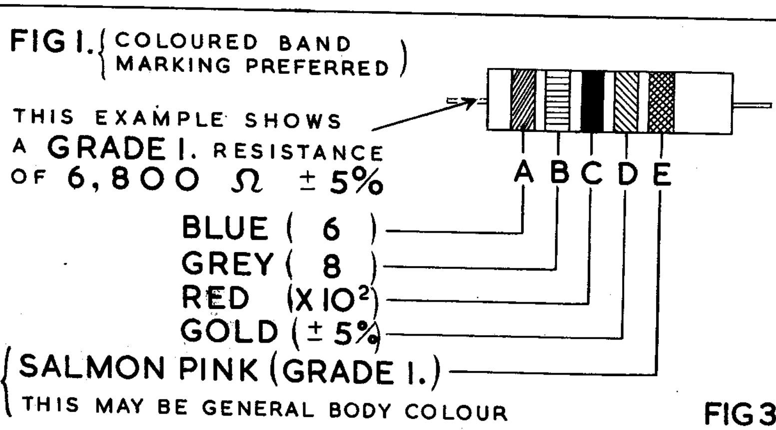
# HEATHKIT
# ASSEMBLY MANUAL

HEATHKIT

## LABORATORY AND GENERAL PURPOSE OSCILLOSCOPE

**MODEL IO-18U**
**595-G625**
**1.12.69.**

# COLOUR CODE FOR FIXED RESISTORS – (B.S.1852–1952)
## COLOUR BAND MARKING



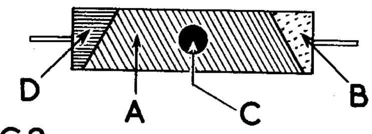




FIG 2. BODY, TIP & SPOT MARKING

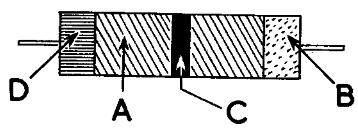
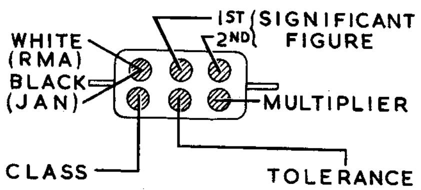


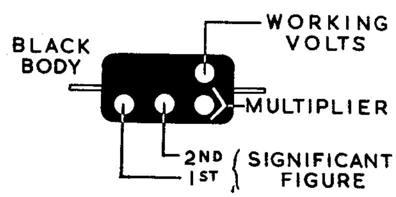

FIG 3. BODY TIP & CENTRAL BAND MARKING

## AMERICAN "RMA", "JAN" & COMMERCIAL CODING FOR MOULDED MICA CAPACITORS

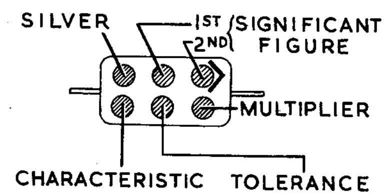
CURRENT STANDARD CODE




MOULDED FLAT CAPACITOR COMMERCIAL CODE




JAN. CODE CAPACITOR




### COLOUR CODE FOR RESISTORS AND CAPACITORS

| Colour | Value in Ohms of pF for Cols. A, B & C. | | | | COL. D. (TOLERANCE RATING) | | | CAPACITORS COL. E. TEMP. COEFFICIENT per $10^6$ per °C. |
|---|---|---|---|---|---|---|---|---|
| | COL. A. 1st Figure | COL. B. 2nd Figure | COL. C. (MULTIPLIER) Resistors ohms | Capacitors pF | Resistors | Ceramic Capacitors Up to 10 pF | Over 10 pF | |
| BLACK | - | 0 | 1 | 1 | - | 2 pF | ± 20% | 0 |
| BROWN | 1 | 1 | 10 | 10 | ± 1% | 0.1 pF | ± 1% | -30 |
| RED | 2 | 2 | 100 | 100 | ± 2% | - | ± 2% | -80 |
| ORANGE | 3 | 3 | 1,000 | 1,000 | | - | ± 2.5% | -150 |
| YELLOW | 4 | 4 | 10,000 | 10,000 | | - | - | -220 |
| GREEN | 5 | 5 | 100,000 | - | | 0.5 pF | ± 5% | -330 |
| BLUE | 6 | 6 | 1,000,000 | - | | - | - | -470 |
| VIOLET | 7 | 7 | 10,000,000 | - | | - | - | -750 |
| GREY | 8 | 8 | 100,000,000 | .01 | | 0.25 pF | - | +30 |
| WHITE | 9 | 9 | 1,000,000,000 | .1 | | 1 pF | ± 10% | +100 |
| SILVER | | | .01 | - | ± 10% | - | - | |
| GOLD | | | .1 | - | ± 5% | - | - | |
| SALMON PINK | | | | | | | | |
| NO "D" COLOUR | | | - | - | - | - | - | |

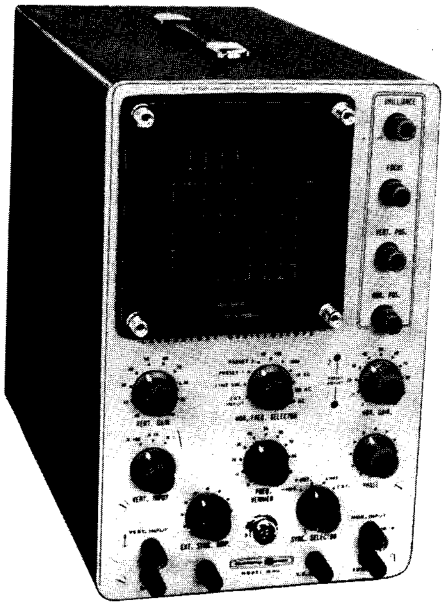
The Colour coding should be read from left to right, in order, starting from the end and finishing near the middle.

Standard ± tolerances for resistors are:- Wire-wound: 1%, 2%, 5%, 10%. Composition, Grade 1: 1%, 2%, 5%. Grade 2: 5%, 10%, 20%. (20% is indicated by 4th (or 'D') colour). Grade 1: ("high-stability") composition resistors are distinguished by a salmon-pink fifth ring or body colour. (Reference: B.S. 1852: 1952 B.S.I.).

N.B. High-Stability Resistors supplied with this kit are not as a rule colour coded but enamelled in one colour on which the value in Ohms is printed in figures. Capacitors supplied in this kit usually have their capacity clearly marked in figures. Some Capacitors coded as above also have additional "voltage rating" coding.

# Assembly and Operation of the
# Heathkit OSCILLOSCOPE

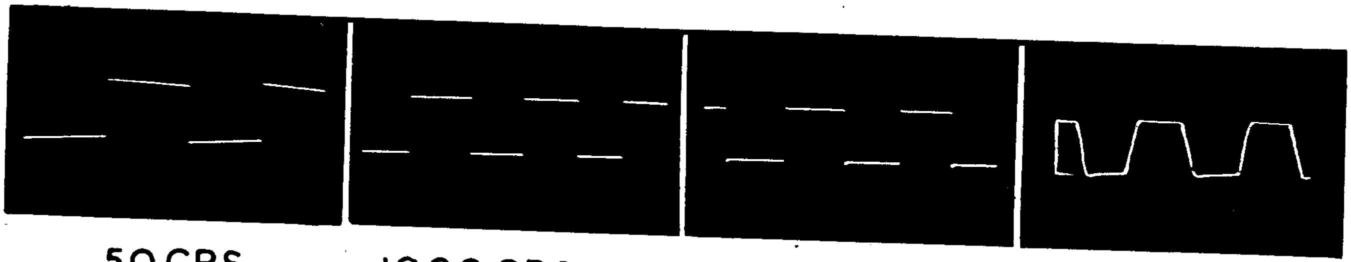
## MODEL IO-18U



SPECIFICATION

Vertical Channel

| | |
|---|---|
| Sensitivity: | 10 mV rms per cm at 1 kc/s |
| Frequency Response (0 dB ref. 1 kc/s): | ± 1 dB 8 c/s - 2.5 Mc/s<br>± 3 dB 3 c/s - 4.5 Mc/s |
| Overshoot: | 10% or less |
| Rise Time: | 0.08 μSec or less |
| Transient Response: | Oscillograms below are unretouched displays of square wave signals. (Rise time of source generator was less than 0.02 μSec.) |



50 CPS 1000 CPS 100 KC 1 MC

| | |
|---|---|
| Input Impedance: | In X1 position - 2.9 MΩ + 21 pF<br>In X10 and X100 positions - 3.4 MΩ + 12 pF |
| Attenuator: | Three position, switch type, fully compensated |
| Input Characteristics: | Input blocking capacitor rated at 600V d.c. |

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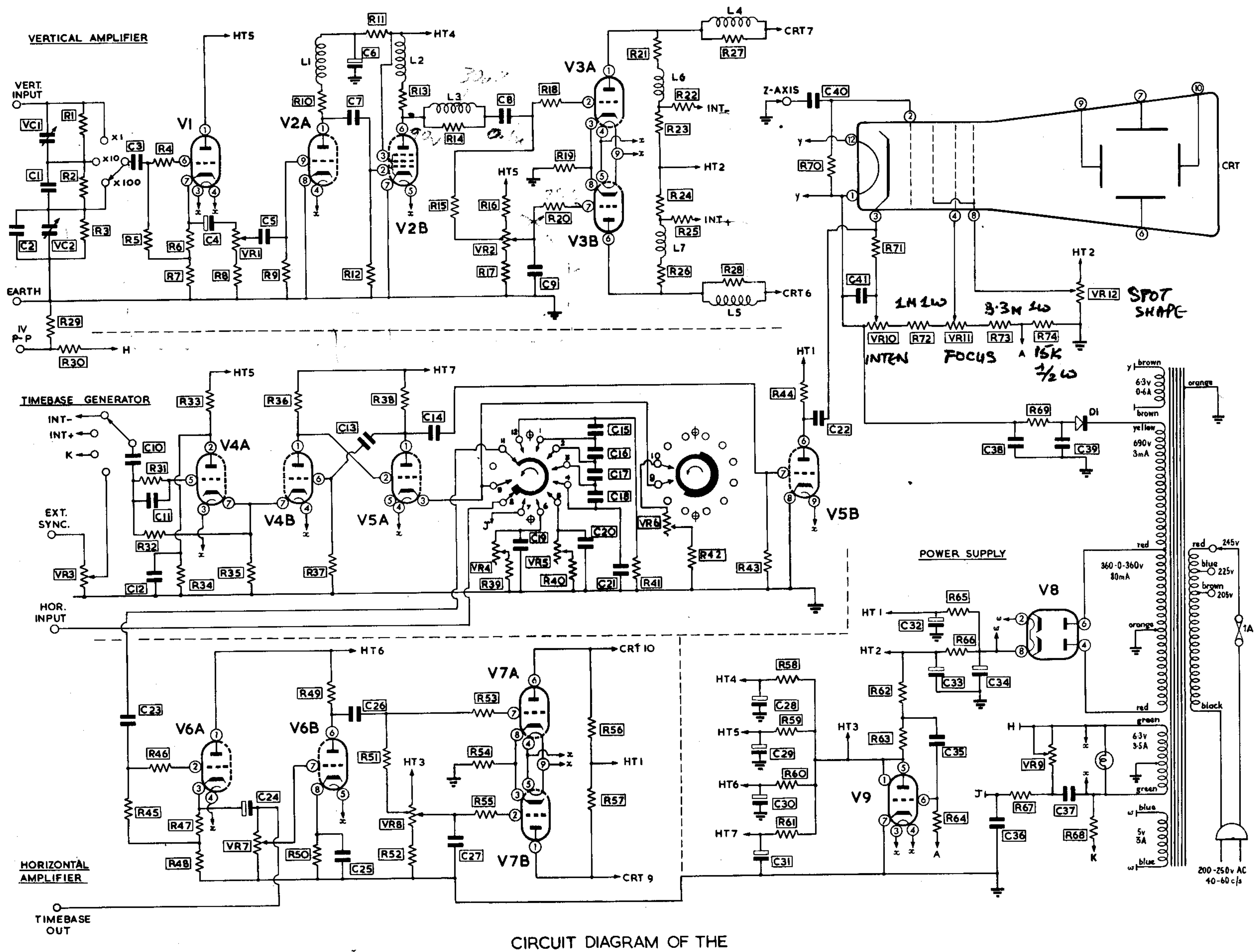



CIRCUIT DIAGRAM OF THE

HEATHKIT LABORATORY and GENERAL PURPOSE OSCILLOSCOPE

Model IO-18U

Heathkit DAYSTROM

| | |
|---|---|
| Vertical Positioning: | D.C. type. ± 4 cm approximately, about centre. Positioning is instantaneous and free from drift |
| **Horizontal Channel** | |
| Sensitivity: | 50 mV rms per cm at 1 kc/s |
| Frequency Response: | ± 1 dB 1 c/s - 200 kc/s<br>± 3 dB 1 c/s - 400 kc/s |
| Input Impedance: | 30 MΩ + 31 pF |
| Attenuator: | Low impedance type, in cathode follower output |
| Input Details: | Selector switch selects the following inputs:<br>(1) internal sweep<br>(2) line frequency sweep<br>(3) external input |
| Horizontal Positioning: | D.C. type; permits examination of any part of trace, even with full horizontal gain |
| **Time Base Generator** | |
| Type: | Recurrent type using Heath sweep circuit |
| Range: | 10 c/s - 500 kc/s in five ranges. Ranges are approximately as follows:<br>(1) 10 c/s - 100 c/s<br>(2) 100 c/s - 1000 c/s<br>(3) 1 kc/s - 10 kc/s<br>(4) 10 kc/s - 100 kc/s<br>(5) 100 kc/s - 500 kc/s |
| Pre-set Ranges (approximate): | Pre-set 1: 10 c/s - 100 c/s<br>Pre-set 2: 1 kc/s - 10 kc/s<br>Either may be changed to cover any frequency between 10 c/s and 500 kc/s |
| Synchronising: | Automatic lock-in circuit using self limiting cathode follower. Sweep speed held essentially independent of vertical gain setting. Sync. Selector switch has following functions:<br>(1) internal positive<br>(2) internal negative<br>(3) line frequency<br>(4) external |
| Time Base Output: | Approximately 10V (p-p) |
| Retrace Blanking: | Blanking intervals less than 30% sweep rate. Blanking amplifier provided. |
| **Power Supplies** | |
| High Voltage: | 1.2 kV transformer/½ wave rectifier type |
| Low Voltage: | Transformer, full wave rectifier type. Electronic regulation for all critical amplifier, time base and positioning potentials |
| **General** | |
| Phasing Control: | Fully controlled phase shift for 50 c/s sweep applications. Variable from 0° - 135° |
| Voltage Calibrator: | 1 volt peak-to-peak. Calibrated graticule |
| Z-Axis Modulation: | Through high voltage capacitor. 8-20V rms required for complete blanking of trace |
| Valve Line up: | Y amp. EC92, ECF80, 12BH7<br>Time Base. ECC91, ECC82<br>X amp. 6BQ7A, ECC82<br>Power Supply. GZ34, 6C4, K8/50 sel. rectifier<br>CRT. 5UP1(F), 5" flat face type, green with medium persistence phosphor |
| Power Requirements: | 200-250V, 40-60 c/s a.c., consumption 80W |
| Dimensions: | 8.5/8" x 13.1/2" x 16.1/2" |
| Net Weight: | 23 lb. (approximately) |
| Shipping Weight: | 35 lb. |

## INTRODUCTION

The Heathkit Model IO-18U Oscilloscope is an extremely useful instrument suitable either for use by the laboratory technician and electronic service engineer or by amateur radio enthusiasts and hobbyists.

It features a wide range of useful facilities e.g. push-pull horizontal and vertical amplifiers with a very wide range, switch selected internal or external sync., and a wide range of time base speeds. The critical sections of the power supply are electronically stabilised.

## CIRCUIT DESCRIPTION

### Vertical Amplifier.

A signal applied to the vertical input terminals is coupled, through the fully compensated attenuator to the cathode follower V1. This valve is arranged as a cathode follower to provide a high input impedance. From the output of V1 the signal goes, via the vertical gain control VR1 to the grid of V2A. This valve together with V2B are straight forward RC coupled amplifiers.

From the anode of V2B, the signal is passed through the series peaking 30 μH coil and coupled to the grid of the push-pull amplifier. Positioning of the trace in the vertical direction is accomplished by adjusting the vertical position control VR2. This varies the relative d.c. voltages between the halves of the push-pull amplifier. The fixed tap on control VR2 provides the reference voltage for V3A. The push-pull stage, V3A and V3B, drives the CRT vertical plates to provide a balanced deflection of the electron beam. The coupling of the cathodes of V3A and V3B accomplishes the necessary phase-splitting between the two halves of the push-pull amplifier. A small proportion of the signal from the anode circuits of the push-pull stage is taken to the sync. selector switch to facilitate positive or negative internal sweep synchronisation.

### Sweep (Time Base) Generator.

The sync. selector switch is used to select the desired synchronising signal. This signal is applied to V4A via the shaping network of R31 and C11. V4A is arranged as a cathode follower and the sync. signal is coupled to the time base generator by means of the common cathode resistor R35. The time base generator consists of V4B and V5A arranged as a multivibrator. The timing capacitor that is switched into the cathode circuit of V5A determines the coarse horizontal sweep frequency as it discharges through R42 and the Frequency Vernier control VR6. Fine frequency control of this sawtooth wave form is obtained by adjusting this Frequency Vernier control. Facilities are provided for two pre-set time base speeds using VR4, VR5, R39, R40, C19 and C20.

A retrace blanking signal is coupled to the CRT, through blanking amplifier V5B from the sweep generator. The positive going part of the sweep sawtooth wave form is used for this purpose.

### Horizontal Amplifier.

The Horizontal Frequency Selector switch is used to select the desired time base speed and apply it to the input cathode follower V6A. This sweep signal may be from the time base generator, 50 c/s line sweep, or an external signal from the Horizontal input terminal.

The signal is coupled from V6A via the horizontal gain control VR7 to amplifier V6B. From the top end of the horizontal gain control the sweep signal is taken to the time base out terminal. From V6B the signal is taken to the push-pull horizontal deflection amplifier V7A and V7B. The horizontal positioning of the trace is accomplished by adjusting VR8. This adjusts the relative d.c. voltages on the grids of V7A and V7B. The centre tap on VR8 provides the reference voltage for V7A. The push-pull amplifier is coupled to the CRT horizontal plates to provide a balanced deflection of the electron beam.

### Cathode Ray Tube (CRT).

The operation and accelerating voltages for the cathode ray tube are supplied by a bleeder network connected from the high voltage supply (EHT) to earth. This network contains the focus and brilliance controls and supplies bias to the stabiliser triode V9. Intensity modulation of the electron beam is accomplished where required by connecting an external signal to the Z-axis input to the CRT, located on the rear circuit board.

### Power Supply.

EHT for the cathode ray tube is obtained from an overwind on the secondary of the mains transformer. It is rectified by the selenium EHT rectifier D1, smoothed by R69, C38 and C39 and thence coupled to the CRT.

The normal HT voltage is supplied by full wave rectifier V8, a heavy duty double diode, and it's associated smoothing circuitry, R65 and R66, C32, C33 and C34.

V9, the stabiliser triode is used to isolate the amplifier and time base stages from power line pulses and surges.

Three separate heater windings are used, one 6.3 volt at 0.6A, supplies the CRT only, one, 5 volt at 3A, supplies the rectifier V8 and the third 6.3 volt at 3.5A centre tapped, supplies all the other valves and supplies a.c. voltage to the HOR/FREQ. switch for line sweep, to the phase control and the 1 volt peak-to-peak calibrating voltage.

RESISTOR AND CAPACITOR IDENTIFICATION CHART (see Circuit Diagram)

| | | | | | |
|---|---|---|---|---|---|
| C1 | 47 pF mica | R8 | 220Ω | R60 | 3.9 KΩ |
| C2 | 390 pF mica | R9 | 10 MΩ | R61 | 10 KΩ |
| C3 | 0.1 μF 600V paper | R10 | 2.2 KΩ | R62 | 5 KΩ 8W |
| C4 | 100 μF 50V electrolytic | R11 | 3.3 KΩ | R63 | 220Ω |
| C5 | 0.1 μF 250V paper | R12 | 10 MΩ | R64 | 1 MΩ |
| C6 | 40 μF 150V electrolytic | R13 | 2 KΩ | R65 | 4.7 KΩ 2W |
| C7 | 0.1 μF 250V paper | R14 | 2 KΩ | R66 | 1 KΩ 8W |
| C8 | 0.1 μF 250V paper | R15 | 3.3 MΩ | R67 | 470 KΩ |
| C9 | .01 μF ceramic disc | R16 | 100 KΩ | R68 | 10 KΩ |
| C10 | 0.25 μF 400V paper | R17 | 33 KΩ | R69 | 470 KΩ 1W |
| C11 | 10 pF ceramic disc | R18 | 100Ω | R70 | 100 KΩ |
| C12 | 0.1 μF 250V paper | R19 | 1.2 KΩ 2W | R71 | 150 KΩ |
| C13 | .05 μF 250V paper | R20 | 100Ω | R72 | 1 MΩ 1W |
| C14 | 100 pF ceramic disc | R21 | 2.7 KΩ 2W | R73 | 3.3 MΩ 1W |
| C15 | 20 pF ceramic disc | R22 | 3.3 KΩ | R74 | 15 KΩ |
| C16 | 200 pF ceramic disc | R23 | 1 KΩ 1W | VR1 | 2 KΩ lin |
| C17 | .002 μF ceramic disc | R24 | 1 KΩ 1W | VR2 | 20 KΩ lin centre tapped |
| C18 | .02 μF ceramic disc | R25 | 3.3 KΩ | VR3 | 2 MΩ lin |
| C19 | 0.2 μF 200V paper | R26 | 2.7 KΩ 2W | VR4 | 7.5 MΩ lin pre-set |
| C20 | .002 μF ceramic disc | R27 | 3.3 KΩ 1W | VR5 | 7.5 MΩ lin pre-set |
| C21 | 0.2 μF 200V paper | R28 | 3.3 KΩ 1W | VR6 | 7.5 MΩ lin |
| C22 | 0.02 μF 2kV ceramic disc | R29 | 62Ω 5% | VR7 | 10 KΩ lin |
| C23 | 0.25 μF 400V paper | R30 | 470Ω | VR8 | 200 KΩ lin centre tapped |
| C24 | 40 μF 150V electrolytic | R31 | 1 MΩ | VR9 | 250 KΩ lin |
| C25 | .002 μF ceramic disc | R32 | 470 KΩ | VR10 | 500 KΩ lin |
| C26 | 0.1 μF 250V paper | R33 | 150 KΩ | VR11 | 2 MΩ lin |
| C27 | 0.1 μF 250V paper | R34 | 33 KΩ | VR12 | 1 MΩ lin |
| C28 | *50 μF 300V electrolytic | R35 | 820Ω | Valves | |
| C29 | +40 μF 275V electrolytic | R36 | 6.8 KΩ | V1 | EC92 |
| C30 | +40 μF 275V electrolytic | R37 | 470 KΩ | V2 | ECF80 |
| C31 | +20 μF 275V electrolytic | R38 | 10 KΩ | V3 | 12BH7 |
| C32 | *20 μF 450V electrolytic | R39 | 150 KΩ | V4 | ECC91/6J6 |
| C33 | *40 μF 450V electrolytic | R40 | 150 KΩ | V5 | ECC82/12AU7 |
| C34 | *20 μF 450V electrolytic | R41 | 4.7 MΩ | V6 | 6BQ7A |
| C35 | 0.25 μF 400V paper | R42 | 150 KΩ | V7 | ECC82/12AU7 |
| C36 | 0.01 μF 400V paper | R43 | 22 MΩ | V8 | GZ34 |
| C37 | 0.05 μF 250V paper | R44 | 100 KΩ 1W | V9 | 6C4 |
| C38 | 0.1 μF 2 kV paper | R45 | 4.7 MΩ | VC1 | 25 pF |
| C39 | 0.1 μF 2 kV paper | R46 | 2.2 KΩ | VC2 | 250 pF |
| C40 | 0.02 μF 2 kV ceramic disc | R47 | 2.2 KΩ | CRT | 5UP1(F) |
| C41 | 0.1 μF 250V paper | R48 | 47 KΩ | D1 | K8/50 Selenium Rectifier |
| | | R49 | 22 KΩ | L1 | 61 μH (RED) |
| R1 | 3.3 MΩ 5% | R50 | 220Ω | L2 | 61 μH (RED) |
| R2 | 330 KΩ 5% | R51 | 10 MΩ | L3 | 30 μH (GREEN) |
| R3 | 36 KΩ 5% | R52 | 22 KΩ | L4 | 33 μH |
| R4 | 100Ω | R53 | 100Ω | L5 | 33 μH |
| R5 | 3.3 MΩ | R54 | 12 KΩ 2W | L6 | 90 μH (BLUE) |
| R6 | 220Ω | R55 | 100Ω | L7 | 90 μH (BLUE) |
| R7 | 2.7 KΩ | R56 | 33 KΩ 1W | | |
| | | R57 | 33 KΩ 1W | | |
| * Denotes in the same can | | R58 | 1.5 KΩ 1W | | |
| + Denotes in the same can | | R59 | 3.9 KΩ | | |

## PRELIMINARY NOTES AND INSTRUCTIONS

The Step-by-Step instructions given in this manual should be followed implicitly to ensure a minimum of difficulty during construction and a completely satisfactory result, including many years of accurate, trouble-free service from the finished instrument.

UNPACK THE KIT CAREFULLY, EXAMINE EACH PART AND CHECK IT AGAINST THE PARTS LIST. In so doing, you will become acquainted with the parts. You will find it helpful to refer to the component identification sheet and also to the general details printed on the inside covers of the manual. If a shortage is found, attach the inspection slip to your claim and notify us promptly.

Lay out all the parts so that they are readily available in convenient categories. Refer to the general information inside the covers of this manual for instructions on how to identify components.

Moulded egg containers make handy trays for holding small parts. Resistors and capacitors may be placed in the edge of a corrugated cardboard box until they are needed.

Unless otherwise stated, use lockwashers under all nuts, and also between controls and the chassis. When shakeproof solder tags are mounted under nuts, the use of lockwashers is unnecessary.

Resistors and capacitors have a tolerance rating of ± 10% unless otherwise stated. Therefore a 100 KΩ resistor may test anywhere between 90 and 110 KΩ. Frequently capacitors show an even greater variation such as -50% to +100%. This Heathkit accommodates such variations.

Unless otherwise stated all wire used is insulated. Bare wire is only used where lead lengths are short and there is no possibility of a short circuit. Wherever there is a possibility of the bare wire leads of resistors or capacitors, etc., shorting to other parts or to chassis, such leads must be covered with insulated sleeving.

To facilitate describing the location of parts, all valveholders, controls, tagstrips, etc., have been lettered or numbered. Where necessary all such coding is clearly shown in the illustrations. When instructions say, for example, "wire to socket G3", refer to the proper figure and connect a wire to tag 3 of socket G.

Valveholders illustrated in the manual are always shown with their tags numbered in a clockwise sequence, from the blank tag position or keyway, when viewed from underneath.

All resistors may be wired either way round.

All capacitors, excepting electrolytic capacitors, may be wired either way round unless otherwise stated.

Carefully letter and number tagstrips, valveholders, transformers, etc. A wax pencil is ideal for this purpose.

When mounting resistors and capacitors make sure that the value can be read when in position.

Observe polarity on all electrolytic capacitors, i.e. RED = POSITIVE = +.

A circuit description is included in this manual so that those with some knowledge of electronics will be able to obtain a clearer picture of the actual functioning of this instrument. It is not expected that those with little experience will understand the description completely, but it should be of help in the event that they desire to become more familiar with the circuit operation and thus learn more from building the kit than just the placing of parts and the wiring.

Read this manual right through before starting actual construction. In this way, you will become familiar with the general step-by-step procedure used. Study the pictorials and diagrams to get acquainted with the circuit layout and location of parts. When actually assembling and wiring, READ THROUGH THE WHOLE OF EACH STEP so that no point will be missed.

A tick (✓) should be made in the space provided at the beginning of each instruction immediately it has been completed. This is most important as it will avoid omissions or errors, especially whenever work is interrupted in the course of construction. Some Kit-builders have found it helpful in addition to mark each lead in the pictorial in coloured pencil as it is completed.

Successful instrument construction requires close observance of the step-by-step procedure outlined in this manual. For your convenience, some illustrations may appear in large size folded sheets. It is suggested that these sheets be fastened to the wall over your work area for reference purposes during instrument construction.

The Company reserves the right to make such circuit modification and/or component substitutions as may be found desirable, indication being by "Advice of Change" included in the kit.

NOTE: Daystrom Ltd. will not accept any responsibility or liability for any damage or personal injury sustained during the building, testing, or operation of this instrument.

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 ONLY "60/40" RESIN CORE RADIO SOLDER BE PURCHASED.

## PROPER SOLDERING PROCEDURE

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

Correct soldering technique is extremely important. Good soldered joints are essential if the performance engineered into the kit is to be fully realised. If you are a beginner with no experience in soldering, half an hour's practice with odd lengths of wire and a valveholder, etc., will be invaluable.

