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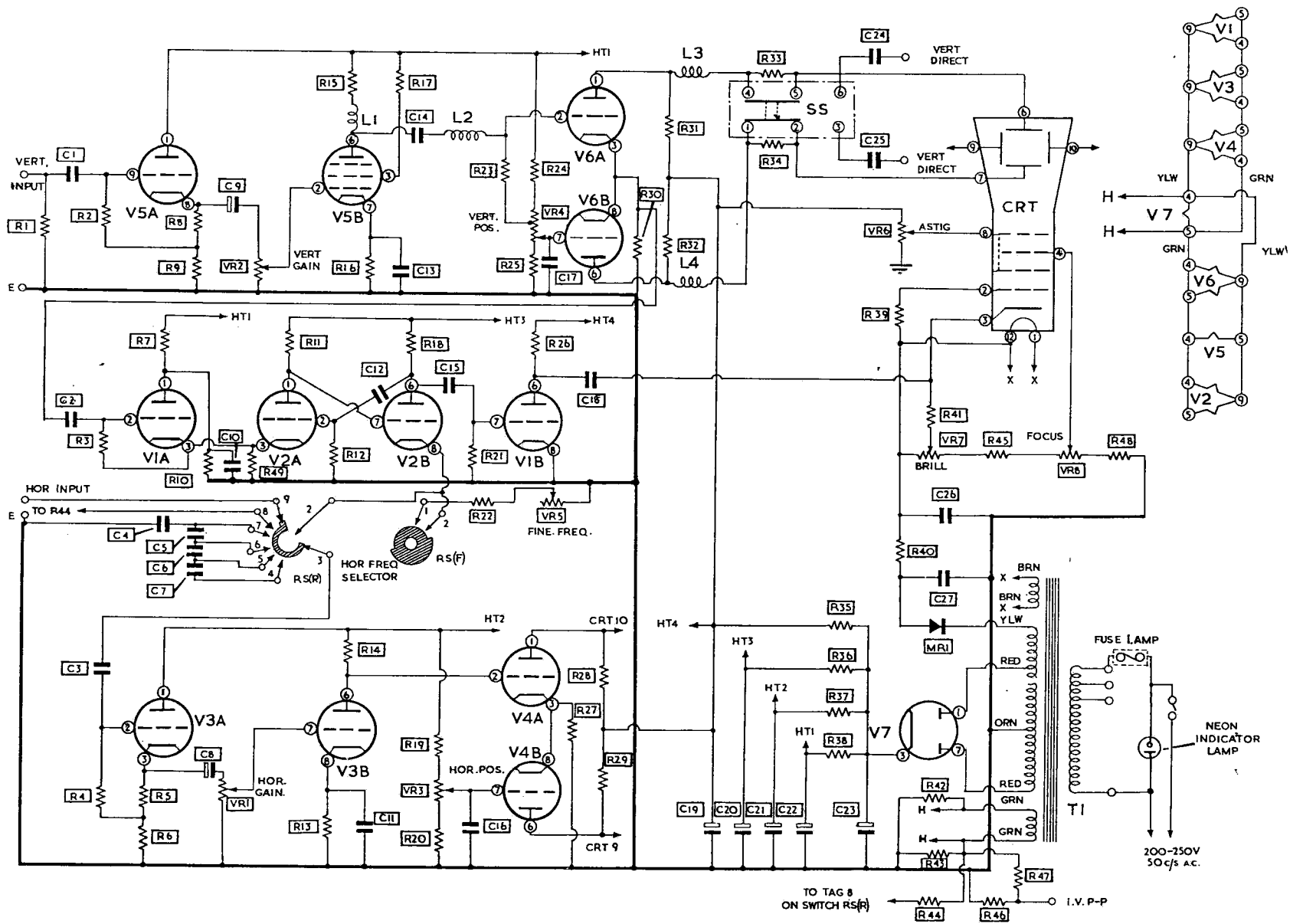
# Assembly and Operation of the Heathkit Service Oscilloscope

## MODEL OS-2



### SPECIFICATION

Vertical Amplifier:	
Sensitivity .....	100 mV r.m.s. per cm
Frequency Response .....	2 c/s - 3 Mc/s, $\pm 3$ dB
Input Impedance .....	3.3 M $\Omega$ shunted by 20 pF
Horizontal Amplifier:	
Sensitivity .....	100 mV r.m.s. per cm
Frequency Response .....	2 c/s - 300 kc/s, $\pm 3$ dB
Input Impedance .....	10 M $\Omega$ shunted by 20 pF
Time Base Generator:	
Recurrent Type .....	Linear sawtooth produced by multivibrator
Range .....	20 c/s to 200 kc/s in four steps. Approximate ranges, 1. 20-200 c/s, 2. 200-2000 c/s, 3. 2-20 kc/s, 4. 20-200 kc/s
Synchronisation .....	Automatic lock-in circuit, using self-limiting synchronising cathode follower
Retrace Blanking .....	Blanking amplifier provided, operates on all ranges
General:	
Valve Complement: .....	1 - ECF80, 4 - 12AU7, 1 - 12AX7, 1 - EZ80, 1 - 3RP1
Front Panel Controls: .....	CRT, medium persistence, green trace BRILLIANCE - AC ON/OFF FOCUS HOR/FREQ. SELECTOR (horizontal input and time base generator frequency selector) FINE FREQUENCY VERTICAL POSITION VERTICAL GAIN HORIZONTAL POSITION HORIZONTAL GAIN
Rear Panel Controls: .....	Vertical input switch Astigmatism (spot shape)



