Assembly

and

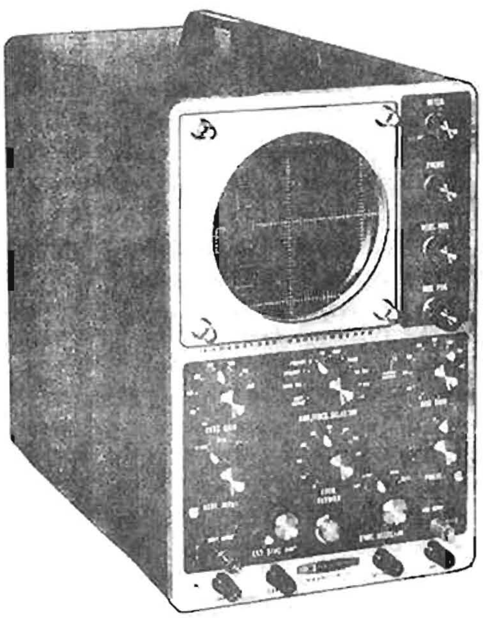
Operation

of the

HEATHKIT by Daystrom

LABORATORY 5" OSCILLOSCOPE

MODEL IO-12



HEATH COMPANY,
BENTON HARBOR,
MICHIGAN

a subsidiary of
DAYSTROM, INCORPORATED

CONDENSED MANUAL

583-3920

SPECIFICATIONS

VERTICAL CHANNEL:

Sensitivity:	0.025 volts (rms) per inch at 1 kc.
Frequency Response:	±1 db from 8 cps to 2.5 mc. +1.5 to -5 db from 3 cps to 5 mc. Response at 3.58 mc: - 2.2 db. (All response measurements referred to 1 kc.)
Rise Time:	0.08 microseconds or less.
Overshoot:	10% or less.
Input Impedance:	In X1 attenuator position, 2.9 megohms shunted by 21 $\mu\mu$f. (1 kc impedance: 2.7 megohms). In X10 and X100 positions, 3.4 megohms shunted by 12 $\mu\mu$f. (1 kc impedance: 3.3 megohms).
Attenuator:	Three-position, switch-type, fully compensated; no visible change in wave shape at any attenuator setting.
Input Characteristics:	Special low-capacity input terminal; built-in blocking capacitor rated at 600 volts DC.
Vertical Positioning:	DC type; permits placement of undeflected trace at any horizontal level on usable area (±1-1/2" from center) of screen; positioning is almost instantaneous and free of drift.

HORIZONTAL CHANNEL:

Sensitivity:	0.3 volts (rms) per inch at 1 kc.
Frequency Response:	±1 db from 1 cps to 200 kc. ±3 db from 1 cps to 400 kc.
Input Impedance:	30 megohms shunted by 31 $\mu\mu$f. (1 kc impedance: 4.9 megohms).
Attenuator:	Low-impedance type in cathode follower output.
Input Characteristics:	Selector switch permits use of external input through panel terminal, line-frequency sweep of variable phase, either of two preset sweep frequencies, or variable internal sweep from the sweep generator.
Horizontal Positioning:	DC type; permits wide range of positioning to examine any part of trace even with full horizontal gain.

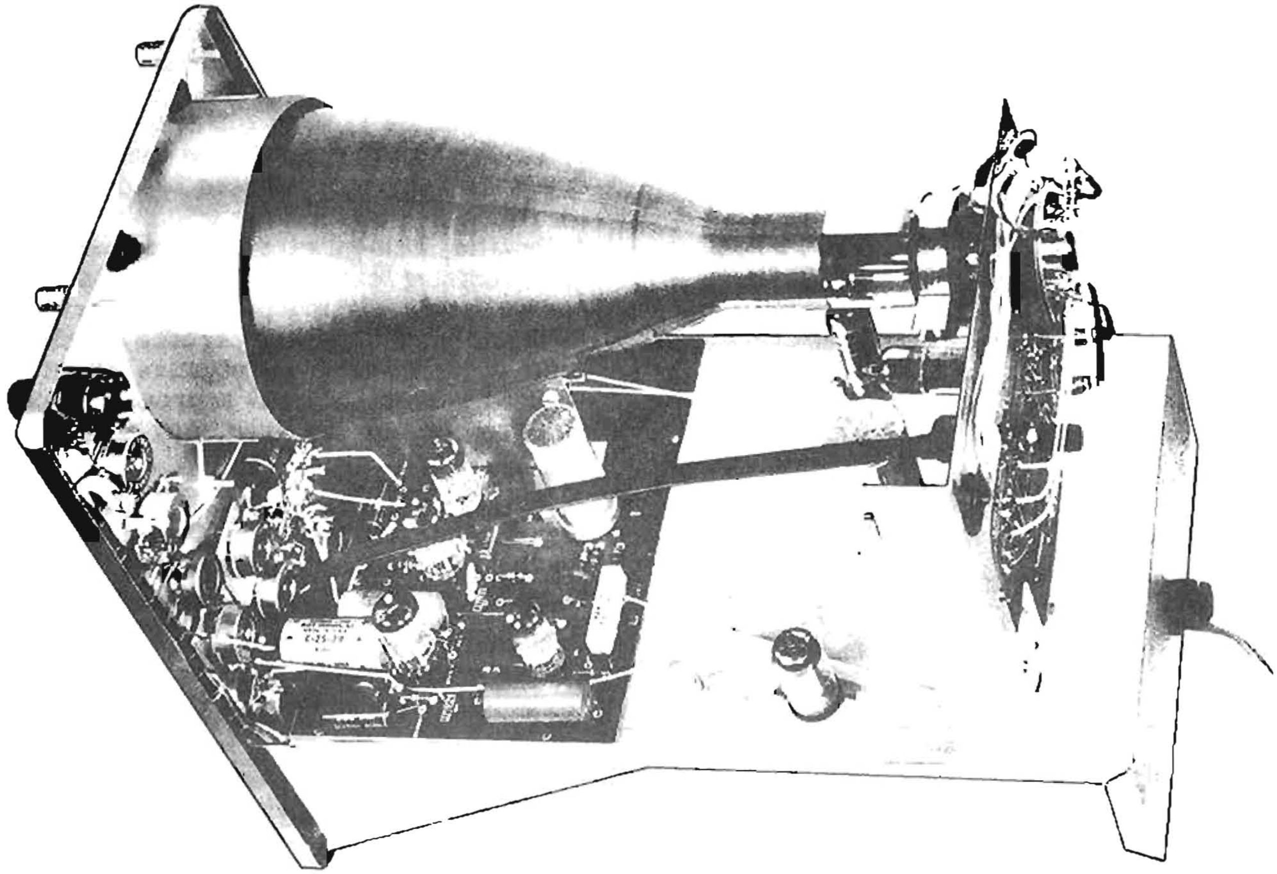
SWEEP GENERATOR:

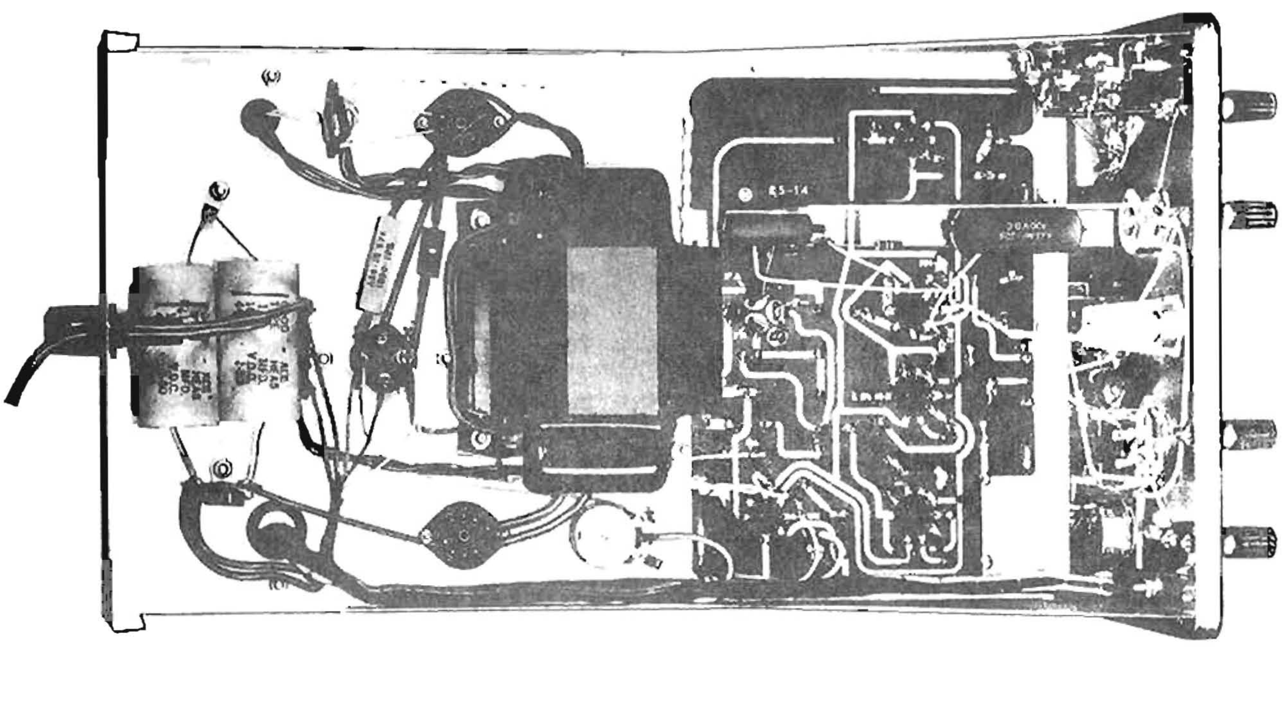
Type:	Recurrent type, utilizing HEATHKIT sweep circuit.

Range:	10 cps to 500 kc in five steps; each range is approximately as follows: 10 to 100 cps, 100 to 1000 cps, 1 to 10 kc, 10 to 100 kc, 100 to 500 kc.
Preset Control Range:	Preset number 1, 10 to 100 cps; preset number 2, 1000 to 10,000 cps. May be easily changed to cover any frequency between 10 cps and 500 kc.
Synchronizing:	Automatic lock-in circuit using self-limiting synchronizing cathode follower. Holds sweep speed essentially independent of vertical gain settings. Selector switch permits synchronizing with either positive or negative signal pulses internally, with external source through panel terminal, or with line frequency.

GENERAL:

Retrace Blanking:	Blanking interval less than 30% of sweep rate regardless of sweep speed. Blanking amplifier provided.
Phasing Control:	Provides fully controlled phase shift for line sweep applications. Phasing is continuously variable from zero to over 135 degrees.
Voltage Calibrator:	Built-in source, 1 volt peak-to-peak; calibrated grid screen and input attenuator permit voltage measurements over range of 10,000 to 1.
Z-Axis Modulation:	Provision for intensity modulation of electron stream through high-voltage isolation capacitor; 8 to 20 volts (rms) required for complete blanking of trace.
Access Panel:	Removable panel at rear of cabinet for easy access to Z-axis binding post.
Cathode Ray Tube:	5UP1, 5" screen, green, medium-persistence phosphor.
Power Supplies:	High-voltage supply: transformer-rectifier type, developing 1200 volts at output of RC filter system. Low-voltage supply: transformer-rectifier type, full electronic voltage regulation for all critical amplifier, sweep generator, and positioning potentials.
Power Requirements:	105-125 volt 50/60 cycles AC at 80 watts; fused for 1 ampere.
Dimensions:	8-5/8" wide x 14-1/8" high x 16" deep.
Net Weight:	20-1/2 lbs.
Shipping Weight:	21 lbs.