Highest quality resin-cored solder is essential for efficiently securing this kit's wiring and components. The resin core acts as a flux or cleaning agent during the soldering operation.

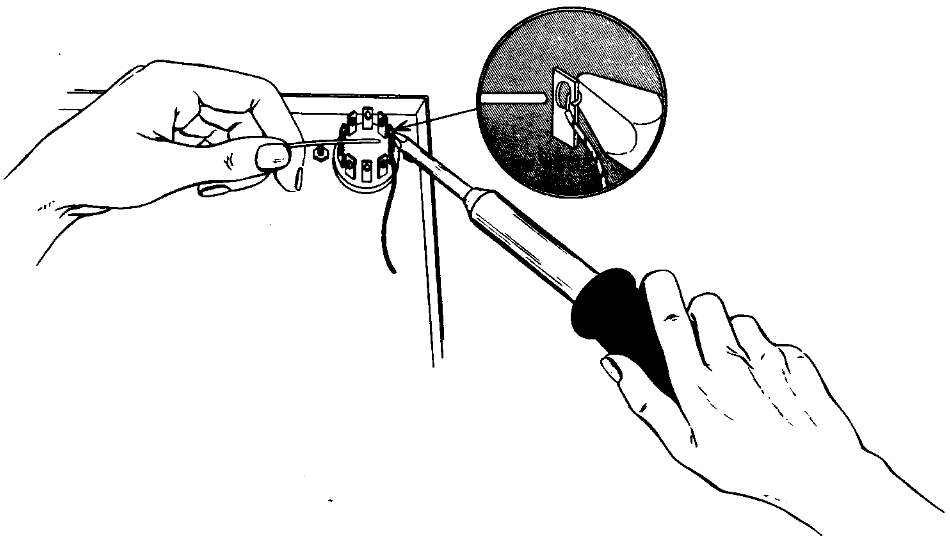
NO SEPARATE FLUX OR PASTE OF ANY KIND SHOULD BE USED. We specifically caution against the use of so-called "non-corrosive" pastes or liquids. Such compounds, although not corrosive at room temperature, will form residues when heated. These residues are deposited on surrounding surfaces and attract moisture.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

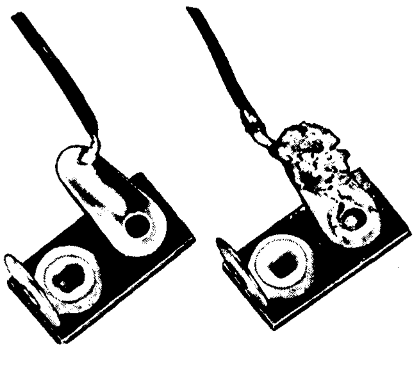
## IMPORTANT

IN THE "STEP-BY-STEP" PROCEDURE the abbreviation "NS" indicates that the connection should not yet be soldered, for other wires will be added. At a later stage the letter "S" indicates that the connection must now be soldered. Note that a number appears after each solder (S) instruction. This number indicates the number of leads connected to the terminal in question. For example, if the instructions read, "Connect one lead of a 47 KΩ resistor to tag 1 (S-2)", it will be understood that there should be two leads connected to the terminal at the time it is soldered. This additional check will help to avoid errors.

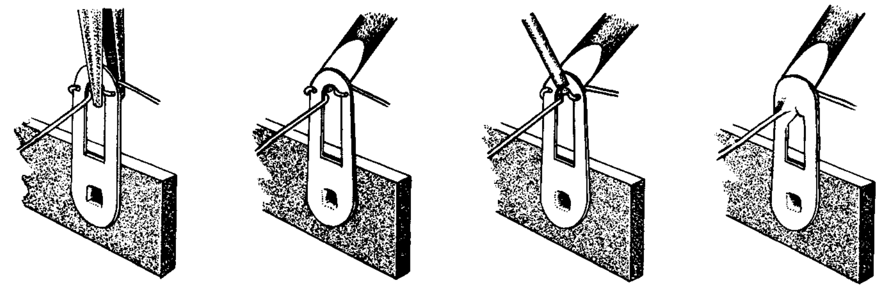
SPECIAL NOTE: Where a wire is passed through a tag to other parts of the circuit, this will be regarded as two connections (S-2).

When two or more connections are made to the same solder tag a common mistake is to neglect to solder the connections on the bottom. Make sure all the wires are soldered.

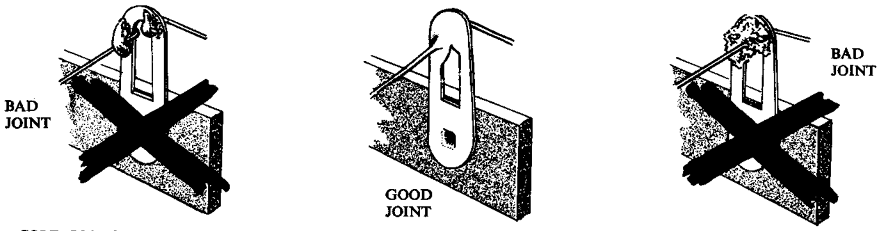




If the tags are bright and clean and wires free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Crimp or otherwise secure the wire (or wires) to the terminal, so a good mechanical joint is made without relying on solder for physical strength.



CRIMP WIRES — HEAT CONNECTION — APPLY SOLDER — ALLOW SOLDER TO FLOW




COLD SOLDER JOINT CONNECTION INSUFFICIENTLY HEATED — PROPER SOLDERED CONNECTION — COLD SOLDER JOINT CONNECTION MOVED WHILE COOLING

Typical good and bad soldered joints are shown above.

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

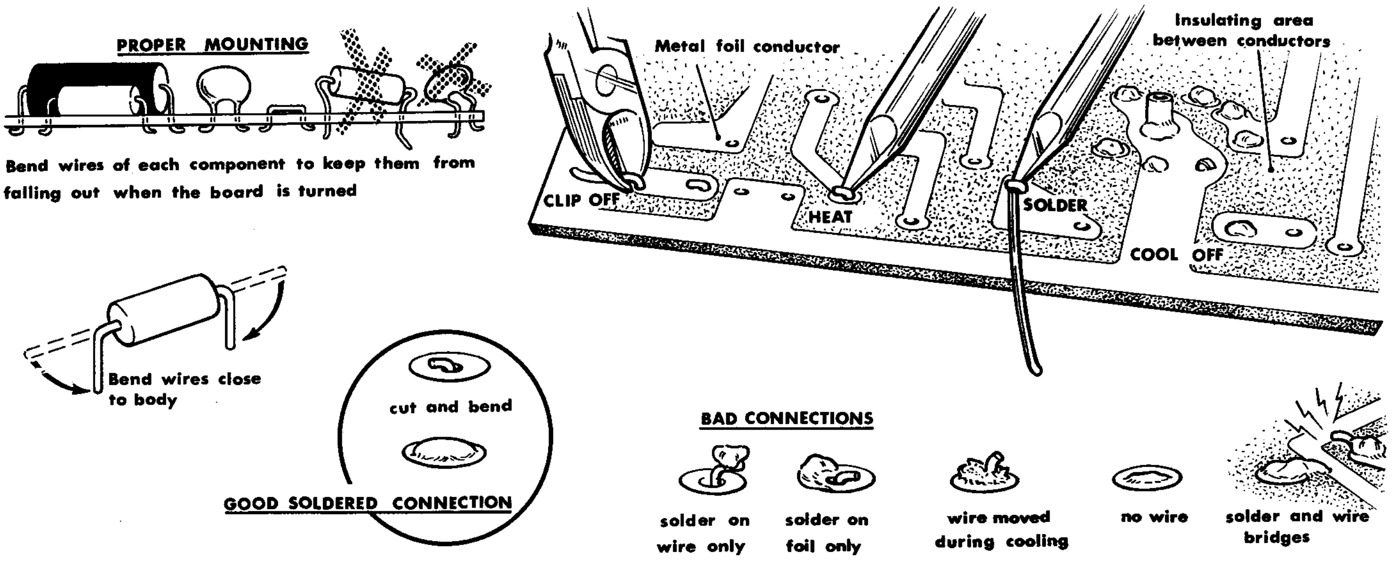
To make a good soldered joint, the clean tip of the hot soldering iron should be placed against the joint to be soldered so that the flat tag is heated sufficiently to melt the solder. Resin core solder is then placed against both the tag and the tip of the iron and should immediately flow over the joint. See illustrations. Use only enough solder to cover the wires at the junction; it is not necessary to fill the entire hole in the tag with solder. Do not allow excess solder to flow into valveholder contacts, ruining the sockets, or to creep into switch sockets and destroy their spring action. Position the work so that gravity tends to keep the solder where you want it.

A clean, well-tinned soldering iron is also important to obtain consistently perfect connections. For most wiring, a 25 to 50 watt iron, or the equivalent in a soldering gun, is very satisfactory. Keep the iron hot and its tip and the connections to be soldered bright and clean. Always place the solder on the heated "work" and then place the bit on top of the solder until it flows readily and "wets" the joint being made. Do not take the solder on to the bit and then try to bring it to the work directly from the soldering iron. Whenever possible a joint should be secured mechanically by squeezing tight with pliers prior to soldering it. The hot soldering bit should frequently be scraped clean with a knife, steel wool or a file, or wiped clean quickly be means of a rag or steel wool.

Do not apply too much solder to the soldered joint. Do not apply the solder to the iron only, expecting that it will roll down onto the connection. Try to follow the instructions and illustrations as closely as possible.

Do not bend a lead more than once around a connecting point before soldering, so that if it should have to come off due to a mistake or for maintenance it will be much easier to remove.

Follow these instructions and use reasonable care during assembly of the kit. This will ensure the deserved satisfaction of having the instrument operate perfectly the first time it is switched on.




## CIRCUIT BOARD WIRING AND SOLDERING

Before attempting any work on the circuit board, read the following instructions carefully and study the figures shown. The observation of a few basic precautions will ensure proper operation of the unit when first switched on.

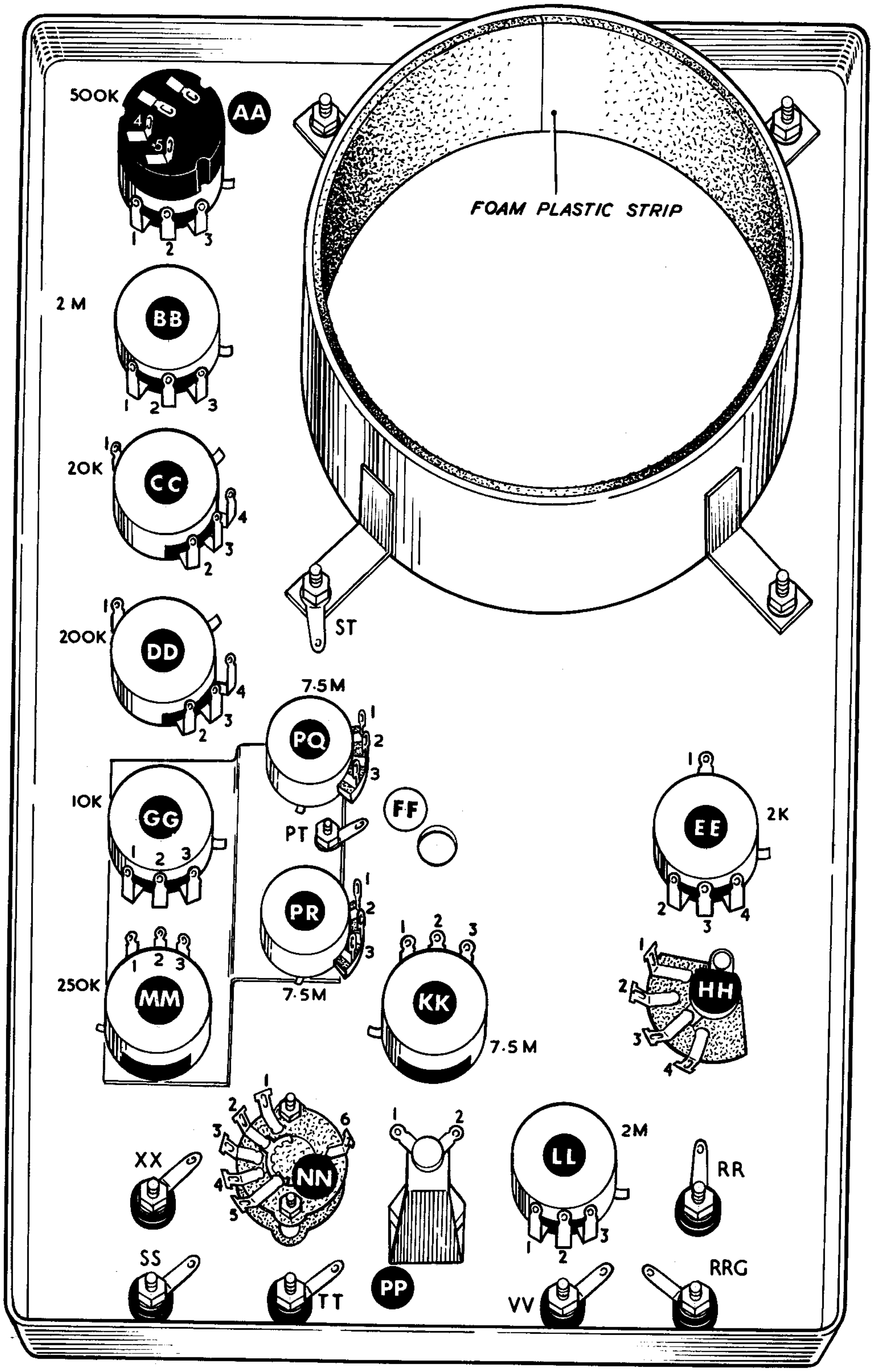
Proper mounting of components on the board is essential for good performance. A good general rule to follow is that all components on the board should be mounted tightly to the board, unless instructions state otherwise. All wires should be kept as short as possible to minimize the effects of stray capacity in the wiring. Proper and improper methods of mounting are illustrated in the accompanying Figures. Tubular capacitors and resistors will fit properly if their wires are bent as shown. Disc capacitors will generally fit in place with no lead preparation other than determining that the leads are straight. Components with tags normally require no preparation unless the tags are bent, in which case they can be straightened with a pair of pliers. Parts should be inserted as instructed, and the leads bent outward to retain in position. Each lead is then cut about 1/8" from the board and dressed flat against the foil, making sure that it does not extend beyond the conductor area.

The technique of soldering leads to a circuit board is quite simple. Position the tip of the soldering iron so that it firmly contacts both the circuit board foil and the wire or tag to be soldered as shown. Then the solder should immediately be placed between the iron and the joint to be soldered. Hold the tip of the iron in place until the solder has "wetted" both the component lead and the foil pattern on the board. Apply more solder if necessary and allow it to flow smoothly over both surfaces and when this is achieved, quickly remove the iron. Sufficient solder must be used to surround and adhere to a component lead on all sides but the possibility of an unwanted bridge between adjacent conductor areas whether by solder or an excessively long component lead must not be overlooked. It is important that no movement should occur during cooling off, otherwise a "cold joint" will occur which will sooner or later give trouble.

A soldering iron of 20 to 30 watts is ideal and in general such irons cannot damage the board due to overheating. If however, a higher wattage iron is used, it is important to remove it as soon as a satisfactory flow of solder is achieved.

After soldering a group of components each and every joint must be carefully examined to ensure that no joint is overlooked and by comparing with the figures above, that no solder bridges, dry, cold or otherwise imperfect joints have been made. This is very important as a higher percentage of failures occur for these reasons than for any others.

If solder is accidentally bridged across insulating areas between conductors, it can be cleaned off by heating the connection carefully and quickly wiping the solder away with a soft cloth. Holes which become plugged can be cleared by heating the area immediately over the hole while gently pushing the lead of a resistor through the hole from the opposite side, and withdrawing the lead before the solder rehardens. Do not force the wire through; too much pressure before the solder has time to soften may separate the foil from the board. In cases where foil becomes damaged, a break in the foil can be rejoined with a small piece of bare wire soldered across the gap, or between the foil and the lead of a component.


500K
AA
2 M
BB
20K
CC
200K
DD
FOAM PLASTIC STRIP
ST
7·5M
PQ
FF
PT
10K
GG
EE
2K
PR
250K
MM
7·5M
KK
7·5M
HH
NN
XX
PP
LL
2M
RR
SS
TT
VV
RRG

PICTORIAL 1

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

(✓) If there is an amendment sheet to this manual, make sure that you have made the alterations in the appropriate places.

## FRONT PANEL SUB-ASSEMBLY

Refer to Pictorial 1 and Figure 1 for the following steps:

(✓) Select the front panel and place face down on a soft cloth to avoid damage.

(✓) Refer to Figure 1 and bend down the locating peg on all the controls except the 7.5 megohm pre-set controls.

(✓) Mount the 500 KΩ control with switch at AA. Position the tags as shown.

(✓) Mount the 2 megohm control with insulated shaft at BB. Position the tags as shown.

(✓) Mount the 20 KΩ centre tapped control at CC. Position the tags as shown.

(✓) Mount the 200 KΩ centre tapped control at DD. Position the tags as shown and ensure that the tags will not touch the control mounting bracket to be fitted later.

(✓) Mount the 2 KΩ control at EE. Position the tags as shown. NOTE: This control has a dummy tag for use as a tie point.

(✓) Mount the 7.5 megohm control at KK. Position the tags as shown.

(✓) Mount the 2 megohm control at LL. Position the tags as shown.

(✓) Mount the 4-tag vertical attenuator switch at HH. Position the tags as shown.

(✓) Mount the 6-tag sync. selector switch at NN. Position the tags as shown.

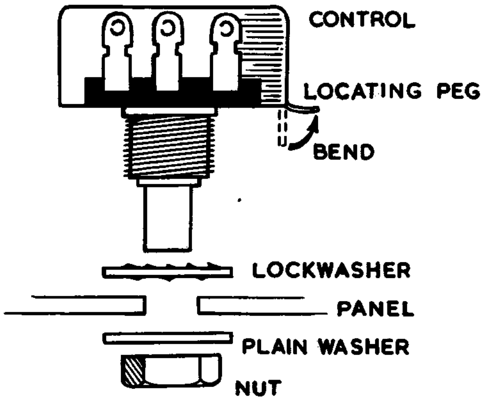



FIGURE 1

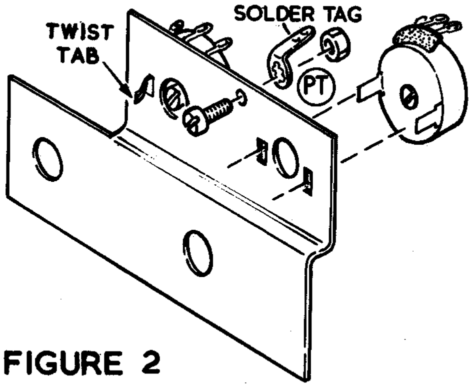



FIGURE 2

Refer to Figure 2 for the following steps:

(✓) Select the control mounting bracket and the two 7.5 MΩ tab mounting pre-set controls.

(✓) Mount the two controls on the bracket as shown in Figure 2.

(✓) Using one 4BA x 3/8" binderhead screw and a 4BA nut, mount a 4BA shakeproof solder tag at PT.

(✓) Mount the control mounting bracket to the front panel, in the position shown in Pictorial 1, by installing the 10 KΩ control at GG. Position the tags as shown. Place the control's lockwasher between the control and the control mounting bracket so that the bracket is flush against the front panel. DO NOT TIGHTEN THE NUT FULLY.

(✓) Similarly install the 250 KΩ lin control at MM. Position the tags as shown in Pictorial 1. DO NOT TIGHTEN THE NUT FULLY.

(✓) Now, checking that the tags on GG and MM are not touching the bracket, tighten both nuts fully.

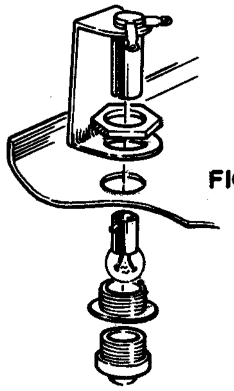


FIGURE 2A

(✓) Refer to Figure 2A and mount the pilot lamp socket at PP. Insert the 6.3V bulb in this socket.

Refer to Pictorial 1 and Figure 3 for the following two steps:

(✓) Mount RED terminals at RR and XX as shown in Figure 3. Under each nut use a 4BA shakeproof solder tag and before tightening the nut, position the solder tag as shown in Pictorial 1 and ensure that the cross-drilled holes in the terminal bodies are horizontal.

(✓) Mount BLACK terminals at RRG, SS, TT and VV as shown in Figure 3. Under each nut use a 4BA shakeproof solder tag and, before tightening the nut, position the solder tag as shown in Pictorial 1 and ensure that the cross-drilled holes in the terminal bodies are horizontal.

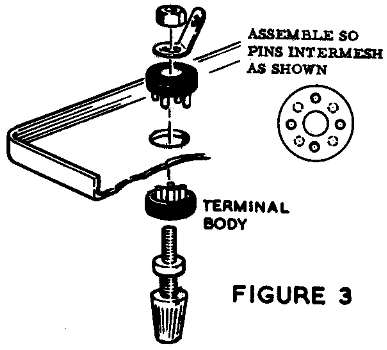



FIGURE 3

(✓) Mount the tube support ring on the front panel as shown in Figure 4. Fit a 4BA solder tag at ST and secure using four terminal bodies, three 4BA lock-washers and four 4BA nuts.

(✓) Clean the inside of the ring with 'Thawpit' or some similar cleaner. Select the foam plastic strip and peel off an inch or so of the protective backing from the adhesive surface. Starting at the top i.e. 12 o'clock, fit the strip to the inside surface of the tube support ring, peeling off the backing as you go. Proceed completely round the ring and cut off any surplus strip.

## HORIZONTAL FREQUENCY SELECTOR SWITCH WIRING

NOTE: The constructor may find it helpful to mount the switch on the base of a small upturned cardboard box. This may make the operation of wiring the switch considerably easier. A 15" rule is provided on loose leaf Pictorial 2.

(✓) Select the HOR/FREQ. SELECTOR switch FF. This is the 12-tag wafer switch. Note that one of the contacts has tags on both sides of the wafer. Using this tag as a reference, position the switch as shown in Figure 5. Also note that tag 10 is on the shaft side of the wafer.

Refer to Figure 5 for the following steps:

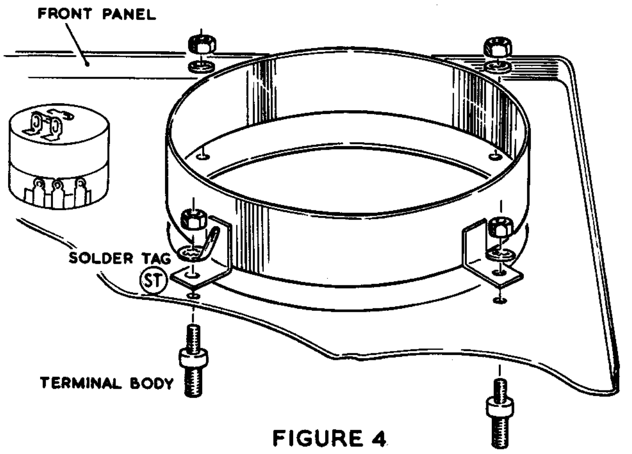



FIGURE 4

(✓) Connect one end of a $2\frac{3}{4}$" length of wire to FF tag 5 (S-1). Leave the other end free, it will be connected later.

(✓) Connect one end of a $3\frac{1}{2}$" length of wire to FF tag 6 (S-1). Leave the other end free.

(✓) Connect one end of a $1\frac{1}{2}$" length of wire to FF tag 10 (S-1). Leave the other end free.

(✓) Connect one end of a $5\frac{3}{4}$" length of wire to FF tag 8 (S-1). Leave the other end free.

(✓) Connect one end of a $2\frac{1}{2}$" length of wire to FF tag 7 (S-1). Leave the other end free.

(✓) Connect one end of a 4" length of wire to FF tag 9 (S-1). NOTE: Make sure that this wire is soldered to both contacts at position 9. Leave the other end free.

(✓) Connect one end of a $2\frac{3}{4}$" length of wire to FF tag 11 (S-1). Leave the other end free.

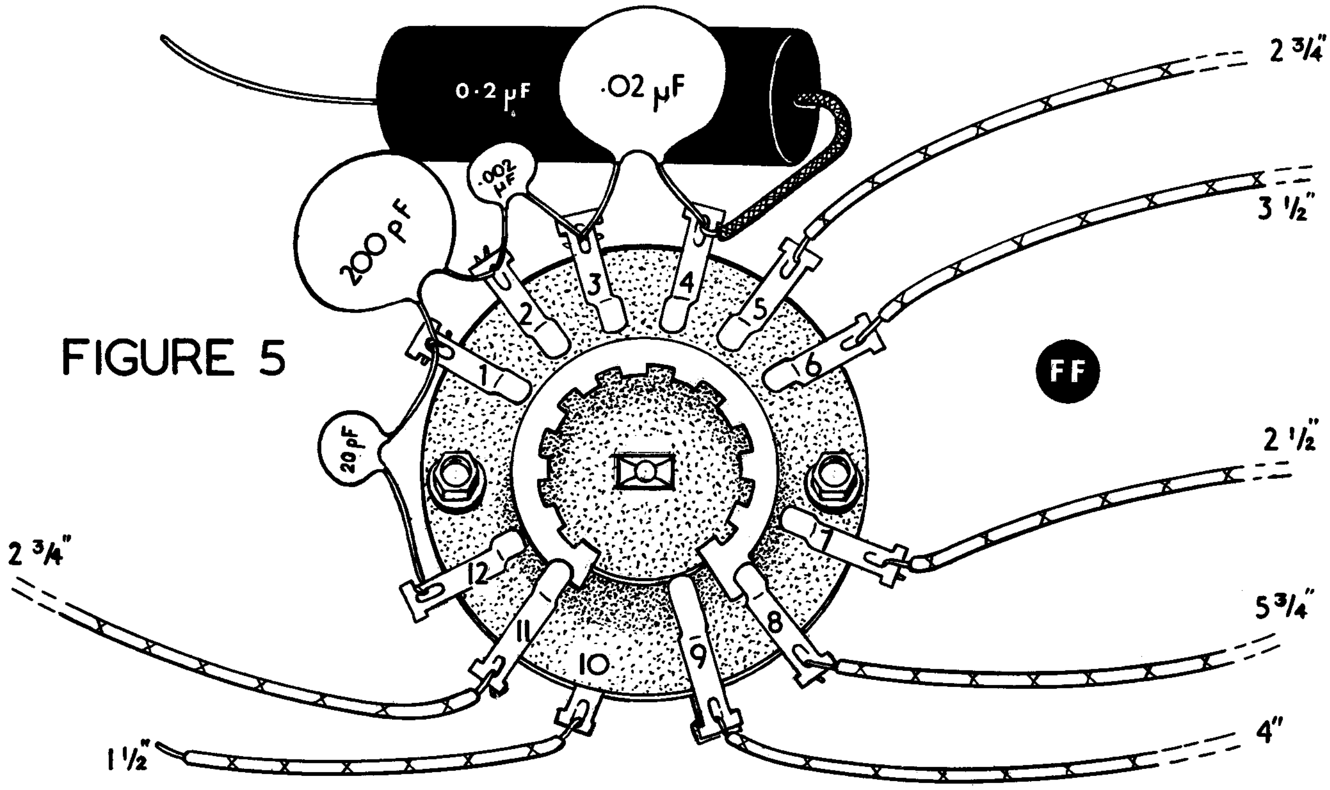



FIGURE 5

( ✓) Connect a 20 pF ceramic disc capacitor from FF tag 12 (NS) to FF tag 1 (NS).

( ✓) Connect a 200 pF ceramic disc capacitor from FF tag 1 (S-2) to FF tag 2 (NS).

( ✓) Connect a .002 µF ceramic disc capacitor from FF tag 2 (S-2) to FF tag 3 (NS).

( ✓) Connect a .02 µF 500V ceramic disc capacitor between FF tag 3 (S-2) to FF tag 4 (NS).

( ✓) Using ¾" of sleeving, connect one end of a 0.2 µF 200V paper capacitor to FF tag 4 (S-2). Leave the other end free.

( ✓) Carefully check the switch wiring against Figure 5. Make sure that there is no short circuit from FF tags 1, 6, 7 and 12, to the nuts holding the switch together.

( ✓) Mount the switch on the front panel at FF as shown in Pictorial 2. Make sure that tags 3 and 4 are pointing towards the top of the panel.

## PANEL WIRING

Refer to Pictorial 2 for the following steps:

( ✓) Refer to Figure 6 and note that on the 500 KΩ control with switch AA, only two of the four switch tags are used. Bend down the other two tags as shown.

( ✓) Using ¾" of sleeving on each end, connect a 1 megohm 1 watt resistor (BROWN, BLACK, GREEN) from AA tag 3 (S-1) to BB tag 3 (S-1).

( ✓) Using ¾" of sleeving on each end, connect a 22 KΩ resistor (RED, RED, ORANGE) from DD tag 2 (S-1) to solder tag ST (NS).

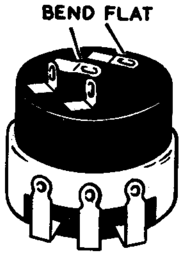



FIGURE 6

( ✓) Using 1" of sleeving on each end, connect a 33 KΩ resistor (ORANGE, ORANGE, ORANGE) from CC tag 2 (S-1) to solder tag ST (NS).

