUMENT

If an ohmmeter is available, check the DC resistance between pin 7 of 6X4 socket A and ground. The resistance should be at least 20,000 ohms after one minute. If lower, carefully recheck wiring for an error. Give special attention to the connections around the 6X4 socket, the filter condenser, terminal strips H and BP and 6CL6 socket C.

Make sure that the line switch is off by rotating the HOR. PHASE control to its full counterclockwise position. Connect the line cord to a 105-125 volt 50/60 cycle AC outlet. DO NOT CONNECT THIS INSTRUMENT TO A DC (DIRECT CURRENT) LINE. SERIOUS DAMAGE TO THE POWER TRANSFORMER WILL RESULT. Do not attempt to use this instrument on a 25 cycle AC source, for it will not operate and the transformer may be damaged.

Turn the instrument on by rotating the HOR. PHASE control clockwise until a click is heard. The filaments of all tubes should light. Now insert the 6X4 rectifier tube in its socket. The filaments should light. Observe the metal elements in the tube to make sure that they remain dark colored. A red glow from the plates of the rectifier indicates the existence of a short circuit somewhere in the B+ circuit and further checks will be necessary to locate the trouble.

ALIGNMENT OF THE INSTRUMENT

Calibration of the marker generator is easily accomplished, for an accurate calibration reference is furnished with the kit. Connect the terminated output lead to the EXT. MARKER post on the front panel. The opposite end of this cable should be connected to the RF probe of a signal tracer or the demodulator probe of an oscilloscope. If neither of these is available, any amplifier or oscilloscope can be used with a crystal diode in series with the input lead. Plug 4.5 mc (4500 kc) crystal into XTAL socket. Turn the instrument on and rotate MARKER AMP. control fully clockwise. Set the indicator to 22.5 mc (the fifth harmonic of the crystal) and adjust the marker oscillator coil slug until a beat note or squeal is heard, or a fuzzy trace appears on the oscilloscope with the 'scope gain at maximum if an oscilloscope is used. Next, set the dial to 27 mc (the sixth harmonic). A beat note should again be evident. The next check points should be at 31.5 mc and 36 mc. If the beat notes occur at frequencies other than those indicated slip the pointer slightly on the shaft and again adjust the marker coil slug. This effectively trims and pads the oscillator to get it to track with the dial markings. It may be necessary to repeat this operation several times to obtain the desired degree of accuracy. If the error should become worse, slip the indicator on the shaft in the opposite direction a small amount at a time until the marker tracks properly. If it is impossible to obtain satisfactory tracking, there is a chance that the oscillator is beating against the wrong harmonic of the crystal. To correct this condition, set the indicator to 22.5 mc once again. Adjust the oscillator coil slug until a beat is heard that is a different one than originally obtained. Then, repeat the operations described above. Once the beats occur at the proper places, the oscillator is correctly calibrated. In general, the slug will be fairly well into the coil when proper calibration is obtained.

In some rare instances, it may be difficult or impossible to properly calibrate the marker oscillator due to a shift of tuning condenser calibration, which may have been caused by handling in transit. Usually the errors will be rather minor, but then they can be cleared up entirely by making a very simple adjustment of the tuning condenser itself.

If it is impossible to obtain good tracking over the entire marker range, it would be advisable to set the dial to 54 mc and adjust the screw slightly until the beat note is evident. The dial should then be rotated to 58.5 to make sure that the right beat is being used. Once sure that the correct frequency has been obtained, move the dial lower in frequency until a discrepancy shows up. When an error does appear, it should be noted whether the dial reads high or low in frequency. If the dial reads high, it will be necessary to turn the condenser outward a little bit and bend the outside serrated plate outward slightly at the point where the frequency error was evident. Reset the condenser to the original setting to see whether or not the error is still present. By very gently pushing the outside plates outward, the gang can be effectively knifed until good accuracy is obtained. Of course, if the frequency reads low, it will be necessary to push the plates inward gently to get the same effect. After this discrepancy has been cleared up, the accuracy should be checked once again at the high end of the dial. When sure that everything is all right, the tuning condenser should be set to a lower frequency until the next discrepancy, if any, appears. Again, a very minor adjustment of the plates will allow this point to be brought in tolerance. Continuing this procedure until the bottom frequency of 22.5 mc is calibrated will insure that a degree of accuracy better than 1% can be obtained over the entire range of the marker oscillator.

Fine calibration of the sweep oscillator dial is not necessary. This portion of the instrument is calibrated by indexing the pointer to the line to the right of band identification letters A, B, C and D with the tuning condenser plates fully meshed. Proper identification of the sweep frequency is accomplished by use of the marker generator.

Similarly, the SWEEP WIDTH control is not calibrated, for the markers will quickly reveal the band width of any circuit being aligned.

IMPORTANT NOTE: If the markers show up moving right to left when the marker frequency is increased, the blanking circuit is operating 180 degrees out of phase. This condition can be corrected quickly by simply reversing the black and black-red leads of the power transformer. These leads are connected to terminal strip T1 and tube socket A2.

Install the instrument in the cabinet, securing with self-tapping screws through the holes in the back.

OPERATION OF THE TS-4 TELEVISION ALIGNMENT GENERATOR

MARKER OSCILLATOR

An extremely versatile marker circuit is employed in the Heathkit Television Alignment Generator. It is capable of providing single, dual or multiple markers, depending upon the desire of the operator. The high output level of the variable marker oscillator makes it possible to use harmonics as well as fundamentals, thus greatly extending the usefulness of this section of the instrument.

The primary function of the marker oscillator is to give an accurate single frequency which can be used to identify portions of a bandpass waveform. This is accomplished by beating a portion of the marker oscillator output against the sweep oscillator output within the instrument. When the frequencies of the two oscillators approach the same point, the difference between the two frequencies will be within the audio range and will show up on the trace as a fuzzy line. If a wide band oscilloscope is used, this line will extend practically the full length of the trace, since most modern oscilloscopes are capable of reproducing frequencies up into the RF spectrum. In order to reduce the oscilloscope response and sharpen the marker pip, a specially compensated scope lead is furnished. This lead provides scope isolation preventing distortion of the trace as well as reducing the high frequency response.

To identify bandwidth of a tuned circuit, the marker pip is set to a point 30% down the slope of one side of the waveform and the frequency on the marker dial noted. The pip is then set to a point 30% down the opposite side and the frequency noted again. The difference between the two frequencies will be the bandwidth of the circuit under test.

When adjusting the bandpass waveform of a circuit, the marker is set to the high or low side of the waveform, depending on which is to be adjusted. The RF or IF transformer adjustment is then made until the waveform conforms to the manufacturer's specifications.

The crystal oscillator is designed so that the output of the crystal oscillator is mixed with the output of the variable marker oscillator in a common cathode resistor. This causes the crystal frequency and its harmonics to be present at the output also, as well as the mixed frequencies, which are the sum and difference of the crystal and variable oscillator outputs. Thus, if the variable marker is operating at 25 mc and the crystal is in its socket, the output frequencies will be 25 mc, 29.5 mc and 20.5 mc. Therefore, if the variable marker is set to the high or low side of a wide band IF or RF waveform, another marker will appear at a point 4.5 mc away on the opposite side of the waveform. Markers spaced farther apart or closer together can be obtained by substituting crystals of higher or lower frequency, respectively.