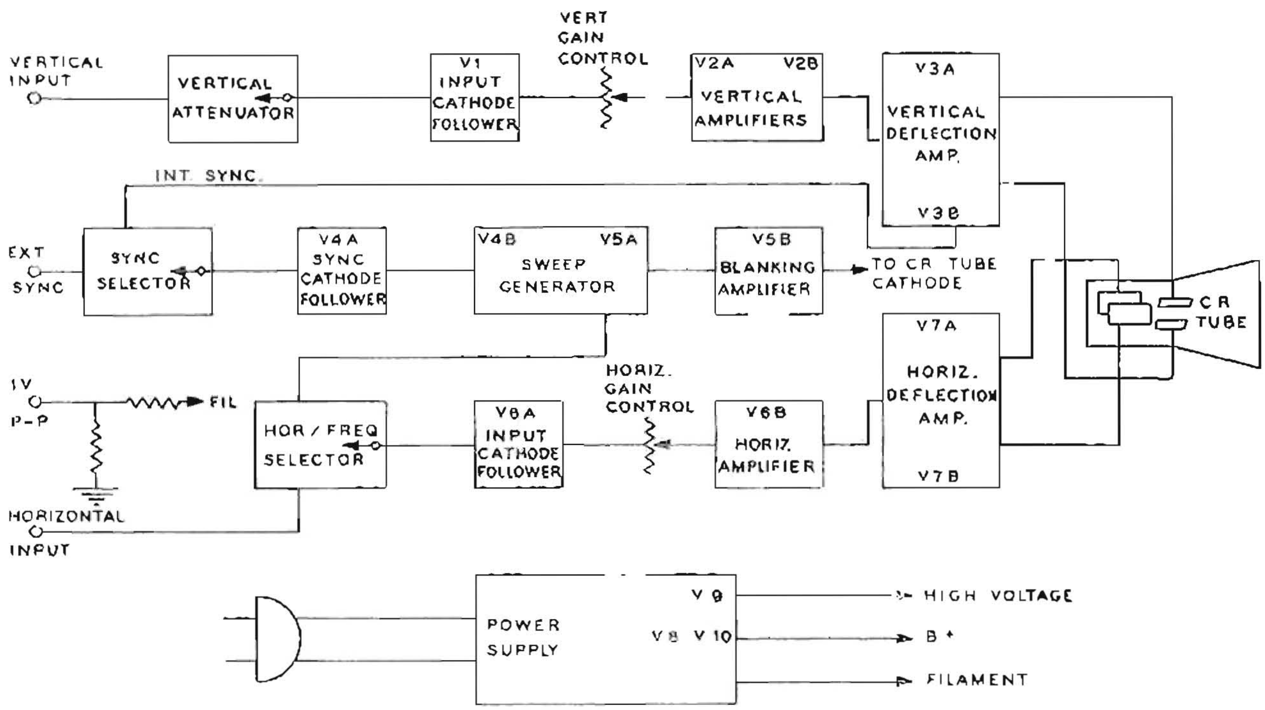
INTRODUCTION

The HEATHKIT Model IO-12 Oscilloscope is a wide-range, general-purpose oscilloscope, designed to satisfy the needs of both the electronic serviceman and the ham operator, or hobbyist. Many years of refinements on earlier models have culminated in this troublefree performer.

The use of two preset adjustments in the horizontal oscillator circuit facilitate instantaneous horizontal lock-in for often-used sweep frequencies. This is especially handy in servicing the vertical and horizontal circuits of television receivers.

CIRCUIT DESCRIPTION

Reference to the fold-out Schematic at the rear of the manual, and to the Block Diagram which follows, will prove helpful in thoroughly understanding this description.



VERTICAL AMPLIFIER

A signal applied to the VERT. INPUT terminals is coupled through the frequency-compensated vertical attenuator to V1. From input cathode follower V1, the signal is coupled through VERT. GAIN control R8 to amplifiers V2A and V2B.

From V2B, the signal is applied through the series peaking coil to the push-pull vertical deflection amplifier. Positioning of the trace is accomplished by adjusting VERT. POS. control R18, which changes the relative DC grid voltages between the halves of the push-pull amplifier. The fixed tap of control R18 provides the reference voltage for V3A.

Push-pull output stage V3A and V3B drives the vertical plates of the CR tube to provide balanced deflection of the electron beam. (Common cathode coupling applies the signal from V3A to V3B.) A small portion of the signal is coupled from the plate circuits of the push-pull stage to the SYNC. SELECTOR switch to facilitate positive or negative internal sweep synchronization.

SWEEP GENERATOR

The SYNC SELECTOR switch is used to select the desired sweep synchronizing signal. This signal is applied to the sweep generator by means of the common cathode resistor, R38, of V4A and V4B. V4A is the sync cathode follower. V4B and V5A, the sweep multivibrator, with their associated circuit components, create the horizontal sweep waveform. The sweep timing capacitor that is switched into the cathode circuit of V5A, determines the coarse horizontal sweep frequency as it discharges through R47 and FREQ. VERNIER control R48. Fine frequency adjustment of this sawtooth waveform is obtained by varying the FREQ. VERNIER control (or the PRESET ADJUST controls).

A retrace blanking signal is coupled to the CR tube through blanking amplifier V5B from the sweep generator. The positive going portion of the sweep waveform is used for this purpose.

HORIZONTAL AMPLIFIER

The HOR./FREQ. SELECTOR is used to select the desired sweep signal and apply it to input cathode follower V6A. This sweep signal may be from the sweep generator, 60 cycle line sweep, or an external sweep signal from the HOR. INPUT.

The sweep signal is coupled from V6A through the HOR. GAIN control and through amplifier V6B to the push-pull horizontal deflection amplifier, V7A and V7B. The HOR. POS. control is used to position the trace by changing the relative DC grid voltages of the push-pull amplifier.

The push-pull horizontal deflection amplifier drives the horizontal plates of the CR tube to provide balanced horizontal deflection of the electron beam.

CATHODE RAY TUBE

Operating and accelerating voltages are supplied to the cathode ray tube (CR tube) by a bleeder network connected from the high voltage power supply to ground. This network contains the FOCUS and INTEN. controls, and supplies bias voltage to regulator tube V10. Intensity modulation of the electron beam may be accomplished by connecting an external signal to the Z-AXIS input of the CR tube.

POWER SUPPLY

High voltage for the CR tube is supplied by V9, the high-voltage rectifier. B+ is supplied by full-wave rectifier V8 and its associated circuitry. V10 is used to prevent power line surges from appearing on the B+ voltages. Two separate filament windings are used on the power transformer, one for the CR tube alone. The other winding supplies filament voltage to all other tubes, and supplies AC voltage to the HOR./FREQ. switch for line sweep, to the PHASE control, and to the 1-V, P-P binding post.

PARTS LIST

Refer to the fold-out Parts Pictorial on page 13 of this manual.

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-84	1	62 Ω 1/2 watt (blue-red-black)
1-3	5	100 Ω 1/2 watt (brown-black-brown)
1-45	3	220 Ω 1/2 watt (red-red-brown)
1-6	1	470 Ω 1/2 watt (yellow-violet-brown)
1-8	1	820 Ω 1/2 watt (gray-red-brown)
1-9	1	1 KΩ 1/2 watt (brown-black-red)
1-90	2	2 KΩ 1/2 watt (red-black-red)
1-57	3	2.2 KΩ 1/2 watt (red-red-red)
1-13	1	2.7 KΩ 1/2 watt (red-violet-red)
1-14	3	3.3 KΩ 1/2 watt (orange-orange-red)
1-46	2	3.9 KΩ 1/2 watt (orange-white-red)
1-19	1	6.8 KΩ 1/2 watt (blue-gray-red)
1-20	3	10 KΩ 1/2 watt (brown-black-orange)
1-21	1	15 KΩ 1/2 watt (brown-green-orange)
1-22	2	22 KΩ 1/2 watt (red-red-orange)
1-24	2	33 KΩ 1/2 watt (orange-orange-orange)
1-88	1	36 KΩ 1/2 watt (orange-blue-orange)
1-25	1	47 KΩ 1/2 watt (yellow-violet-orange)
1-26	2	100 KΩ 1/2 watt (brown-black-yellow)
1-27	4	150 KΩ 1/2 watt (brown-green-yellow)
1-87	1	330 KΩ 1/2 watt (orange-orange-yellow)
1-33	3	470 KΩ 1/2 watt (yellow-violet-yellow)
1-35	3	1 megohm 1/2 watt (brown-black-green)
1-38	2	3.3 megohm 1/2 watt (orange-orange-green)