( ✓) Using $\frac{3}{4}$" of sleeving on each end, connect a 220Ω resistor (RED, RED, BROWN) from EE tag 4 (S-1) to EE tag 1 (NS).

( ✓) Connect the $2\frac{3}{4}$" wire from FF tag 5 to PQ tag 3 (NS).

( ✓) Connect the $3\frac{1}{2}$" wire from FF tag 6 to PR tag 2 (NS).

( ✓) Connect the $1\frac{1}{2}$" wire from FF tag 10 to KK tag 3 (S-1).

( ✓) Connect the $5\frac{3}{4}$" wire from FF tag 8 to XX (hor. input terminal) (S-1).

( ✓) Connect the free end of the 0.2 μF capacitor connected to FF tag 4 to solder tag ST (NS).

( ✓) Using $\frac{1}{2}$" of sleeving on one end of a 150 KΩ resistor (BROWN, GREEN, YELLOW), pass it through PQ tag 1 (NS) and connect to PQ tag 2 (S-1). Now solder PQ tag 1 (S-2).

( ✓) Using $\frac{1}{2}$" of sleeving, connect the other end of this resistor to solder tag ST (S-4).

( ✓) Connect a 0.002 μF ceramic disc capacitor from PQ tag 3 (S-2) to solder tag PT (NS).

( ✓) Connect a 4.7 megohm resistor (YELLOW, VIOLET, GREEN) from FF tag 12 (S-2) to solder tag PT (NS).

( ✓) Connect a 150 KΩ resistor (BROWN, GREEN, YELLOW) from KK tag 2 (S-1) to solder tag PT (NS).

( ✓) Connect a $2\frac{1}{4}$" length of wire from GG tag 3 (S-1) to solder tag PT (S-4).

( ✓) Using 1" of sleeving on each end, connect a 150 KΩ resistor (BROWN, GREEN, YELLOW) from PR tag 3 (S-1) to NN tag 6 (NS).

( ✓) Using $\frac{1}{2}$" of sleeving on each end, connect a 0.2 μF 200V paper capacitor from PR tag 2 (S-2) to NN tag 6 (NS).

( ✓) Connect a $4\frac{1}{2}$" length of wire from NN tag 6 (S-3) to LL tag 3 (NS).

( ✓) Connect one end of a 3" length of wire to LL tag 3 (S-2). Leave the other end free.

( ✓) Connect one end of a 13" length of wire to CC tag 4 (S-1). Leave the other end free. Route as shown.

( ✓) Connect one end of a 16" length of wire to EE tag 1 (S-2). Leave the other end free.

( ✓) Connect one end of a 3" length of wire to EE tag 2 (S-1). Leave the other end free.

( ✓) Connect one end of a 4" length of wire to GG tag 2 (S-1). Leave the other end free.

( ✓) Connect a 1" length of bare wire from HH tag 4 (S-1) to RR (NS) (vert. input terminal).

( ✓) Connect a 5" length of wire from LL tag 2 (S-1) to NN tag 4 (S-1).

( ✓) Connect a 5" length of wire from LL tag 1 (S-1) to SS (S-1) (ext. sync. terminal).

( ✓) Connect one end of a 5" length of wire to VV (S-1) (1 volt p-p terminal). Leave the other end free.

( ✓) Connect one end of a $4\frac{1}{2}$" length of wire to NN tag 5 (S-1). Leave the other end free.

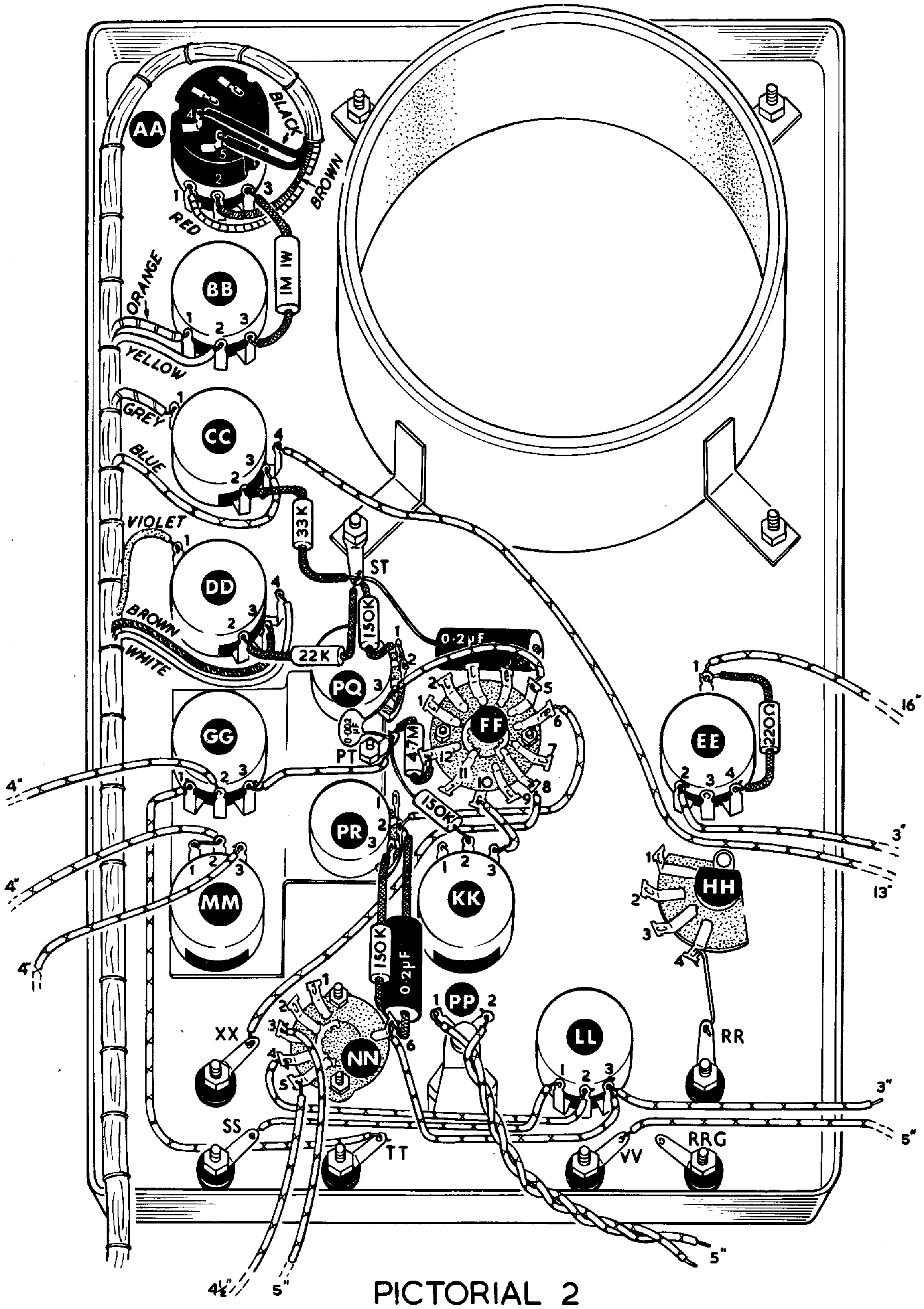
( ✓) Connect one end of a 5" length of wire to NN tag 3 (S-1). Leave the other end free.

( ✓) Connect a 7" length of wire from GG tag 1 (NS) to TT (S-1) (T.B. output terminal).

( ✓) Connect one end of a 4" length of wire through MM tag 2 to MM tag 1 (S-1). Now solder MM tag 2 (S-2). Leave the other end free.

( ✓) Connect one end of a 4" length of wire to MM tag 3 (NS). Leave the other end free.

( ✓) Twist together two 5" lengths of wire. Strip the insulation from all four ends $\frac{1}{4}$".


AA
BLACK
BROWN
RED
1M 1W
BB
ORANGE
YELLOW
GREY
CC
BLUE
33K
VIOLET
DD
BROWN
WHITE
ST
150K
0·2μF
22K
PQ
FF
0·002 μF
4·7M
PT
GG
PR
150K
KK
MM
EE
220Ω
HH
150K
0·2μF
PP
NN
LL
XX
RR
SS
TT
VV
RRG
16"
3"
13"
4"
4"
4"
3"
5"
5"
4½"
5"

PICTORIAL 2

(✓) At one end of this pair, connect one wire to PP tag 1 (S-1) and the other to PP tag 2 (S-1). Leave the other ends free.

## WIRING OF CABLE ASSEMBLY TO FRONT PANEL

(✓) Select the cable assembly and identify the panel end. This is the end with four wires, two BLACK wires with thin insulation and RED and BROWN wires with thick high voltage insulation.

NOTE: The abbreviation HV will refer to those wires that have thick high voltage insulation.

(✓) Route this cable assembly down the left-hand side of the panel as shown in Pictorial 2.

(✓) Connect the RED HV wire to AA tag 1 (S-1).

(✓) Connect the BROWN HV wire to AA tag 2 (S-1).

(✓) Connect either of the BLACK wires to AA tag 4 (S-1).

(✓) Connect the other BLACK wire to AA tag 5 (S-1).

(✓) Connect the ORANGE HV wire to BB tag 1 (S-1).

(✓) Connect the YELLOW HV wire to BB tag 2 (S-1).

(✓) Connect the GREY wire to CC tag 1 (S-1).

(✓) Connect the BLUE wire to CC tag 3 (S-1).

(✓) Connect the VIOLET wire to DD tag 1 (S-1).

(✓) Connect the BROWN wire to DD tag 3 (S-1).

(✓) Connect the WHITE wire to DD tag 4 (S-1).

## DUAL TRIMMER WIRING AND ASSEMBLY

Refer to Figure 7 for the following steps:

(✓) Select the dual 25/250 pF ceramic trimmer.

(✓) Position as shown in Figure 7A with the 'roll' on the trimmer plates at the bottom.

(✓) Connect a 3.3 MΩ 5% precision resistor (value marked) between TT tag 1 (NS) and TT tag 2 (NS).

(✓) Connect a 1½" length of wire to TT tag 1 (S-2). Leave the other end free.

(✓) Prepare a 47 pF mica capacitor and 330 KΩ 5% resistor (ORANGE, ORANGE, YELLOW, GOLD) combination as shown in detail 1 on Figure 7.

(✓) Prepare a 390 pF mica capacitor and 36 KΩ 5% resistor (ORANGE, BLUE, ORANGE, GOLD) combination as shown in detail 1 on Figure 7.

(✓) Connect the 47 pF/330 KΩ combination from TT tag 2 (NS) to UU tag 1 (NS).

(✓) Connect a 3" length of wire to TT tag 2 (S-3). Leave the other end free.

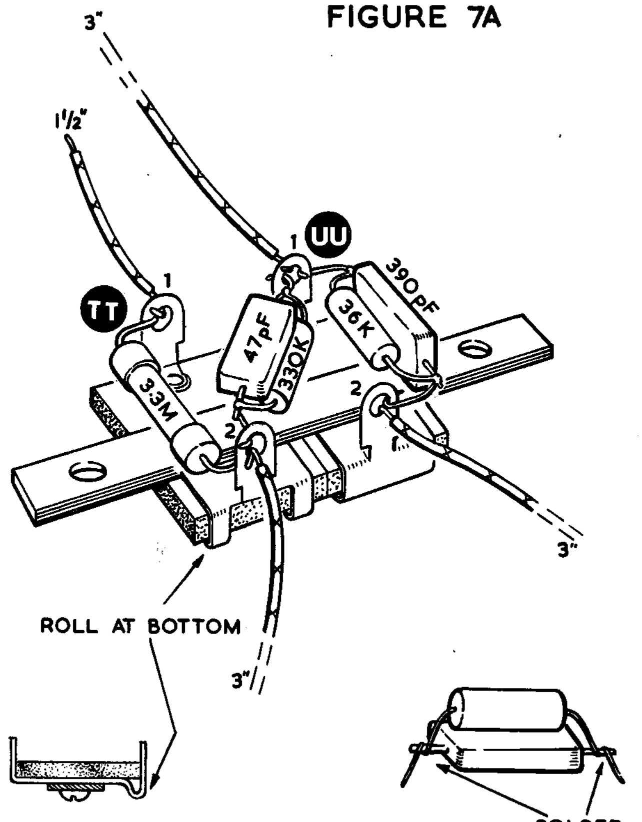
(✓) Connect the 390 pF/36 KΩ combination from UU tag 1 (NS) to UU tag 2 (NS).

(✓) Connect a 3" length of wire to UU tag 1 (S-3). Leave the other end free.

(✓) Connect a 3" length of wire to UU tag 2 (S-2). Leave the other end free.

(✓) Using two 6BA x ¾" screws, 6BA spacers, lockwashers and nuts, mount the dual trimmer assembly with the 3.3 MΩ resistor to the front, inside the corner of the chassis as shown in Figure 7B.

FIGURE 7A




DETAIL 1

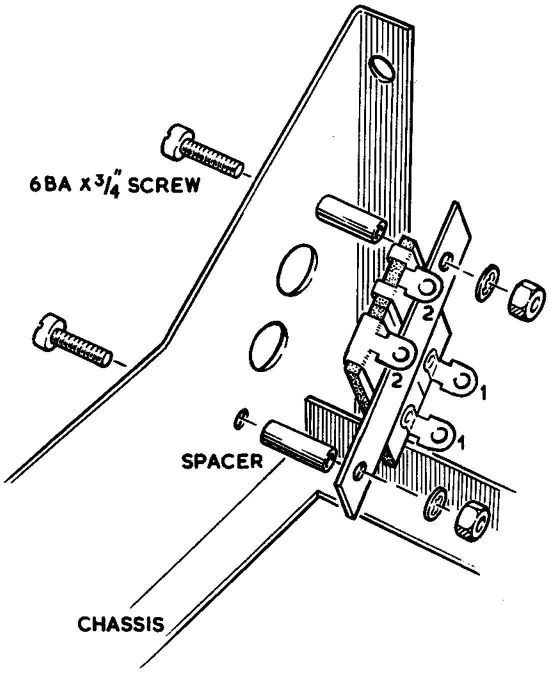



FIGURE 7B

Refer to Figure 8 for the following steps:

( ) Using four 4BA x 3/8" chrome plated binderhead screws, lockwashers and nuts and making sure that the cable assembly is inside the chassis bracket, attach the front panel to the chassis. Install a 4BA shakeproof solder tag at Y.

( ) Connect the 1½" length of wire from TT tag 1 to RR (S-2).

( ) Connect the 3" length of wire from TT tag 2 to HH tag 3 (S-1).

( ) Connect the 3" length of wire from UU tag 1 to HH tag 2 (S-1).

( ) Connect the 3" length of wire from UU tag 2 to RRG (NS).

( ) Connect a 1½" length of bare wire from RRG (S-2) to solder tag Y (NS).

( ) Connect the 3" length of wire from LL tag 3 to solder tag Y (S-2).

## CHASSIS ASSEMBLY

Refer to Pictorial 3 for the following steps:

( ) Using two 4BA x 3/8" binderhead screws, lockwashers and nuts, mount the octal valveholder at V8. Position the tags as shown.

( ) Select the capacitor mounting plate and, using two 6BA x 5/16" binderhead screws, lockwashers and nuts, mount it under the chassis at G.

( ) Select the 40-20-20-50 µF capacitor and, making sure that the tags on the capacitor are in the positions shown in Pictorial 3, insert the prongs into the slots on the mounting plate. Holding the capacitor tightly against the mounting plate, twist each prong 45°, using a pair of pliers or similar tool, to secure the capacitor.

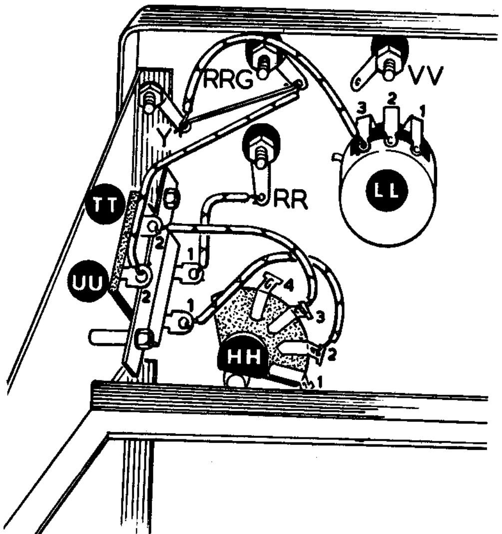
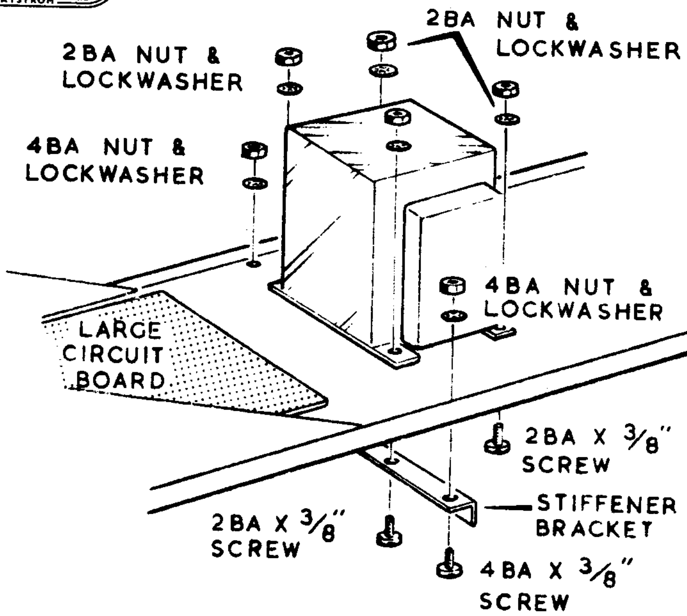
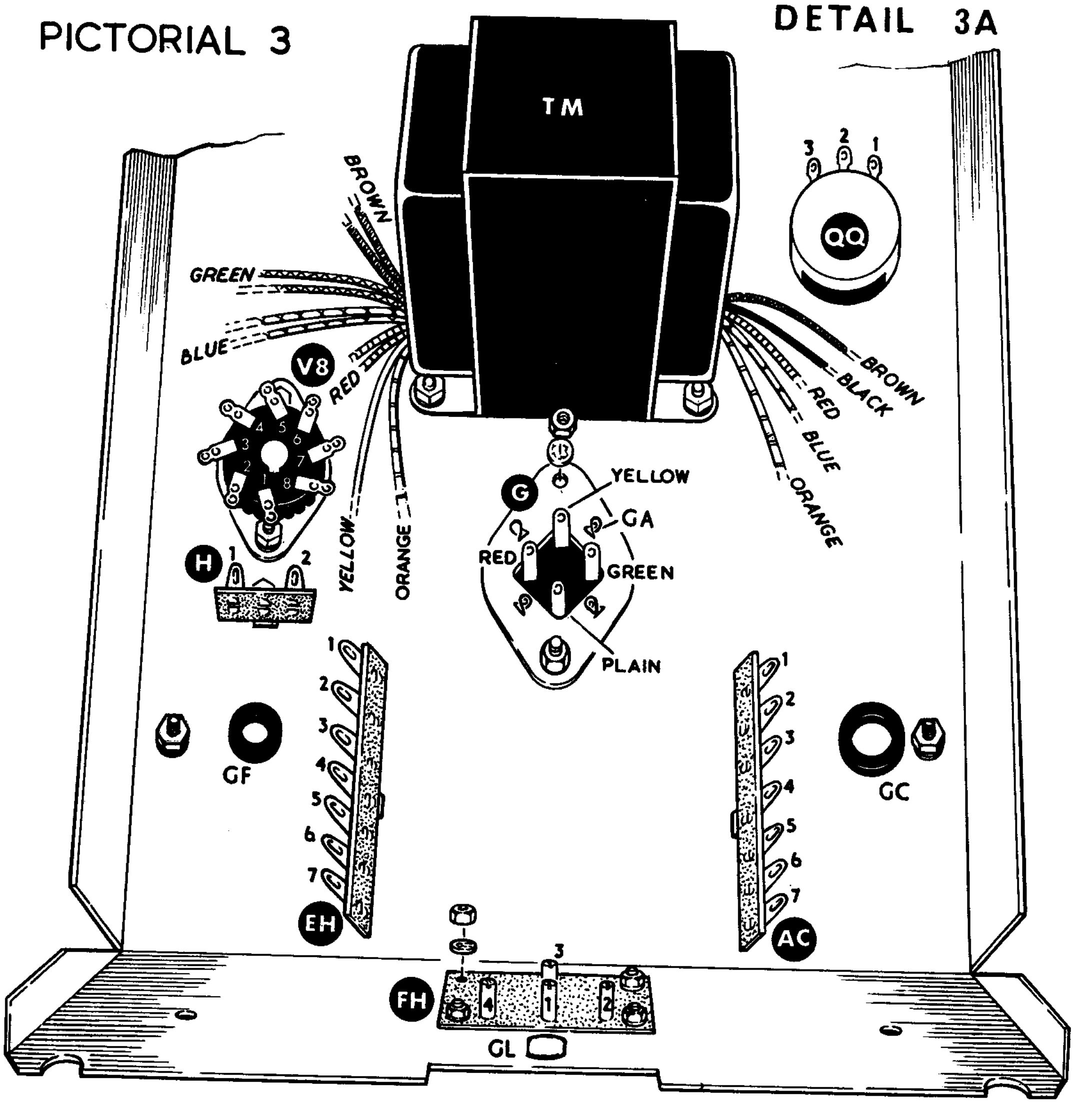



FIGURE 8




DETAIL 3A

PICTORIAL 3



( ) Using four 6BA x 5/16" binderhead screws, lockwashers and nuts, mount the voltage selector panel at FH. Position the tags as shown.

( ) Using one 4BA x 3/8" binderhead screw, lockwasher and nut, mount a 2-way tagstrip at H. Position as shown.

( ) Using four 4BA x 3/8" binderhead screws, lockwashers and nuts, mount the tube support bracket to the top of the chassis. Position as shown in Figure 9. Using the two centre screws, mount under the chassis at EH and AC two 7-way tagstrips. Position as shown in Figure 9.

( ) Insert a 3/8" grommet at GN as shown in Figure 9.

( ) Insert a 5/8" grommet at GD as shown in Figure 9.

( ) **Insert a 3/8" rubber grommet into the hole GF.**

( ) Insert a 5/8" rubber grommet into hole GC.

( ) Select the 1 MΩ linear control with the slotted shaft.

( ) Mount this 1 MΩ control at QQ. Position the tags as shown in Pictorial 3.

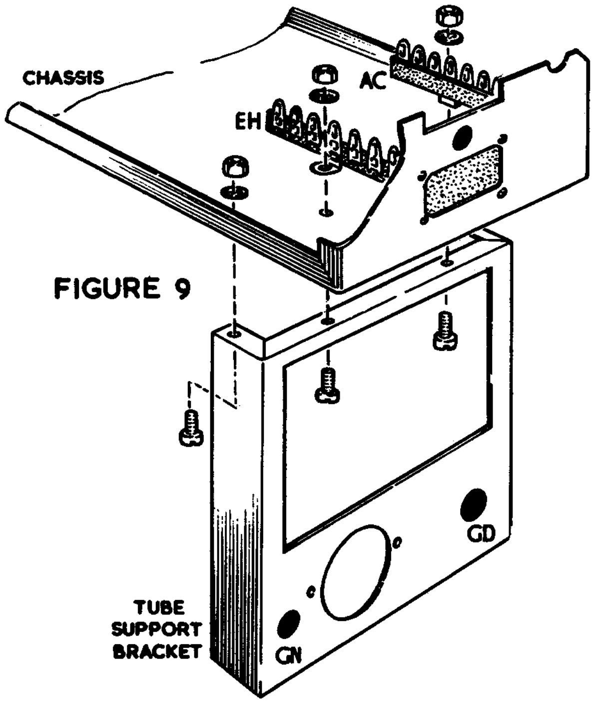



**FIGURE 9**

( ) Route the cable assembly along the edge of the chassis to grommet GC and, as shown in Pictorial 4, pass all wire ends of the cable assembly through grommet GC up to the two short RED HV and two BLACK wires.

( ) Mount the mains transformer and the stiffener bracket as shown in Detail 3A and Pictorial 3. Use four 2BA x 3/8" binderhead screws, lockwashers and nuts at the four corners of the transformer and the two centre holes of the stiffener bracket. Use 4BA x 3/8" screws, lockwashers and nuts in the two end holes of the stiffener bracket.

## CHASSIS WIRING

In this section and in subsequent sections, all wire used, unless otherwise indicated, is insulated connecting wire.

The leads on components are generally longer than is necessary. These leads should be cut to the proper length which results in a neater looking instrument. In many instances, excessive lead lengths will actually affect the operation of the instrument and should be avoided.

Refer to Pictorial 4 for the following steps:

( ) Tin the slotted ends of the four pins of the voltage selector panel FH.

( ) Cut the BROWN, BLACK, RED, BLUE and ORANGE leads from the side of the mains transformer nearest QQ to the following lengths: ( ) BROWN - 12", ( ) RED - 12", ( ) ORANGE - 4", ( ) BLACK - 9½", ( ) BLUE - 12".

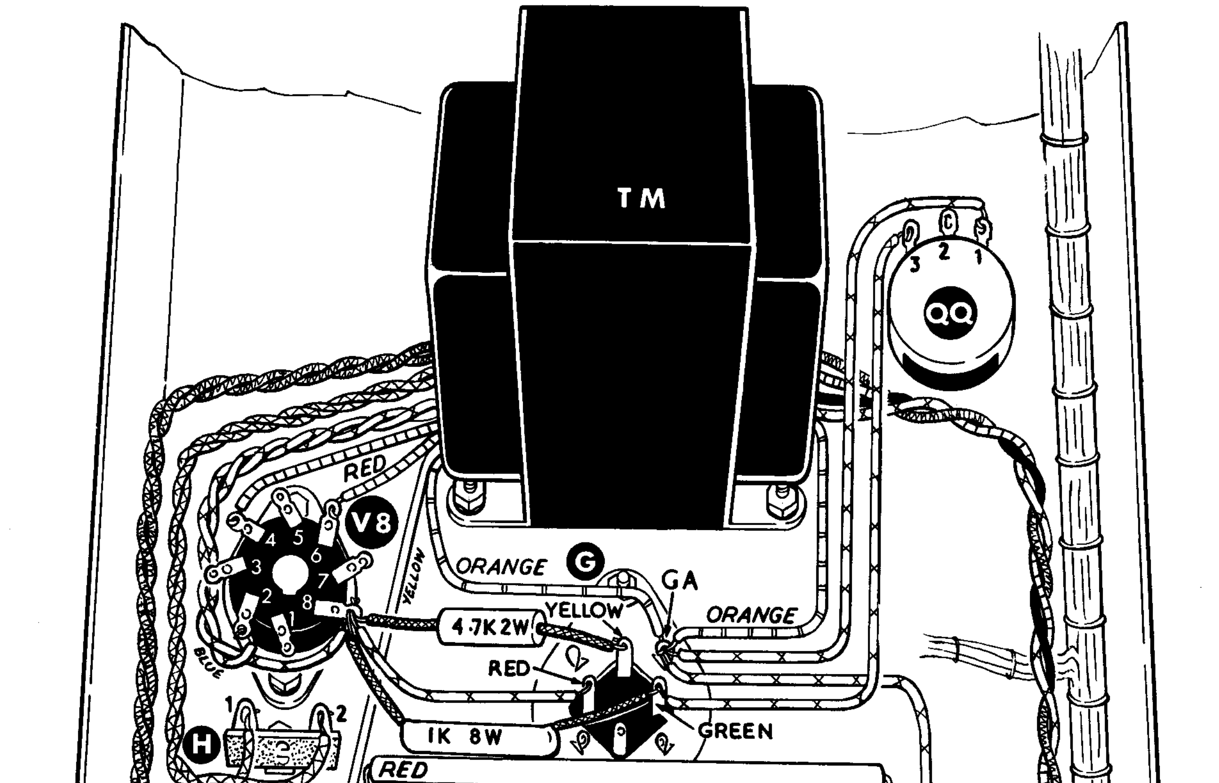
( ) Twist together the BROWN, BLACK, RED and BLUE leads and route them down the side of the chassis as shown in Pictorial 4.

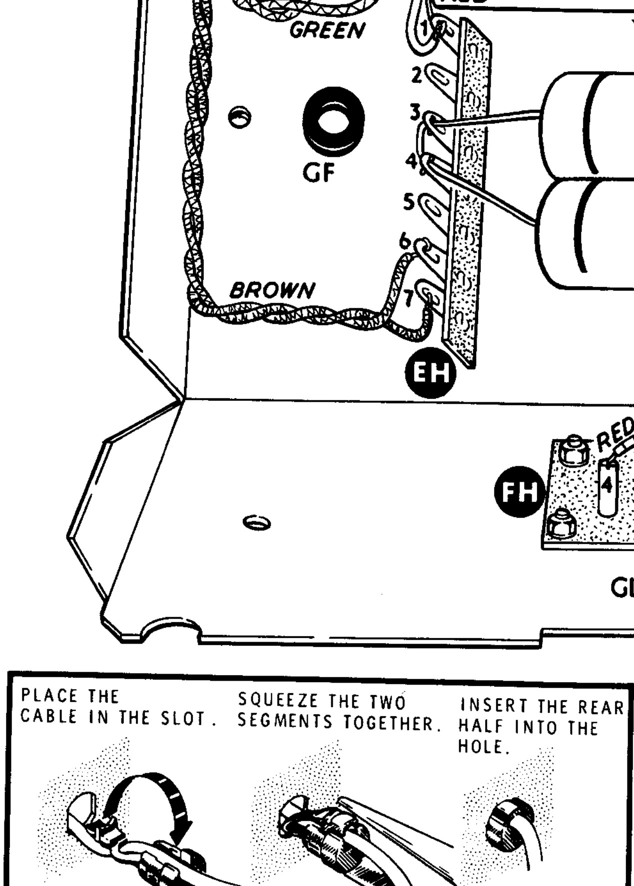
( ) Connect the BLACK lead to AC tag 7 (NS).