CIRCUIT DIAGRAM  
 HEATHKIT SERVICE OSCILLOSCOPE  
 Model OS-2



Inputs: ..... VERTICAL INPUT  
 HORIZONTAL INPUT  
 Input to vertical plates of CRT, via .002  $\mu$ F 1 kV capacitors, at rear of oscilloscope

Voltage Calibrator: ..... 1 volt peak-to-peak  
 Power Requirements: ..... 200-250V, 40-60 c/s a.c., 40 watts  
 Dimensions: ..... 5" wide x 7.3/8" high x 12" deep  
 Net Weight: ..... 9 $\frac{3}{4}$  lb.  
 Shipping Weight: ..... 12 lb.

RESISTOR AND CAPACITOR CHART

R1	4.7 M $\Omega$	R26	100 K $\Omega$	C1	.1 $\mu$ F 400V	C26	.1 $\mu$ F 1000V
R2	1 M $\Omega$	R27	6.8 K $\Omega$ 2W	C2	.1 $\mu$ F 250V	C27	.1 $\mu$ F 1000V
R3	470 K $\Omega$	R28	22 K $\Omega$ 1W	C3	.1 $\mu$ F 400V		
R4	2.2 M $\Omega$	R29	22 K $\Omega$ 1W	C4	.2 $\mu$ F		
R5	1.2 K $\Omega$	R30	3.3 K $\Omega$ 2W	C5	.02 $\mu$ F		
R6	56 K $\Omega$	R31	6.8 K $\Omega$ 2W	C6	.002 $\mu$ F	V1	12AU7
R7	150 K $\Omega$	R32	6.8 K $\Omega$ 2W	C7	200 pF	V2	12AX7
R8	470 $\Omega$ 5%	R33	1 M $\Omega$	C8	16 $\mu$ F 150V	V3	12AU7
R9	10 K $\Omega$	R34	1 M $\Omega$	C9	16 $\mu$ F 150V	V4	12AU7
R10	33 K $\Omega$	R35	470 $\Omega$ 1W	C10	.1 $\mu$ F 250V	V5	ECF80
R11	6.8 K $\Omega$	R36	39 K $\Omega$ 1W	C11	.002 $\mu$ F	V6	12AU7
R12	2.2 M $\Omega$	R37	27 K $\Omega$ 1W	C12	.02 $\mu$ F	V7	EZ80
R13	1.2 K $\Omega$	R38	18 K $\Omega$ 5W	C13	1000 pF		
R14	100 K $\Omega$	R39	100 K $\Omega$	C14	.1 $\mu$ F 250V		
R15	6.8 K $\Omega$	R40	470 K $\Omega$	C15	1000 pF	VR1	20 K $\Omega$ HOR. GAIN
R16	220 $\Omega$	R41	1 M $\Omega$	C16	.02 $\mu$ F	VR2	20 K $\Omega$ VERT. GAIN
R17	270 $\Omega$	R42	47 $\Omega$	C17	.25 $\mu$ F	VR3	100 K $\Omega$ HOR. POS.
R18	3.3 K $\Omega$	R43	47 $\Omega$	C18	.03 $\mu$ F	VR4	100 K $\Omega$ (C/TAP) VERT. POS.
R19	240 K $\Omega$ 5%	R44	56 K $\Omega$	C19	50 $\mu$ F	VR5	7.5 M $\Omega$ FINE FREQ.
R20	47 K $\Omega$ 5%	R45	470 K $\Omega$	C20	20 $\mu$ F	VR6	250 K $\Omega$ (preset) ASTIGMATISM
R21	22 M $\Omega$	R46	62 $\Omega$ 5%	C21	40 $\mu$ F	VR7	500 K $\Omega$ (w. switch) BRILL.
R22	220 K $\Omega$	R47	470 $\Omega$ 5%	C22	40 $\mu$ F	VR8	1 M $\Omega$ FOCUS
R23	1 M $\Omega$	R48	2.2 M $\Omega$	C23	50 $\mu$ F		
R24	100 K $\Omega$	R49	330 $\Omega$	C24	.002 $\mu$ F		
R25	100 K $\Omega$			C25	.002 $\mu$ F		

All resistors are 10% unless otherwise stated.



## INTRODUCTION

The Model OS-2 Oscilloscope was designed as a small, compact instrument for use by the electronic service engineer, laboratory technician or by amateur radio enthusiasts and hobbyists.

A number of useful facilities are incorporated including push-pull horizontal and vertical amplifiers, automatic lock-in synchronisation circuit, retrace blanking amplifier, provision for connection to vertical plates of CRT, etc.

## CIRCUIT DESCRIPTION

In order to obtain a better understanding of the circuit, follow the CIRCUIT DIAGRAM while reading the CIRCUIT DESCRIPTION.