PART No.	PARTS Per Kit	DESCRIPTION
Resistors (cont'd.)		
1-71	2	4.7 megohm 1/2 watt (yellow-violet-green)
1-40	3	10 megohm 1/2 watt (brown-black-blue)
1-70	1	22 megohm 1/2 watt (red-red-blue)
1A-2	2	1 KΩ 1 watt (brown-black-red)
1A-22	1	1.5 KΩ 1 watt (brown-green-red)
1A-27	2	33 KΩ 1 watt (orange-orange-orange)
1A-28	1	100 KΩ 1 watt (brown-black-yellow)
1A-32	1	470 KΩ 1 watt (yellow-violet-yellow)
1A-34	1	1 megohm 1 watt (brown-black-green)
1A-37	1	3.3 megohm 1 watt (orange-orange-green)
1B-19	1	1.2 KΩ 2 watt (brown-red-red)
1B-1	2	2.7 KΩ 2 watt (red-violet-red)
1B-2	1	4.7 KΩ 2 watt (yellow-violet-red)
1B-22	1	12 KΩ 2 watt (brown-red-orange)
2-129	1	3.3 megohm 1/2 watt 5% precision
3G-15	1	1000 Ω 7 watt wire-wound
3G-4	1	5000 Ω 7 watt wire-wound
Controls-Switches		
10-65	1	2000 Ω linear control with dummy lug
10-31	1	10 KΩ linear control
10-41	1	20 KΩ control, center-tapped
10-13	1	200 KΩ control, center-tapped
10-26	1	500 KΩ linear control
10-32	1	1 megohm linear control
10-39	2	2 megohm linear control
10-45	1	7.5 megohm linear control
10-115	2	7.5 megohm linear control, tab-mounting
19-40	1	500 KΩ control with SPST switch and dummy lug
63-47	1	3-position switch
63-88	1	4-position switch
63-237	1	9-position switch

PART No.	PARTS Per Kit	DESCRIPTION
Capacitors		
21-3	1	10 μμf ceramic
21-5	1	20 μμf ceramic
20-1	1	47 μμf mica (yellow-violet-black)
21-9	1	100 μμf ceramic
21-21	1	200 μμf ceramic
20-43	1	390 μμf mica (orange-white brown)
21-13	1	500 μμf ceramic
21-36	2	.002 μfd ceramic
21-16	1	.01 μfd ceramic
23-3	1	.01 μfd paper tubular, 400 V
21-31	1	.02 μfd ceramic, 500 V
21-38	2	.02 μfd ceramic, 1600 V
23-59	2	.05 μfd plastic molded tubular, 200 V
23-11	1	.1 μfd paper tubular, 600 V
23-28	6	.1 μfd plastic molded tubular, 200 V
23-62	2	.1 μfd paper tubular, 1600 V
23-58	2	.2 μfd plastic molded tubular, 200 V
23-63	3	.25 μfd plastic molded tubular, 400 V
25-20	2	40 μfd electrolytic, 150 V
25-28	1	100 μfd electrolytic, 50 V
25-31	1	20-20-20 μfd at 250 V-250 V-250 V electrolytic
25-32	1	40-20-20-50 μfd at 450 V-450 V- 450 V- 300 V electrolytic
31-12	1	Dual trimmer
Chokes-Transformer		
45-25	1	30 μh (green band)
45-12	2	33 μh on 3300 Ω 1 watt resistor
45-23	2	61 μh (red band)
45-24	2	90 μh (blue-band)
54-103	1	Power transformer
Insulators-Wire		
73-1	2	3/8" grommet
73-2	2	3/4" grommet
73-3	4	1/2" grommet
73-5	1	Cushion strip
75-24	1	Line cord strain relief
89-1	1	Line cord
134-19	1	Cable assembly
340-8	1	Length bare wire
341-1	1	Length black test lead
341-2	1	Length red test lead
344-1	1	Length hookup wire
346-1	1	Length 1/16" sleeving
347-2	1	Length 300 Ω twin lead

PART No.	PARTS Per Kit	DESCRIPTION
Connectors-Terminal Strips-Sockets		
70-5	1	Banana plug sleeve, black
70-6	1	Banana plug sleeve, red
75-17	12	Binding post insulator
100-M16B	5	Binding post cap, black
100-M16R	2	Binding post cap, red
260-1	2	Alligator clip
427-2	11	Binding post base
431-1	1	Dual-lug terminal strip
431-2	3	2-lug terminal strip
431-12	3	4-lug terminal strip
434-16	2	9-pin socket
434-22	1	Pilot lamp socket
434-41	1	12-pin socket
434-45	3	7-pin socket - circuit board type
434-46	5	9-pin socket - circuit board type
438-13	2	Banana plug
481-1	1	Capacitor mounting wafer, metal
Sheet Metal Parts		
90-234	1	Cabinet
100-M294	1	Chassis
100-M296	1	Panel ring
203-219F752, 753, 754	1	Front panel
204-M361	1	Rear support bracket
204-M362	1	Control mounting bracket
204-M363	2	CR tube mounting bracket
206-M144	1	Top shield plate
206-M145	1	Bottom shield plate
207-M1	2	CR tube clamp
210-21F	1	Bezel
Hardware		
250-8	3	#6 sheet metal screw
250-29	2	6-32 x 3/4" screw
250-48	4	6-32 x 1/2" screw
250-49	18	3-48 x 1/4" screw
250-83	2	#10 sheet metal screw
250-89	20	6-32 x 3/8" screw
250-137	4	8-32 x 3/8" screw
252-1	18	3-48 nut
252-3	37	6-32 nut
252-4	4	8-32 nut
252-7	13	3/8"-32 control nut
252-35	4	Thumbnut
253-9	4	#8 flat washer
253-10	13	Steel flat washer, 5/8" OD (control)
253-39	4	Steel flat washer, 9/16" OD
254-1	33	#6 lockwasher
254-2	4	#8 lockwasher
254-4	9	Control lockwasher
259-1	10	#6 solder lug
259-10	4	Control solder lug

PART No.	PARTS Per Kit	DESCRIPTION
Tubes*-Lamp		
411-4	1	6C4 tube
411-153	3	12AU7/ECC82 tube
411-49	1	5UP1 cathode ray tube (CR tube)
411-58	1	6AB4 tube
411-65	1	1V2 tube
411-68	1	6AN8 tube
411-73	1	12BH7 tube
411-79	1	6J6 tube
411-110	1	EZ81/6CA4 tube
412-1	1	#47 lamp

*The type markings on the tubes furnished with this kit may or may not be followed by the letter "A."

PART No.	PARTS Per Kit	DESCRIPTION
Miscellaneous		
85-12F179	1	Small circuit board
85-14F178	1	Large circuit board
211-15	1	Handle
261-9	4	Rubber feet
414-11	1	Green grid screen
414-10	1	Grid screen window
421-23	1	1 ampere slow-blow fuse
423-1	1	Fuseholder
462-138	4	Small knob
462-139	8	Large knob
463-27	8	Knob pointer
595-561	1	Manual

45-85

PROPER SOLDERING TECHNIQUES

Only a small percentage of HEATHKIT equipment purchasers find it necessary to return an instrument for factory service. Of these instruments, by far the largest portion malfunction due to poor or improper soldering.

If terminals are bright and clean and free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Correctly soldered connections are essential if the performance engineered into a kit is to be fully realized. If you are a beginner with no experience in soldering, a half hour's practice with some odd lengths of wire may be a worthwhile investment.