( ) Connect the BLUE lead to FH tag 3 (S-1).

( ) Connect the BROWN lead to FH tag 2 (S-1).

( ) Connect the RED lead to FH tag 4 (S-1).



Detail 4A

PICTORIAL 4

(✓) Connect the ORANGE lead to GA (NS).

(✓) Connect a $3\frac{1}{2}$" length of wire from FH tag 1 (S-1) to AC tag 5 (NS).

(✓) From the wires emerging from the other side of the mains transformer select the two BROWN wires.

(✓) Cut them to an 11" length and twist them together.

(✓) Connect one wire of the BROWN pair to EH tag 6 (NS) and the other to EH tag 7 (NS).

(✓) Similarly select the two GREEN wires from the mains transformer.

(✓) Cut them to a $7\frac{1}{2}$" length and twist them together.

(✓) Connect one wire of the GREEN pair to H tag 1 (NS) and the other to H tag 2 (NS). NOTE: If these wires are varnished, the varnish must be removed from the exposed wire end by scraping with a penknife or similar tool, before connecting to the tag.

(✓) Similarly, select the two BLUE leads from the mains transformer.

(✓) Cut them to a 5" length and twist them together.

(✓) Connect one wire of the BLUE pair to V8 tag 2 (S-1) and the other to V8 tag 8 (NS). NOTE: The varnish must be removed from the exposed wire by scraping with a penknife or similar tool, before connecting to the tag.

(✓) Cut the remaining wires from the mains transformer to the following lengths: (✓) ORANGE - 5", (✓) RED - $2\frac{1}{2}$", (✓) YELLOW - $5\frac{1}{2}$", (✓) RED - $2\frac{1}{2}$".

(✓) Connect the ORANGE wire to GA (NS).

(✓) Connect the YELLOW wire to EH tag 1 (NS).

(✓) Connect one RED wire to V8 tag 4 (S-1).

(✓) Connect the other RED wire to V8 tag 6 (S-1).

(✓) Connect a 6" length of wire from QQ tag 1 (S-1) to GA (NS).

(✓) Connect a 5" length of wire from GA (S-4) to AC tag 4 (NS).

(✓) Connect a 6" length of wire from QQ tag 3 (NS) to G GREEN tag (NS).

(✓) Using 1" of sleeving on each end, connect a 1 KΩ 8 watt resistor (value marked) from G GREEN tag (NS) to V8 tag 8 (NS).

(✓) Using 1" of sleeving on each end, connect a 4.7 KΩ 2 watt resistor (YELLOW, VIOLET, RED) from G YELLOW tag (NS) to V8 tag 8 (NS).

(✓) Connect a 3" length of wire from G RED tag (S-1) to V8 tag 8 (S-4).

(✓) Select the tubular selenium rectifier and connect the RED end to EH tag 1 (S-2).

(✓) Connect the other end of the rectifier to AC tag 1 (NS).

(✓) Select the two 0.1 μF 2000V capacitors and identify the outside foil lead of each. This lead is the one at that end of the capacitor that has a BLACK band round the body.

(✓) Connect one end of one of these 0.1 ΩF 2000V capacitors to EH tag 3 (NS).

(✓) Connect the other end to AC tag 2 (NS).

(✓) Connect one end of the other 0.1 μF 2000V capacitor to EH tag 4 (NS).

(✓) Connect the other end to AC tag 3 (NS).

NOTE: Pull the leads of these capacitors taut to hold them firmly against the chassis.

(✓) Connect a 1" length of bare wire between EH tag 3 (S-2) and EH tag 4 (S-2).

(✓) Connect a 1" length of bare wire between AC tag 1 (S-2) and AC tag 2 (NS).

(✓) Connect a 470 KΩ 1 watt resistor (YELLOW, VIOLET, YELLOW) from AC tag 2 (S-3) to AC tag 3 (NS).

(✓) Select the mains lead and carefully remove 2" of the outer insulation.

(✓) Pass this end through hole GL and connect the Red wire to AC tag 6 (NS).

(✓) Connect the Black wire to AC tag 7 (S-2).

(✓) Connect the Green wire to AC tag 4 (S-2).

(✓) Position the strain relief bush on the mains lead and install the bush and mains lead through the hole GL as shown in Detail 4A.

## CIRCUIT BOARD WIRING

### Front (Large) Circuit Board.

Refer to Pictorials 5 and 6 for the following steps:

NOTE: (1) Before proceeding read the notes on CIRCUIT BOARD WIRING AND SOLDERING.
(2) Use thin gauge solder for all printed circuit wiring.

(✓) Select the large circuit board, three 7-pin valveholders and two 9-pin valveholders.

(✓) Insert 7-pin valveholders in the locations marked V1, V4 and V9 and press them firmly against the circuit board.

(✓) Insert 9-pin valveholders in the locations marked V5 and V6.

(✓) Solder each tag and the centre spigot to the foil of the circuit board.

(✓) Proceed with the steps shown on Pictorial 5. These detail the assembly of resistors to the front circuit board.

(✓) Proceed with the steps shown on Pictorial 6. These detail the assembly of capacitors and wires etc. to the front circuit board.

(✓) Mount the 40-40-20 μF electrolytic capacitor at F. Make sure that the coloured tags are inserted into the correct holes as indicated. NOTE: DO NOT ATTEMPT TO TWIST THE MOUNTING LUGS OF THIS CAPACITOR. Solder the mounting lugs to the foil surrounding the slots, then solder the capacitor tags in the same way.

### Rear (Small) Circuit Board.

Refer to Pictorials 7 and 8 for the following steps:

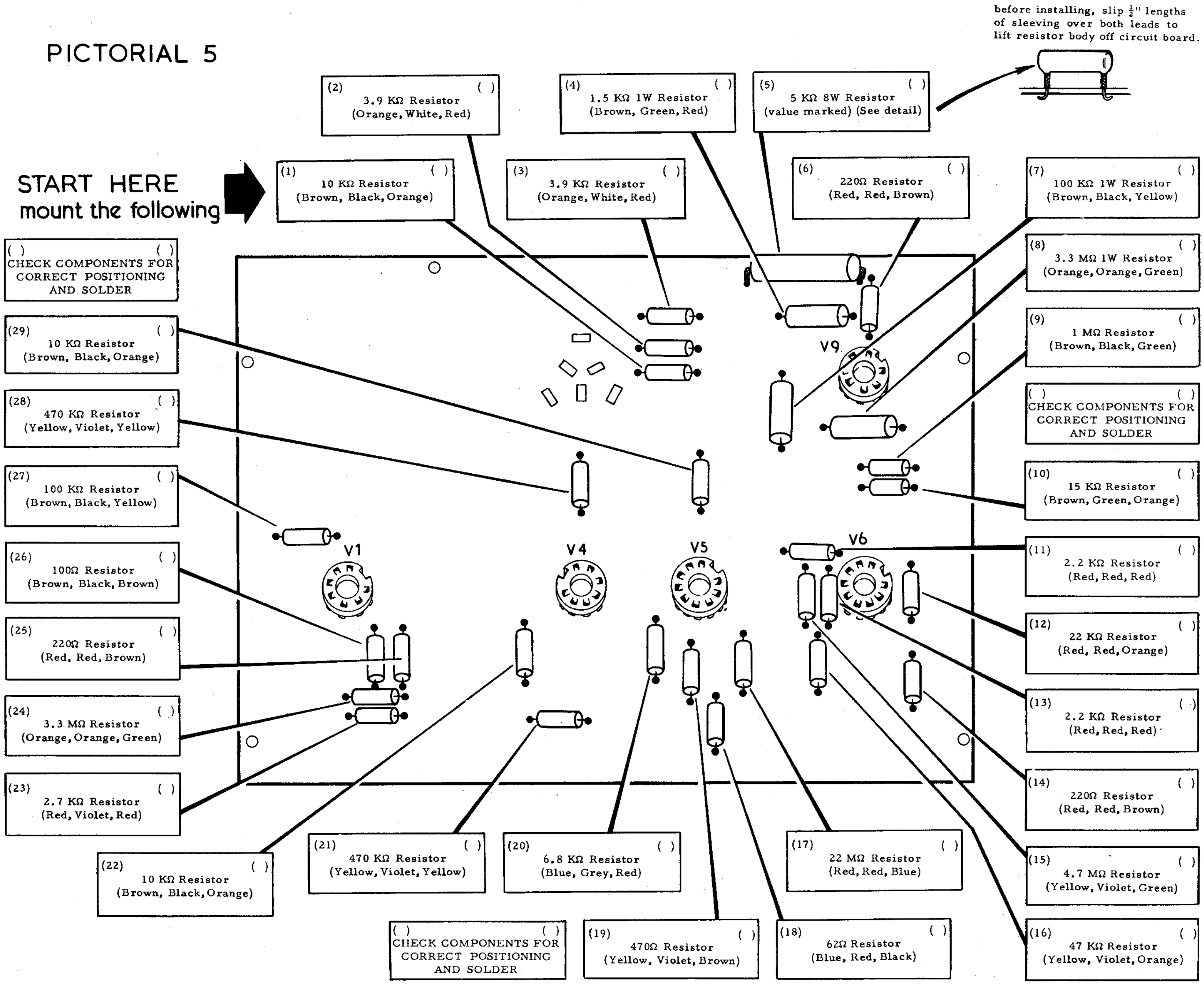
(✓) Select the small circuit board and three 9-pin valveholders.

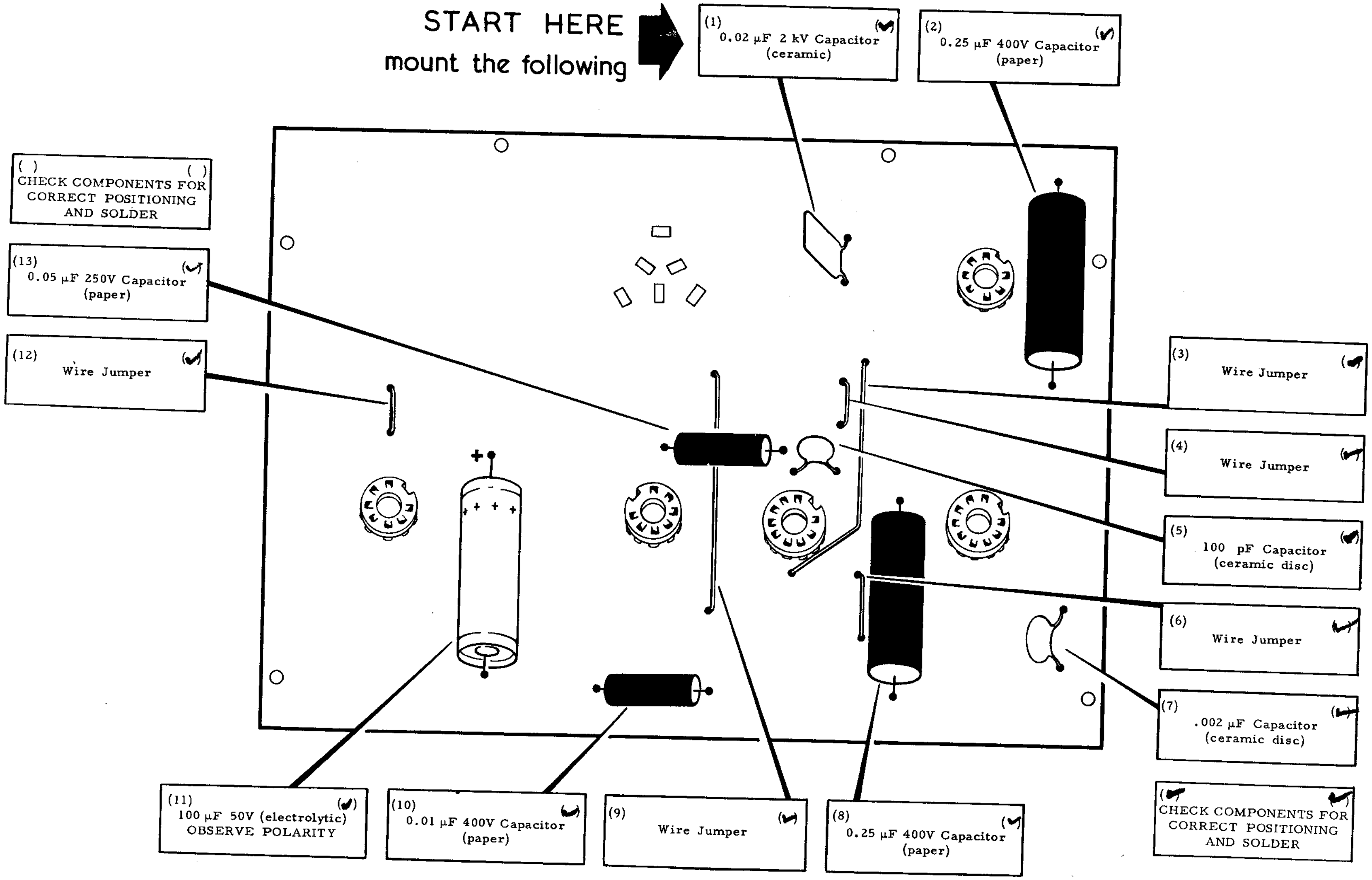
(✓) Mount these valveholders in the holes marked V2, V3 and V7 as instructed for those on the large circuit board.

(✓) Proceed with the steps shown on Pictorial 7. These detail the assembly of the resistors to the rear circuit board.

(✓) Continue with the steps shown on Pictorial 8. These detail the assembly of the coils, capacitors, wires etc. to the rear circuit board.

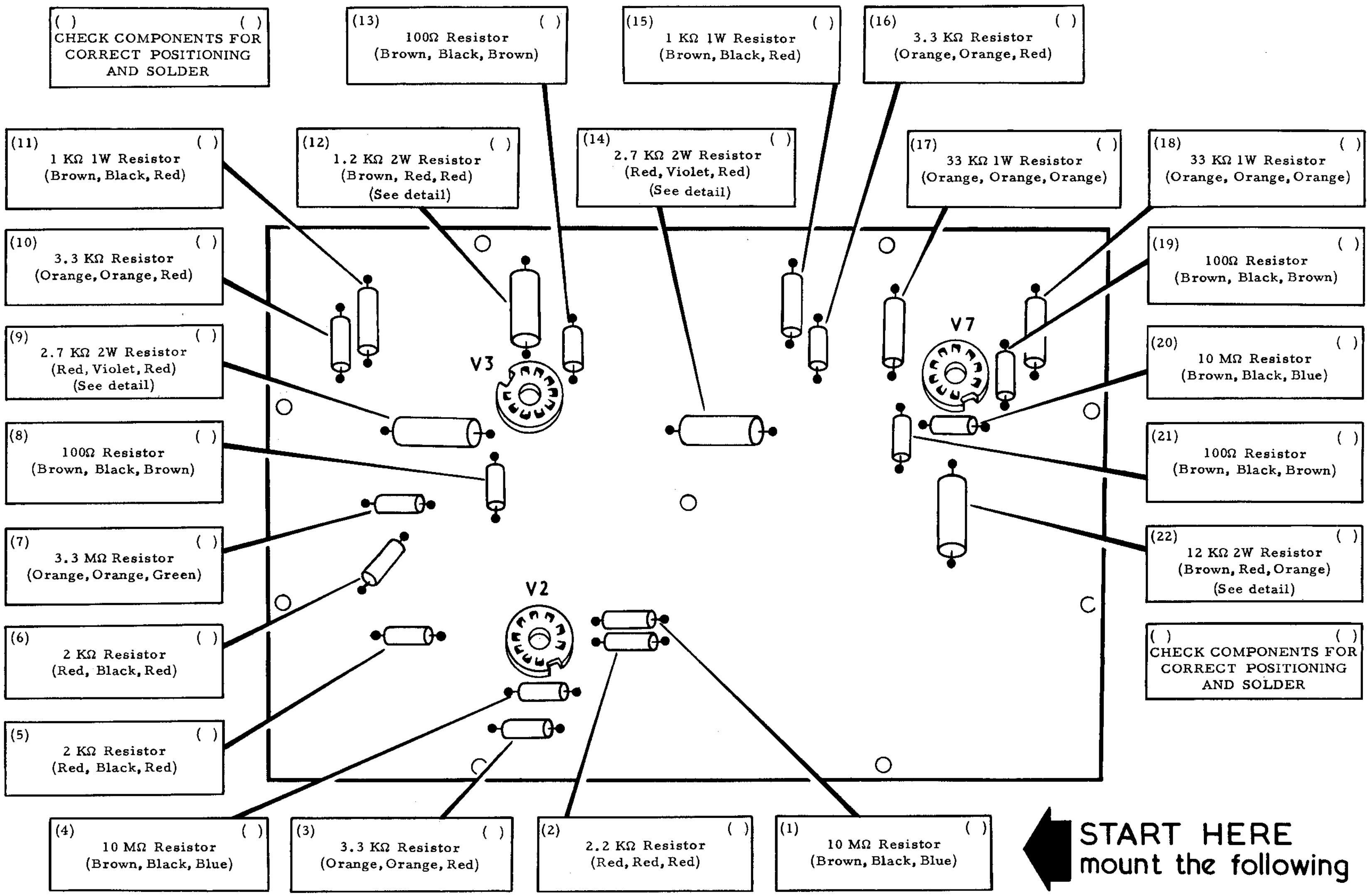
# PICTORIAL 5

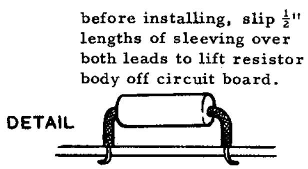

START HERE
mount the following
(1) 10 KΩ Resistor (Brown, Black, Orange) ( )
(2) 3.9 KΩ Resistor (Orange, White, Red) ( )
(3) 3.9 KΩ Resistor (Orange, White, Red) ( )
(4) 1.5 KΩ 1W Resistor (Brown, Green, Red) ( )
(5) 5 KΩ 8W Resistor (value marked) (See detail) ( )
before installing, slip ½" lengths of sleeving over both leads to lift resistor body off circuit board.
(6) 220Ω Resistor (Red, Red, Brown) ( )
(7) 100 KΩ 1W Resistor (Brown, Black, Yellow) ( )
(8) 3.3 MΩ 1W Resistor (Orange, Orange, Green) ( )
(9) 1 MΩ Resistor (Brown, Black, Green) ( )
( ) CHECK COMPONENTS FOR CORRECT POSITIONING AND SOLDER ( )
(10) 15 KΩ Resistor (Brown, Green, Orange) ( )
(11) 2.2 KΩ Resistor (Red, Red, Red) ( )
(12) 22 KΩ Resistor (Red, Red, Orange) ( )
(13) 2.2 KΩ Resistor (Red, Red, Red) ( )
(14) 220Ω Resistor (Red, Red, Brown) ( )
(15) 4.7 MΩ Resistor (Yellow, Violet, Green) ( )
(16) 47 KΩ Resistor (Yellow, Violet, Orange) ( )
(17) 22 MΩ Resistor (Red, Red, Blue) ( )
(18) 62Ω Resistor (Blue, Red, Black) ( )
(19) 470Ω Resistor (Yellow, Violet, Brown) ( )
( ) CHECK COMPONENTS FOR CORRECT POSITIONING AND SOLDER ( )
(20) 6.8 KΩ Resistor (Blue, Grey, Red) ( )
(21) 470 KΩ Resistor (Yellow, Violet, Yellow) ( )
(22) 10 KΩ Resistor (Brown, Black, Orange) ( )
(23) 2.7 KΩ Resistor (Red, Violet, Red) ( )
(24) 3.3 MΩ Resistor (Orange, Orange, Green) ( )
(25) 220Ω Resistor (Red, Red, Brown) ( )
(26) 100Ω Resistor (Brown, Black, Brown) ( )
(27) 100 KΩ Resistor (Brown, Black, Yellow) ( )
(28) 470 KΩ Resistor (Yellow, Violet, Yellow) ( )
(29) 10 KΩ Resistor (Brown, Black, Orange) ( )
( ) CHECK COMPONENTS FOR CORRECT POSITIONING AND SOLDER ( )
V1
V4
V5
V6
V9




PICTORIAL 6

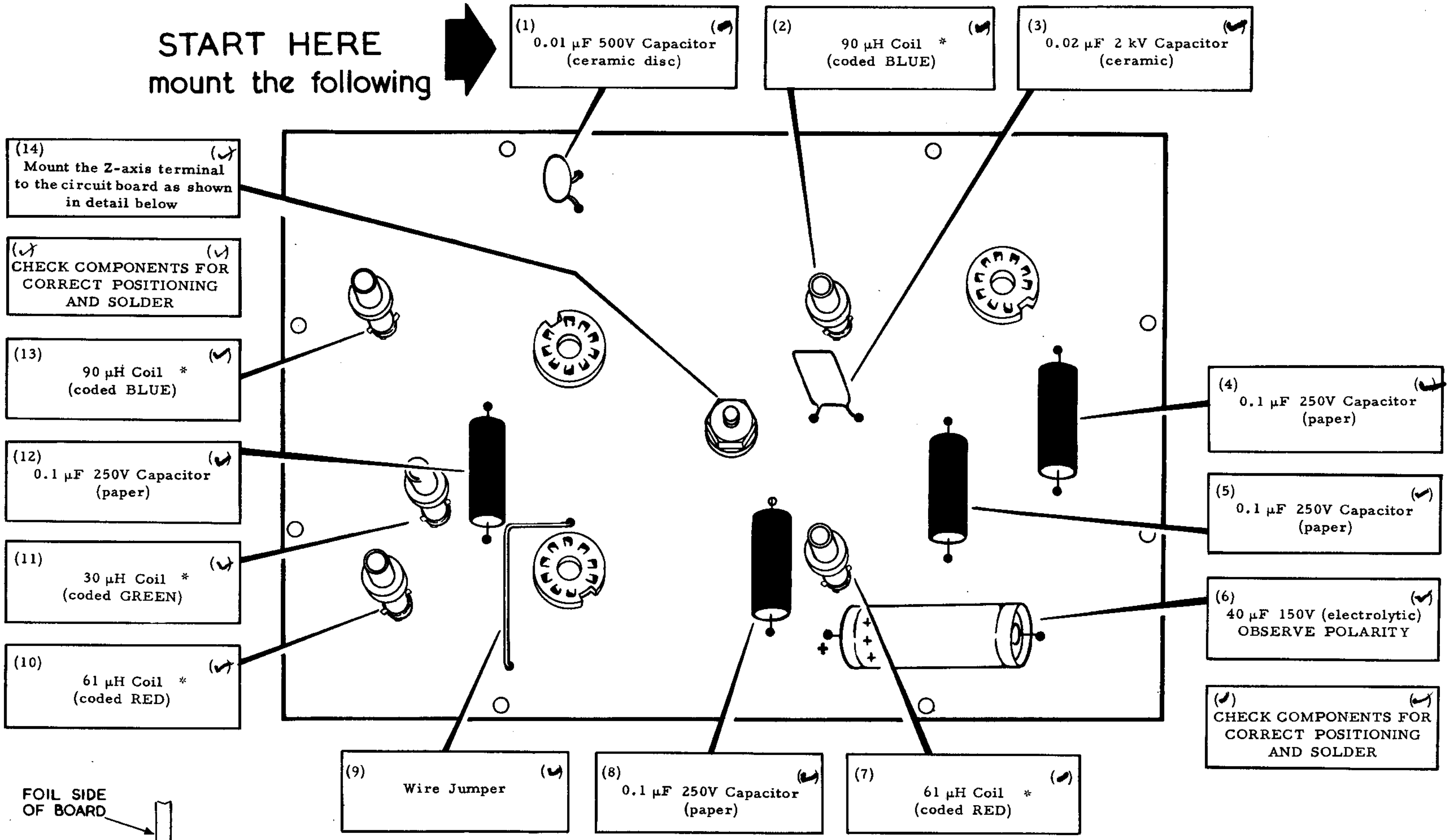
GLOUCESTER — DAYSTROM LTD. — ENGLAND

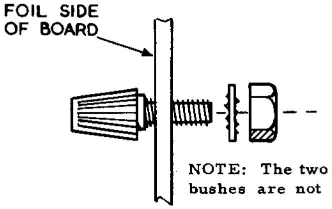

( ) ( )
CHECK COMPONENTS FOR CORRECT POSITIONING AND SOLDER
(13) ( ) 100Ω Resistor (Brown, Black, Brown)
(15) ( ) 1 KΩ 1W Resistor (Brown, Black, Red)
(16) ( ) 3.3 KΩ Resistor (Orange, Orange, Red)
(11) ( ) 1 KΩ 1W Resistor (Brown, Black, Red)
(12) ( ) 1.2 KΩ 2W Resistor (Brown, Red, Red) (See detail)
(14) ( ) 2.7 KΩ 2W Resistor (Red, Violet, Red) (See detail)
(17) ( ) 33 KΩ 1W Resistor (Orange, Orange, Orange)
(18) ( ) 33 KΩ 1W Resistor (Orange, Orange, Orange)
(10) ( ) 3.3 KΩ Resistor (Orange, Orange, Red)
(19) ( ) 100Ω Resistor (Brown, Black, Brown)
(9) ( ) 2.7 KΩ 2W Resistor (Red, Violet, Red) (See detail)
(20) ( ) 10 MΩ Resistor (Brown, Black, Blue)
V3
V7
(8) ( ) 100Ω Resistor (Brown, Black, Brown)
(21) ( ) 100Ω Resistor (Brown, Black, Brown)
(7) ( ) 3.3 MΩ Resistor (Orange, Orange, Green)
(22) ( ) 12 KΩ 2W Resistor (Brown, Red, Orange) (See detail)
V2
(6) ( ) 2 KΩ Resistor (Red, Black, Red)
( ) ( )
CHECK COMPONENTS FOR CORRECT POSITIONING AND SOLDER
(5) ( ) 2 KΩ Resistor (Red, Black, Red)
(4) ( ) 10 MΩ Resistor (Brown, Black, Blue)
(3) ( ) 3.3 KΩ Resistor (Orange, Orange, Red)
(2) ( ) 2.2 KΩ Resistor (Red, Red, Red)
(1) ( ) 10 MΩ Resistor (Brown, Black, Blue)
START HERE
mount the following


before installing, slip ½" lengths of sleeving over both leads to lift resistor body off circuit board.
DETAIL

PICTORIAL 7

START HERE
mount the following




DETAIL

PICTORIAL 8

* The tags on these coils may be slightly too large for the holes in the circuit board. If this is the case, trim them to size with sidecutters.

FIGURE 10A

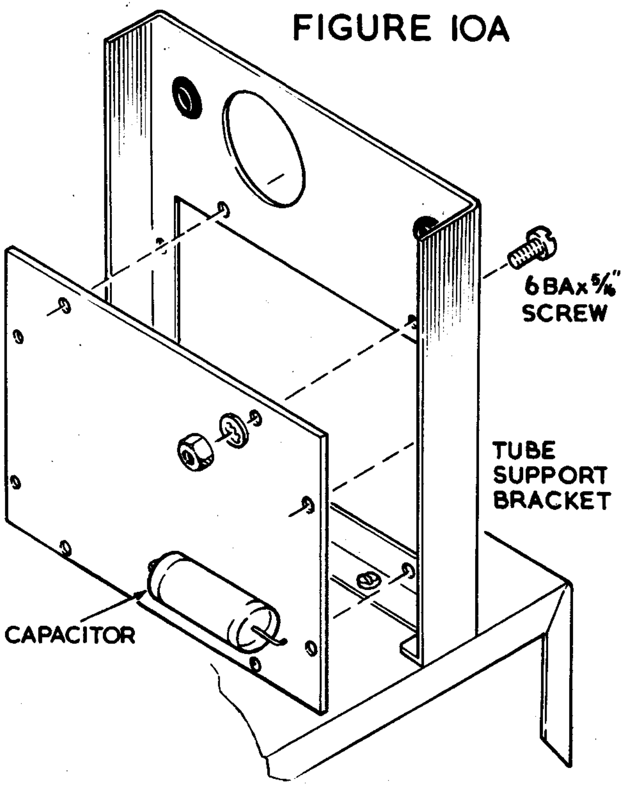
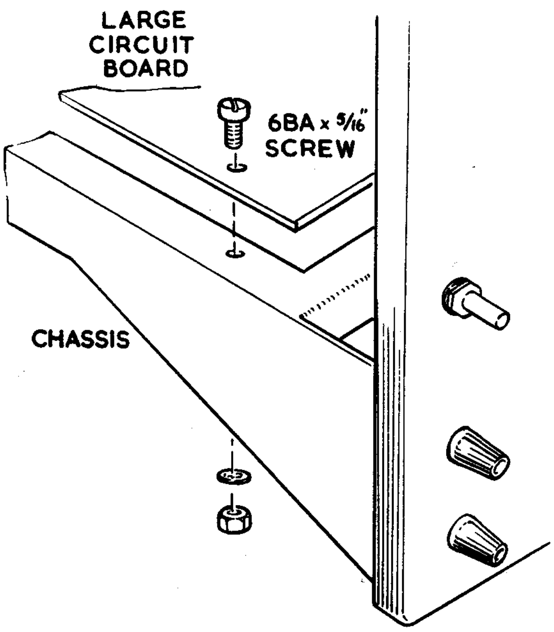



FIGURE 10B




ASSEMBLY OF SUB-UNITS

(✓) Referring to Figure 10A and using eight 6BA x 5/16" binderhead screws, lockwashers and nuts, mount the small circuit board to the inside of the tube support bracket. NOTE: The foil side of the board goes toward the rear of the instrument with the tubular electrolytic capacitor at the bottom.