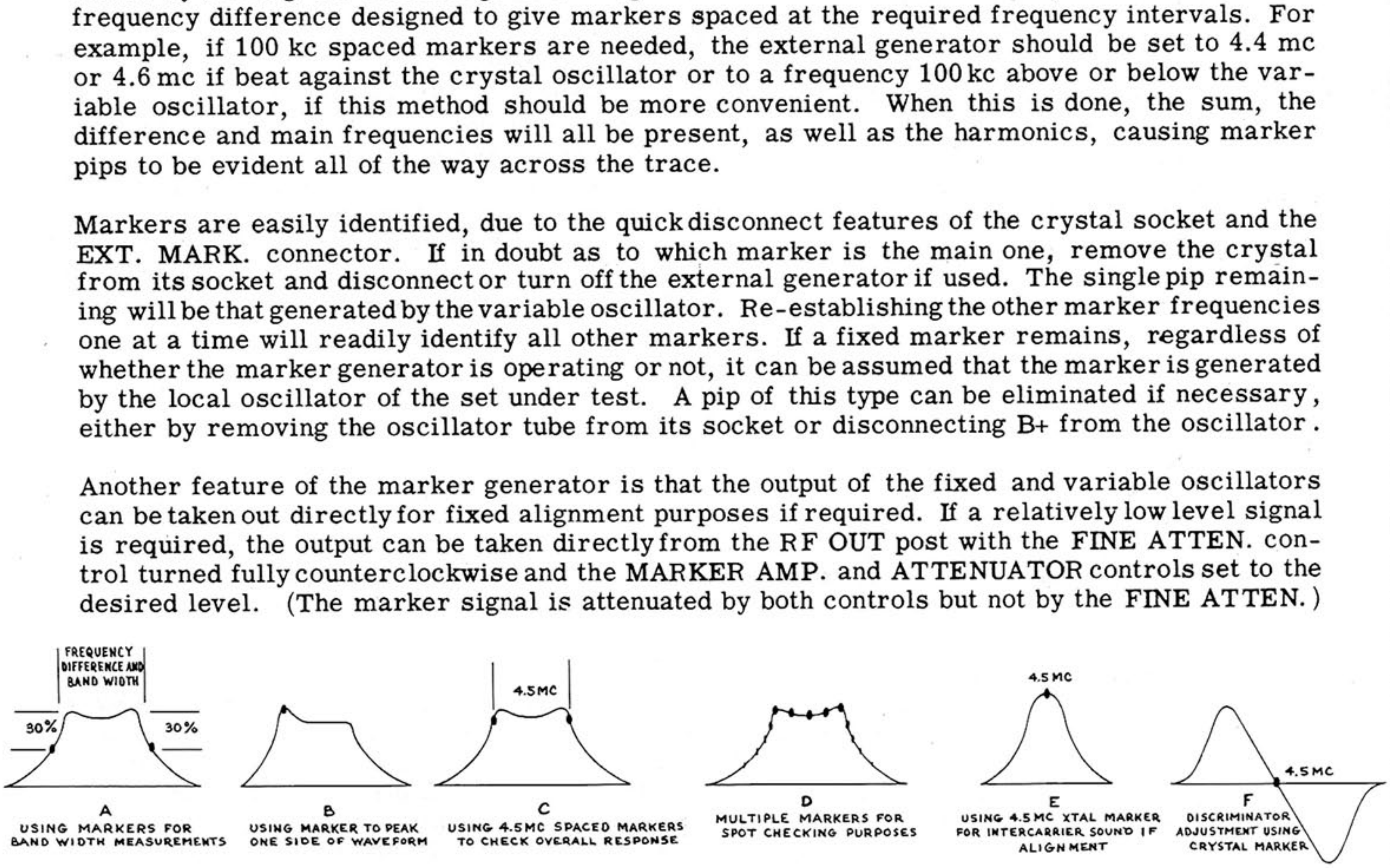
It must be remembered that the crystal operates on harmonics at these higher frequencies and so the 4.5 mc spaced markers will be much lower in amplitude than will the fundamental marker provided by the variable oscillator. Usually a good check can be obtained by moving the variable oscillator marker pip well down one side of the trace so that the marker gain can be turned up without distorting the trace. The other bandwidth marker will then show up clearly on the opposite side. Sometimes the bandwidth marker amplitude can be effectively increased by simply moving the variable marker to the opposite side of the trace. In some cases, the plus beat may be more evident than the minus beat or vice versa.

Many additional uses for the crystal marker exist. Direct crystal markers can be obtained by use of a crystal operating directly at the desired frequency or at a harmonically related lower frequency. The 4.5 mc crystal furnished with the kit is very useful as a signal generator for the alignment of the 4.5 mc sound IF encountered in intercarrier TV sets. It also provides a highly accurate marker when sweep techniques are used. For FM alignment purposes, a 10.7 mc or a 5.35 mc crystal can be used to give a highly accurate marker. Harmonics of a crystal of this frequency can also be used for FM RF alignment. The ninth and tenth harmonics of a 10.7 mc crystal both fall in the 88-108 mc FM spectrum. The 18th, 19th and 20th harmonics of a 5.35 mc crystal could be used in the same manner. Similarly, crystals having harmonics in the TV IF or RF regions can be used if needed.

Multiple markers can be achieved by feeding the output of an external signal generator into the EXT. MARK. connector. Output of the external generator can be used to give direct marker indication at any frequency within the range of the generator. The MARKER AMP. control will also control the level of any signal fed into the EXT. MARK. connector. Multiple markers are obtained by beating the external generator against either the variable or crystal oscillator at a frequency difference designed to give markers spaced at the required frequency intervals. For example, if 100 kc spaced markers are needed, the external generator should be set to 4.4 mc or 4.6 mc if beat against the crystal oscillator or to a frequency 100 kc above or below the variable oscillator, if this method should be more convenient. When this is done, the sum, the difference and main frequencies will all be present, as well as the harmonics, causing marker pips to be evident all of the way across the trace.

Markers are easily identified, due to the quick disconnect features of the crystal socket and the EXT. MARK. connector. If in doubt as to which marker is the main one, remove the crystal from its socket and disconnect or turn off the external generator if used. The single pip remaining will be that generated by the variable oscillator. Re-establishing the other marker frequencies one at a time will readily identify all other markers. If a fixed marker remains, regardless of whether the marker generator is operating or not, it can be assumed that the marker is generated by the local oscillator of the set under test. A pip of this type can be eliminated if necessary, either by removing the oscillator tube from its socket or disconnecting B+ from the oscillator.

Another feature of the marker generator is that the output of the fixed and variable oscillators can be taken out directly for fixed alignment purposes if required. If a relatively low level signal is required, the output can be taken directly from the RF OUT post with the FINE ATTEN. control turned fully counterclockwise and the MARKER AMP. and ATTENUATOR controls set to the desired level. (The marker signal is attenuated by both controls but not by the FINE ATTEN.)



FM IF AND DETECTOR PATTERNS ARE SIMILAR TO FIGURES E AND F EXCEPT THAT MARKER FREQUENCY WILL USUALLY BE 10.7 MC.

NOTE: IN MANY CASES, THE PATTERNS WILL APPEAR INVERTED ON THE OSCILLOSCOPE SCREEN. PATTERN POLARITY DEPENDS UPON THE TYPE OF DETECTOR EMPLOYED IN THE SET UNDER TEST. INVERTED PATTERNS ARE JUST AS EASY TO INTERPRET AND SHOULD NOT CAUSE DIFFICULTY IN ALIGNMENT

Figure 18

Should higher level output be required, the output cable should be connected to the EXT. MARK. connector and the energy taken directly from the oscillators. When this is done, it must be remembered that the attenuator is ineffective and it may be necessary to attenuate the signal by means of a resistor in series with the "hot" output lead. The value of this resistor will depend upon the amount of attenuation required. When the marker generator is used in this manner, unmodulated signal from the variable or fixed oscillators can be used to align traps, RF and IF tuned amplifiers and discriminators. The 4.5 mc output of the crystal can be used directly for sound IF alignment of intercarrier type TV sets. Traps etc. are adjusted by setting the variable oscillator to the required frequency and adjusting for a null on a VTVM or oscilloscope. The crystal oscillator can be used as a fixed frequency generator for many additional purposes by substituting crystals of the correct frequency for the application. The crystal oscillator was designed to operate with high frequency crystals, operating at frequencies of 1 mc or more and so reliable operation with lower frequency crystals cannot be obtained. When purchasing crystals at a fundamental frequency near 1 mc, make sure that it is a high sensitivity type, for many 1 mc crystals will not function in this type of circuit.