For most wiring, a 30 to 100 watt iron or its equivalent in a soldering gun is very satisfactory. A lower wattage iron than this may not heat the connection enough to flow the solder smoothly over the joint. Keep the iron tip clean and bright by wiping it from time to time with a cloth.

CHASSIS WIRING AND SOLDERING

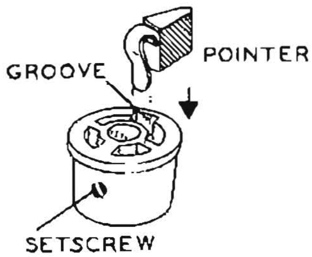
1. Unless otherwise indicated, all wire used is the type with colored insulation (hookup wire); the size of the conductor is the same for all colors of hookup wires furnished with this kit. In preparing a length of hookup wire, 1/4" of insulation should be removed from each end unless directed otherwise in the construction step.

2. To avoid breaking internal connections when stripping insulation from the leads of transformers or similar components, care should be taken not to pull directly on the lead. Instead, hold the lead with pliers while it is being stripped.

3. Leads on resistors, capacitors and similar components are generally much longer than they need to be to make the required connections. In these cases, the leads should be cut to proper length before the part is added to the chassis. In general, the leads should be just long enough to reach their terminating points.

4. Wherever there is a possibility of bare leads shorting to other parts or to the chassis, the leads should be covered with insulating sleeving. Where the use of sleeving is specifically intended, the phrase "use sleeving" is included in the associated construction step. In any case where there is the possibility of an unintentional short circuit, sleeving should be used. Extra sleeving is provided for this purpose.

5. Crimp or bend the lead (or leads) around the terminal to form a good joint without relying on solder for physical strength. If the wire is too large to allow bending or if the step states that the wire is not to be crimped, position the wire so that a good solder connection can still be made.



Detail 11A

NOTE: In the following step, use care when installing tubes in the circuit board. If the tubes are forced into their sockets with extreme pressure, the circuit board may crack.

( ) Insert the tubes in their sockets as follows: (See Pictorial 8.)

V1 = 6AB4	V6 = 12AU7
V2 = 6AN8	V7 = 12AU7
V3 = 12BH7	V8 = EZ81/6CA4
V4 = 6J6	V9 = IV2
V5 = 12AU7	V10 = 6C4

( ) Secure the cover plate on the back of the cabinet with a #6 sheet metal screw.

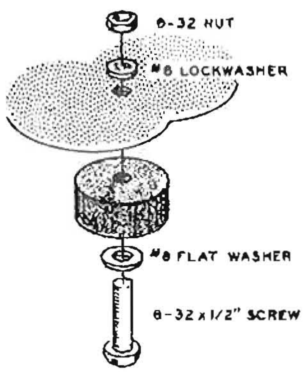
( ) Install the handle on the top of the cabinet, using the #10 sheet metal screws. It may be helpful if the screws are run into the handle first, and then removed, before the handle is installed.

( ) Install the rubber feet in the bottom of the cabinet as shown in Detail 11B. Use 6-32 x 1/2" screws, #8 flat washers, #6 lockwashers, and 6-32 nuts.

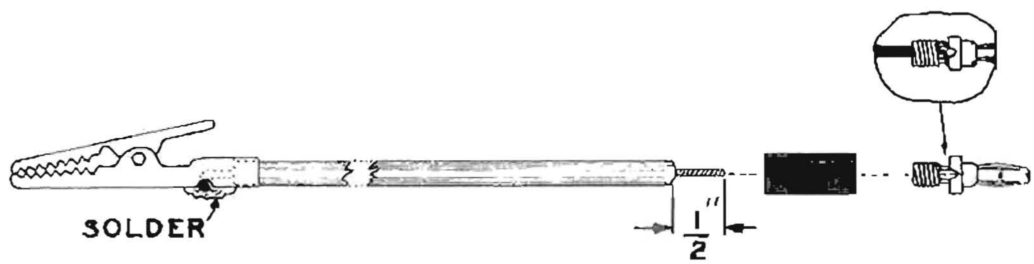
( ) Assemble the pair of test leads, one red and one black, as shown in Detail 11C.

This completes the construction and wiring of your HEATHKIT oscilloscope.

Before attempting to operate the instrument, remove any loose bits of solder or wire clippings. Check the instrument against the pictorial diagrams for any obvious mistakes. Now proceed to the ADJUSTMENT section.



Detail 11B



Detail 11C

ADJUSTMENT

CAUTION: The voltages in the instrument are dangerous. Extreme care should be exercised whenever the instrument is connected to the AC line without being installed in its case. DO NOT connect the line cord to an AC outlet until you have read and fully understand 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 oscilloscope is operated without the cabinet, be sure to remove the line cord from the outlet before attempting to change the position of the scope on the bench. Some of the highest voltages in the circuit appear on the INTEN. and FOCUS control terminals, just below the top edge of the panel. It is easy to get a finger on one of these terminals.

( ) Set the controls as follows BEFORE connecting the line cord to an AC outlet:

INTEN. - Full counterclockwise.
FOCUS - At approximate center of rotation.
VERT. POS. - At approximate center of rotation.
HOR. POS. - At approximate center of rotation.
VERT. GAIN - Full counterclockwise.
HOR./FREQ. SELECTOR - Full counterclockwise.
HOR. GAIN - 0.
VERT. INPUT - X100.
FREQ. VERNIER - 50.
PHASE - At approximate center of rotation.
EXT. SYNC. AMPLITUDE - Full counterclockwise.
SYNC. SELECTOR - EXT. Spot Shape (on chassis) - At approximate center of rotation.

( ) Connect the line cord to a 105-125 volt 50/60 cycle AC outlet. CAUTION: This instrument will not operate and may be seriously damaged if connected to a DC or 25 cycle AC power source, or to an AC line of more than 125 volts.

( ) Turn the INTEN. control full clockwise. The pilot light should light and all tube filaments (except IV2) should show color. Allow about one minute for the tube filaments 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 INTEN. control counterclockwise. Now, adjust the FOCUS control to reduce the size of the spot to a minimum.

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 HOR. POS. control and notice that the spot moves horizontally across the screen. Now, using the VERT. POS. control, move the spot up and down. Adjust these two controls so that the spot is centered on the screen.

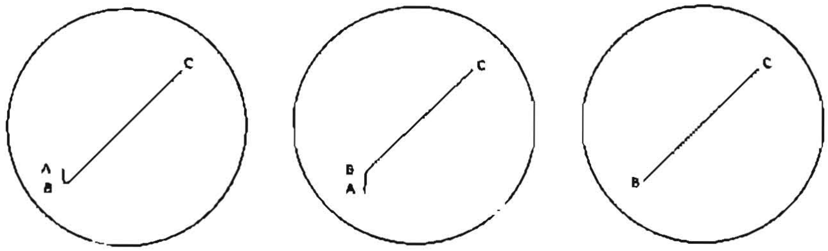
If no spot appears, rotate the HOR. control, since this control may position the spot well off the screen. It may also be necessary to readjust the FOCUS and INTEN. controls to form the spot. If still no spot can be seen, refer to the IN CASE OF DIFFICULTY section of this manual.