(✓) Referring to Figure 10B and using six 6BA x 5/16" binderhead screws, lockwashers and nuts, mount the large circuit board to the front of the chassis. Position the board on top of the chassis with the electrolytic capacitor at the rear.

FINAL WIRING

Front Panel to Front Circuit Board.

Refer to Pictorial 9 for the following steps:

NOTE: It may help in these steps, to stand the instrument carefully on the front panel.

(✓) Connect the 13" length of wire from CC tag 4 to circuit board position CC4 (S-1).

(✓) Connect the 3" length of wire from EE tag 2 to circuit board position EE2 (S-1).

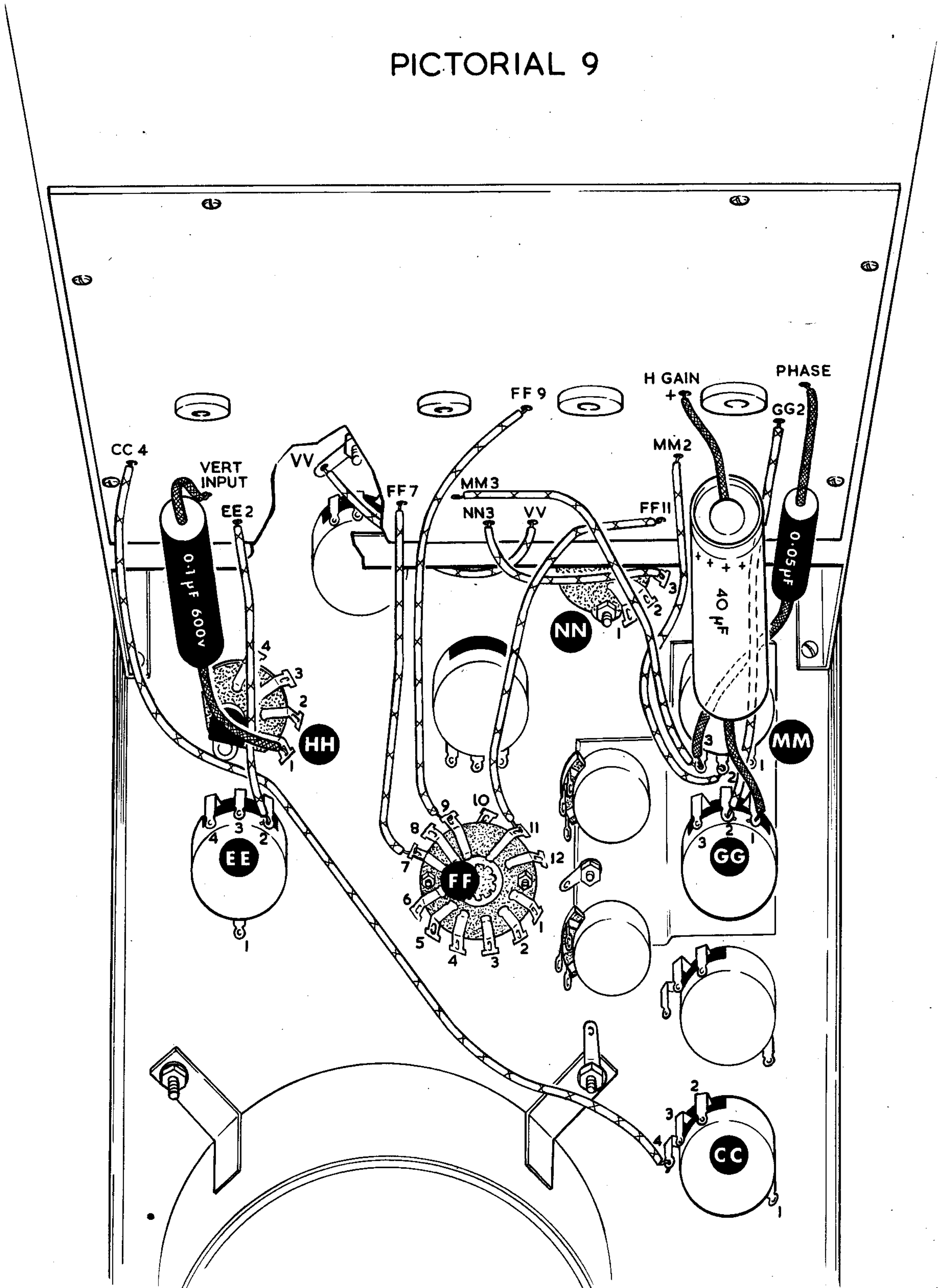
(✓) Connect the 4" length of wire from MM tag 2 to circuit board position MM2 (S-1).

(✓) Connect the 4" length of wire from MM tag 3 to circuit board position MM3 (S-1).

(✓) Connect the 2½" length of wire from FF tag 7 to circuit board position FF7 (S-1).

(✓) Connect the 4" length of wire from FF tag 9 to circuit board position FF9 (S-1).

# PICTORIAL 9


FF 9
H GAIN
PHASE
GG2
MM2
CC 4
VERT INPUT
VV
FF 7
MM 3
EE 2
NN3
VV
FF11
0·1 µF 600v
40 µF
0·05µF
NN
HH
MM
EE
FF
GG
CC

(✓) Connect the $2\frac{3}{4}$" length of wire from FF tag 11 to circuit board position FF11 (S-1).

(✓) Connect the 5" length of wire from NN tag 3 to circuit board position NN3 (S-1).

(✓) Connect the 6" length of wire from VV to circuit board position VV (S-1).

(✓) Connect the 4" length of wire from GG tag 2 to circuit board position GG2 (S-1).

(✓) Using $1\frac{1}{4}$" of sleeving on each end, connect a 0.05 µF 250V capacitor from MM tag 3 (S-2) to circuit board location PHASE (S-1).

(✓) Using $1\frac{1}{2}$" of sleeving on each end, connect the negative end of a 40 µF 150V electrolytic capacitor to GG tag 1 (S-2) and the positive end to circuit board location H GAIN (S-1). Position the capacitor clear of valveholder V6.

(✓) Using $1\frac{1}{2}$" of sleeving on each end, connect a 0.1 µF 600V capacitor from HH tag 1 (S-1) to circuit board location VERT INPUT (S-1).

Under Chassis Wiring.

Refer to Pictorial 10 for the following steps:

(✓) Connect the two RED HV wires to AC tag 3 (S-4).

(✓) Connect one of the BLACK wires to AC tag 5 (S-2).

(✓) Connect the other BLACK wire to AC tag 6 (S-2).

In the following steps, connections are made to the foil side of the front circuit board.

(✓) Connect the ORANGE HV wire to circuit board location ORG HV (S-1).

(✓) Connect the WHITE wire to circuit board location WH (S-1).

(✓) Connect the GREY HV wire to QQ tag 2 (S-1).

(✓) Connect a 7" length of wire from circuit board location G▲(S-1) to G YELLOW tag (NS).

(✓) Connect a 7" length of wire from circuit board location G▬(S-1) to G PLAIN tag (NS).

(✓) Connect the twisted pair from PP, one wire to circuit board location PP1 (S-1), the other to circuit board location PP2 (S-1).

(✓) Connect a 3" length of wire from QQ tag 3 (S-2) to circuit board location QQ3 (S-1).

(✓) Connect a 4" length of wire from circuit board location 9 (near pin 9 of V6) (S-1) to the other circuit board location 9 (near to front edge of board) (S-1).

(✓) Identify the short branch of the cable assembly containing the RED, ORANGE and YELLOW wires. Route this towards capacitor G.

(✓) Connect the YELLOW wire to G YELLOW tag (S-3).

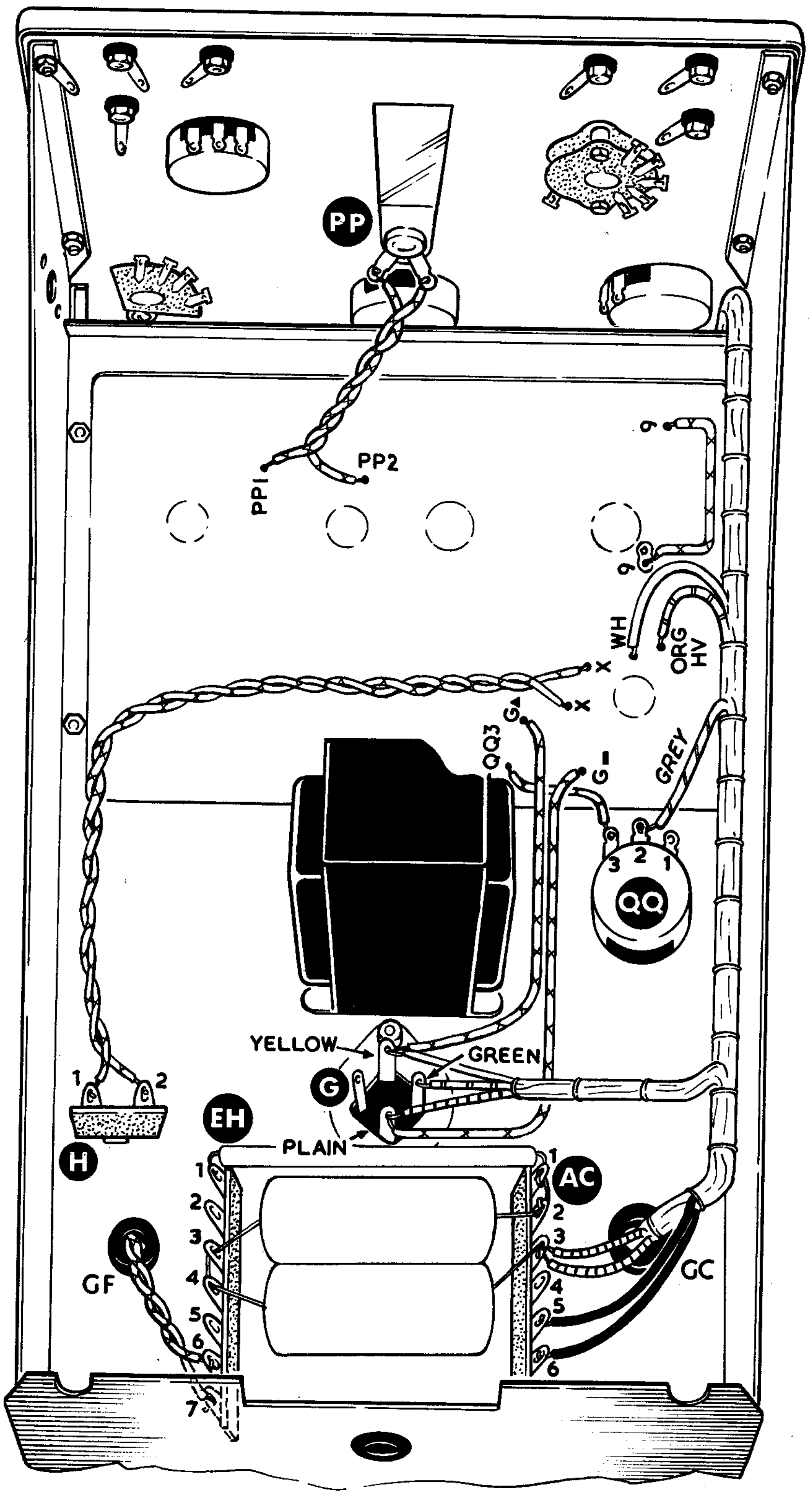
(✓) Connect the RED wire to G PLAIN tag (S-2).

(✓) Connect the ORANGE wire to G GREEN tag (S-3).

(✓) Twist together two 13" lengths of connecting wire and strip all four ends $\frac{1}{4}$".

(✓) Connect one end of this twisted pair, one wire to H tag 1 (NS) and the other to H tag 2 (NS).

(✓) Route the twisted pair as shown and connect one wire to one of the two circuit board locations X (S-1) and the other wire to the second location X (S-1).




PICTORIAL 10

(✓) Twist together two 17" lengths of connecting wire and strip all four ends ¼".

(✓) Connect one end of this twisted pair, one wire to EH tag 6 (S-2) and the other wire to EH tag 7 (S-2).

(✓) Route the twisted pair through grommet GF.

Above Chassis Wiring.

Refer to Pictorial 11 for the following steps:

(✓) Route the twisted pair from GF through GN. Leave this end free, it will be connected later.

(✓) Route the GREY and RED wire branch of the cable assembly across the chassis as shown in Pictorial 11.

(✓) Connect the GREY wire to rear circuit board location GREY (S-1).

(✓) Connect the RED wire to rear circuit board location RED (S-1).

(✓) Route the main cable assembly up the side of the tube support bracket as shown in Pictorial 11.

(✓) Pass the end of the cable assembly containing the RED, BROWN, GREY, YELLOW and ORANGE wires through GD.

(✓) Connect the BLUE wire to circuit board location BLUE (S-1).

(✓) Connect the ORANGE wire to circuit board location ORANGE (S-1). NOTE: This is not the ORANGE wire emerging from the cable assembly near grommet GD.

(✓) Connect the YELLOW wire to circuit board location YELLOW (S-1).

(✓) Connect the BROWN wire to circuit board location BROWN (S-1).

(✓) Connect the VIOLET wire to circuit board location VIOLET (S-1).

(✓) Connect the ORANGE wire emerging from the cable assembly near GD to the front circuit board location CRT3 (S-1).

(✓) Connect one end of a 12½" length of connecting wire to front circuit board location HOR-OUT (S-1).

(✓) Pull the wire straight back, around the body of valveholder V6 to the rear circuit board. Measure carefully to the point on the rear board marked HOR-IN, allow about 1" extra for stripping and cut the wire.

(✓) Strip off 1" of insulation from the wire, insert it in the hole marked HOR-IN, pull it taut to clear the 5 KΩ 8 watt resistor on the front circuit board and solder (S-1). NOTE: DO NOT CLIP OFF THE EXCESS WIRE.

(✓) Using a similar technique, connect the wire from EE tag 1 to rear circuit board location EE1 (S-1). This time do not pull wire taut, leave it a little slack.

(✓) Prepare a length of 300Ω transmission line as shown in Figure 11. Twist the strands of each conductor together and lightly tin.

(✓) At the end of this line that has ¼" stripped ends, connect one wire to NN tag 2 (S-1) and the other wire to NN tag 1 (S-1).

(✓) Pass this line up over the front circuit board and straight back to the location on the rear circuit board marked SYNC+ and -. DO NOT TWIST THIS LINE.

(✓) Pass the 1" tinned leads through the two holes, pull taut and solder the two connections. Trim off excess leads.

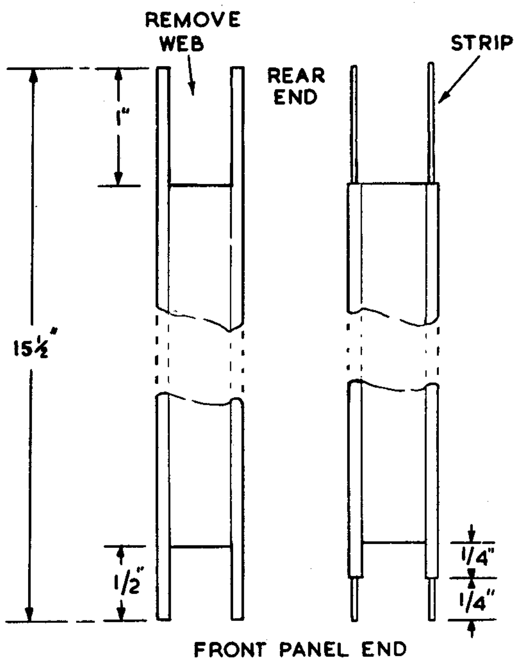
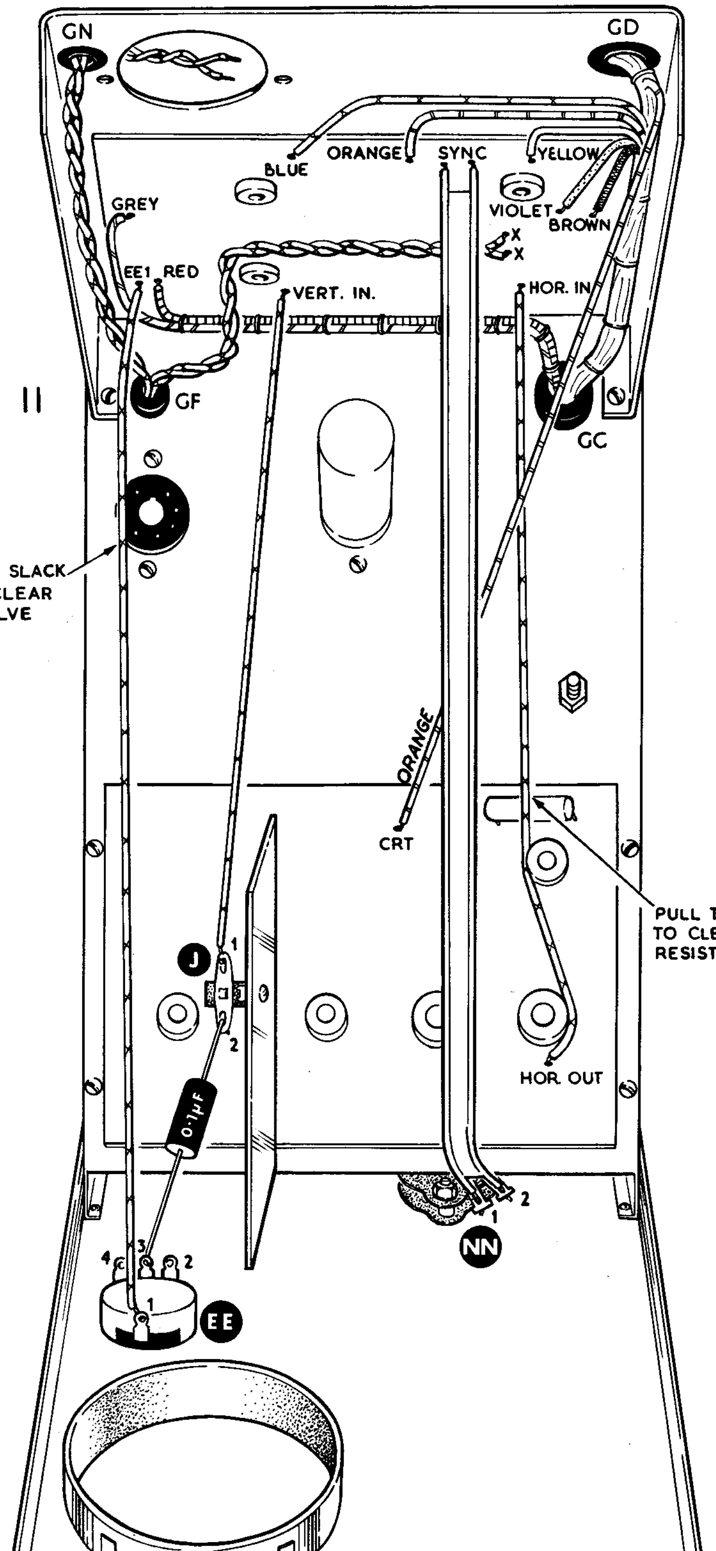



FIGURE 11

PICTORIAL II



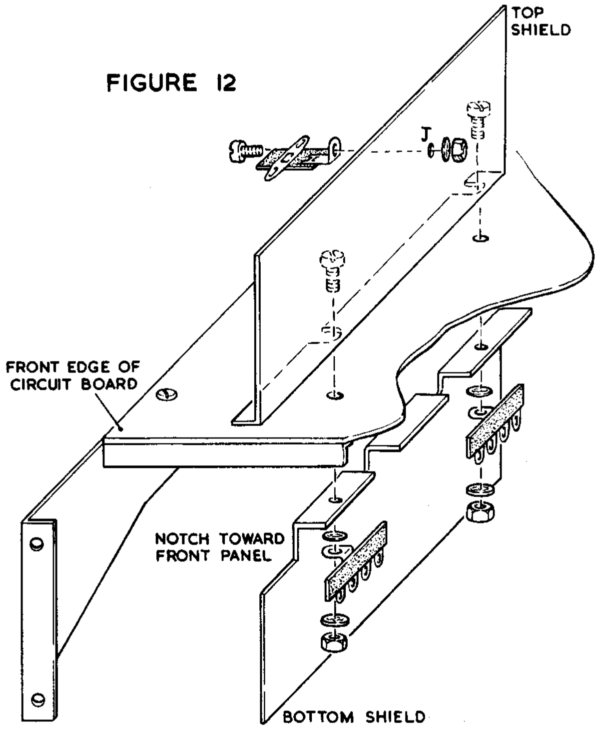
Refer to Figure 12 for the following steps:

( ) Using one 4BA x 3/8" binderhead screw, lockwasher and nut, mount a 1-way tagstrip to the top shield at J. Position as shown.

( ) Using two 4BA x 3/8" binderhead screws, four lockwashers and two nuts, mount the bottom shield to the front circuit board. Under each nut mount a 4-way tagstrip. Do not fully tighten the hardware. BE SURE TO POSITION THE SHIELD AND TAGSTRIPS AS SHOWN IN FIGURE 12. The notched corner should be next to the front panel. Failure to do this will result in a heater short and the destruction of the circuit board.

( ) Slip the top shield under the screw heads and tighten both screws securely.

FIGURE 12




Refer to Pictorial 11 for the following steps:

( ) Connect a 0.1 µF 250V capacitor between EE tag 3 (S-1) and J tag 2 (S-1).

( ) Connect one end of an 11" length of wire to J tag 1 (S-1).

( ) Strip 1" of insulation from the other end, pass it through the hole in the rear circuit board marked VERT IN, pull the wire taut and solder (S-1). Cut off the excess wire.

( ) Twist together two 10" lengths of connecting wire. Strip $\frac{1}{4}$" of insulation from all four ends.

( ) At one end of this twisted pair, connect either wire to one of the locations marked X on the rear circuit board (S-1).

( ) Connect the other end to the other location marked X (S-1).

( ) Route the other end of this twisted pair through grommet GF as shown in Pictorial 11 and connect one wire to H tag 1 (S-3) and the other to H tag 2 (S-3).

Wiring of Tagstrips L and R.

It will be found convenient to lay the 'scope on its left side to wire these tagstrips.

Refer to Figure 13 for the following steps:

( ) Connect the $4\frac{1}{2}$" length of wire from NN tag 5 to L tag 1 (NS).

( ) Connect a $2\frac{1}{2}$" length of wire from L tag 3 (NS) to front circuit board location GR (S-1).

( ) Connect a 4" length of wire from R tag 4 (NS) to front circuit board location PL (S-1).

( ) Connect a 2" length of wire from R tag 1 (NS) to front circuit board location KA (S-1).

( ) Connect a 1 MΩ resistor (BROWN, BLACK, GREEN) from L tag 3 (NS) to L tag 4 (NS).

( ) Connect a 10 pF ceramic disc capacitor from L tag 3 (S-3) to L tag 4 (NS).

( ) Connect a 470 KΩ resistor (YELLOW, VIOLET, YELLOW) from L tag 4 (NS) to R tag 1 (NS).

( ) Using $1\frac{1}{2}$" of sleeving on each end, connect a 0.25 µF 400V capacitor from L tag 1 (S-2) to L tag 4 (S-4).

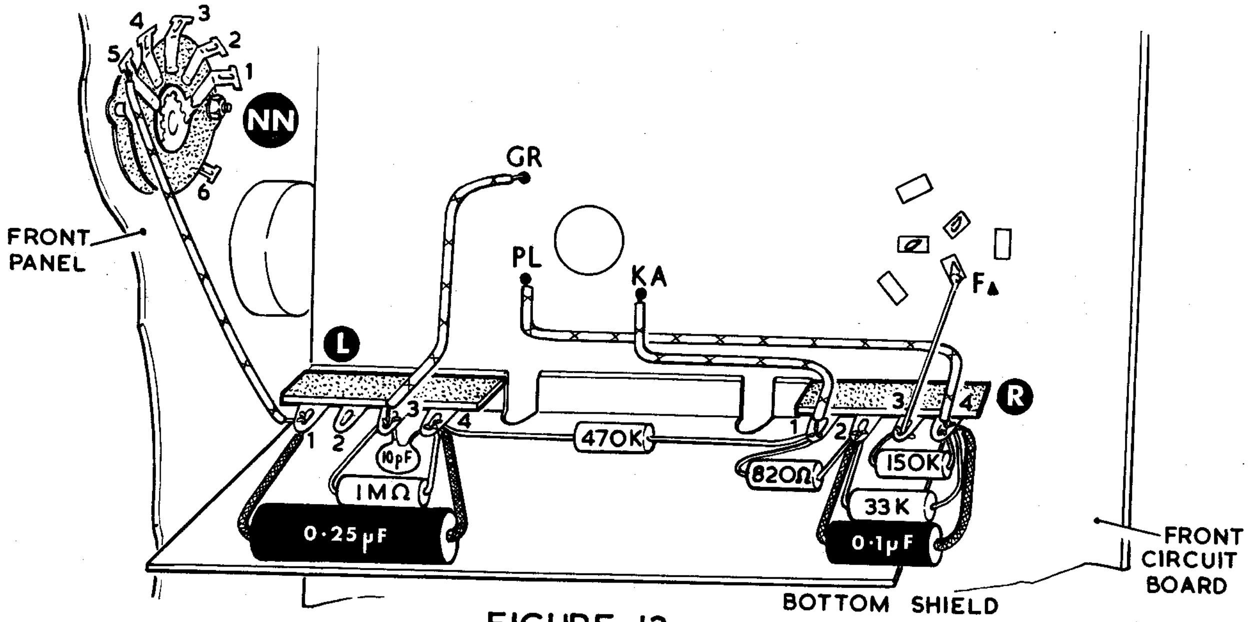



FIGURE 13

(✓) Connect a $1\frac{1}{2}$" length of bare wire from R tag 3 (NS) to tag F▲on the electrolytic capacitor mounted on the front circuit board (S-1).

(✓) Connect a 150 KΩ resistor (BROWN, GREEN, YELLOW) from R tag 3 (S-2) to R tag 4 (NS).

(✓) Connect a 33 KΩ resistor (ORANGE, ORANGE, ORANGE) from R tag 4 (NS) to R tag 2 (NS).

(✓) Using 1" of sleeving, connect a 0.1 μF 250V capacitor from R tag 4 (S-4) to R tag 2 (NS).

(✓) Connect an 820Ω resistor (GREY, RED, BROWN) from R tag 1 (S-3) to R tag 2 (S-3).

## CATHODE RAY TUBE INSTALLATION

Refer to Figure 14 for the following steps:

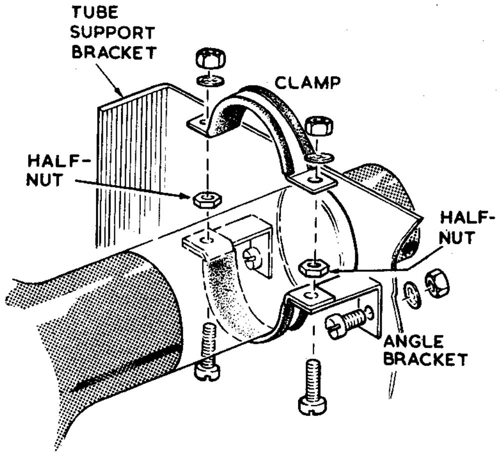



FIGURE 14

(✓) Select the two angle brackets and the two tube clamps.

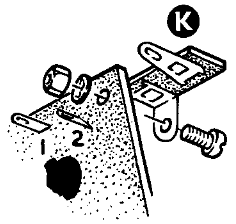
(✓) Using two 4BA x 3/8" binderhead screws, lockwashers and nuts, mount the two small angle brackets to the tube support bracket as shown in Figure 14. Do not fully tighten the screws.

(✓) Referring to Figure 14, insert a length of rubber cushion over each clamp, making sure that the clamp is seated in the groove of the rubber strip. Cut off any surplus material.

(✓) Using two 4BA x $\frac{3}{4}$" binderhead screws and two 4BA half nuts, assemble the lower half of the tube clamp and tighten the angle bracket screws.