### Vertical Amplifier.

A signal applied to the VERT. INPUT sockets is coupled to the grid of the input cathode follower valve, V5A, through C1. The signal from the cathode of V5A is coupled through C9 and VERT. GAIN control VR2 to amplifier stage V5B. This valve is frequency compensated by L1 and partly by C13. From the anode of V5B, the amplified signal is passed through the series peaking coil L2 and coupled to the push-pull output stage V6A and V6B. Positioning of the trace in the vertical direction is accomplished by adjusting the VERT. POS. control VR4. This varies the relative d.c. voltages between the two halves of the push-pull amplifier, the fixed tap on control VR4 providing the reference voltage for V6A. The coupling of the cathodes of V6A and V6B accomplishes the necessary phase-splitting between the two halves of the push-pull amplifier which drives the CRT vertical plates to provide a balanced deflection of the electron beam. Series compensation is provided by L3 and L4. The signal at the cathodes is taken to the synchronising cathode follower via C2.

Connecting the vertical input switch to the EXT. position allows the oscilloscope to be used, via sockets at the rear of the oscilloscope, for monitoring the quality of modulated RF signals and similar uses.

### Horizontal Amplifier.

The HORIZONTAL/FREQUENCY SELECTOR switch is used to select the desired input signal to the cathode follower V3A. This signal may be from the time base generator, 50 c/s  $\sim$  sweep, or an external signal from the HOR. INPUT socket. The signal is coupled from V3A to the HOR. GAIN control VR1 and thence to the amplifier stage V3B. The amplified signal at V3B is d.c. coupled to the push-pull stage and horizontal positioning of the trace is accomplished by adjusting the HOR. POS. control VR3. Common cathode coupling is used to provide a push-pull output and provides a balanced deflection of the electron beam.

### Time Base Generator.

The time base generator consists of V2A and V2B arranged as a multivibrator. The timing capacitor that is switched into the cathode circuit of V2B with the HOR./FREQ. SELECTOR switch determines the time base frequency range. The FINE FREQ. control VR5 provides fine frequency adjustment. The time base waveform, a sawtooth, has a fixed amplitude which is synchronised by the internal sync. signal.

The synchronisation signal from V6A/B is coupled to the sync. cathode follower V1A which is coupled to the time base generator by means of the common cathode resistor R49. A retrace blanking signal is taken from the time base generator, amplified at the blanking amplifier stage V1B and coupled to the CRT via C18.

### Cathode Ray Tube (CRT).

The operating voltages for the cathode ray tube are supplied by a resistor network connected between the EHT supply and earth. This network contains the BRILLIANCE and FOCUS controls VR7 and VR8 respectively. VR6 is the ASTIGMATISM control and is adjusted in conjunction with the BRILLIANCE and FOCUS controls to produce a well defined trace.

### Power Supplies.

The high voltage 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 MR1, smoothed by R40, C27 and C26 and thence coupled to the CRT.

The normal HT voltage is supplied by full wave rectifier V7 and its associated smoothing circuitry, R38, R37, R36, R35, C23, C22, C21, C20 and C19.

The 1 volt peak-to-peak calibrating voltage is derived from the 6.3 volt heater supply by means of a potential divider R47 and R46. The heater supply also supplies an a.c. voltage to the HOR./FREQ. SELECTOR switch for the sine sweep ( $\sim$ ) facility.