MARKER AMPLITUDE CONTROL

Attenuation of the marker oscillator output is accomplished by use of the MARKER AMP. control. This control should always be set to a point where the markers are easily seen but no higher. Excessive marker amplitude will result in severe distortion of the trace. If distortion is noted when the marker frequency is varied, reduce the control setting until the undesirable condition disappears. It may be difficult to achieve adequate attenuation of marker amplitude when working with extremely high gain circuits. When this occurs, improvement of control can be obtained by increasing the value of the 270 Ω resistor connected between lugs Z1 and Z5 of the attenuator switch. When the markers are not required, they can be turned off by rotating the MARKER AMP. control to MARKER OFF.

SWEEP OSCILLATOR

The sweep oscillator uses the center frequency sweep system, providing excellent frequency and amplitude linearity at all frequencies. Blanking occurs for 180 degrees of the line cycle, which gives an excellent straight reference line to help alignment. To set up the sweep generator, it is only necessary to set the sweep dial to the center frequency of the tuned stage to be aligned and turn up the SWEEP WIDTH control until a satisfactory trace is obtained. If the left hand edge (the low frequency side) of the trace is square instead of coming down to a point with the base reference line, set the sweep dial to a slightly lower frequency until the beginning of the trace comes down to the reference line. See Figure 19. If the right hand edge of the trace is squared off, increase the frequency setting of the OSCILLATOR dial. When both ends are clipped increase the SWEEP WIDTH control setting. Center the trace by adjusting the HOR. PHASE and OSCILLATOR controls as necessary.

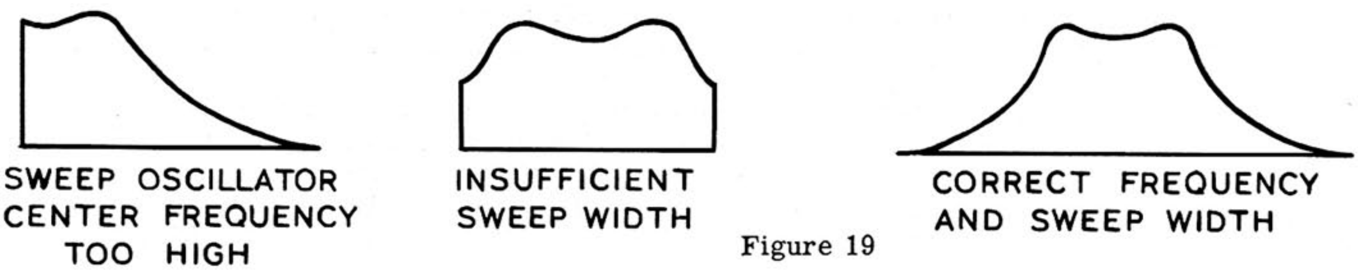


Figure 19

High fundamental output from the sweep oscillator makes it possible to align single or multiple stages of a receiver as required. The output is more than sufficient to give a very readable trace on a scope connected to the video detector when the generator is connected to the grid of the last video IF stage. Careful design of the attenuator circuit gives adequate control of this high output level, allowing easy operation of the instrument into multiple stage high gain amplifiers as well as single stages of the same RF or IF strip. An additional advantage of the high output is that the fourth and fifth harmonics of the high band (band D) are strong enough to give readable traces on UHF channels, if the oscilloscope is connected to the video detector. To identify these frequencies, however, harmonics of a VHF signal generator or output of a UHF generator should be used as markers.

Another feature of the sweep generator is the extremely wide band sweep width available. For normal applications the SWEEP WIDTH control will not be advanced very far. If desired, however the SWEEP WIDTH can be advanced to a point where all traps as well as the IF and RF bandpass waveforms can be seen. As the operator becomes more familiar with the unusual characteristics of the instrument, additional uses will be found for this large reserve of sweep width, for this feature can frequently save a considerable amount of time in trap alignment, etc.

BAND CONTROL

The BAND control switch is used to select the range of frequencies covered by the sweep oscillator. Proper bands can be identified by noting the corresponding letters below the sweep oscillator dial. Band A is the low band covering a range of 3.6 mc to 10 mc; band B, 10 mc to 26 mc; band C, 30 mc to 80 mc and band D, 80 mc to 220 mc. The figures on the OSCILLATOR dial refer to the frequency at the center of the sweep. A point to remember is that the upper frequency of the sweep oscillator is not limited by the highest indicated frequency on the OSCILLATOR dial for the unit is capable of sweeping across bands. Another point worth considering is that the maximum available sweep width on each band is generally achieved with the sweep frequency indicator set near the high frequency side of any given band. In other words, more sweep width will be available at the high end of band B than at the same frequency at the low end of band C, etc.

HORIZONTAL PHASE

Compensation for phase shift in the receiver under test is accomplished by proper use of the HOR. PHASE control. Before setting the OSCILLATOR and SWEEP WIDTH controls to produce a bandpass waveform, the phasing control should be set to approximately 12 o'clock. Once the desired waveform is obtained, the phase control should be adjusted until the trace is centered or shows no foldover at the right or left hand edges. Adjustment is completed by careful touch up of the OSCILLATOR, SWEEP WIDTH and HOR. PHASE controls. Figure 20 clearly illustrates proper adjustment of the phasing control.

Frequency linearity is dependent on phase control settings to a certain extent. If non-linearity becomes evident, reset the phase control and center the trace, using the OSCILLATOR dial.

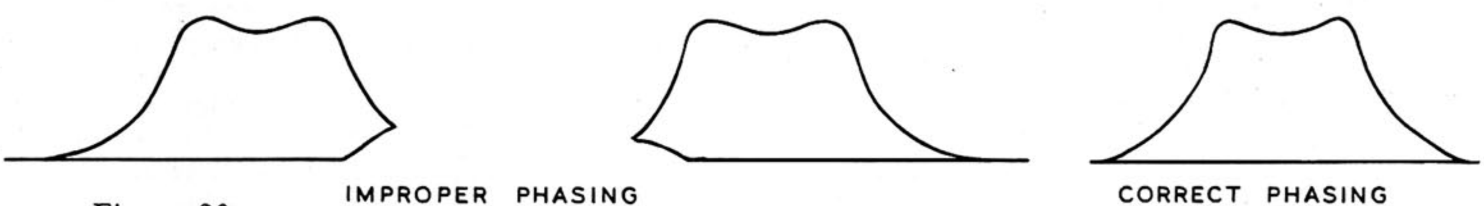


Figure 20

SWEEP WIDTH

The SWEEP WIDTH control is used to control the amount of sweep deviation of the sweep oscillator. The OSCILLATOR dial is set to the center frequency of the IF or RF stage to be aligned as described previously and the SWEEP WIDTH control advanced until the trace is completed. This control should be set just high enough to give complete coverage of the bandpass waveform when IF or RF adjustments are to be made. If trap settings are to be observed also, the setting may be increased as required.

FINE ATTENUATOR AND ATTENUATOR

Output of the sweep generator is controlled by the FINE ATTEN. and ATTENUATOR controls. Alignment should usually be started with the ATTENUATOR in the X1 position and the FINE ATTEN. at approximately 5. As soon as a response is obtained, the settings should be increased or decreased as required. Good alignment practice requires that the output be kept as low as possible, consistent with good indication on the oscilloscope screen. Too much output will result in serious distortion of the trace and misalignment. To make sure that the response is not distorted, back the FINE ATTEN. control off, observing the waveform. If a point is found where the waveshape changes, the IF or RF strip of the receiver was overloaded. Final attenuator settings should be made at a point below that at which distortion occurred. If it becomes necessary to set the FINE ATTEN. control to a point near 1 on the dial, the ATTENUATOR switch should be backed off a position and the other control reset. The FINE ATTEN. control affects the sweep oscillator only, while the ATTENUATOR switch attenuates the sweep and marker output at the same time, helping to prevent marker overloading.

GENERAL ALIGNMENT PROCEDURES USING THE HEATHKIT SWEEP GENERATOR

Most television receivers will fall into one of four general patterns of alignment, which will be described later. However, each different set will have one or more special procedures involved in relation to special circuits in the set, so it is very desirable that the manufacturer's instructions be available and used. In addition to the time saved, better results will undoubtedly be obtained.