CAUTION: Carefully open the carton containing the 5UP1 cathode ray tube. Handle the tube with care since it has been highly evacuated. Should the envelope be broken, the resulting implosion could spray the area with fragments of glass and a serious accident may result. Avoid handling the tube with diamond rings that may scratch the glass. DO NOT STRIKE THE GLASS ENVELOPE WITH ANY BLUNT INSTRUMENT AND DO NOT SUBJECT IT TO ANY IMPACT OR SHOCK.

(✓) Slip the base end of the tube through the tube support ring from the front and rest the base on the lower half of the tube clamp.




MOUNTING OF TAGSTRIP- DETAIL

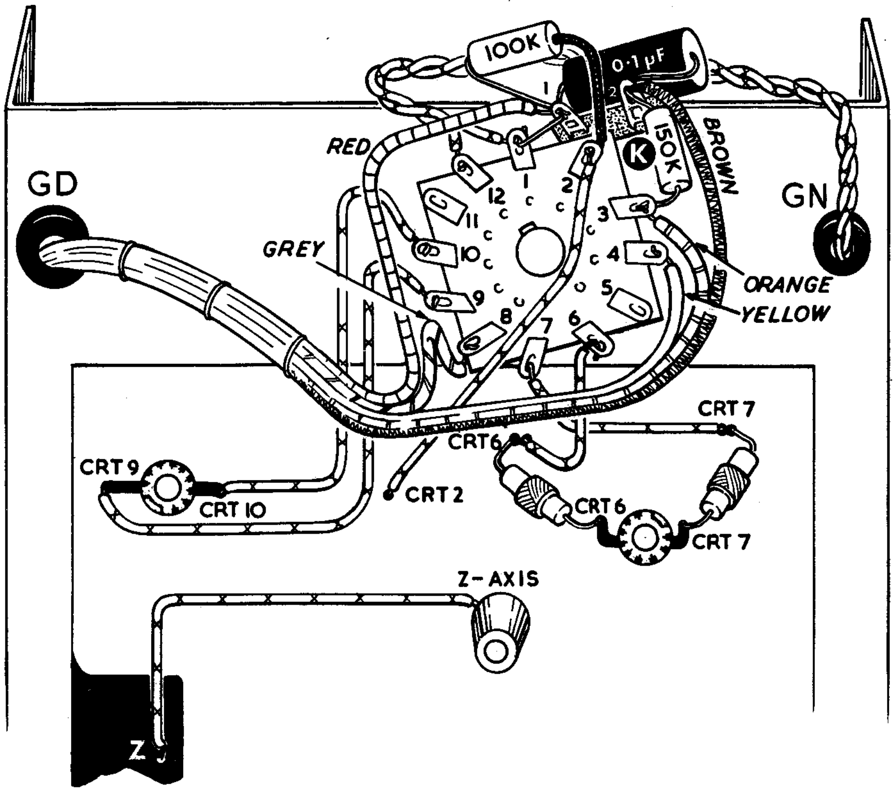



FIGURE 15

(✓) Position the tube with pin 1 in the vertical position as shown in Figure 15.

NOTE: The pins on the CRT are numbered in a clockwise direction starting from the keyway. See Figure 15.

(✓) Position the tube so that its face is flush with the front face of the front panel. Check this with a straight edge.

(✓) Place the other half of the tube clamp over the tube base and gently tighten down using two 4BA lockwashers and nuts.

(✓) Select a 2-way tagstrip and the 12-pin CRT base.

(✓) Using one 4BA x 3/8" binderhead screw, lockwasher and nut, mount the 2-way tagstrip K to the hole on the CRT base next to pin 2 as shown in the detail on Figure 15.

WIRING OF CRT BASE

Refer to Figure 15 for the following steps:

NOTE: In making connections to socket CRT, leave enough slack in the leads to permit rotating the socket through $10^{o}$ either way from its present position. This is to enable the undeflected trace on the screen to be made horizontal.

(✓) Carefully fit socket CRT to the base of the cathode ray tube.

(✓) Connect a 0.1 μF 250V tubular capacitor from K tag 2 (NS) through K tag 1 (NS) to CRT tag 1 (NS).

(✓) Connect a 100 KΩ resistor (BROWN, BLACK, YELLOW) from K tag 1 (NS) to CRT tag 2 (NS). Use $\frac{3}{4}$" of sleeving on one end as shown in Figure 15.

(✓) Using $\frac{1}{2}$" of sleeving on each end, connect a 150 KΩ resistor (BROWN, GREEN, YELLOW) from K tag 2 (NS) to CRT tag 3 (NS).

(✓) Route the end of the cable assembly emerging from grommet GD as shown in Figure 15.

(✓) Connect the RED HV wire to K tag 1 (S-4).

(✓) Connect the BROWN HV wire to K tag 2 (S-3).

(✓) Connect the ORANGE wire to CRT tag 3 (S-2).

(✓) Connect the YELLOW HV wire to CRT tag 4 (S-1).

(✓) Connect the GREY HV wire to CRT tag 8 (S-1).

(✓) Identify the twisted pair emerging from grommet GN.

(✓) Connect one wire of this twisted pair to CRT tag 1 (S-2) and the other to CRT tag 12 (S-1).

(✓) Cut two 5" lengths of connecting wire, strip ¼" insulation from all four ends and tin each end with solder.

NOTE: The following connections are made to the foil side of the circuit board.

(✓) Connect one of these wires from CRT tag 9 (S-1) to rear circuit board location CRT9 (S-1).

(✓) Connect the other of these wires from CRT tag 10 (S-1) to rear circuit board location CRT10 (S-1).

(✓) Connect a 6" length of wire from rear circuit board location CRT2 (S-1) to CRT tag 2 (S-2).

(✓) Connect a 33 μH choke (mounted on a 3.3 KΩ resistor (ORANGE, ORANGE, RED)) from one circuit board location CRT7 (S-1) to the other location marked CRT7 (S-1). When bending resistor wires, take care not to break choke terminations.

(✓) Connect a 33 μH choke from one circuit board location marked CRT6 (S-1) to the other location marked CRT6 (S-1). When bending resistor wires, take care not to break choke terminations.

(✓) Connect a 3" length of wire from CRT tag 7 (S-1) to the upper circuit board location CRT7 (S-1).

(✓) Connect a 4" length of wire from CRT tag 6 (S-1) to location CRT6 (S-1).

( ) Connect a 4½" length of wire from the Z-axis terminal to circuit board location Z (S-1).

## FINAL ASSEMBLY

IMPORTANT WARNING: MINIATURE VALVES CAN BE EASILY DAMAGED WHEN PLUGGING THEM INTO THEIR VALVEHOLDERS. USE EXTREME CARE WHEN INSTALLING THEM.

Support the underside of the circuit boards when inserting the valves.

(✓) Insert the valves in the valveholders as follows:-

| | | | | | |
|---|---|---|---|---|---|
| Valveholder V1 | - | EC92 | Valveholder V6 | - | 6BQ7A |
| Valveholder V2 | - | ECF80 | Valveholder V7 | - | 12AU7 (ECC82) |
| Valveholder V3 | - | 12BH7 | Valveholder V8 | - | GZ34 |
| Valveholder V4 | - | ECC91 (6J6) | Valveholder V9 | - | 6C4 |
| Valveholder V5 | - | 12AU7 (ECC82) | | | |

(✓) Insert the 1 amp fused plug in the voltage selector panel at the appropriate voltage tapping to suit your mains voltage.

(✓) Rotate all the four controls by the side of the tube fully anticlockwise. NOTE: THE BRILLIANCE ON/OFF control must be off.

(✓) Install a small knob on the shaft of the BRILLIANCE control. Set the pointer to AC OFF.

(✓) Install small knobs on the other controls so that their pointers are parallel with that on the BRILLIANCE control.

(✓) Rotate all the other controls on the front panel fully clockwise.

(✓) Install the eight large knobs on these shafts with the pointers in the following positions:-

| | | | | | |
|---|---|---|---|---|---|
| VERT. GAIN | - | 100 | HOR. GAIN | - | 100 |
| VERT ATTENUATOR | - | X1 | PHASE | - | Last clockwise marking |
| FREQ. SELECTOR | - | Line between 100 kc and 500 kc | EXT.SYNC.AMPLITUDE | - | Last clockwise marking |
| | | | SYNC. SELECTOR | - | EXT. |
| FREQ. VERNIER | - | 100 | | | |

Refer to Pictorial 12 for the following three steps:

(✓) Over the four terminal bodies round the screen of the cathode ray tube, mount the GREEN graticule. Position as shown with the printed side outwards.

(✓) On top of the graticule, mount the grid screen window.

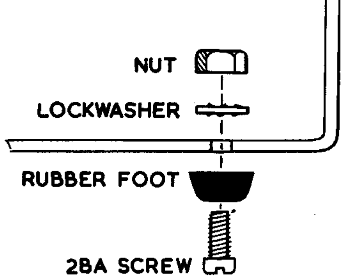
(✓) As shown in the inset to Pictorial 12, fit four small pieces of foam plastic to the inside of the bezel.

(✓) Over the grid screen window, fit the bezel and secure using the four $\frac{1}{4}$" nickel plated washers and the four thumbnuts.

(✓) Using one 4BA x 3/8" chrome plated screw, mount the cover plate on the back of the cabinet.

(✓) Using lockwashers and the nuts supplied, mount the handle on top of the cabinet.

FIGURE 16




(✓) Using 2BA x $\frac{1}{2}$" binderhead screws, lockwashers and nuts, mount the four rubber feet on the bottom of the cabinet as shown in Figure 16.

(✓) Insert a 5/8" rubber grommet in the hole at the rear of the cabinet.

(✓) Refer to Figure 17 and assemble the two test leads, one RED and one BLACK.

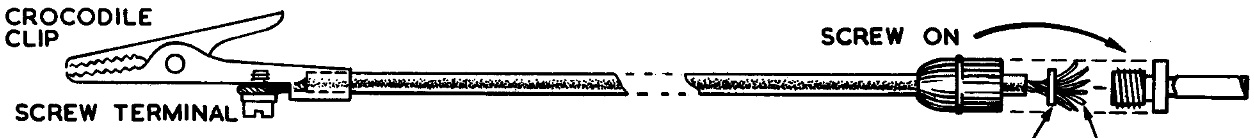



FIGURE 17

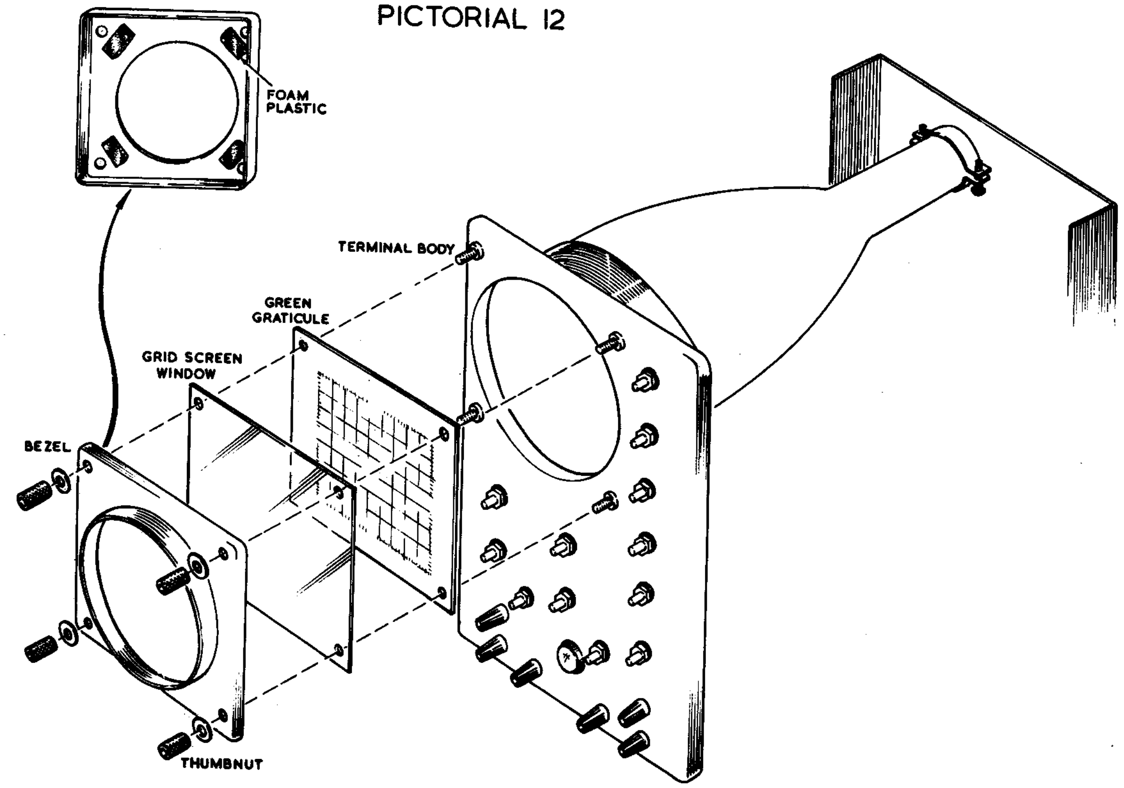
This completes the actual construction and wiring of your Heathkit oscilloscope.

Before attempting to operate the instrument, recheck each step in the wiring against the pictorial diagrams. It is sometimes helpful to mark each lead on the diagram with a coloured pencil as it is checked. This precludes the possibility of missing a connection. When satisfied that the wiring is complete and correct, proceed with the adjustment and testing of the instrument.

CAUTION: The voltages in the instrument are dangerous. Extreme care should be exercised whenever the instrument is connected to the a.c. mains without being installed in its case. DO NOT connect the mains lead to an a.c. outlet until you have read and fully understood the following instructions on testing the oscilloscope.

Some of the adjustments which must be made on the instrument cannot be performed with the cabinet in place. Whenever the 'scope is operated without the cabinet, be sure to remove the mains lead from the outlet before attempting to change position of the 'scope on the bench. Some of the highest voltages in the circuit appear on the BRILLIANCE and FOCUS control terminals, near to the edge of the panel. It is easy to touch one of these terminals when moving the oscilloscope.

PICTORIAL 12




## ADJUSTING THE OSCILLOSCOPE

(✓) Set the controls as follows BEFORE connecting the mains lead to an a.c. outlet:

| | | |
|---|---|---|
| BRILLIANCE | - | Fully anti-clockwise |
| FOCUS | - | At approximate centre of rotation |
| HORIZONTAL POSITION | - | At approximate centre of rotation |
| VERTICAL POSITION | - | At approximate centre of rotation |
| VERT. GAIN | - | Fully anti-clockwise |
| HOR/FREQ. SELECTOR | - | Fully anti-clockwise |
| HOR. GAIN | - | 0 |
| VERT. ATTENUATOR | - | X100 |
| FREQ. VERNIER | - | 50 |
| PHASE | - | At approximate centre of rotation |
| EXT. SYNC. AMPLITUDE | - | Fully anti-clockwise |
| SYNC. SELECTOR | - | EXT. |
| SPOT SHAPE | - | At approximate centre of rotation |

(✓) Connect the mains lead to a 200-250 volt 40-60 cycle a.c. outlet. Ensure that the fused plug is in the appropriate tap. CAUTION: This instrument will not operate and may be seriously damaged if connected to a d.c. supply or to a supply other than that mentioned.

(✓) Turn the BRILLIANCE control fully clockwise.. The pilot lamp should light and all valve heaters should glow red. Allow about one minute for the valve heaters to reach operating temperature.

(✓) Watch the screen of the CR tube carefully until a green spot appears. Reduce the brightness of the spot at once by rotating the BRILLIANCE control anti-clockwise.

CAUTION: DO NOT PERMIT A HIGH INTENSITY SPOT TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME. THIS MAY DESTROY THE FLUORESCENT MATERIAL ON THE SCREEN AND LEAVE A DARK SPOT.

(✓) Rotate the HORIZONTAL POSITION control and notice that the spot moves horizontally across the screen. Now, using the VERTICAL POSITION control, move the spot up and down. Adjust these two controls so that the spot is centred on the screen.

If no spot appears, rotate both the HORIZONTAL and VERTICAL POSITION controls simultaneously, since the controls may position the spot well off the screen. It may also be necessary to readjust the FOCUS and BRILLIANCE controls to form the spot. If again no spot appears, some error has been made in assembly or wiring. Refer to a later section of this manual entitled IN CASE OF DIFFICULTY for a fault finding procedure.

(✓) With the spot centred on the screen, adjust the SPOT SHAPE control (at the right side of the chassis) to produce the spot as round as possible. It may be necessary to readjust the FOCUS and BRILLIANCE controls several times during this procedure as there is some interaction between the three circuits. The result should be a sharply defined spot of small size, the brightness of which can be varied with the BRILLIANCE control. CAUTION: In making this adjustment, be careful not to touch any of the wiring at the rear of the chassis.

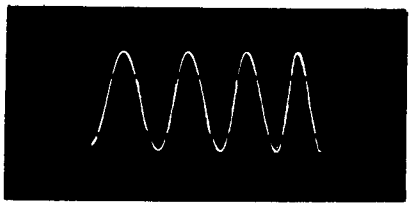
(✓) Using one of the test leads, connect the 1 volt P-P terminal to the HOR. INPUT terminal. Turn the HOR. GAIN control clockwise. The spot should now become a horizontal line, whose length increases to a maximum of about 10 cm as the HOR. GAIN control is advanced. If the trace is not level, indicate the slope of the line with a wax pencil or crayon on the glass face of the CR tube. Turn off the power, loosen the tube clamp on the base of the CR tube and rotate it slightly until the markings are horizontal. Tighten clamp and check trace to see that it is level. CAUTION: DO NOT ATTEMPT TO MAKE THIS ADJUSTMENT WITHOUT TURNING OFF THE INSTRUMENT. SOME SOCKET CONTACTS ON THE CR TUBE HAVE A POTENTIAL OF APPROXIMATELY 1200 VOLTS; CONTACT TO THESE TERMINALS COULD EASILY BE FATAL.

(✓) Next, connect the test lead from the 1 volt P-P terminal to the VERT. INPUT terminal. Rotate the VERT. GAIN control clockwise and note that the trace is now vertical and again is controlled in length by the setting of the control. Switch the VERT. ATTENUATOR control to X10. The line now can be extended to the same length at a fairly low setting of the VERT. GAIN control. Try the X1 position and notice that the same height can be obtained with a very small amount of vertical gain.

(✓) Set the SYNC. SELECTOR switch to the +INT. position, the HOR. GAIN control to 30, the VERT. ATTENUATOR switch to X10 and the VERT. GAIN control to 100. Now set the HOR/FREQ. SELECTOR to the line between 10 and 100 and adjust the FREQ. VERNIER to obtain a pattern consisting of four complete sine waves similar to that shown in Figure 18. This check indicates that the time base generator is operating normally at a frequency of 50/4 or $12\frac{1}{2}$ cycles per second. Reduce the HOR. GAIN setting if necessary. The breaks are caused by the fields of the power transformer. This will not be present with the external signal.

( ) Disconnect the test lead from the 1 volt P-P terminal. Turn off the power and connect the free end of the test lead to the excess lead from the HOR. IN on the rear circuit board. Set the FREQ. SELECTOR to the line between 1000 and 10 K and the FREQ. VERNIER to 0. Now turn on the power. The trace should now be similar to that in Figure 19A or B. Reduce both gain control settings so that the trace is about 2" long.

FIGURE 18



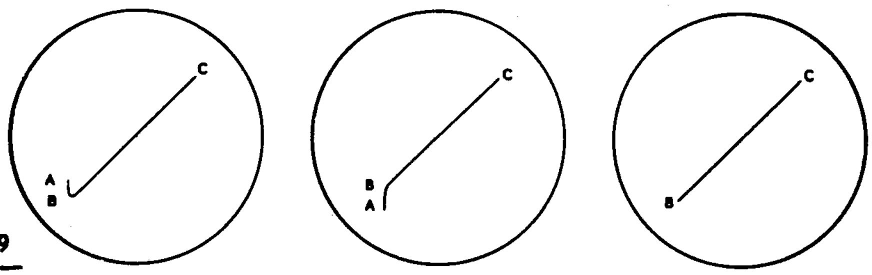



FIGURE 19

A TRIMMER CAPACITY LOW

B TRIMMER CAPACITY HIGH

C TRIMMER PROPERLY ADJUSTED

(✓) With the VERT. ATTENUATOR switch on the X10 position, adjust trimmer TT until the AB portion of the trace disappears and only a straight sloping line is left. (TT is the front trimmer on the left panel bracket.)

(✓) Switch the VERT. ATTENUATOR switch to the X100 position and adjust trimmer UU to obtain the same result. In this adjustment, you will notice that the slope of the BC portion of the trace is more nearly horizontal because of the lower vertical gain being employed. The adjustment can still be made very accurately. Turn power off and disconnect the test lead from rear circuit board. Clip off all but $\frac{1}{4}$" of this wire. This will enable any adjustment to be made more easily in the future.

The adjustments just made are to compensate the vertical input attenuators so that they are not frequency conscious. This compensation preserves the excellent frequency response of the vertical amplifier even with high input attenuation.

NOTE: The adjustment of the PRE-SET ADJUST controls is described in the OPERATION OF THE OSCILLOSCOPE section of this manual on Page 41.

( ) The chassis should now be installed in the cabinet. Pass the mains lead through the hole in the back of the cabinet, then slide the chassis in and fasten it in place using two 4BA x $\frac{1}{2}$" binderhead screws through the back of the cabinet into the tapped pillars at the rear of the chassis.

This completes the construction and adjustment of your Heathkit Oscilloscope.

## OPERATION OF THE OSCILLOSCOPE

The operation of an oscilloscope and its many controls is quite simple once the basic principles are clear.

The controls can be divided into groups with specific functions.

Two knobs, marked BRILLIANCE and FOCUS, control the quality of the trace. The BRILLIANCE control adjusts the brightness and the FOCUS control sharpness of the trace on the oscilloscope screen.

Two knobs, marked VERTICAL POSITION and HORIZONTAL POSITION, control the location of the trace on the screen. Turning the vertical knob shifts the trace up or down and the horizontal knob moves the trace to left or right.

One knob, marked HOR. GAIN, varies the width of the display on the screen.

Two knobs, marked VERT. GAIN and VERT. ATTENUATOR, control the height of the display on the screen.

The PHASE knob controls the phase shift of the line-frequency voltage used for sinusoidal sweep.

Three knobs, marked HOR/FREQ. SELECTOR, FREQ. VERNIER and EXT. SYNC. AMPLITUDE, control the operation of the time base generator. The selector switch and vernier control permit selection of a suitable sweeping rate to provide a clear display. The EXT. SYNC. AMPLITUDE control operates only on external synchronisation to adjust the voltage input to the synchronising circuit.

The HOR/FREQ. SELECTOR switch also performs the following additional functions:

(1) EXT. INPUT: The HOR. INPUT terminal is connected directly to the input grid of the horizontal amplifier system. The time base generator is non-operating.

(2) LINE SW: Line frequency voltage, controlled in phase by the PHASE control, is applied to the horizontal amplifier system. The sweep thus applied is sinusoidal in wave-form.

(3) PRE-SETS 1 and 2: Frequently used sweep frequencies (TV line and frame) can be pre-adjusted by means of the screwdriver adjustments available through the holes in the front panel.

The SYNC. SELECTOR switch operates as follows:

- and +INT: The time base generator is operating, providing saw-tooth sweep at any frequency within its range, synchronised with the signal at the VERT. INPUT terminal.

**LINE:** The time base generator is operating, providing saw-tooth sweep at any frequency within its range, but synchronised with the line frequency or its harmonics.

**EXT:** The time base generator is operating, providing saw-tooth sweep at any frequency within its range, but synchronised with any signal applied to the EXT. SYNC. terminal.

The 1 volt P-P terminal supplies a voltage for establishing the overall gain of the vertical amplifier. When this voltage is applied to the VERT. INPUT terminal and the VERT. GAIN control and VERT. ATTENUATOR switch are set for a given measured vertical deflection on the graticule, it becomes a simple matter to determine the peak-to-peak value of any unknown voltage. For example; a specification refers to a particular wave-form, designating the normal peak-to-peak voltage as 50 volts. Connect the 1 volt P-P terminal to the VERT. INPUT terminal. With the VERT. ATTENUATOR switch in the X1 position, adjust the VERT. GAIN control for a deflection of say, 4 cm on the graticule. Do not touch the VERT. GAIN control again until the measurement is completed. Disconnect the calibrating voltage and apply the unknown voltage to the VERT. INPUT terminal. Set the VERT. ATTENUATOR switch to the X100 position. Now, a 4 cm deflection indicates a peak-to-peak voltage of 100 volts. (With the VERT. ATTENUATOR switch in the X10 position, it would indicate 10 volts.) Adjust the sweep controls to lock the wave-form and adjust the positioning controls for convenient vertical measurement. Observe that the unknown voltage shows a peak-to-peak deflection of 2 cm representing 50 volts.

The TB OUTPUT terminal provides saw-tooth voltages for controlling other instruments such as frequency-swept oscillators. The peak-to-peak voltage is approximately 10 volts.

## Adjusting the Pre-Set Time Base Controls.

Adjustment of the two PRE-SET ADJUST controls may be made directly from the front panel of the oscilloscope with a screwdriver. This makes possible two completely pre-adjusted horizontal sweep frequencies. The instrument does not need to be removed from it's case to make these adjustments. The frequency range of Pre-set 1 is from 10 c/s to 100 c/s and that of Pre-set 2 from 1000 c/s to 10 kc/s. By changing the values of C19 or C20 to the values of C15, C16 or C18, the pre-set controls may be used to set any fixed sweep frequency within the range of the sweep generator.

Since, probably, the most common use of this facility will be in television repair work we will describe the adjustment procedure for setting them for the line and frame frequencies of a television set.

NOTE: WHEN MAKING THESE ADJUSTMENTS, BE CAREFUL NOT TO COME INTO CONTACT WITH THE HIGH VOLTAGES PRESENT IN TV SETS.

### Pre-Set 1.

( ) Make sure that both TV set and oscilloscope are thoroughly warm.

( ) Turn the Sync. Selector switch to the EXT. position.

( ) Turn the HOR/FREQ. SELECTOR to PRE-SET 1.

( ) Connect the vertical input of the oscilloscope to a point in the TV set where the frame wave-form is present and adjust the vertical gain controls to give a convenient size display.

( ) Adjust PRE-SET 1 control until two complete cycles of the wave-form appear on the oscilloscope.

( ) Now check this adjustment by turning the SYNC. SELECTOR switch to INT+ or - to make sure that the wave-form locks solidly.

### Pre-Set 2.

This control may be adjusted to the TV line frequency in the same manner as Pre-Set 1 is adjusted to the frame frequency.

NOTE: Very high voltages are present in some parts of the line circuit of a TV set.

## NOTES ON THE OPERATION OF THE OSCILLOSCOPE

One of the outstanding features of this instrument is the ease with which the sweep may be synchronised with the incoming signal. You will notice that the EXT. SYNC. AMPLITUDE control has no effect at any setting of the SYNC. SELECTOR switch except the EXT. position. The amplitude control is unnecessary in the other positions because of the built-in sync. limiting circuit. This circuit makes synchronisation easily adjustable by the FREQ. VERNIER control. Settings of this control may become quite critical at low vertical gain settings and very high frequencies.

When operating on external synchronisation, the EXT. SYNC. AMPLITUDE control should be set just above the lowest setting which will give the desired synchronisation.

At maximum gain settings, the sensitivity of the amplifiers is very high. Therefore, without a signal source connected to the input terminal, stray pickup may produce patterns on the screen. This is equivalent to the noise obtained from high gain audio amplifiers when the pickup or the microphone is disconnected. Such behaviour is a normal characteristic of the instrument and does not interfere with proper operation.

At low sweep rates (30 cycles or less) the screen has insufficient persistance to provide a steady trace. This flicker is inherent with medium persistence screeens at low sweep rates.

In addition to the above notes, there are several other effects which may be noticed under actual operation of the 'scope. All the following characteristics are normal to the oscilloscope design and should cause no concern.

1. At extreme sweep rates and with fairly high intensity settings, retrace blanking is not complete. Some indication of the retrace, particularly at the left side, is to be expected.

2. When adjusting for minimum spot size, some deflection of the beam may take place due to external magnetic fields. This condition will remain, even with both horizontal and vertical gain controls set to minimum. It is caused by magnetic fields generated by other electrical equipment in proximity to the oscilloscope and the extent of such fields is often surprising. These extraneous fields can be identified by observing whether the spot shape, adjusted for minimum size, seems to change with the orientation of the instrument. To check, turn the 'scope cabinet around the vertical axis. Soldering guns, fan motors, power transformers, voltage regulators and conduit carrying heavy a.c. conductors are particularly bad offenders in this respect. In the past, such deflections have been swamped out by the relatively large spot size which could be resolved. With present cathode ray tube designs and improved circuitry, the effect is much more noticeable.

3. The same magnetic deflection mentioned above may cause a 'breathing' or hum-modulation effect on any waveform displayed, if the time base circuit is operating near the line frequency or a harmonic of it. Although not so easy to identify, one can usually spot this effect by varying the sweep speed slightly to present one less or one more full cycle in the display; the fluctuation will change and may even become evident as a dual trace under some conditions.

4. Vertical positioning range is deliberately limited to approximately ± 4 cm from centre, while horizontal positioning has been extended to several times screen width at normal sweep frequencies. This limited vertical positioning is required to maintain proper operating conditions in the vertical deflection amplifier and no attempt to extend it should be considered.