( ) With the spot centered on the screen, adjust the Spot Shape control (at the right side of the chassis) to make the spot as round as possible. It may be necessary to readjust the FOCUS and INTEN. controls several times during this procedure as there is some interaction between the circuits. The result should be a sharply defined spot of small size, the brightness of which can be varied with the INTEN. 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 a jumper from the 1-V, 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 1-1/4" as the HOR. GAIN control is advanced. If the trace is not level, turn off the power, loosen the tube clamp on the base of the CR tube and rotate the tube slightly to make the trace 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 ARE APPROXIMATELY 1200 VOLTS "HOT". CONTACT WITH THESE TERMINALS WOULD CAUSE A SEVERE ELECTRIC SHOCK.

( ) Next, connect the jumper from the 1-V, P-P terminal to the VERT. INPUT terminal. Turn the HOR. GAIN to "0." Rotate the VERT. GAIN control clockwise and notice that the trace is now vertical and controlled in length by the VERT. GAIN control setting. Switch the VERT. INPUT to X10. The line now can be extended to the same length at a fairly low setting of the VERT. GAIN control.



A
TRIMMER CAPACITY
LOW

B
TRIMMER CAPACITY
HIGH

C
TRIMMER
PROPERLY ADJUSTED

Figure 2

( ) Set the SYNC. SELECTOR switch to the +INT. position, the HOR. GAIN control to 30, the VERT. INPUT switch to X10, and the VERT. GAIN control to 100. Now set the HOR./FREQ. selector to the dot 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 1. This check indicates that the sweep generator is operating normally at a frequency of 60/4, or 15 cycles per second. Reduce the HOR. GAIN setting if necessary. The breaks in the trace are caused by the fields of the power transformer. This will not be present with external signals.

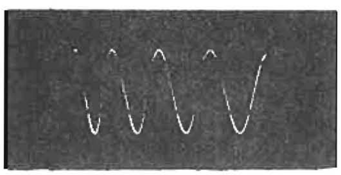


Figure 1

( ) Disconnect the jumper from the 1-V, P-P terminal. Turn off the power and connect the free end of the jumper to the excess lead coming from HOR. IN. on the rear circuit board. Set the HOR./FREQ. SELECTOR to the dot between 1000 and 10 kc, and the FREQ. VERNIER to 0. Now turn on the power. You should get a trace similar to that in Figure 2A or B. Reduce both GAIN control settings so that the trace is about 2" long.

( ) With the VERT. INPUT switch in the X10 position, adjust the front trimmer of the dual trimmers until the AB portion of the trace disappears and only a straight sloping line remains. (The dual trimmer is located on the left front part of the chassis.)

( ) Switch the VERT. INPUT to X100 and adjust the rear trimmer of the dual trimmer to obtain the same result as in the preceding step. 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 jumper from rear circuit board. Clip off the excess wire at HOR. IN.

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: Adjustment of the PRESET ADJUST controls is described in the OPERATION section of this manual on Page 32.

( ) The chassis should now be installed in the cabinet. Pass the line cord through the large hole in the back of the cabinet, then slide the chassis in and fasten it in place, using two #6 sheet metal screws through the back of the cabinet and into the rear chassis apron. Be careful not to pinch the wires along the edge of the front panel when installing the cabinet.

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.

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

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

The knob marked HOR. GAIN, varies the width of the pattern on the screen.

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

The PHASE knob controls the phase shift of the line-frequency voltage and is used for LINE sweep (LINE SW.).

Three knobs, marked HOR./FREQ. SELECTOR, FREQ. VERNIER and EXT. SYNC. AMPLITUDE, control the operation of the sweep generator. The HOR./FREQ. SELECTOR and FREQ. VERNIER permit selection of the desired sweeping rate to provide a clear pattern. The EXT. SYNC. AMPLITUDE control operates only on external synchronization to adjust the voltage input to the synchronizing circuit.

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

EXT. INPUT: The HOR. INPUT binding post is connected directly to the input grid of the horizontal amplifier system. The sweep generator is not operating and external sweep can be applied to the binding posts.

LINE SW.: Line frequency voltage, controlled in phase by the PHASE control, is applied to the horizontal amplifier system. The sweep thus applied to the amplifier is sinusoidal in waveform.

PRESETS #1 and #2: Often used horizontal sweep frequencies (such as the sweep frequencies of a TV set) can be preadjusted by means of the screwdriver adjustments available on the front panel of the oscilloscope.

See the ADJUSTMENT section (Page 33) for these controls.

The SYNC. SELECTOR switch operates as follows when the sweep generator is operating.

-INT. and +INT.: The sweep generator is synchronized internally with the signal applied at the VERT. INPUT binding post.

LINE: The sweep generator is synchronized with the line frequency or its harmonics.

EXT.: The sweep generator is synchronized with any signal applied to the EXT. SYNC. binding post.

The 1-V, P-P binding post 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. INPUT switch are set for a given measured vertical deflection on the grid screen, it becomes a simple matter to determine the peak-to-peak value of any unknown voltage. For example; a service specification refers to a particular waveform, designating the normal peak-to-peak voltage as 25 volts. Connect the 1-V, P-P terminal to the VERT. INPUT terminal. With the VERT. INPUT switch in the X10 position, adjust the VERT. GAIN control for a deflection of 1" on the grid screen. 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 post. Set the VERT. INPUT switch to the X100 position. Now, a 1" deflection indicates a peak-to-peak voltage of 10 volts. (With the VERT. INPUT switch in the X1 position, it would indicate 0.1 volts.) Adjust the sweep controls to lock the waveform and adjust the positioning controls for convenient vertical measurement. Observe that the unknown voltage shows a peak-to-peak deflection of 2.5", or 25 volts.

ADJUSTING THE PRESET ADJUST CONTROLS

Adjustment of the PRESET ADJUST controls may be made directly from the front panel of the oscilloscope with a screwdriver, making possible two completely preadjusted horizontal sweep frequencies. The instrument does not need to be removed from its case for these two adjustments. The frequency range of PRESET ADJUST control number 1 is from 10 cps to 100 cps, and the frequency range of PRESET ADJUST control number 2 is from 1000 cps to 10 kc. By changing the values of C22 or C23 to the values of C17, C18, or C20, the PRESET controls may be used to set fixed sweep frequencies at any frequencies within the range of the sweep generator.

Since the most common use of this facility will be in television repair work, we will describe the adjustment procedure for presetting them for the vertical and horizontal sweep frequencies of a television set.

NOTE: When making these adjustments, be careful not to come into contact with the high voltages present in television sets.

PRESET ADJUST 1

( ) Connect the vertical input of the oscilloscope to a point where a waveform is present in the vertical section of a television set.