FIGURE -7

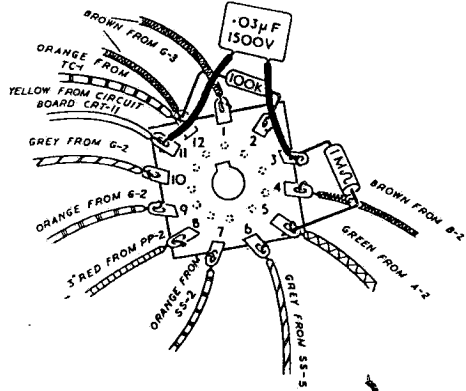
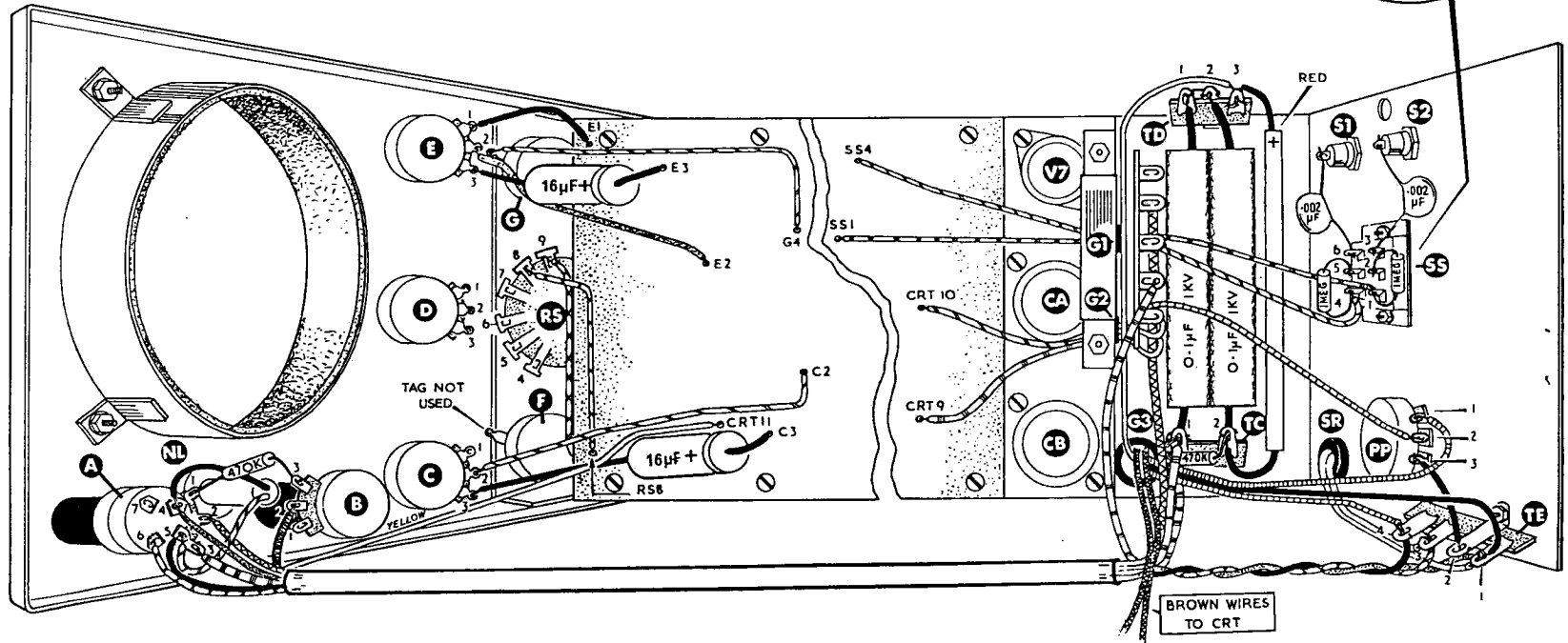
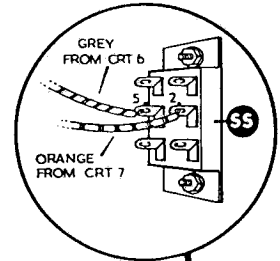
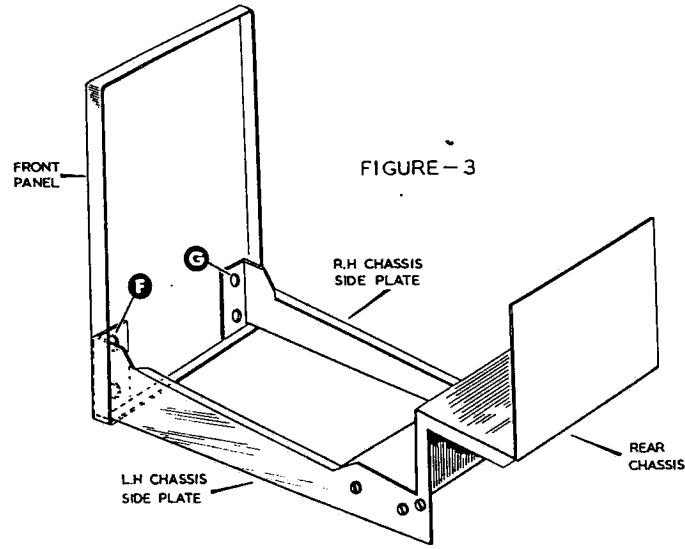
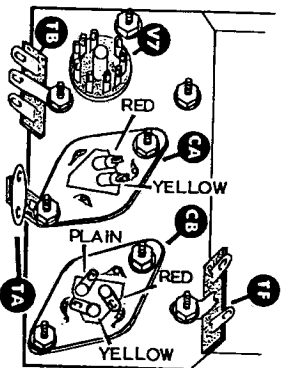
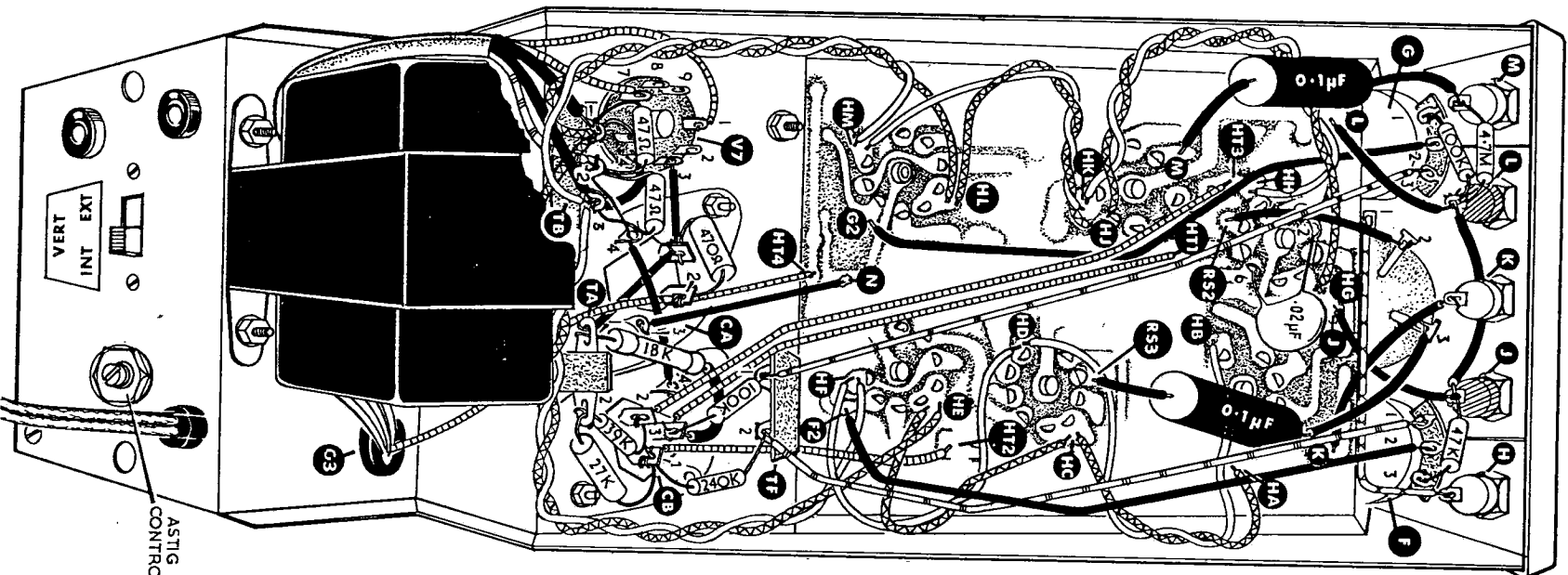