5. You will note that it is impossible to turn the signal entirely off with the vertical gain control. This has been done purposely in order to force the user of the 'scope to reduce gain with the vertical attenuator switch to prevent possible overloading of the input stage of the vertical amplifier.

6. A slight overshoot or ringing effect may be noticed with square-wave inputs at frequencies of 100 kc/s and higher. This effect should not exceed 10%. Bear in mind, however, that square-wave generators are prone to create this condition themselves. Do not condemn your oscilloscope until this possibility has been checked.

7. As time base sweep rates are increased, particularly above 200 kc/s, a reduction in available sweep amplitude will be noted. This is a function of the falling frequency response of the horizontal amplifier and is normal. At maximum sweep rates, at least 4" of horizontal deflection should be obtained with full horizontal gain. Bear in mind that under these conditions, the time base generator is operating at radio frequencies and may be heard on adjacent radio receivers.

8. If the 'scope is operating with a total horizontal sweep width of 4" for example, and the horizontal gain setting is increased to give a much greater sweep width, the apparent intensity of the trace will be reduced. This action is normal. It is caused by the fact that the trace intensity is inversely related to the writing speed of

the electron beam. As the sweep width is increased, the writing speed increases also and the intensity will drop.

9. Some de-focusing may be experienced at the extreme right-hand edge of the trace. This condition does not indicate a fault in the CRT and will in no way interfere with normal oscilloscope operation.

## IN CASE OF DIFFICULTY

If the test procedure described does not produce the expected results, the following procedure is recommended:

1. Check the wiring against the pictorial diagrams. Follow each wire in the instrument and check the connections at each end for good soldered joints and for termination at the proper points. We cannot over emphasise the importance of good solder connections. A good solder connection will appear bright. If a connection is dull looking, we suggest it be resoldered. Checking each lead off in coloured pensil on the pictorial as it is compared with the instrument will sometimes reveal an error consistently overlooked. Sometimes having a friend check over the wiring will help to locate a wiring error which may be overlooked repeatedly by the kit builder. Mistakes in wiring are responsible for the majority of troubles experienced by kit builders.

2. Check the voltages at the valveholder tags. The readings should compare with the table on Page 46 within 15%. These measurements were made with a Heathkit VVM. Voltage checks made with instruments of other input characteristics may vary greatly. Should a discrepancy in voltage readings show up, carefully check the components associated with that valve.

3. Check the values of the component parts. Be sure that the correct part has been wired into the circuit, as shown in the pictorial diagrams and as called up in the wiring instructions.

4. If the dot moves off the face of the CRT immediately after the kit warms up and cannot be brought back by adjusting the positioning controls, it is generally caused by a defective deflection amplifier valve. If the trace drifts up or down, check the 12BH7 at V3. If the drift is right or left, check the ECC82 (12AU7) at V7. Other probable causes are incorrect or defective anode load resistors, for these stages - the 2.7 KΩ 2 watt and 1 KΩ 1 watt resistors to V3, and the 33 KΩ 1 watt resistors to V7. Also, check coupling capacitors C8 and C26.

5. If you are unable to obtain straight diagonal lines when adjusting the vertical trimmers, please refer to Figure 19 on Page 39 of your 'scope manual. The patterns shown there present a perfectly straight line between points B and C on the traces. Some constructors have raised questions on this point, stating that they cannot obtain a straight line between B and C. This is perfectly normal. The indication which is significant is that portion of trace between A and B. The intention of the adjustment is to reduce this portion of the trace to a point at the lower end of the trace, thus indicating neither overshoot or slow rise time on the sharp wave-front of the saw-tooth generated by the time base generator. If the remaining portion of the line is not quite straight, a read-justment of the sweep frequency will probably locate a point where the effect is changed radically. This variation is due to minor phase shift relationships in the amplifier circuits, not to defective or improper compensation.

6. If you are troubled with hum or ripple when the oscilloscope is operated with shorted vertical input terminals, please make the following checks:

   A. To determine if the hum level is abnormal, short the VERT. INPUT terminal to EARTH, increase the VERT. GAIN control to 100 and set the VERT. ATTENUATOR to X1. The total vertical trace width should not exceed 1/16" peak-to-peak. With the input terminals open-circuited and not shielded, this deflection will increase many times because of the normal pickup of the input circuit. This condition is perfectly normal and is typical of any high-gain, high-impedance amplifier circuit.

   B. If the shorted-input condition results in a trace more than 1/16" in vertical width, connect a shorting lead between CRT7 and CRT6 on the cathode ray tube socket. This will eliminate any <u>electrostatic</u> deflection of the beam which is the normal method by which the 'scope operates. If the trace height then appears to be normal - that is, in the order of 1/16" or so - the difficulty lies in the vertical deflection amplifier circuits and may be isolated readily by tracing back through the various stages until the source of hum or noise is located.

   C. If, with CRT7 and CRT6 shorted, the vertical width of the trace exceeds 1/16" the deflection or ripple is caused by <u>magnetic</u> deflection of the beam by stray magnetic fields passing through the beam path. This is the same type of deflection used in most modern television receivers.

The magnetic field creating the deflection is almost always a composite of many separate field patterns. A portion of this field is created by the oscilloscope transformer, but the relation between the CR tube and transformer has been carefully established so that the sensitive portions of the tube structure are located in a null of the magnetic field surrounding the transformer. Severe overloading of the power transformer will upset this balanced condition, however. The greatest sources of trouble in this respect are magnetic fields from equipment external to the 'scope itself. Anything which consumes power at mains frequency creates a magnetic field. The worst offenders are those equipments which draw a considerable amount of current - soldering irons, soldering guns, a.c. motors, electric heaters and similar items.

Figure 20A shows the general type of wave shape caused by external magnetic fields. Notice the semi-sawtooth wave shape. It is possible to change the wave shape by simply rotating the oscilloscope physically about any of its axes. Figure 20B for example, was obtained by tilting the 'scope about 45 degrees to its left. Observe that now the ripple has actually reduced itself in height, but appears to sweep back on itself for about 30% of its cycle.

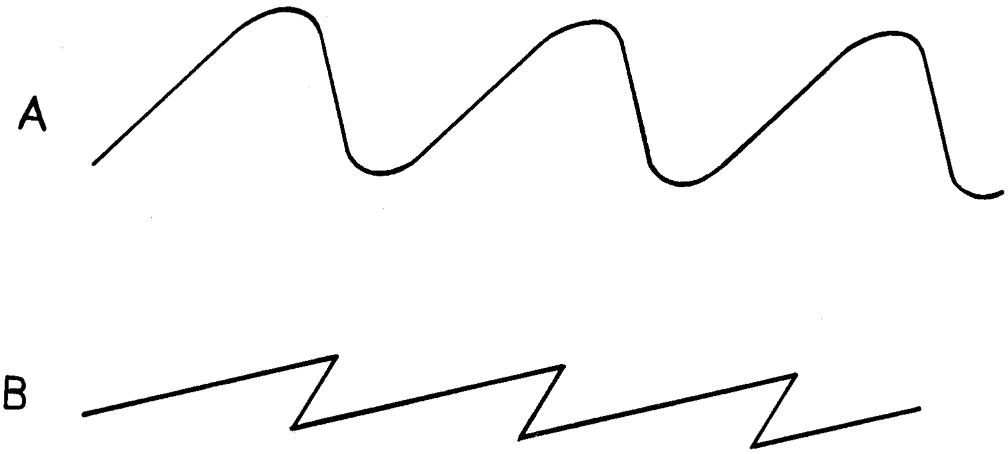



FIGURE 20.

Variations in the ripple appearance with changes in physical location of the 'scope are definite proof that the deflection is not caused by a defect in the 'scope and no known way exists for eliminating the difficulty except by complete shielding of the entire cathode ray tube from socket to face with a high permeability metallic shield. Such a shield would cost about £8. 0. 0d. for the 5UP1 and is an obvious impossibility in a kit selling for as low a price as the oscilloscope.

Fortunately, interference of this kind is usually small in amplitude and presents no problem to the average user. A little judicious experimenting will isolate the principal offender creating the field. Physical separation is in general a quick and easy solution to the problem.

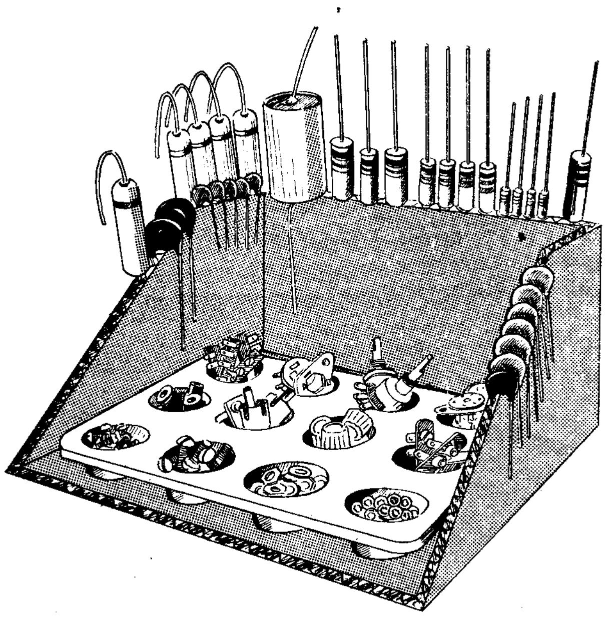
7. Should the procedure as outlined fail to correct your difficulty, write to Daystrom Limited describing the nature of the trouble by giving all possible details, including voltage readings obtained and other indications you may have noticed. We will try to analyse your trouble and advise you accordingly. No charge is made for this service.

# BIBLIOGRAPHY

While many issues of the popular radio and service magazines have carried excellent articles on the construction and application of oscilloscopes and their reading is highly recommended, we also suggest the following excellent books:-


| | | |
|---|---|---|
| The Oscilloscope at Work | - | Haas and Hallows |
| The Cathode Ray Oscilloscope | - | J. Czech - Philips Electrical Ltd. |
| The Oscilloscope and its Applications | - | Philips Electrical Ltd. |
| *Modern Oscilloscopes and their Uses | - | Ruiter |
| *How to Service Radios with an Oscilloscope | - | Sylvania |
| *How to use the CR Oscilloscope in Servicing Radio and TV | - | Hickok |
| *The Cathode Ray Tube at Work | - | Rider |
| *Basic Electronic Test Instruments | - | Turner |
| *Radio Handbook | - | Editors and Engineers |
| *Encyclopedia on Cathode Ray Oscilloscopes and Their Uses | - | Rider and Uslan |
| The Amateur Radio Handbook | - | R.S.G.B. |


* These are American publications. If difficulty is experienced in obtaining any one of them, contact a well-known bookseller such as W.H. Smith & Sons or Foyle's of Charing Cross Road, London W.C.2.



This illustration shows how resistors and capacitors may be placed in the cut edge of a corrugated cardboard carton until they are needed. Their values can be written on the cardboard next to each component.

## CONTROL SETTING FOR VOLTAGE CHECKS

| | |
|---|---|
| BRILLIANCE | - Minimum rotation for barely visible spot |
| FOCUS | - Minimum spot size |
| VERT. POSITION | - Spot centred |
| HOR. POSITION | - Spot centred |
| VERT. ATTENUATOR | - X100 |
| VERT. GAIN | - 10 |
| HOR. GAIN | - 0 |
| HOR/FREQ.SELECTOR | - 10-100 |
| FREQ. VERNIER | - 100 |
| PHASE | - Fully clockwise |
| EXT. SYNC. AMPLITUDE | - Fully anti-clockwise |
| SYNC. SELECTOR | - INT. |
| SPOT SHAPE | - Spot as round as possible. |

## VOLTAGE CHART

| VALVE TYPE | Pin 1 | Pin 2 | Pin 3 | Pin 4 | Pin 5 | Pin 6 | Pin 7 | Pin 8 | Pin 9 | Pin 10 | Pin 11 | Pin 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 EC92 | 125 | N | H | H | NC | 4* | 10.6 | - | - | | | |
| V2 ECF80 | 58 | -0.75* | 108 | H | H | 90 | 0 | 0 | -0.8* | | | |
| V3 12BH7 | 280 (1) (250-300) | 27 | 42 (1) (38-46) | H | | 280 (1) | 35 (1) (25-45) | 42 (1) (38-46) | H | | | |
| V4 ECC91 (6J6) | 75 | 16.5 (2) (15-17) | H | H | 2* | 0 | 3.2* | - | - | | | |
| V5 ECC82 (12AU7) | 100 | 75 | 85 | H | | 80 | -2.4* (2) | 0 | H | | | |
| V6 6BQ7A | 125 | 15* | 45 | H | H | 55 | N | 0.75* | - | | | |
| V7 ECC82 (12AU7) | 250 (6) (150-360) | 80 (6) (130-10) | 96 (6) (75-120) | H | | 250 (6) (150-360) | 44 | 96 (6) (75-120) | H | | | |
| V8 GZ34 | NC | HR | NC | 360 a.c. | NC | 360 a.c. | NC | HR | - | | | |
| V9 6C4 | 138 | NC | H | H | 138 | -3.5* | 0 | - | - | | | |
| CRT 5UP1 | HVH | -1220 (3) | -1120 (3) | -750 (4) | NC | 270 (1) (310-240) | 270 (1) (310-240) | 270 (5) (0-335) | 250 (6) (150-360) | 250 (6) (150-360) | NC | HVH |

All voltages are positive with respect to chassis unless indicated otherwise (e.g. CRT voltages).
All voltages measured with Heathkit VVM.
Voltages may vary by ± 15% due to component tolerances etc. Any voltage in this range may be considered satisfactory.
Voltages in brackets represent approximate variations over the range of the particular control.

H - a.c. voltage this point to chassis: 3.15 volt. Between points: 6.3 volt.
HR - a.c. voltage between points: 5 volt. CAUTION: These terminals +410 volts with respect to chassis.
HVH - a.c. voltage between points: 6.3 volt. CAUTION: These terminals -1200 volts with respect to chassis.
(1) - Varies with VERT./POS. control setting.

(2) - Varies with HOR/FREQ. SELECTOR and FREQ. VERNIER setting.
(3) - Varies with BRILLIANCE setting.
(4) - Varies with FOCUS setting.
(5) - Varies with SPOT SHAPE setting.
(6) - Varies with HOR. POS. control setting.
NC - No connection.
- - No reading, or no contact on socket.
N - Not significant.
* - When measured with a 20,000 ohms/volt meter or lower, these voltages will probably read less than half that stated and may, in fact, not indicate at all.

## WAVEFORM INVESTIGATION

The following portion of this manual is simply to familiarise you with the basic applications of your oscilloscope. Each one of the uses described is well within the capabilities of the Heathkit Oscilloscope.

Probably the major use of most oscilloscopes is in the study of recurrent or transient variations in an electrical quantity. Since the oscilloscope is a voltage-operated device, these variations must be first converted into changes in voltage.

It is common practice to apply the signal voltage to the vertical input to the oscilloscope. By means of attenuators and amplifiers, this voltage is made to displace vertically the electron beam in the cathode ray tube. At the same time, the beam is being swept horizontally by the time base generator within the instrument. The sweep frequency is normally a sub-harmonic or simple fraction of the signal frequency. Therefore, more than one complete cycle of the signal is shown on the screen.

With this brief background, we describe below the more common applications of the oscilloscope in studying waveforms.

Testing Audio Amplifiers and Circuits.

Figure 21 shows the conventional set-up of equipment for this application. The audio generator should be capable of producing a pure sine wave with very low harmonic distortion. The load resistor should match the output impedance of the amplifier. The usual practice is to perform all tests at an input voltage sufficient to develop a reference power output. This prevents over-loading of any portion of the amplifier and consequent inaccuracies in measurements.

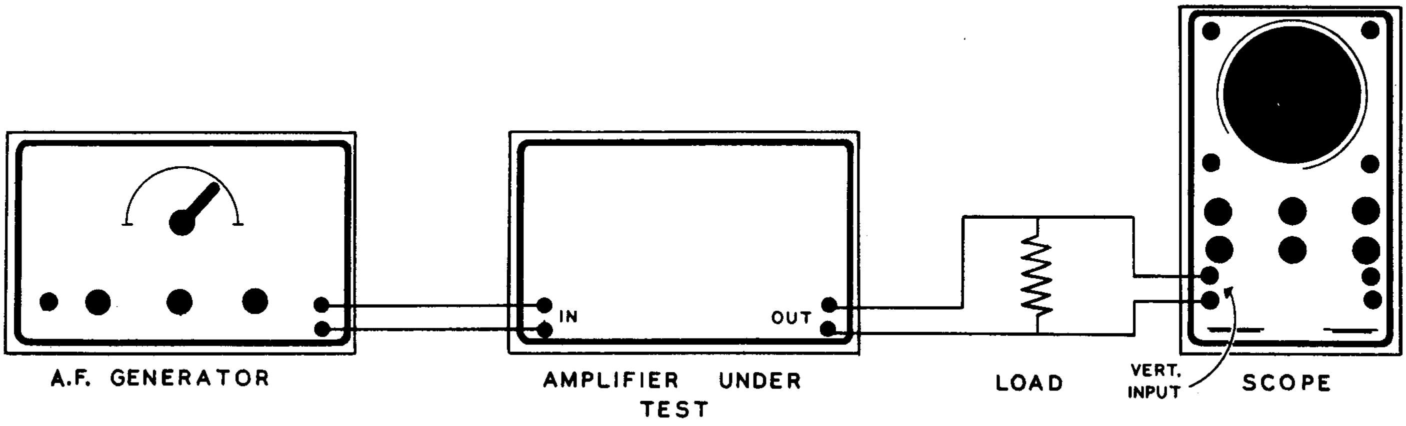



FIGURE 21

Figure 22A shows serious flattening of one peak, representing about 10% harmonic distortion. This condition may be caused by incorrect bias on any stage, or by an inoperative valve in a push-pull stage. Figure 22B indicates third harmonic distortion, a particularly objectionable fault. Figure 22C shows flattening of both peaks, usually an indication of overload somewhere in the circuit.

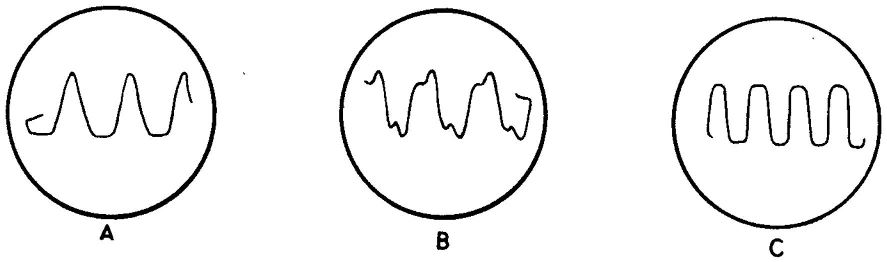



FIGURE 22

Although the use of a sine wave input tells us a lot about an amplifier, the use of a square-wave input waveform gives a very accurate and extremely sensitive indication of the performance of the system with respect to both amplitude distortion and phase shift. Assume that we apply a wave of the form shown in Figure 23A. In a theoretically perfect amplifier, the output waveform would be an exact duplicate except at a greater power level as determined by the gain of the amplifier. Actually, the distortion of this wave-form as shown by the 'scope tells a great deal about the amplifier at frequencies considerably separated from the test frequency. If the high frequency performance of the amplifier is excellent, the front of the square-wave will be sharp cornered and clean. A distortion similar to that shown in Figure 23B indicates poor high frequency response, which may be amplitude distortion, phase shift, or both. We may assume, therefore, that the shape of the rising portion of the wave-form indicates the ability of the amplifier to faithfully reproduce high frequencies. Conversely, the slope of the flat-top portion of the wave indicates the performance of the amplifier in the low frequency range. Figure 23C is the characteristic indication of an amplifier with a poor low frequency response.

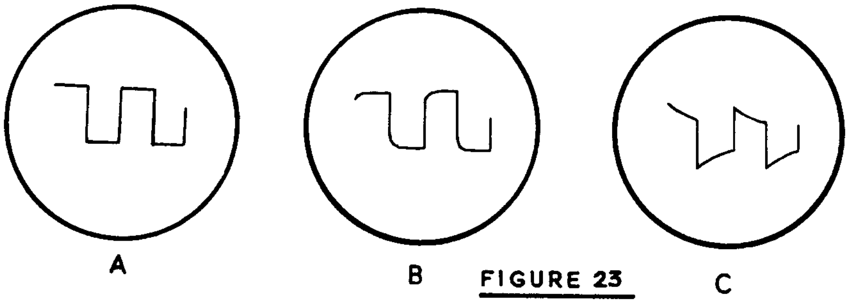



FIGURE 23

Further discussion of this method is beyond the scope of this manual. Interested readers are referred to the bibliography for further sources.

Servicing Television Receivers.

Servicing television receivers is a rapidly expanding application of the cathode ray oscilloscope. Each of the following basic uses requires some additional equipment, but none of them can be performed without using the oscilloscope. This particular field has been given specific attention in the design of the Heathkit oscilloscope.

1. Alignment of a television receiver is virtually impossible without the use of an oscilloscope and a television alignment generator. This generator supplies an RF signal over all VHF frequencies involved in modern television receiver operation. The signal can be frequency-modulated at 50 cycles per second with a deviation of several megacycles. The generator also provides a 50 cycle sweep voltage, controllable in phase, to drive the horizontal deflection amplifiers in the oscilloscope It also provides a blanking system which cuts off the RF output of the generator during one-half of its operating cycle. In effect, the generator output starts at a base frequency and sweeps

at a uniform rate from the base frequency to a frequency several megacycles higher. The oscillator output is then cut off and the cycle is repeated. The vertical input to the 'scope is driven by the voltage developed at the input to the video amplifier. Since this voltage varies in exact accordance with the gain of the RF and/or IF amplifier stages over the frequency range being swept, the trace on the 'scope screen is actually a graphic representation of the response of the amplifiers being tested.

FIGURE 24

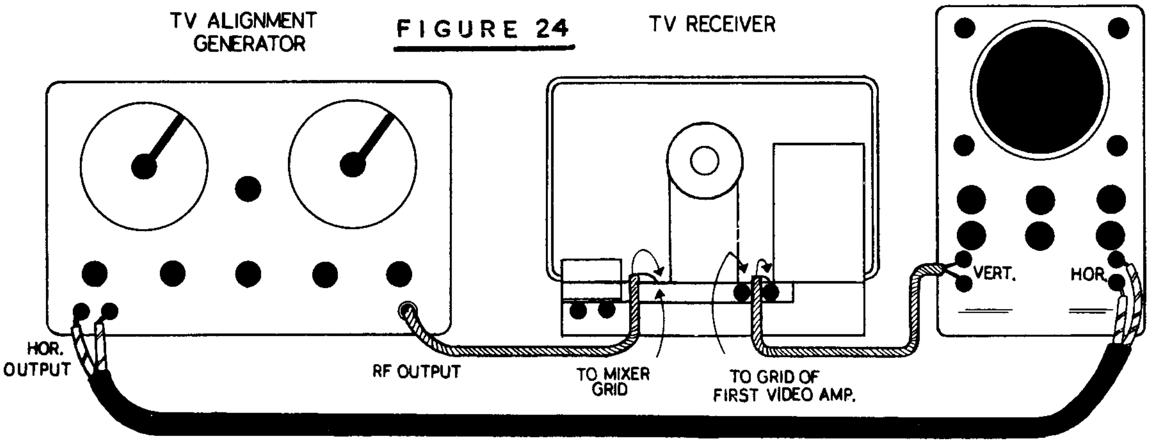



Figure 24 outlines the connections between the alignment generator, the receiver and the oscilloscope. The exact procedure for alignment varies greatly. This information is generally available in the manufacturer's service bulletin. Usually, a drawing of the desired response curve is given, together with a sequence of adjustments to roughly approach the desired pattern. Final adjustments are made whilst watching the trace on the oscilloscope.

2. The wave-form of the complex television picture signal as it is passed through the receiver is undoubtedly the most important characteristic of the signal voltage. In order to properly display the minute variations in wave-form, which incidentally make the difference between good and bad picture quality, the oscilloscope is required to attenuate, amplify and display voltage changes over an extremely wide frequency range without in any way distorting them. The performance of the Heathkit oscilloscope is entirely adequate for this application.

Again, you must rely upon the manufacturer to furnish representative patterns showing the wave-form to be expected at specific test points within the receiver. You will find that these diagrams cover the entire receiver with the exception of the 'front-end' or tuner portion. However, in order to pick off the modulation envelope in the IF or video amplifier sections, a demodulator probe is used to make connection to the anode, grid, or cathode of the stage being investigated. This is necessary since the signal in these stages is still contained in the amplitude modulated envelope of the carrier and must be detected, or demodulated, before it can be shown on the oscilloscope. At any point after the video detector, no such probe is necessary and a simple shielded low-capacity cable can be used.

In either case, the signal voltage is fed into the vertical amplifier of the oscilloscope as shown in Figure 24. At any point up to the video detector, the voltages picked off will be quite small and very little vertical attenuation will be required. Within the sync. circuits and deflection circuits, however, these voltages can be quite high and considerable attenuation is required. It is for this reason that the vertical input section of the 'scope utilises fully compensated attenuators. Any other method of reducing such voltages would result in enough distortion to render the display signal completely useless.

In checking a wave-form, remember that two basic frequencies are involved in the television signal. The vertical or frame frequency is 50 cycles per second. Any investigation of the circuit, <u>except</u> within the horizontal oscillator, its differentiator network and the horizontal amplifier stages, can generally be made using a time base generator frequency of 16 to 25 cycles, thus showing two or three complete frame wave-forms of the signal. In order to study the line pulse shape, or the operation of the line (horizontal) deflection system in 405 line receivers, it is generally necessary to operate the time base generator at 10, 125 or 5, 062.5 cycles per second. This sweep rate will show the wave-form of one or two complete lines of the signal. For 625 line transmissions, the time base should be set to 7812.5 c/s to obtain two complete cycles of signal.

The signal-tracer method of analysis is most helpful in going through a receiver in this fashion, since faulty receiver operation is generally caused by the loss of all or a significant portion of the picture information and pulses at some stage within the receiver. With a basic understanding of the function of each part of the signal, and with the means available to determine what the signal actually looks like at any part of the receiver, it is a comparatively simple matter to isolate the defective portion and the particular component causing the failure.

Remember, in making connections to the test points, that grid circuits are generally high-impedance points, and that the addition of any capacity can disrupt the performance of the stage to some degree. Anode circuits and cathode circuits are usually lower-impedance points and more desirable for testing purposes. Also, bear in mind that the anode circuit indication with respect to phase will be exactly opposite to indications obtained on grid or cathode, since a phase difference of 180 degrees takes place within the valve. Therefore, the pattern shown on the 'scope screen may be inverted when such interchanges are made. The form of the wave will not be changed, however.

3. Video Amplifier response can be measured in exactly the same manner described for testing audio amplifiers and again a square-wave signal is the most efficient method to use. Because a video amplifier must pass signals from d.c. to as high as 3.5 megacycles, however, a more comprehensive test is required. Usually a 50 cycle check is made to cover low and medium-frequency characteristics. A second check at 25-100 kc/s covers the high-frequency portion of the response curve. Again, such tests require extreme fidelity on the part of the oscilloscope and these requirements are fully met by the Heathkit oscilloscope The signal tracing technique can be used in these tests also. The square-wave generator is fed directly into the first video amplifier grid. Very low signal input will be required. The oscilloscope is then connected to various points, starting near the output end and working back until any distortion is isolated. Patterns such as Figure 25B are responsible for poor picture detail, or 'fuzziness', while distortion of the form shown in Figure 25C can cause shading of the picture from top to bottom.

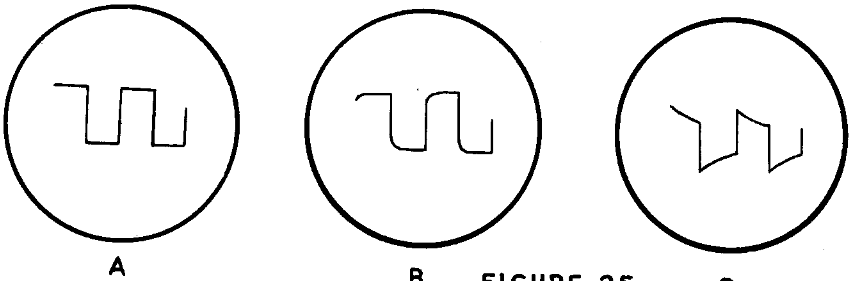



FIGURE 25

Miscellaneous Wave-form Measurements.

In this category, we can place such wave-form investigations as measurement of modulation percentage, studies of noise and vibration, sub-sonic and ultra-sonic applications and hundreds of others. Each of these fields is highly specialised and it is obviously impossible to cover them here. We again refer you to the bibliography for further reading in this field.

## AC VOLTAGE MEASUREMENTS

Because of its characteristics, the oscilloscope is particularly suited to the measurement of a.c. voltages. With the advent of television, it has become imperative that such measurements be made accurately with no regard to wave-shape, so that the conventional r.m.s. reading a.c. voltmeter is no longer adequate. Most television service bulletins specify peak-to-peak voltages which appear at various points of the circuit. Other applications for such measurements are becoming more common every day.