For all alignment except RF, it is necessary to render the local oscillator of the TV receiver inoperative. This is done either by removing the oscillator tube or temporarily removing the B+ lead to its plate circuits. Also, the AGC circuit should be made ineffective by removing the AGC tube, if necessary, and grounding the AGC bus or applying a fixed DC potential from a battery or potentiometer, as required by the manufacturer. For safety, the high voltage to the picture tube should be eliminated by removing the horizontal oscillator tube or the horizontal multivibrator tube, depending on the type of circuits involved.

Alignment of any television receiver should not be attempted unless there is evidence of misalignment. By connecting an oscilloscope and the Heathkit Television Alignment Generator to the receiver as outlined below and checking the gain of each stage before any adjustments are made, an excellent idea of stage gain is obtained and any stage not showing gain can be checked. A check of the tubes and other circuit elements is recommended before changing tuned circuits.

Generally, alignment is started with the trap circuits. The sound traps which keep the audio from modulating the picture and the traps to prevent adjacent channels from interfering are almost always aligned before the balance of the receiver. The 4.5 mc trap in most intercarrier type sets should be aligned after the sound and video IF strips have been adjusted in most cases. Sound IF sections are aligned with conventional FM procedure. The TV tuner oscillator and RF sections are aligned only if defective indication is observed showing that misalignment has taken place.

SOUND AND ADJACENT CHANNEL TRAP ALIGNMENT

A DC vacuum tube voltmeter is generally used as the indicator for trap adjustment. The indicator is connected across the second detector load resistance. CW (unmodulated) signal from the marker generator is coupled into the grid of an IF stage ahead of the trap circuit through a .001 μfd or larger condenser. The marker generator is tuned to the trap circuit frequency and its output increased until an indication is observed. Adjust the trap for minimum indication. Locate the other traps and resetting the generator to the proper frequency, adjust each for minimum indication. Energy from the marker oscillator can be taken from the RF OUT connector by setting the FINE ATTEN. and ATTENUATOR to 0 and X1 respectively and placing the BAND switch at position D, so that the sweep oscillator will not cause interference. Should the output be too low when signal is taken from this point, connect the output cable to the EXT. MARK connector instead and attenuator the signal as necessary by installing a suitable value of resistance in series with the "hot" lead. In cases where the manufacturer specifies a modulated signal for trap alignment, refer to the manual section headed SPECIAL PROCEDURES.

INTERMEDIATE FREQUENCY (IF) ALIGNMENT
STAGGER TUNED TYPE

To align stagger tuned type IF stages, the output of the generator is either fed to the grid of the mixer tube through a capacitor or to the grid of each individual stage as it is aligned, in sequence, beginning at the stage before the video detector. Manufacturer's instructions regarding this should be followed in all cases. The oscilloscope is connected across the load resistance of the picture detector. Loading of this stage of the receiver is prevented by use of the special oscilloscope lead furnished with the kit, which has an isolating resistor built in. Connect the horizontal input of the scope to the HOR. and GND. posts of the sweep generator. Render the TV receiver oscillator tube inoperative by using one of the previously described methods. Set the OSCILLATOR dial to the frequency of the IF strip and advance the SWEEP WIDTH control until a large, easily seen trace appears. If the horizontal line at each end of the trace is too long, the sweep width should be reduced and the sweep oscillator frequency adjusted slightly if necessary to properly center the trace. If the trace does not return to the horizontal line, the sweep width should be increased. Regardless of the amount of sweep used, the width of the band pass trace will be limited by the band width of the IF amplifiers under test and a more accurate trace will be obtained by using all of the trace for the amplified portion.

The MARKER AMP. control is advanced and the MARKER control adjusted to the frequency of the first IF stage as outlined in the manufacturer's instructions and this stage adjusted for maximum indication. If recommended, the primary of the IF transformer preceding the stage under alignment should be shorted. The marker pip is then moved to the frequency of the next stage and this stage adjusted. Be sure to reduce the output of the generator as alignment proceeds. Use maximum gain of the oscilloscope vertical amplifier during entire alignment always reducing output of the generator rather than that of the scope. Each IF stage is aligned in the above manner. The overall response is then compared with the recommended curve in the manufacturer's instructions. The locations of the sound and picture sections can be checked with the dual markers and compared with proper positions. Slight readjustment of individual stages may be necessary to properly match manufacturer's recommended trace. The overall response check is usually made by feeding the output of the generator to the mixer grid through a capacitor of suitable size.

In some cases, the IF stages will be prealigned using fixed frequency procedure with a VTVM used as an output indicator at the video detector stage. When this type of alignment is called for, the marker oscillator can be used as a signal generator by turning the FINE ATTEN. to its maximum counterclockwise position and the ATTENUATOR and MARKER AMP. controls to a point that will give adequate output. If it should be impossible to obtain sufficient output in this manner, the signal can be taken directly from the EXT. MARK. connector and attenuation accomplished by use of a suitable value of resistance in series with the "hot" output lead.

OVERCOUPLED IF TYPE

Connections are made with the scope as outlined under stagger tuned types. The output of the alignment generator is fed into the grid of the final IF stage (nearest picture detector) through a coupling capacitor (.001 μfd). Proceed to align the last IF transformer in the manner outlined in the manufacturer's instructions. Manufacturers usually supply a pattern to be obtained for each stage and these should be followed. It is sometimes necessary to short out the primary of the IF transformer preceding the stage under alignment and this should be done when recommended. Alignment proceeds stage by stage from the stage nearest the picture detector to the mixer tube. After alignment of the final stage, the trace should appear similar to the typical TV IF response curve shown in the instructions. The markers are again used to locate sound and picture carriers to check shape and width of the trace.

Fixed frequency pre-alignment procedures may be used for this type of IF system. When this is the case, observe the instructions under STAGGER TUNED TYPES.

SOUND IF ALIGNMENT

Discriminator, ratio detector and beam gated circuits are commonly encountered as detectors in TV sound IF systems. Except for the gated beam detector, alignment procedures are much the same, the only difference being the point to which the oscilloscope is connected. In almost all cases, the output of the sweep generator will be connected to the grid of the first sound IF amplifier through a suitable capacitor.

To observe the bandpass waveform in a circuit employing a discriminator, the scope should be connected to the grid return of the last limiter tube and the output of the generator increased to give a satisfactory trace. The marker is set to the center frequency of the sound IF strip and adjustments are made keeping the waveform symmetrical on each side of the marker. When this adjustment is completed, the scope is connected at the volume control or at the opposite side of the isolating resistor running to the control and the discriminator transformer adjusted for maximum amplitude and straightness of the slanted detecting curve. Adjustment is complete when the marker is in the center of the curve. (NOTE: The crystal oscillator will furnish the marker for 4.5 mc intercarrier type sound systems.)

When a ratio detector is employed, the scope should be connected to the plate of the detector or diode which is in turn connected to the negative terminal of an electrolytic stabilizing condenser. This condenser should be disconnected to make IF transformer adjustments. After the IF stages are properly adjusted, the condenser is reconnected and the oscilloscope vertical test lead connected to the "hot" terminal of the volume control. Final adjustments are made as in the preceding paragraph.

Adjustments of beam gated stages are generally made on actual signal from a television broadcasting station and alignment methods described by the manufacturer should be used. Where modulated fixed frequency signal sources are required, refer to the manual section under SPECIAL PROCEDURES.

OSCILLATOR AND RF ALIGNMENT

Alignment of the tuner section of a TV receiver should not be attempted unless the performance of the set indicates the necessity of doing so. When necessary, alignment is usually started by adjusting the oscillator frequency, after the oscillator is restored to operation. To accomplish this, the alignment generator is connected to the antenna terminals of the set through suitable impedance matching resistors (usually 120 Ω) in series with the ground and hot lead of the output cable. The scope is connected to the video detector as before. Alignment is begun starting at the highest frequency (channel 13) and finishing at the lowest frequency (channel 2) unless otherwise specified.