FIGURE -3



PICTORIAL - 2

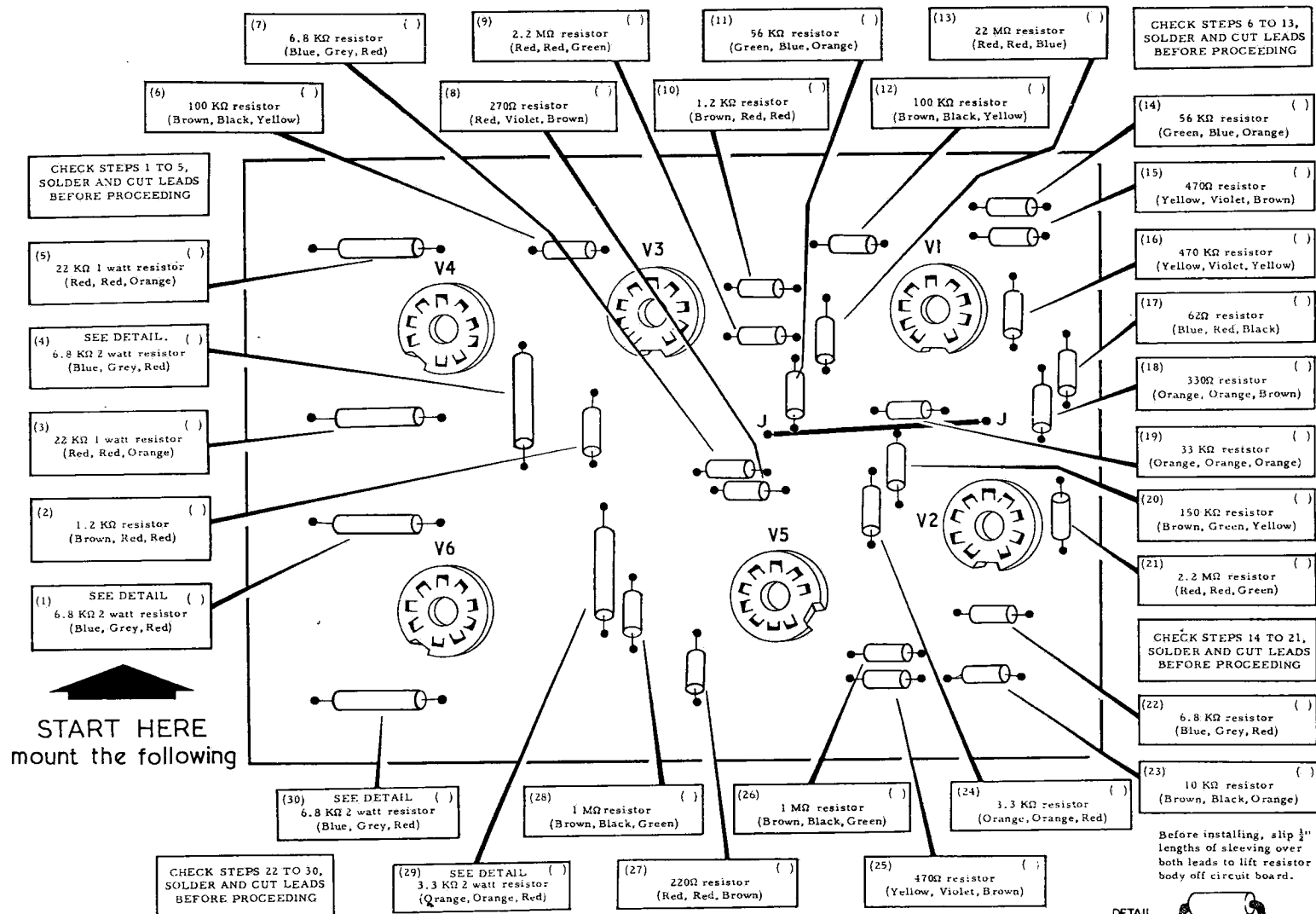


PICTORIAL-3

ASTIG  
CONTROL

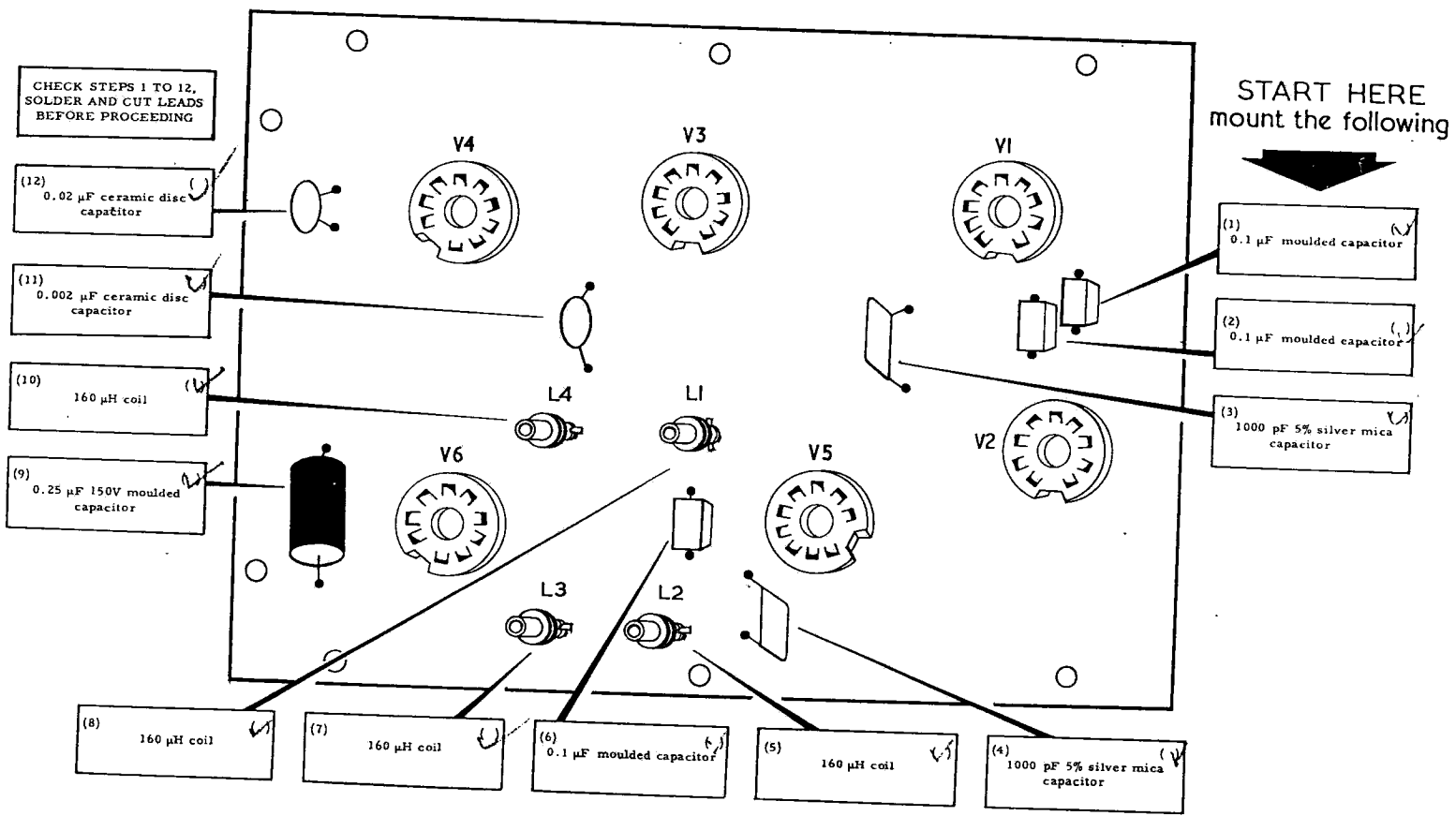
VERT  
INT EXT

Continue with the steps as shown in Pictorial 4 soldering only when instructed.



PICTORIAL - 4

( ) Continue with the steps as shown in Pictorial 5, soldering only when instructed.



PICTORIAL - 5



) Set the controls as follows before connecting the mains cable to an AC outlet:

BRILLIANCE	- Fully anticlockwise	
FINE FREQ.	- Fully anticlockwise	
VERT. GAIN	- Fully anticlockwise	
HOR. GAIN	- Fully anticlockwise	
VERT. POS.	- Centre of rotation	
HOR. POS.	- Centre of rotation	
HOR/FREQ. SELECTOR	- Fully clockwise	
FOCUS	- Centre of rotation	
Astigmatism	- Centre of rotation	) these controls are on the rear chassis of the instrument
VERT (INT-EXT)	- INT	

) Connect the mains cable to a 200-250 volt 50-60 c/s a.c. outlet. CAUTION: This instrument may be seriously damaged if connected to a power source other than that stated.