The IO-18U oscilloscope has been designed to accurately measure and display these voltages. Previous instructions have shown how to calibrate the instrument for direct measurement of peak-to-peak wave-forms. The attenuators are especially designed for maximum accuracy and readings can be relied on to within ± 2 dB when referred to a calibration voltage of the same frequency. An additional error of 1 dB may be encountered when the calibrating voltage and the signal voltage are greatly different in frequency.

When using the graticule for a.c. voltage measurements, it is sometimes helpful to use the EXT. INPUT setting for the HOR. SELECTOR switch. This produces a vertical line which can be focused and centred exactly for more accurate readings.

The following relationships exist for sine wave-forms:-

r.m.s. x 1.414 = Peak voltage
r.m.s. x 2.828 = Peak-to-peak voltage

Peak voltage x 0.707 = r.m.s. voltage
Peak-to-peak voltage x 0.3535 = r.m.s. voltage

## AC MEASUREMENTS

Frequency measurements can be made with an accuracy limited only by the reference frequency source available. The unknown frequency is applied to the vertical input and the reference frequency to the horizontal input. (Time base generator is not used.) The resultant pattern may take on any one of a number of shapes. Typical patterns are shown below.

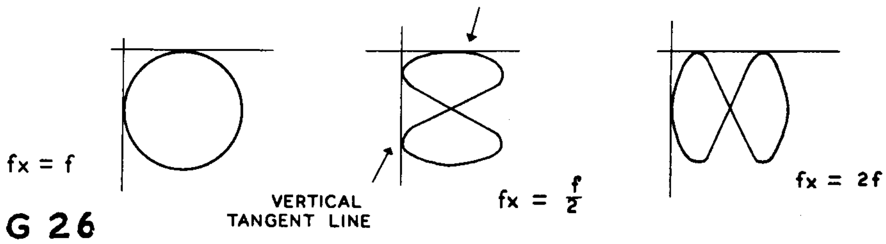



FIG 26

The frequency ratio can be calculated from the formula: $f_x = \frac{T_h \times f}{T_v}$

Where $f_x$ is the unknown frequency; f is the reference frequency; $T_h$ is the number of loops which touch the horizontal tangent line; $T_v$ is the number of loops which touch the vertical tangent line.

When using Lissajous figures, as these patterns are called, it is good practice to have the figure rotating slowly rather than stationary. This eliminates the possibility of an error in counting the tangent points. If the pattern is stationary, a double image similar to the figure below may be formed. In such cases, the end of the trace should be counted as one-half a tangent point rather than a full point. This condition may occur when neither frequency can be varied.

## PHASE MEASUREMENTS

It is sometimes necessary to determine the phase relationship between two a.c. voltages of the same frequency. This can be accomplished quite easily by applying one of the voltages to the horizontal input and the other voltage to the vertical input. The phase relationship can be estimated from the figures below.

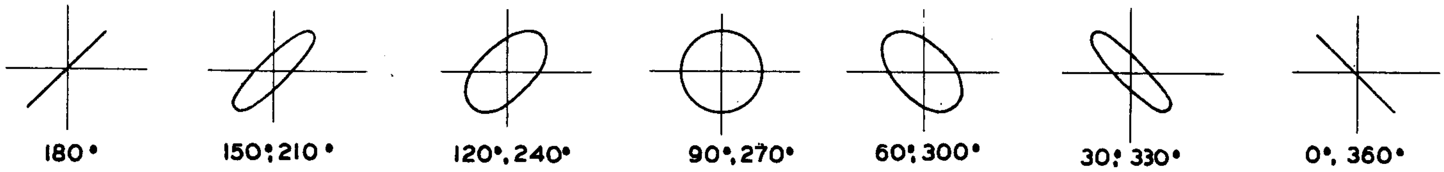



FIGURE 27

To calculate the phase relationship, use the following formula: $\sin \theta = \frac{A}{B}$

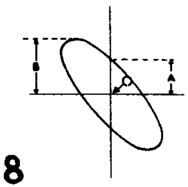


FIG 28

The distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance B represent the height of the pattern above the X axis. The axes of the ellipse must pass through the point O.

## SERVICE INFORMATION

### SERVICE

If, after applying the information contained in this manual, you are still unable to obtain proper performance, it is suggested that you take advantage of the technical facilities which we make available to our customers.

The Technical Consultation Department is maintained for your benefit. This service is available to you at no charge. Its primary purpose is to provide assistance for those who encounter difficulty in the construction, operation or maintenance of HEATHKIT equipment.

Although the Technical Consultants are familiar with all details of this kit, the effectiveness of their advice will depend entirely upon the amount and the accuracy of the information furnished by you. Please use this outline:

1. Before writing, fully investigate each of the hints and suggestions listed in this manual under In Case of Difficulty. Possibly one of these will solve your problem.

2. When writing, clearly describe the nature of the trouble and mention all associated equipment. Specifically report operating procedures, switch positions, connections to other units and anything else that might help to isolate the cause of trouble.

3. Report fully on the results obtained when testing the unit initially and when following the suggestions under In Case of Difficulty. Be as specific as possible and include voltage readings if test equipment is available.

4. Identify the kit model number, invoice number and date of purchase, if available.

5. Print or type your name and address, preferably at the head of the letter.

With the preceding information, the consultant will know exactly what kit you have, what you would like him to do for you and the difficulty you wish to correct. The date of purchase tells him whether or not engineering changes have been made since it was sent to you. He will know what you have done in an effort to locate the cause of trouble and, thereby, avoid repetitious suggestions. In short, he will devote full time to the problem at hand, and through his familiarity with the kit, plus your accurate report, he will be able to give you a complete and helpful answer. If replacement parts are required, they will be sent to you, subject to the terms of the Guarantee.

HEATHKIT equipment purchased locally and returned to Daystrom Limited for service must be accompanied by your copy of the dated sales receipt from your authorised HEATHKIT dealer in order to be eligible for parts replacement under the terms of the Guarantee.

If the completed instrument should fail to function properly and attempts to find and cure the trouble prove ineffective, the facilities of Daystrom's Service Department are at your disposal. Your instrument may be returned carriage paid to Daystrom Limited, Gloucester, and the Company will advise you of the service charge where not covered within the terms of the Guarantee (i.e. a faulty component supplied by us).

For information regarding modification of HEATHKIT equipment for special applications, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at most electronic equipment stores. Although Daystrom Ltd. sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for special purposes. Therefore, such modifications must be made at the discretion of the kit builder, using information available from sources other than Daystrom Limited.

### REPLACEMENTS

Material supplied with HEATHKIT products 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 component. Should inspection reveal the necessity for replacement, write to Daystrom Limited 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 date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

Daystrom Limited 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. 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.

SHIPPING INSTRUCTIONS

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

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

Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper, wood wool or plastic cushioning material on all sides. DO NOT DESPATCH IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

PRICES: All prices are subject to change without notice.

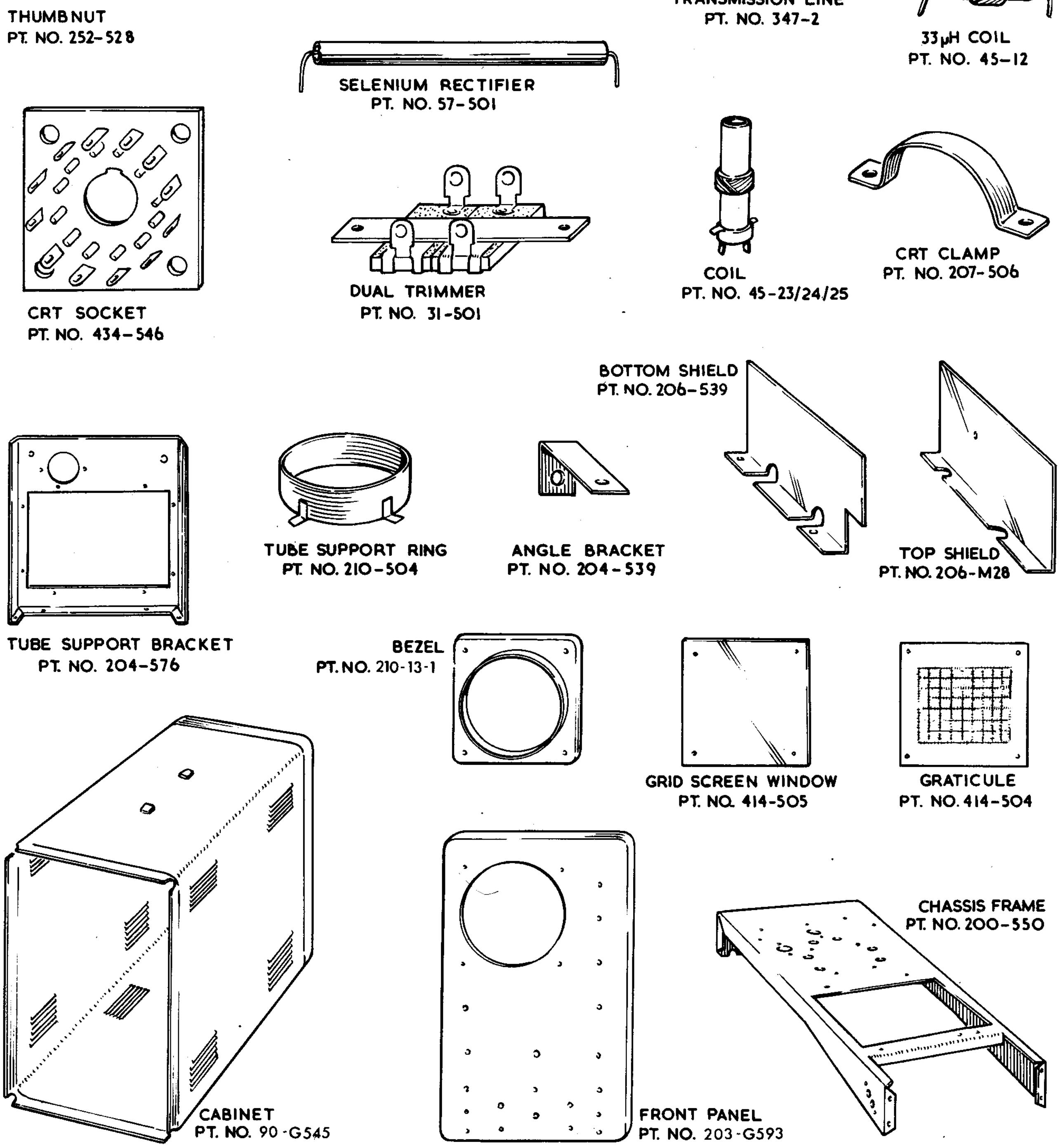
MODIFICATIONS TO SPECIFICATIONS: Daystrom Limited reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

* * * * * * * * * * * * * * *

The Heathkit builder is again strongly urged to follow step-by-step instructions given in this Manual to ensure successful results. Daystrom Limited assumes no responsibility for any damages or injuries sustained in the assembly or handling of any of the parts of this kit or the completed instrument.

# COMPONENT IDENTIFICATION CHART

*NOT DRAWN TO SCALE*




A convenient method of arranging small components is shown on Page 45.

## PARTS LIST

Resistors (10%, carbon, $\frac{1}{2}$ watt)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| H-101C10 | 5 | 100Ω (Brown, Black, Brown) |
| H-221C10 | 4 | 220Ω (Red, Red, Brown) |
| H-471C10 | 1 | 470Ω (Yellow, Violet, Brown) |
| H-821C10 | 1 | 820Ω (Grey, Red, Brown) |
| H-202C10 | 2 | 2 KΩ (Red, Black, Red) |
| H-272C10 | 1 | 2.7 KΩ (Red, Violet, Red) |
| H-332C10 | 3 | 3.3 KΩ (Orange, Orange, Red) |
| H-392C10 | 2 | 3.9 KΩ (Orange, White, Red) |
| H-682C10 | 1 | 6.8 KΩ (Blue, Grey, Red) |
| H-103C10 | 3 | 10 KΩ (Brown, Black, Orange) |
| H-153C10 | 1 | 15 KΩ (Brown, Green, Orange) |
| H-223C10 | 2 | 22 KΩ (Red, Red, Orange) |
| H-333C10 | 2 | 33 KΩ (Orange, Orange, Orange) |
| H-473C10 | 1 | 47 KΩ (Yellow, Violet, Orange) |
| H-104C10 | 2 | 100 KΩ (Brown, Black, Yellow) |
| H-154C10 | 5 | 150 KΩ (Brown, Green, Yellow) |
| H-474C10 | 3 | 470 KΩ (Yellow, Violet, Yellow) |
| H-105C10 | 2 | 1 megohm (Brown, Black, Green) |
| H-335C10 | 2 | 3.3 megohm (Orange, Orange, Green) |
| H-475C10 | 2 | 4.7 megohm (Yellow, Violet, Green) |
| H-106C10 | 3 | 10 megohm (Brown, Black, Blue) |
| H-226C10 | 1 | 22 megohm (Red, Red, Blue) |

Resistors (5%, carbon, $\frac{1}{2}$ watt)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| H-620C5 | 1 | 62Ω (Blue, Red, Black, Gold) |
| H-222C5 | 3 | 2.2 KΩ (Red, Red, Red, Gold) |
| H-363C5 | 1 | 36 KΩ (Orange, Blue, Orange, Gold) |
| H-334C5 | 1 | 330 KΩ (Orange, Orange, Yellow, Gold) |

Resistors (10%, carbon, 1 watt)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 1-102C10 | 2 | 1 KΩ (Brown, Black, Red) |
| 1-152C10 | 1 | 1.5 KΩ (Brown, Green, Red) |
| 1-333C10 | 2 | 33 KΩ (Orange, Orange, Orange) |
| 1-104C10 | 1 | 100 KΩ (Brown, Black, Yellow) |
| 1-474C10 | 1 | 470 KΩ (Yellow, Violet, Yellow) |
| 1-105C10 | 1 | 1 megohm (Brown, Black, Green) |
| 1-335C10 | 1 | 3.3 megohm (Orange, Orange, Green) |

Resistors (10%, carbon, 2 watt)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 2-122C10 | 1 | 1.2 KΩ (Brown, Red, Red) |
| 2-272C10 | 2 | 2.7 KΩ (Red, Violet, Red) |
| 2-472C10 | 1 | 4.7 KΩ (Yellow, Violet, Red) |
| 2-123C10 | 1 | 12 KΩ (Brown, Red, Orange) |

Resistors (wire-wound and precision)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 8-102W5 | 1 | 1 KΩ 8 watt ± 5% wire-wound |
| 8-502W5 | 1 | 5 KΩ 8 watt ± 5% wire-wound |
| Q-335HS5 | 1 | 3.3 megohm 5% $\frac{1}{4}$ watt precision (may be marked ORANGE, ORANGE, GREEN, GOLD) |

Capacitors (all types)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 20-508 | 1 | 47 pF 10% silver mica, 350V |
| 20-509 | 1 | 390 pF 10% silver mica, 350V |

Capacitors (all types) (cont'd.)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 21-505 | 1 | 10 pF ceramic disc, 500V |
| 21-506 | 1 | 20 pF ceramic disc, 500V |
| 21-507 | 1 | 200 pF ceramic disc, 500V |
| 21-~~509~~ 502 | 1 | 100 pF ceramic tubular |
| 21-510 | 3 | .002 μF ceramic disc, 500V |
| 21-511 | 1 | .01 μF ceramic disc, 500V |
| 21-512 | 1 | .02 μF ceramic disc, 500V |
| 21-513 | 2 | .02 μF ceramic disc, 2 kV |
| 23-3 | 1 | .01 μF 400V, paper |
| 23-11 | 1 | .1 μF 600V, paper |
| 23-58 | 2 | .2 μF 200V, paper |
| 23-63 | 3 | .25 μF 400V |
| 23-504 | 2 | .05 μF 250V |
| 23-505 | 7 | .1 μF 250V |
| 23-506 | 2 | .1 μF 2 kV |
| 25-20 | 2 | 40 μF 150V, electrolytic |
| 25-28 | 1 | 100 μF 50V, electrolytic |
| 25-506 | 1 | 40-20-20 μF 450V, 50 μF 300V, electrolytic |
| 25-507 | 1 | 40-40-20 μF 275V, electrolytic |
| 31-501 | 1 | 25 pF + 250 pF dual trimmer |

Controls (potentiometers)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 10-505 | 1 | 2 KΩ lin with dummy tag |
| 10-506 | 1 | 10 KΩ lin |
| 10-507 | 1 | 20 KΩ lin - centre tapped |
| 10-508 | 1 | 200 KΩ lin - centre tapped |
| 10-509 | 1 | 250 KΩ lin |
| 10-511 | 1 | 2 megohm lin with HV insulated shaft |
| 10-512 | 1 | 7.5 megohm lin |
| 10-513 | 1 | 2 megohm lin |
| 10-522 | 1 | 1 megohm lin with slotted shaft |
| 10-551 | 2 | 7.5 megohm lin pre-set, tab mounting |
| 19-502 | 1 | 500 KΩ lin with HV insulated shaft and DPST switch |

Controls (switches)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 63-47 | 1 | 3-position rotary switch |
| 63-88 | 1 | 4-position rotary switch |
| 63-550 | 1 | 9-position rotary switch |

Valves, CRT, Rectifier, Lamp etc.

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| 57-501 | 1 | Selenium rectifier |
| 411-4 | 1 | 6C4 |
| 411-25 | 2 | ECC82 (12AU7) |
| 411-49 | 1 | 5UP1 cathode ray tube |
| 411-58 | 1 | EC92 |
| 411-73 | 1 | 12BH7 |
| 411-79 | 1 | ECC91 (6J6) |
| 411-502 | 1 | ECF80 |
| 411-504 | 1 | GZ34 |
| 411-535 | 1 | 6BQ7A |
| 412-501 | 1 | Pilot lamp, 6.3V, 0.15 A |

## PARTS LIST (cont'd.)

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Transformers, Coils etc.** | | |
| 45-12 | 2 ✓ | 33 μH coil (wound on 3.3 KΩ 1W 10% res.) |
| 45-23 | 2 ✓ | 61 μH coil (red band) |
| 45-24 | 2 ✓ | 90 μH coil (blue band) |
| 45-25 | 1 ✓ | 30 μH coil (green band) |
| 54-503 | 1 ✓ | Mains transformer |
| **Valveholders, Plugs, Sockets, Tagstrips etc.** | | |
| 70-501 | 1 ✓ | Black wander plug |
| 70-502 | 1 ✓ | Red wander plug |
| 431-1 | 1 ✓ | 1-way tagstrip |
| 431-32 | 2 ✓ | 2-way tagstrip |
| 431-12 | 2 ✓ | 4-way tagstrip |
| 431-506 | 2 ✓ | 7-way tagstrip |
| 434-522 | 3 ✓ | 7-pin valveholder |
| 434-521 | 5 ✓ | 9-pin valveholder |
| 434-503 | 1 ✓ | Octal valveholder |
| 434-508 | 1 ✓ | Pilot lamp socket |
| 434-546 | 1 ✓ | 12-pin CRT socket |
| 438-502 | 1 ✓ | 1 amp fused plug |
| **Hardware (screws, nuts, washers, etc.)** | | |
| 250-9 | 16 | 4BA x 3/8" binderhead screw |
| 250-502 | 21 | 6BA x 5/16" binderhead screw |
| 250-511 | 4 | 2BA x 3/8" binderhead screw |
| 250-512 | 4 | 2BA x ½" binderhead screw |
| 250-514 | 5 | 4BA x 3/8" binderhead screw, chrome plated |
| 250-515 | 2 | 4BA x ¾" binderhead screw |
| 250-517 | 2 | 4BA x ½" binderhead screw |
| 250-520 | 2 | 6BA x ¾" binderhead screw |
| 252-3 | 25 | 4BA hex nut |
| 252-501 | 22 | 6BA hex nut |
| 252-503 | 10 | 2BA hex nut |
| 252-504 | 2 | 4BA half nut |
| 254-1 | 28 | 4BA lockwasher |
| 254-501 | 23 | 6BA lockwasher |
| 254-502 | 10 | 2BA lockwasher |
| 255-502 | 2 | 6BA spacer |
| 259-504 | 9 | 4BA shakeproof solder tag |
| 253-521 | 4 | ¼" BSF flat washer (nickel plated) |
| **Wire, Solder etc.** | | |
| 89-G504 | 1 length ✓ | Mains cable |
| 100-550 | 1 ✓ | Cable assembly |
| 331-501 | 1 length ✓ | Solder, 18 swg. (thick) |
| **Wire, Solder etc. (cont'd)** | | |
| 331-502 | 1 length ✓ | Solder, 22 swg. (thin) |
| 340-501 | 1 length ✓ | Tinned copper wire, 22 swg. |
| 341-1 | 1 length ✓ | Black test lead |
| 341-2 | 1 length ✓ | Red test lead |
| 344-506 | 1 length ✓ | Connecting wire |
| 346-501 | 1 length ✓ | 1.5 mm. sleeving |
| 347-2 | 1 length ✓ | 300Ω transmission line |
| **Sheet Metal Parts** ✗ | | |
| 90-G545 | 1 ✗ | Cabinet |
| 200-550 | 1 ✗ | Chassis frame |
| 203-G593 | 1 ✗ | Front panel |
| 204-539 | 2 ✗ | Bracket, angle |
| 204-576 | 1 ✗ | Tube support bracket |
| 205-G587 | 1 ✗ | Cover plate |
| 206-M28 | 1 ✗ | Shield top |
| 206-539 | 1 ✗ | Shield bottom |
| 207-506 | 2 ✗ | C.R. tube clamp |
| 210-504 | 1 ✗ | Tube support ring |
| 204-578 | 1 ✗ | Control mounting bracket |
| 204-618 | 1 ✗ | Stiffener bracket |
| **Miscellaneous** | | |
| 75-30 | 1 ✓ | Strain relief bush |
| 73-501 | 2 ✓ | 3/8" grommet |
| 73-502 | 3 ✓ | 5/8" grommet |
| 73-505 | 1 length ✓ | Cushion strip |
| 73-506 | 1 length ✓ | ¼" foam plastic strip |
| 85-531 | 1 ✓ | Front circuit board |
| 85-532 | 1 ✓ | Rear circuit board |
| 210-13-1 | 1 ✓ | Bezel |
| 211-G506 | 1 ✓ | Handle with two end plates |
| 252-528 | 4 ✓ | Thumbnut |
| 260-1 | 2 ✓ | Crocodile clip |
| 261-501 | 4 ✓ | Rubber feet |
| 320-501 | 1 length ✓ | Foam plastic strip (wide) |
| 414-504 | 1 ✓ | Graticule (green) |
| 414-505 | 1 ✓ | Grid screen window |
| 427-501 | 2 ✓ | Red terminal complete |
| 427-502 | 5 ✓ | Black terminal complete |
| 427-503 | 4 ✓ | Terminal body |
| 462-G539 | 8 ✓ | Knob, Large |
| 462-G540 | 4 ✓ | Knob, small |
| 481-502 | 1 ✓ | Mounting plate for electrolytic capacitor |
| 605-501 | 1 ✓ | Voltage selector panel |
| 630-501 | 1 ✓ | Nut starter |
| 595-G625 | 1 | Instruction manual |
| 252-7 | 15 | 3/8" control nut ✓ |
| 253-10 | 15 | 3/8" flatwasher ✓ |
| 254-4 | 15 | control lockwasher ✓ |

REPLACEMENT CATHODE RAY TUBE. R.C.A. INTERNATIONAL, ELECTRONICS
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## A selection of typical symbols found in circuit diagrams

| | | | |
|---|---|---|---|
| AERIAL | CAPACITOR (VARIABLE) | SWITCH — SINGLE POLE (S.P.) SINGLE THROW (S.T.) | BATTERY + |
| LOOP | RESISTOR | SWITCH — DOUBLE POLE (D.P.) DOUBLE THROW (D.T.) | FUSE OR |
| DIPOLE | RESISTOR (TAPPED) | SWITCH — TRIPLE POLE (T.P.) DOUBLE THROW (D.T.) | CRYSTAL |
| EARTH | RESISTOR (VARIABLE) | LOUDSPEAKER | TERMINAL & TERMINAL STRIP |
| INDUCTOR (COIL OR R.F. CHOKE) | POTENTIOMETER | RECTIFIER | WIRING BETWEEN LIKE LETTERS IS UNDERSTOOD →X →Y XY XY |
| R.F. COIL WITH ADJUSTABLE IRON DUST CORE | JACK (TWO CONDUCTOR) | MICROPHONE | MICRO (x 1/1,000,000) = $\mu$ |
| L.F. CHOKE (IRON CORED) WITH TAPPINGS | JACK (THREE CONDUCTOR) | TYPICAL TUBE SYMBOL: ANODE, SUPPRESSOR GRID, SCREEN GRID, CONTROL GRID, CATHODE, HEATER FILAMENT | MILLI (x 1/1000) = m |
| R F TRANSFORMER (AIR CORE) | WIRES CONNECTED | | KILO (x 1000) = K |
| TRANSFORMER (R.F. OR I.F.) ADJUSTABLE IRON DUST CORE | WIRES CROSSING BUT NOT CONNECTED | TRANSISTOR (P.N.P. TYPE) | MEGA (x 1,000,000) = M |
| TRANSFORMER (MAINS OR L.F.) IRON CORE | A-AMMETER V-VOLTMETER mA-MILLIAMMETER $\mu$A-MICROAMMETER ETC. (A) | TRANSISTOR (N.P.N. TYPE) | OMEGA (OHMS) = $\Omega$ |
| CAPACITOR | NEON LAMP STABILISER VALVE | SOCKET OUTLET — CO AXIAL | MICROFARAD = $\mu$F |
| CAPACITOR (ELECTROLYTIC) + | LAMP PILOT OR ILLUMINATING | TWO PIN SOCKET AND TWO PIN PLUG | PICOFARAD = pF MICRO,MICRO FARAD = $\mu\mu$F |

REPLACEMENTS ALSO AVAILABLE FROM G.E.C.
1 Stanhope Gate W1 01-493-8454

## GENERAL ADVICE OF CHANGE

Some of the components supplied with this kit may differ slightly from the descriptions and pictorials given in the manual.

### Resistors

These may be colour coded instead of value marked. For identification, use the chart found on the inside cover of the Manual.

### Capacitors (Polyester)

These may be colour coded instead of value marked. The value colour code is the first three colour bands, starting with the end furthest from the leads. Where the first two colours are the same, this is denoted by a very wide first colour band. The remaining colours are used to denote tolerance and voltage working. The following values are in common use:-

| | | | | |
|---|---|---|---|---|
| .01 µF | = | 10,000 pF | = | Brown, Black, Orange |
| .022 µF | = | 22,000 pF | = | Red, Red, Orange |
| .1 µF | = | 100,000 pF | = | Brown, Black, Yellow |
| .22 µF | = | 220,000 pF | = | Red, Red, Yellow |
| .47 µF | = | 470,000 pF | = | Yellow, Violet, Yellow. |

### Capacitors, (Electrolytic) Polarity Identification

The positive (+) lead of electrolytic capacitors is the end with a Red, White or Black insulator and on the larger types also with a + sign. The negative lead is always the lead attached to the aluminum case.

The capacity values supplied may be slightly higher or lower than that specified in the parts. For example 2 5µF may be supplied in lieu of 2µF and 640µF may be supplied in lieu of 650µF. Also the voltage working may be slightly higher than that specified.

### Diodes and Transistors

Transistors and diodes may be supplied with an improved or alternative type to that stated in the manual and will perform satisfactorily.

For example:-

Part No. 56-510 IN191 / OA79 Diode. Now replaced by AA119 Diode. The positive (+) end is marked with a coloured ring.

Part No. 417-522 2N408 Transistor. AC128 transistors may be supplied in lieu.

# ADVICE OF CHANGE

## Colour Coding of Mains Cables.

H.M. Government have decided to make regulations requiring the core colours of three-core flexible cables to comply with the following international coding recently agreed by most of the countries in Europe:

| | |
|---|---|
| Green and Yellow striped core | EARTH |
| Brown core | LIVE |
| Light blue core | NEUTRAL |

Under the old system the colour code was Green- EARTH; Red - LIVE; Black - NEUTRAL.

When connecting the mains cable in your kit, please amend the appropriate step/s in your manual as follows:-

Amend Green to read Green and Yellow stripe.

Amend Red to read Brown.

Amend Black to read Light blue.

A.O.C. 8-10-69/Gen.

# RESISTOR CODING

Any insulated wire wound resistors in this kit may be value coded as shown below.

Resistor

| Resistor Value | Code |
|---|---|
| 0.1 Ω | R10 |
| 0.24 Ω | R24 |
| 1 Ω | 1RO |
| 10 Ω | 10R |
| 1 KΩ | 1KO |
| 1.5 KΩ | 1K5 |

Tolerance

| Tolerance | Code |
|---|---|
| ± 0.1 % | B |
| ± 0.25 % | C |
| ± 0.5 % | D |
| ± 1% | F |
| ± 2% | G |
| ± 5% | J |
| ± 10% | K |
| ± 20% | M |
| ± 30% | N |
| ± .05 Ω | ± .05 Ω |

Examples

| Value | | Code | |
|---|---|---|---|
| 0.24 Ω | ± .05 Ω | R24 | ± .05 Ω |
| 10 Ω | ± 5% | 10R | J |
| 90 Ω | ± 10% | 90R | K |