Oscillator tuning is adjusted to place the sound and video markers at the manufacturer's specified points on the response curve. Where marker frequencies higher than those marked on the MARKER dial are called for, the fourth harmonic of the variable oscillator can be used. The specified marker frequency is divided by four and the marker dial set to the resulting frequency. 4.5 mc spacing of markers for identification of the other carrier will be generated by the crystal oscillator.

When fixed frequency alignment procedures are recommended, harmonic or fundamental output of the variable marker oscillator can be used, taken from the appropriate output connector. A vacuum tube voltmeter will be used as an indicator when this method of alignment is undertaken. The VTVM is usually connected to the load for the sound detector and the oscillator adjustment made for zero reading (a null). Other connection points for the VTVM may be recommended and these should be used as specified by the manufacturer.

After oscillator alignment is completed, RF and mixer alignment is done. The sweep generator remains connected to the antenna terminals through matching resistors and the oscilloscope is usually connected to the grid return of the mixer tube at a point specially provided for this purpose. Alignment is again started at the highest frequency channel and the response waveform adjusted to conform to the recommended shape. (NOTE: The output level at the signal takeoff point in the tuner is usually quite low and most oscilloscopes have insufficient vertical gain to give an easily readable pattern. When this condition is encountered, a single stage pentode preamplifier such as a microphone pre-amp should be used ahead of the scope to increase the gain to a satisfactory level. Sometimes a demodulator probe connected at the recommended point will give better results without a preamplifier. This situation will not develop when alignment instructions specify that the scope be connected to the video detector.

INTERCARRIER TYPE SETS

Intercarrier alignment procedures are much the same as those previously specified. Usually the video IF strip is aligned using fixed frequency procedure with a VTVM as a detector. The VTVM is usually connected to the video detector load and IF adjustments made for maximum indication. Again, direct output from the variable or fixed marker oscillator can be used. If sweep techniques are called for, the previously described methods can be used.

After alignment is completed using fixed frequency methods, the overall response is checked with the sweep generator and scope. This is accomplished with the generator connected to the mixer stage and the scope to the video detector. If necessary, the IF adjustment screws are touched up to get the waveform to conform to the recommended pattern.

Sound IF alignment is accomplished as before, except that the 4.5 mc crystal is used exclusively as the signal source or marker, depending upon the alignment method employed. After the sound strip is correctly aligned, the 4.5 mc trap (if any) is adjusted using the 4.5 mc output of the marker and a VTVM with an RF probe at the cathode or grid of the picture tube. In some cases, the DC probe of the VTVM will be connected instead to a point in the sound detector circuit. In all cases, the manufacturer's instructions should be followed.

Alignment procedures for the tuner of intercarrier type sets will follow the same general course outlined under OSCILLATOR AND RF ALIGNMENT, mentioned previously.

FM RECEIVER ALIGNMENT

The alignment of FM receivers is similar to the outline under SOUND IF ALIGNMENT of television receivers. The normal FM IF frequency is 10.7 mc and as nearly every signal generator covers this frequency, markers can easily be obtained from external generators and fed into the EXT. MARK. connector of the alignment generator. If extremely accurate alignment is required a 10.7 mc or 5.35 mc crystal can be plugged into the XTAL socket.

Extra bandwidth identification markers may be achieved by use of an external signal generator tuned to a frequency 100 kc above or below the frequency of the crystal oscillator. In some cases a satisfactory 10.7 mc marker can be obtained by setting the marker oscillator dial to the second harmonic of the receiver IF frequency, or 21.4 mc. This does not always provide a satisfactory marker, but it may work out well with a large percentage of FM sets encountered.

SPECIAL PROCEDURES

In some cases, a modulated RF signal is required for adjustment of traps, detectors, etc. If the operator is thoroughly familiar with the type of circuits involved, other methods of alignment can sometimes be used, employing the output of the marker generator. When methods other than those recommended are not feasible, certain steps should be taken to insure alignment accuracy consistent with that of the alignment generator. Observance of the following instructions will help to improve the performance of the receiver after alignment is completed.

When a modulated signal for trap alignment is called for, an unmodulated signal can sometimes be used in conjunction with a DC VTVM connected to the video or audio detector, depending on the location of the trap in the circuit. The usual procedure is to connect an AC meter or an oscilloscope to the grid or cathode of the picture tube when a modulated signal is used. Regardless of which method is employed, the trap will be tuned for minimum indication. If it is essential that a modulated source be used, a separate signal generator must be employed. Before using the external generator to make adjustments, it should be zero beat against the crystal or variable marker generator, depending upon the frequencies involved. This can be accomplished by feeding the output of both generators to the RF probe of a signal tracer or to the input of a receiver tuned to the frequency in question. This method of instrument calibration should always be used to keep alignment consistent with the original aligning instrument. While errors in any given instrument may be small, they may be in opposite directions and the resultant error may be sufficient to cause the set under alignment to perform at less than optimum level.

Occasionally a modulated signal is required to adjust the detector of the sound strip in TV or FM sets. The procedure outlined under SOUND IF ALIGNMENT can sometimes be substituted with very good results. However, if any doubt as to the efficiency of this method exists, the recommended procedure should be observed. Again the external generator should be calibrated against the marker generator to insure best performance.

Too many different procedures exist for aligning of beam gated detectors to outline all of them within this manual. Generally, these detectors are aligned on station with attenuation in the antenna circuit to keep the signal level below the limiting level of the detector. The IF transformers are adjusted for maximum indication, using a scope or AC meter across the volume control and keeping the input attenuated below the limiting level of the detector. After these adjustments are made, the input is increased beyond the limiting point and the AM rejection control in the cathode circuit and the quadrature coil adjusted for minimum intercarrier buzz. When a modulated signal source is used to align this type of circuit, the external generator should be calibrated against the marker generator.

ACCESSORY INSTRUMENTS

A stable, high sensitivity, wide band oscilloscope is a must if satisfactory alignment is to be accomplished with a minimum of nervous strain. Although wide band response is not required for sweep alignment purposes, it is desirable for observance of synchronizing pulses, etc. encountered when doing routine service work on television receivers. The Heathkit OL-1, OM-1 and O-10 oscilloscopes meet these requirements and incorporate other refinements very useful in general service work. High intensity levels along with excellent focusing characteristics make it easy to operate these scopes even in brilliantly illuminated rooms.

Two probe kits are available which add to the usefulness of the oscilloscope. One is the #342 Low Capacity Probe which allows accurate measurement of sync waveforms etc. in high impedance circuits. Normally, distortion occurs when a scope is connected to a high impedance point where complex waveforms are present, due to capacitive loading by the scope input. The #342 probe effectively cancels this capacity, thus preventing distortion.

Signal tracing and waveform checks in the RF sections of receivers can be made using the #337C Demodulator Probe. This probe is also useful for making stage gain measurements in low impedance RF circuits.

Another instrument that is absolutely necessary for alignment purposes is a high impedance vacuum tube voltmeter. The Heathkit V-7 VTVM has an input impedance of 11 megohms on all DC ranges. This is sufficiently high to make loading effects negligible and all readings will be true indications of potential existing in the circuit under investigation. An additional advantage of this type of VTVM is that a variety of probes can be used, greatly extending the usefulness of the instrument. A high voltage probe and an RF probe are available as accessories. This instrument features many ranges of peak-to-peak and RMS AC and OHMS as well, making it extremely useful for all general service work.

Although not essential, a grid dip meter such as the Heathkit GD-1B is very useful for television and general service work. Every serviceman is familiar with the occasional set that comes into the shop with all of the alignment screws tightened down. It is extremely difficult to put sets in this condition back into alignment, for it is almost impossible to jam an alignment signal through the set. A grid dip meter can be used to make surprisingly close rough adjustments of the tuned circuits and traps with the set "cold." Finishing touch-up of alignment is then easy. Another use of the grid dip meter employs the instrument as a marker generator. The grid dipper operates over a very wide range of frequencies, all on fundamentals, making it especially useful for tuner alignment work. To be used as a marker, the grid dipper is merely placed near the set under alignment, no direct connections are needed. Many additional uses of this instrument have been listed in various magazines and even more may become apparent as the operator becomes more familiar with the characteristics of the unit.