) Turn the BRILLIANCE control fully clockwise. This will apply power to the oscilloscope. All valves should glow. Allow one minute for the valves to warm up.

) Watch the screen of the CRT until a spot appears.

) If no spot appears, rotate both the HOR. POS. and VERT. POS. knobs simultaneously until a spot appears. If spot cannot be located, refer to the IN CASE OF DIFFICULTY section of the manual.

) Rotate the HOR. POS. control and notice that the spot moves horizontally across the screen. Now turn the VERT. POS. control and the spot will move up and down. Adjust these two controls so that the spot is centred on the screen.

Now adjust both the FOCUS and Astigmatism controls for minimum spot size. CAUTION: Do not permit the 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. If necessary, reduce spot brilliance by turning the BRILL control in an anticlockwise direction.

With the spot centred, slowly turn the HOR. GAIN control clockwise. The spot should now become a horizontal line.

If the trace is not perfectly horizontal, correct this condition as follows:

Observe the position of the trace on the CRT and estimate how far the CRT should be turned. Turn off the power and disconnect the mains lead. Loosen the clamp at the base of the CRT and rotate the tube the proper amount. Do not allow the tube to slide forward and come into contact with the grid screen. This process may be repeated if the trace is still slightly tilted. When finished, carefully tighten the CRT clamp to hold the tube in place. Do not overtighten as the tube could be broken.

Connect a test lead between the VERT. INPUT RED socket and the socket marked 1V P-P.

Adjust the VERT. GAIN control for a trace height of about 2 cm. Move the HOR/FREQ. SELECTOR switch to the  $\sim$  (50 c/s LINE SWEEP) position and slowly advance the HOR. GAIN control clockwise. The vertical line should begin to slope to the left (anticlockwise motion) as the HOR. GAIN control is rotated. At maximum horizontal amplitude, the line will be almost horizontal and it will extend well beyond the edges of the CRT.

Turn the HOR. GAIN control fully anticlockwise and move the HOR/FREQ. SELECTOR switch to the No. 1 position. Advance the HOR. GAIN control until the pattern reaches a width of about 4 cm. Now adjust the FINE FREQ. control until you obtain a pattern similar to that shown in Figure 13. The pattern will flicker because of the low sweep rate. The next three positions of the HOR/FREQ. SELECTOR switch should produce varied patterns, depending upon the frequency relationships between the 50 cycle voltage applied to the VERT. INPUT socket and the time base generator frequency, which is controlled by the HOR/FREQ. SELECTOR switch in conjunction with the FINE FREQ. control.



**FIGURE 13**

NOTE: When using the calibrating voltage from the 1V P-P socket it may be noticed that small breaks appear near the peaks in the display. This is of no importance and will not occur with external signals.



- ( ) Turn off the oscilloscope by turning the BRILLIANCE control fully anticlockwise. If proper results were obtained in the preceding steps, the oscilloscope may be assumed to be adjusted correctly and operating properly.
- ( ) Position the chassis in the cabinet so the front panel fits snugly around the front rim of the cabinet. Fasten the chassis in place by installing two 4BA x 3/8" chrome screws through the rear of the cabinet, into the nuts at the rear of the chassis.

### OPERATION

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.

The BRILLIANCE and FOCUS controls and the Astigmatism preset control (the latter mounted at the rear of the instrument) control the quality of the trace.

Two knobs, marked VERT. GAIN and HOR. GAIN, control the height and width of the pattern on the screen.

Two knobs, marked VERT. POS. and HOR. POS., control the location of the trace on the screen. Turning the VERT. POS. knob moves the trace up or down; the HOR. POS. knob is used to move the trace left or right.

Two knobs, marked HOR./FREQ. SELECTOR and FINE FREQ., control the operation of the time base generator. The HOR./FREQ. SELECTOR and FINE FREQ. controls permit selection of the desired sweeping rate to provide a stationary pattern. The HOR./FREQ. SELECTOR switch also performs the following functions.

EXT: In this position, the HOR. INPUT socket is connected directly to the input grid of the horizontal amplifier system. The time base generator is not operating and external signals can be applied to the sockets.

$\sim$ (50 c/s LINE SWEEP): In this position, a 50 c/s voltage is applied to the horizontal amplifier system. The sweep thus applied to the amplifier is sinusoidal in waveform.

VERT. INT-EXT switch: Unless the oscilloscope is required for direct connection to the Y plates, this switch MUST be in the INT position, otherwise the vertical frequency response will be impaired.