( ) Allow sufficient time for both the television set and the oscilloscope to warm up thoroughly, and turn the SYNC. SELECTOR switch of the oscilloscope to the EXT. position. Turn the HOR./FREQ. SELECTOR to PRESET 1.

( ) Turn PRESET ADJUST control number 1 until two complete cycles appear on the oscilloscope. Now check this adjustment by turning the SYNC. SELECTOR to the INT. position to make sure the waveforms lock in solidly.

PRESET ADJUST 2

( ) Turn the HOR./FREQ. SELECTOR to PRESET 2. Turn the SYNC. SELECTOR back to the EXT. position.

( ) Connect the vertical input of the oscilloscope to a point where a waveform is available in the horizontal section of a television set.

( ) Turn PRESET ADJUST control number 2 until two complete cycles of the horizontal waveform appear on the oscilloscope. Now check the waveform for stability by turning the SYNC. SELECTOR back to the INT. position.

NOTES ON OSCILLOSCOPE OPERATION

One of the outstanding features of this instrument is the ease with which the sweep may be synchronized 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 in the EXT. position. The AMPLITUDE control is unnecessary in the other positions because of the built-in sync. limiting circuit. This circuit makes synchronization easily adjustable by the FREQ. VERNIER control. Settings of this control may become quite critical at low vertical gain settings and at very high frequencies.

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

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 behavior is a normal characteristic of the instrument and does not interfere with proper operation.

The maximum undistorted input voltage of the vertical amplifier generally does not provide deflection much in excess of 5". Maximum deflection of 3" will provide adequate utilization of the available screen area. Vertical deflection of greater than 3" will give an apparent distortion, as the trace is then operating in the curved portion of the CR tube face. Some scope manufacturers incorporate vertical limiting circuits or a mask to limit the trace to 3", which then utilizes only the flat portion of the CR tube giving greatest accuracy.

At low sweep rates (30 cycles or less) the screen has insufficient persistence to provide a steady picture. The resulting flicker is inherent with medium persistence screens at low sweep rates and represents a compromise with the ability to follow high sweep rates.

In addition to the above notes, there are several other effects which might 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 with high intensity settings, 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 will take place due to external magnetic fields. This condition will remain, even with both the HOR. and VERT. 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 amazing. These extraneous fields can be identified by observing whether the spot shape, adjusted for minimum size, seems to change with orientation of the instrument. To check, turn the scope cabinet around its vertical axis. Soldering guns, fan motors, power transformers, voltage regulators, and conduit carrying heavy AC conductors are particularly bad offenders in this respect. In the past, such deflections have been swamped out by the relatively large minimum spot size which could be resolved. With the present day high resolution cathode ray tubes 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 sweep 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 "breathing" rate will change and may even become evident as a dual trace under some conditions.

4. At signal frequencies of 1 megacycle and higher, some fuzziness of the trace is normal. With signal frequencies higher than 3 mc, settings of the frequency vernier become critical and great care must be used.

5. Vertical positioning range is deliberately limited to ±1-1/2" from center, 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 correct it should be considered.

6. 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 input switch to keep from overloading the input stage of the vertical amplifier. If you cannot reduce the waveform height on the screen to a useable level with these controls, an external attenuator probe or voltage divider may be used to reduce the input signal.

7. A slight overshoot or ringing effect may be noticed with square-wave inputs at frequencies of 100 kc and higher. This effect should not exceed 10%. However, since square-wave generators are prone to create this condition themselves, be sure of the output waveform of your generator.

8. As sweep rates are increased, particularly above 200 kc, a definite reduction in available sweep amplitude will be noted. This is a function of the rapidly-falling frequency response of the horizontal amplifier and is perfectly 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 sweep generator is operating at broadcast band frequencies and may be heard on adjacent radio receivers.

9. At reduced intensity settings and low sweep speeds, some intensity modulation of the trace may be noticed. This condition is normal and may be eliminated by a slight increase in trace intensity.

10. In operating the positioning controls, you will observe a "dead spot" at about the center of rotation; that is, the position of the spot 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 on the resistance element. At this tap position, no change in resistance takes place, hence the spot does not change position.

11. Some defocusing may be experienced at the extreme right-hand edge of the trace. This condition does not indicate a fault in the CR tube. It is caused in part by amplifier design and is an intended compromise between sensitivity and bandwidth which will in no way interfere with normal oscilloscope operation.

12. If the scope is operating with a total horizontal sweep width of 4", for example, and the HOR. 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 rate of the electron beam. As the sweep width is increased, this rate increases also and the intensity will drop. If proper voltages are obtained at the CR tube socket, and adequate intensity is available under normal room lighting with 5" total sweep width, your oscilloscope is performing normally. As sweep width is increased beyond this, the trace intensity will be reduced.

OSCILLOSCOPE APPLICATIONS

The cathode ray oscilloscope is a most versatile device. It has the unique ability to measure the basic electrical quantities and, more important, to show the relationships between as many as three of these quantities at any one time. Or, it can relate one or two of the variables against a controlled time reference. Therefore, it can indicate such characteristics as frequency, phase relations, and waveform.

By the use of supplementary devices, called transducers, a great variety of other physical attributes can be investigated with the oscilloscope. These transducers are used to convert sound, heat, light, stress, or physical movement into electrical impulses. The impulses can be studied by displaying them on the screen of the oscilloscope.

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

WAVEFORM INVESTIGATION

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 of the oscilloscope. By means of attenuators and amplifiers, this voltage is made to vertically displace the electron beam in the cathode ray tube. At the same time, the beam is being swept horizontally by the sweep 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 have described below the more common applications of the oscilloscope in studying waveforms.

Testing Audio Amplifiers and Circuits

Figure 3 shows the conventional setup 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 overloading of any portion of the amplifier and consequent inaccuracies in measurements.

Figure 4A shows serious flattening of one peak, representing about 10% harmonic distortion in the amplifier. This condition may be caused by incorrect bias on any stage, or by an inoperative tube in a push-pull stage. Figure 4B indicates third harmonic distortion, a particularly objectionable fault. Figure 4C shows flattening of both peaks, usually an indication of overload somewhere in the amplifier circuit.