Finishing touches on the completely serviced television set can be made using the Heathkit BG-1 Bar Generator. This instrument generates horizontal and vertical bars which are evenly spaced making horizontal and vertical linearity adjustments easy. A few moments spent making these simple adjustments can result in a large amount of customer good will.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored pencil on the pictorial and schematic as it is followed in the instrument. Most cases of difficulty result from wrong connections. Often having a friend check the wiring will reveal a mistake consistently overlooked.
2. If possible, compare tube socket voltages with those shown on Page 37. The readings should be within 20% of those tabulated if a VTVM is used. Other type meters may give lower readings due to loading effects. If the voltage fails to compare with the value shown, check further into the circuit involved by checking the various components (resistors, condensers, tubes, etc.)

Carefully recheck the color codes on resistors and transformer leads. If there is a question concerning the color of a transformer lead, scraping the insulation lightly with a knife may help to identify the color quickly.

Some common troubles are listed below along with trouble-shooting procedures which may be helpful in locating the source of difficulty.

INSTRUMENT COMPLETELY INOPERATIVE: If the instrument fails to operate, check the tubes to see if the filaments are lit. If there is no evidence of heating, measure across the end of the AC line at the terminal strip next to the grommet on the back of the chassis. Lack of AC energy at this point indicates either an open line cord or imperfect connection at the outlet. The AC cord can be checked quickly with an ohmmeter. When voltage is obtained at this point on the terminal strip, the voltmeter should be moved to the strip at the opposite end of the line chokes.

VOLTAGE CHART

SOCKET TUBE TYPE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
12AX7	70	-8	0	6.3 VAC	6.3 VAC	-23	-23	75 VAC	0
12AT7	135	-10 to -30	1.5	6.3 VAC	6.3 VAC	210	-10 to -25	1.5	0
6CL6	0	-2.4	150	0	6.3 VAC	100	0	NC	-2.4
6X4	210 VAC	*	6.3 VAC	0	NC	210 VAC	250		
6BQ7A	150	NS	1.7	6.3 VAC	0	96	-9	0	0

NS - not significant. NC - no connection.
Line voltage: 115 volts AC
* - voltage from 6X4 pin 2 to terminal strip T1, 115 volts AC.
Unless otherwise indicated, all voltages positive and measured to chassis.
Voltages taken with a Heathkit 11 megohm VTVM.
Bias voltage across inductor primary terminals: 6 volts on bands A, B and C, 15 volts on band D.
Readings taken with BAND switch at C, MARKER and OSCILLATOR dials full clockwise.
MARKER AMP. and HOR. PHASE about 1/2 open and all other controls fully counterclockwise.

No voltage at this point indicates an open choke. Finally, check with the meter connected across the black and red-black leads of the power transformer. No voltage at this point indicates a defective switch on the back of the phase control or a wiring error.

Should voltage be present at all points in the 110 volt AC circuit, a short in the filament or rectifier plate or cathode circuits can be suspected. Careful visual inspection will usually reveal the source of trouble. If not, all tubes should be removed and the power transformer disconnected from the circuit. Ohmmeter checks for wiring shorts can then be made and power transformer checked for open windings.

NO SWEEP OSCILLATOR OUTPUT: Lack of RF output can be traced to either failure of the oscillator to function or a defect in the attenuator and output network. Check components and connections in the attenuator network to make sure that everything is wired properly and no shorts exist. Once sure that everything is all right at this point, pins 1 and 6 of the 6BQ7A sweep oscillator should be checked to see if B+ is present. Special attention should be given to the four stator lugs on the variable condenser. B+ should be present at all four terminals. If not, carefully check the stator lug connections for a break. If a break is present, it can be repaired quickly by resoldering the connections.

Failure of the sweep oscillator to function due to voltages far out of line with those shown on the voltage chart might be caused by a defect somewhere in the power supply or by improper connection of the wires running from the main chassis to the sweep sub-chassis. Once sure that the interconnecting wires are connected properly, check under POWER SUPPLY MALFUNCTION.

Tubes can always be suspected of causing trouble, especially at higher frequencies. It might be worthwhile to substitute tubes to see if performance can be improved. While a certain tube might not operate will in one circuit, it may be perfectly good in another and so exchanging identical types is often advantageous.

NO MARKER OSCILLATOR OUTPUT: The same procedure as outlined above should be observed. Again, special attention should be given to the four stator lugs on the tuning condenser. Lack of high voltage on the plates (pins 1 and 6) of the 12AT7 will indicate either an open RF choke or a defective switch on the MARKER AMP. control. If the choke is open, repairs can usually be made by soldering the choke leads carefully close to the body of the choke. Checks should also be made for short circuits in the wiring, the tube and the tuning condenser.

POWER SUPPLY MALFUNCTION: To locate trouble in the power supply, voltage checks should be made in a definite sequence. First, pins 1 and 6 of the 6X4 socket should be checked for AC voltage. Next, check all filaments to make sure that they are lit. If not, check for a short, open circuit or misconnection at one of the sockets. If everything is all right at these points, the potential at pin 7 of the 6X4 should be checked. If no B+ exists, look for a short in the B+ line and in the filter condenser. Also, check the 6X4 for open circuits and low emission. When sure that everything is correct at these points, check voltage at pin 1 of the 12AX7 and pins 3 and 6 of the 6CL6. Discrepancies at these points should be straightened out before going further. Possible sources of trouble are the .25 μfd condenser connecting between pin 1 of the 12AX7 and pin 9 of the 6CL6, the .06 μfd condenser between ground and the 220 Ω resistor to pin 6 of the 6CL6, leakage to ground in the 30 h plate choke, short circuits at terminal strips K, H and BP, and defective parts or wiring around the front wafer of switch BM. Short circuits are easily located by disconnecting wires one at a time from the point where the short is found. A follow up of the wire which remains shorted will reveal the fault.

The final power supply check point is at pin 6 of the 6CL6. If no voltage or low voltage is present at this point regardless of whether or not the tube is in its socket, the sweep oscillator chassis should be checked for short circuits and wiring errors.

NO HORIZONTAL OUTPUT FOR SCOPE: If it should be impossible to obtain a horizontal line on the scope, the lead running between the two instruments should be checked for open or short circuits. Also, the 1 megohm, the two 100 KΩ resistors and the 100 KΩ potentiometer should be checked as well as the .01 μfd and the .05 μfd condenser used in the phasing circuit.

If sweep can be obtained but the phasing control is ineffective, there is a possibility that the wires from the 6X4 socket and terminal strip K have been accidentally exchanged. Reversal of the wires will correct this condition. If the wiring is all right, make sure that the 1 megohm resistor is connected to the proper point on the phase control and that the .01 μfd high voltage condenser is not shorted.

NO FREQUENCY SWEEP: Lack of sweep or sweep width will be caused by some defect in the 110 volt circuit leading to the controllable inductor. The 10 KΩ sweep width control should be checked for continuity as well as the 6800 Ω resistor connected to it. A shorted .25 μfd condenser across the primary of the inductor or an open 12 μfd between the control and the inductor will cause lack of sweep. Voltage at the small selenium rectifier should be checked since this provides bias for the Increductor unit. Connections to the front wafer of the band switch should be inspected and the switch itself checked against the schematic to be sure that everything is correct.

REVERSED SWEEP: Should the markers move from right to left on the trace when the marker frequency is increased, the sweep oscillator is unblanking on the wrong phase of the AC line. This condition can be corrected, if desired, by reversing the black and red-black power transformer primary wire connections.