### GENERAL CONSIDERATIONS

1. OPERATING LOCATION. Although the CRT is shielded to prevent trace distortion due to magnetic fields, it is possible that some trace distortion due to a very high field may still occur. The shield will certainly reduce these effects, but may not entirely eliminate them, and if this appears to be a problem the simplest remedy is usually to find a location for the 'scope further from the offending equipment or source of the field.
2. OVERLOAD. To prevent overloading the input stages in the amplifier, keep the vertical and horizontal input signal voltages less than 20 volts r.m.s. Use an auxiliary attenuator probe for higher voltages to prevent overloading. The Heathkit Model PK-1 is suitable for this purpose.
3. VERT. and HOR. POSITION. In operating the position controls, you will observe a 'dead spot' near the centre of rotation; that is, the position of the trace does not change even though the control is turning through several degrees. This is perfectly normal and is caused by the slider of the control passing over the tap position of the resistance element. At this tap position, no change in resistance takes place, hence the trace does not change position.
4. INTENSITY MODULATION. At reduced brilliance settings and low time base speeds, some intensity modulation of the trace may be noticed. This condition is normal and may be eliminated by a slight increase in trace brilliance.
5. STRAY PICK-UP. At maximum gain settings, the sensitivity of the amplifiers is very high. Therefore, without a signal source connected to the input sockets, stray pick-up may produce patterns on the CRT screen. Such behaviour is normal to this type of instrument.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in coloured pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the constructor. An X-ray view of the printed circuit board is shown on Page 40.
2. It is interesting to note that about 90% of the kits that are returned for repair, do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the PROPER SOLDERING PROCEDURE section of this manual.
3. Check to be sure that all valves are in their proper locations. Make sure that all valves light up properly.
4. Check the valves with a valve tester or by substitution of valves of the same types and known to be good.
5. Check the values of the component parts. Be sure that the proper part has been wired into the circuit as shown in the pictorial diagrams and as called up in the wiring instructions.
6. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring beneath the chassis.
7. If, after careful checks, the trouble is still not located and a voltmeter is available, check voltage readings against those found in the VOLTAGE CHART. NOTE: All voltage readings were taken with a 20,000 ohms/volt voltmeter. Voltages may vary as much as  $\pm 15\%$  due to component tolerance and mains voltage variations.
8. A review of the CIRCUIT DESCRIPTION will prove helpful in indicating where to look for trouble.

FAULT FINDING CHART

TROUBLE	SUGGESTED TEST
Valve heaters do not light	Check fuse - check heater voltage
No spot or trace	Remove vertical output valve V6A and B, if spot appears check vertical circuit voltages and valve. Remove horizontal output valve V4A and B, if spot appears check horizontal circuit voltages and valve. Check the high voltage supply at rectifier MR1 and CRT base. Check the continuity of peaking coils L3 and L4.
No vertical deflection	Check vertical valves V5A and B, V6A and B and voltages. Check the continuity of peaking coils L1, L2, L3 and L4.
No horizontal deflection	Check horizontal valves V3A and B, V4A and B and voltages.
No time base	Check time base generator valve V2A and B and voltages. Check that capacitor C12 (.02) is connected between pins 2 and 6 on V2.
A valve heater does not light	Check valve.
No HT supply	Check fuse. Check V7. Check for open-circuit resistors R35-R38, short-circuit capacitors C19-C23 or defective valves.
Poor focussing	Check rectifier MR1 - check high voltage resistor network VR7, R45, VR8 and R48. Check C18 and VR6.
Distorted Waveform	Too much signal input.



## CONTROL SETTINGS FOR VOLTAGE CHECKS

BRILLIANCE	-	Visible trace	HOR. POS.	-	Trace centred
FOCUS	-	Well defined trace	FINE FREQ.	-	Centre of rotation
VERT. GAIN	-	Anticlockwise	HOR./FREQ. SELECTOR	-	1
HOR. GAIN	-	4 cm. trace length approx.	ASTIGMATISM	-	Well defined trace
VERT. POS.	-	Trace centred	VERT. INT - EXT.	-	INT.

## VOLTAGE CHART

VALVE TYPE REF.		Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
12AU7	V1	12	N	1.0	H		48	0.35	0	H
12AX7	V2	200	N	1.0	H		216	200	200	H
12AU7	V3	215	-	140	H		54	N	1.65	H
12AU7	V4	225	54	61	H		222	52 (25-67)	61	H
ECF80	V5	112	-	112	H	H	60	1.5	51	N
12AU7	V6	260	38	63 (56-66)	H		256	53 (25-67)	63 (56-66)	H
EZ80	V7	320 a.c.	NC	332	H	H	NC	320 a.c.	NC	NC
3RP1	CRT	HVH	-710	-665 (600-685)	-440 (360-550)	-680 (620-710)	+260 (200-315)	+250 (195-325)	-270 (2-325)	-222 (135-315)
3RP1	CRT	Pin 10	Pin 11	Pin 12	HT1	HT2	HT3	HT4	RECTIFIER MR1	
		+225 (145-300)	48	HVH	112V	215V	215V	320V	-850V	

All voltages are positive with respect to chassis unless indicated otherwise.

All voltages measured with a 20,000 ohms/volt meter.

Voltages may vary by  $\pm 15\%$  due to component tolerances etc.

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 volts.

HVH - a.c. voltage between pins: 6.3 volt. CAUTION: These terminals -725 volt with respect to chassis.

NC - No connection.

- - No reading.

N - Not significant.