POOR FREQUENCY LINEARITY AND CALIBRATION: Poor linearity and calibration will most likely be caused by improper biasing of the controllable inductor. The steps outlined under NO FREQUENCY SWEEP should be observed and the 18 KΩ and 10 KΩ resistors which make up the load for the biasing circuit checked out. Very high or low line voltage will have some effect on linearity and frequency, but the errors will not be serious. A substantial deviation from recommended value of these resistances could cause poor operation.

POOR AMPLITUDE LINEARITY: A non-linear trace indicates improper biasing on either the 12AX7 AGC amplifier or the 6CL6 regulator. The 220 KΩ, 22 megohm and 5.6 megohm resistors on the front deck of the band switch should be checked for value and connection. These resistors control the bias on the 12AX7 regulator amplifier. If the trouble shows up only on the low end of band D, the 1 megohm resistor between pin 1 of the 12AX7 and pin 2 of the 6CL6 should be checked. If the value is approximately correct, it may be necessary to reduce it slightly until the regulation is perfect. Decreasing the value of this resistor will also decrease the output of the sweep generator, however, so care should be exercised.

Poor regulation on the lower frequency bands or all bands will most likely be due to some fault around the resistors or switch previously mentioned.

Amplitude or output variations can be expected as sweep frequency settings or band settings are changed. This is not important, since these adjustments will not be made during any alignment procedure. The important thing is that the output be flat over any given sweep width with the center frequency set at a common reference.

MARKER DISTORTION: In some cases, distortion of the trace will occur when the marker oscillator is turned on. This condition will most usually be encountered when overall alignment techniques are employed in high gain IF or RF circuits. This condition can usually be alleviated by simply increasing the value of the 270 Ω resistor which connects between step attenuator switch Z1 and Z5. The value should be increased until the marker action is satisfactory. Where insufficient marker amplitude is evident, the value can be decreased to obtain the desired results.

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 $5.00 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 the possible modification of existing kits, the volumes listed in the Bibliography section are recommended. 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

BIBLIOGRAPHY

Alignment data can usually be obtained from the manufacturer of the set in question. Some other excellent sources of the same information are listed below:

Photofact Publications; Howard W. Sams and Company, Inc.
Perpetual Trouble-Shooters Manuals; Rider, John F.

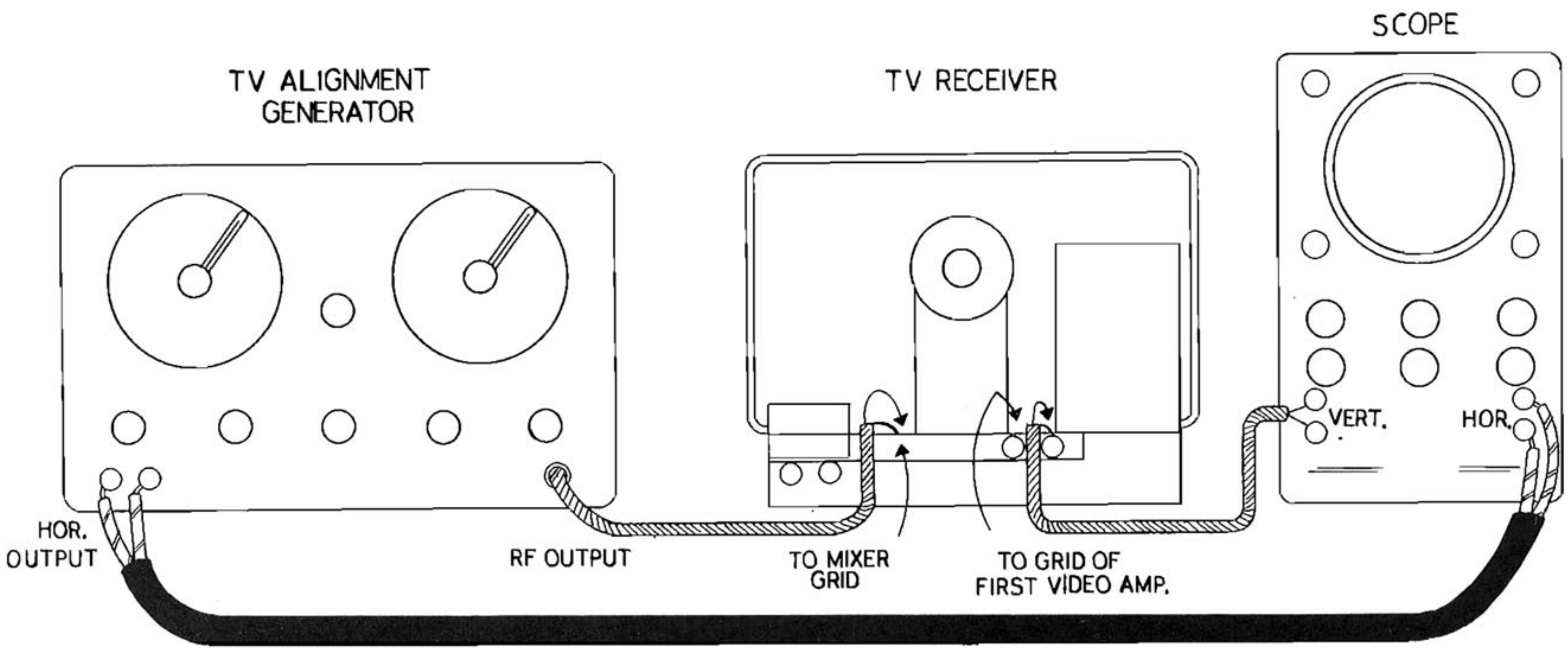
Many fine books and pamphlets are currently available describing approved techniques using modern instruments for all types of general service and developmental work. Information concerning this literature can usually be obtained from the catalogs put out by large electronic wholesale concerns. A few booklets written especially for television servicing and alignment are also presently obtainable. Some of these are listed below:

Kiver, Milton S.; How to Understand and Use TV Test Instruments
Liebscher, Art.; TV Sweep Alignment Techniques

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-1	3	47 Ω 1/2 watt
1-2	1	68 Ω 1/2 watt
1-7	2	680 Ω 1/2 watt
1-16	2	4700 Ω 1/2 watt
1-19	1	6800 Ω 1/2 watt
1-22	2	22 KΩ 1/2 watt
1-24	1	33 KΩ 1/2 watt
1-26	5	100 KΩ 1/2 watt
1-27	1	150 KΩ 1/2 watt
1-29	1	220 KΩ 1/2 watt
1-35	3	1 megohm 1/2 watt
1-41	1	10 Ω 1/2 watt
1-42	1	270 Ω 1/2 watt
1-44	1	2200 Ω 1/2 watt
1-45	1	220 Ω 1/2 watt
1-47	1	56 KΩ 1/2 watt
1-66	1	150 Ω 1/2 watt
1-70	1	22 megohm 1/2 watt
1-86	1	5.6 megohm 1/2 watt
1-1A	1	470 Ω 1 watt
1-25A	1	6.8 KΩ 1 watt
1-27A	2	33 KΩ 1 watt
1-~~44A~~	1	15 ~~18~~ KΩ 1 watt
1-3B	1	10 KΩ 2 watt
1-17B	1	6800 Ω 2 watt
3-6J	1	2500 Ω 10 watt
1-9A	1	10 KΩ 1 watt
Condensers		
21-9	3	100 μμf (.0001 μfd)
21-11	1	150 μμf (.00015 μfd)
21-14	10	1000 μμf (.001 μfd)
21-16	1	.01 μfd disc (10,000 μμf)
21-27	1	5000 μμf (.005 μfd)
21-32	1	47 μμf (.000047 μfd)
23-4	1	.01 μfd 1000 volt
23-55	1	.06 μfd 400 volt
23-59	1	.05 μfd 200 volt
23-63	2	.25 μfd 400 volt
25-5	1	16 μfd 150 volt
25-20	1	40 μfd 150 volt
25-30	1	20-20 μfd 350 volt
26-10	2	Tuning condenser
Tubes-Lamp-Diode-Crystal		
57-13	1	100 ma Selenium rectifier
404-1	1	4.5 mc crystal (4500 kc)
411-24	1	12AT7 tube
411-26	1	12AX7 tube
411-63	1	6CL6 tube
411-64	1	6X4 tube
411-71	1	6BQ7A tube
412-1	1	#47 pilot lamp

PART No.	PARTS Per Kit	DESCRIPTION
Sockets-Terminal Strips-Insulators		
70-2	3	Acetate sleeve, black
70-3	3	Acetate sleeve, red
75-11	2	Insulated chassis board
75-15	1	Terminal half-shell, drilled
75-16	1	Terminal half-shell, plain
100-M16B	2	Binding post cap, black
100-M16R	2	Binding post cap, red
431-1	1	1-lug terminal strip
431-2	3	2-lug terminal strip
431-3	1	3-lug terminal strip
431-10	3	3-lug terminal strip
431-12	1	4-lug terminal strip
431-14	2	2-lug terminal strip
431-15	2	1-lug terminal strip
434-15	1	7-pin tube socket
434-16	4	9-pin tube socket
434-22	1	Pilot lamp socket
434-38	1	Crystal socket
453-10	1	Insulated extension shaft
453-11	1	Insulated extension shaft
456-1	2	Flexible shaft coupling
Hardware		
250-2	10	3-48 x 1/4 screw
250-7	4	6-32 x 3/16 screw
250-8	2	#6 x 3/8 sheet metal screw
250-9	20	6-32 x 3/8 screw
250-18	2	8-32 x 3/8 screw
250-19	2	10-24 x 3/8 screw
250-25	6	4-40 x 1/8 screw
250-34	1	4-40 x 1/2 screw
250-40	7	6-32 x 1 1/2 screw
250-43	8	8-32 x 1/4 set screw
250-48	1	6-32 x 1/2 screw
252-1	10	3-48 x 7/32 nut
252-3	26	6-32 x 1/4 nut
252-4	4	8-32 x 3/8 nut
252-7	8	3/8-32 x 1/8 control nut
252-12	1	Pilot light nut
252-15	1	4-40 x 3/16 nut
253-1	2	#6 flat fiber washer
253-2	1	#6 shoulder fiber washer
253-10	5	Control flat washer
253-22	2	13/32" ID x 3/4 OD washer
254-1	27	#6 lockwasher
254-2	4	#8 lockwasher
254-3	2	#10 lockwasher
254-4	8	Control lockwasher
255-1	1	#6 x 1/8" spacer
255-6	7	#6 x 1 1/8" spacer
259-1	9	#6 solder lug

PART No.	PARTS Per Kit	DESCRIPTION
Wire		
89-1	1	Line cord
340-2	1	length Bare wire
343-2	4	length Coaxial cable
344-1	1	length Hookup wire
345-1	1	length Braid
346-1	2	length Spaghetti
346-2	1	length 3/16" Spaghetti
Controls-Switches		
10-31	1	10 KΩ sweep width
10-33	1	200 Ω fine attenuator
19-11	1	100 KΩ w/switch hor. phase
19-19	1	200 Ω w/switch marker amp.
63-70	1	3-pos. attenuator
63-82	1	4-pos. band
Transformers-Coils-Chokes		
40-52	1	Marker oscillator coil
45-2	1	RF choke
45-6	2	28 μh choke
46-9	1	30 h filter choke
54-5	1	Power transformer
100-M45	1	750 Ω ww ferrite core choke
403-2	1	Controllable inductor
Chassis Parts-Knobs		
90-24	1	Cabinet
100-M46	2	Pointer knob
200-M68	1	Chassis
203-65F85	1	Panel
204-M57	1	Switch bracket
204-M74	1	Reinforcing bracket
205-M27	1	Shield plate
211-1	1	Handle
462-19	6	Knob
Grommets-Clips-Connectors		
73-1	3	Rubber grommet
260-1	4	Alligator clip
261-1	4	Rubber feet
427-2	4	Binding post base
432-1	1	Cable connector
432-3	2	Connector
438-M8	6	Banana plug
Miscellaneous		
413-1	1	Pilot light jewel
455-1	1	Pilot light bushing
455-6	2	Panel bushing
595-92	1	Manual



A TYPICAL ALIGNMENT SET-UP

Figure 21

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.

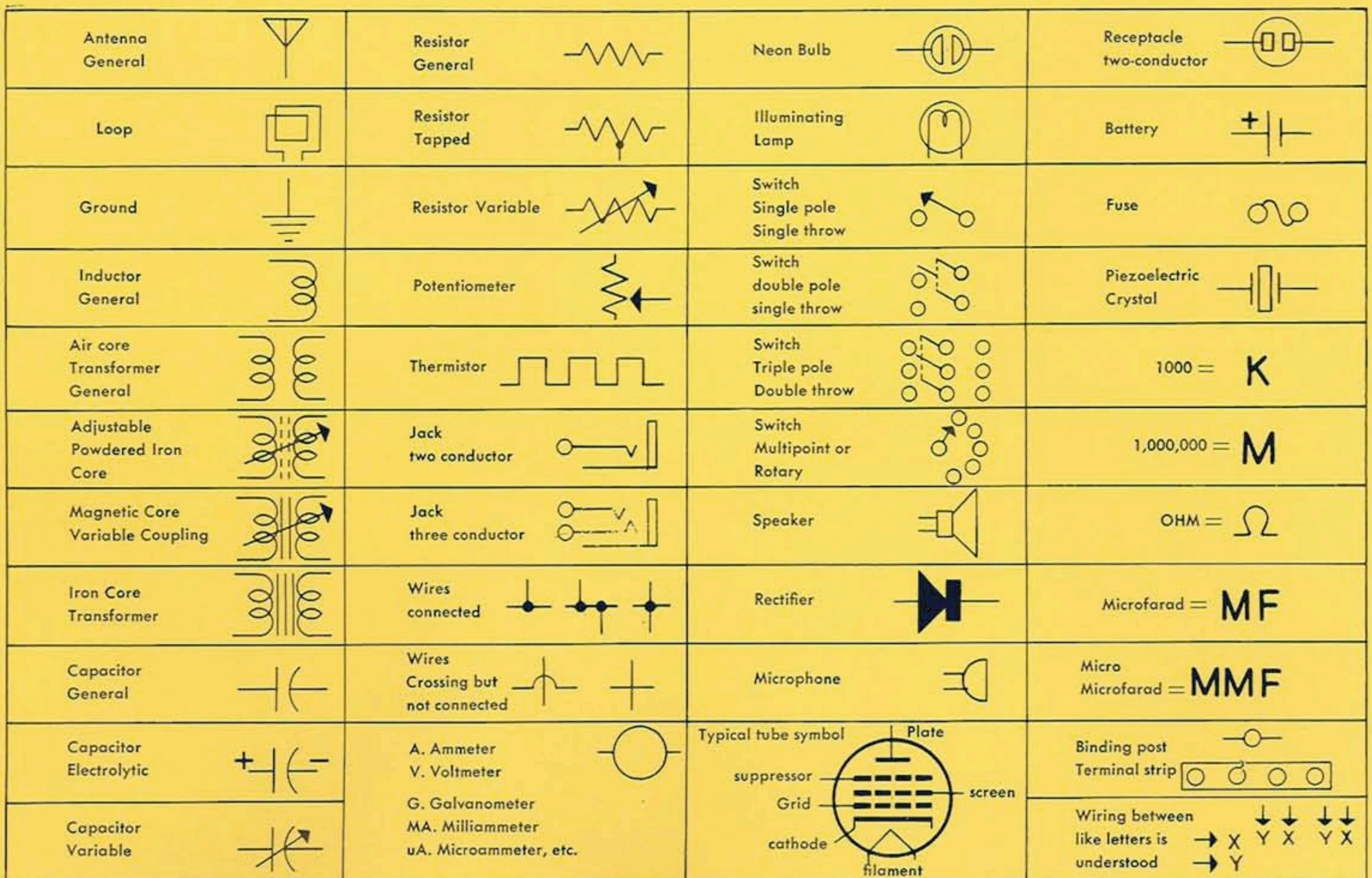
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown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

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