Although the use of 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 audio system with respect to both amplitude distortion and phase shift. Assume that we apply a wave of the form shown in Figure 5A, with a fundamental frequency of 60 cycles. 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 waveform as shown in 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 5B 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 waveform indicates the ability of the amplifier to faithfully reproduce high frequencies. Conversely, the slope of the flat-top por-

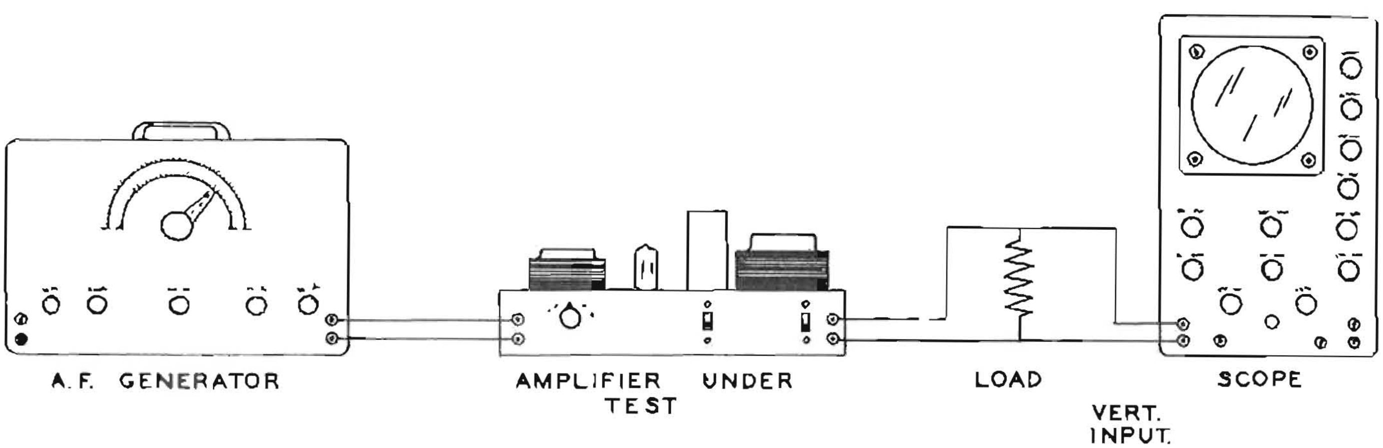


Figure 3

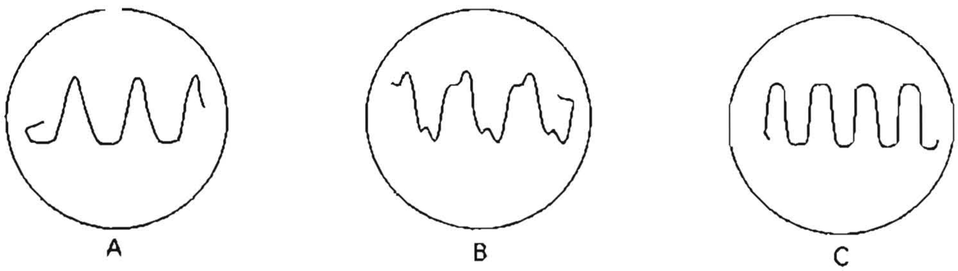


Figure 4

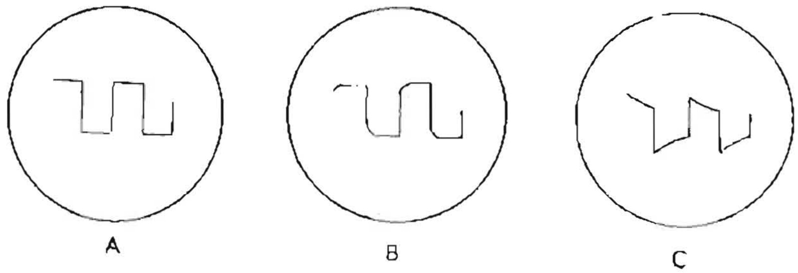


Figure 5

tion of the wave indicates the performance of the amplifier in the low frequency range. Figure 5C is the characteristic indication of an amplifier with poor low frequency response. Again, the square-wave generator used must be capable of producing the desired waveform with excellent voltage regulation and low inherent distortion.

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

Servicing Television Receivers

Servicing of 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 an oscilloscope. This particular field was given specific attention in the design of the 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 60 cycles per second with a deviation of several megacycles. The generator also provides a 60 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 in the television set. 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.

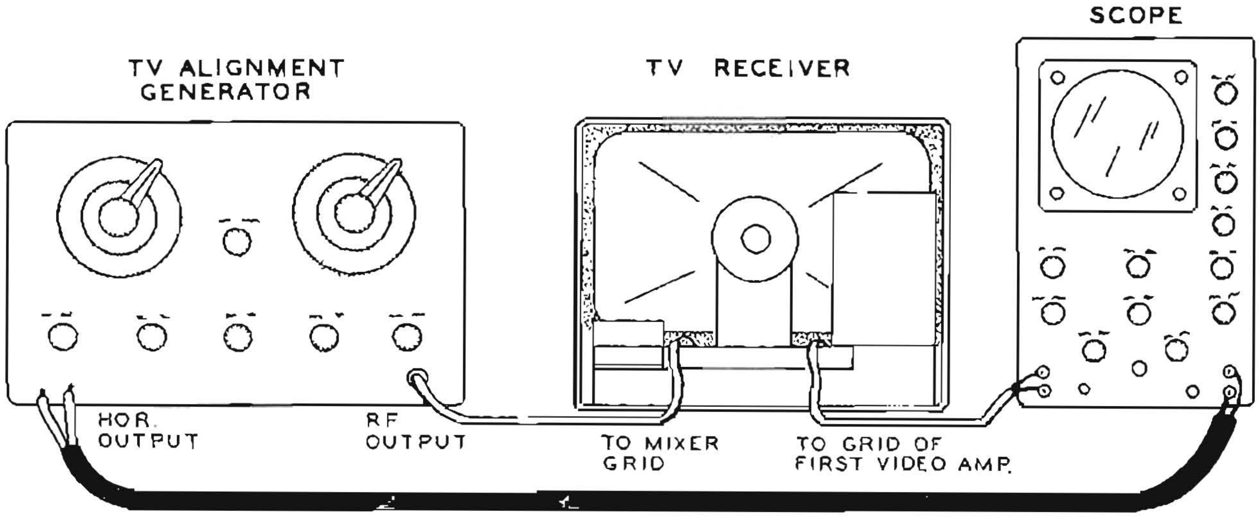


Figure 6

Figure 6 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 TV manufacturer's service information. 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 while watching the trace on the oscilloscope.

2. The waveform 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 waveform, 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 oscilloscope is entirely adequate for this application.

Again, you must rely upon the manufacturer to furnish representative patterns showing the waveform 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 plate, 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. The HEATHKIT Demodulator Probe is designed for this purpose. At any point after the video detector, no such probe is necessary and a simple shielded low capacity cable can be used.

NOTE: For simplicity, all amplifier stages are shown within one block in the diagram. Tests may be made at the input or output of individual amplifier stages using the indicated mode of operation. At several of the points designated "R", some waveform distortion may result, due to capacitive loading. If this problem exists, it is recommended that a low-capacity scope input probe be used.

In either case, the signal voltage is fed into the vertical amplifier of the oscilloscope as shown in Figure 7. 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 reach very respectable proportions, and considerable attenuation is required. It is for this reason that the vertical input section of the oscilloscope utilizes fully compensated attenuators. Any other method of reducing such voltages would result in enough distortion to render the displayed signal completely useless.

In checking waveform, remember that two basic frequencies are involved in the television signal. The vertical, or field frequency is 60 cycles per second. Any investigation of the circuit, except within the horizontal oscillator, its dif-

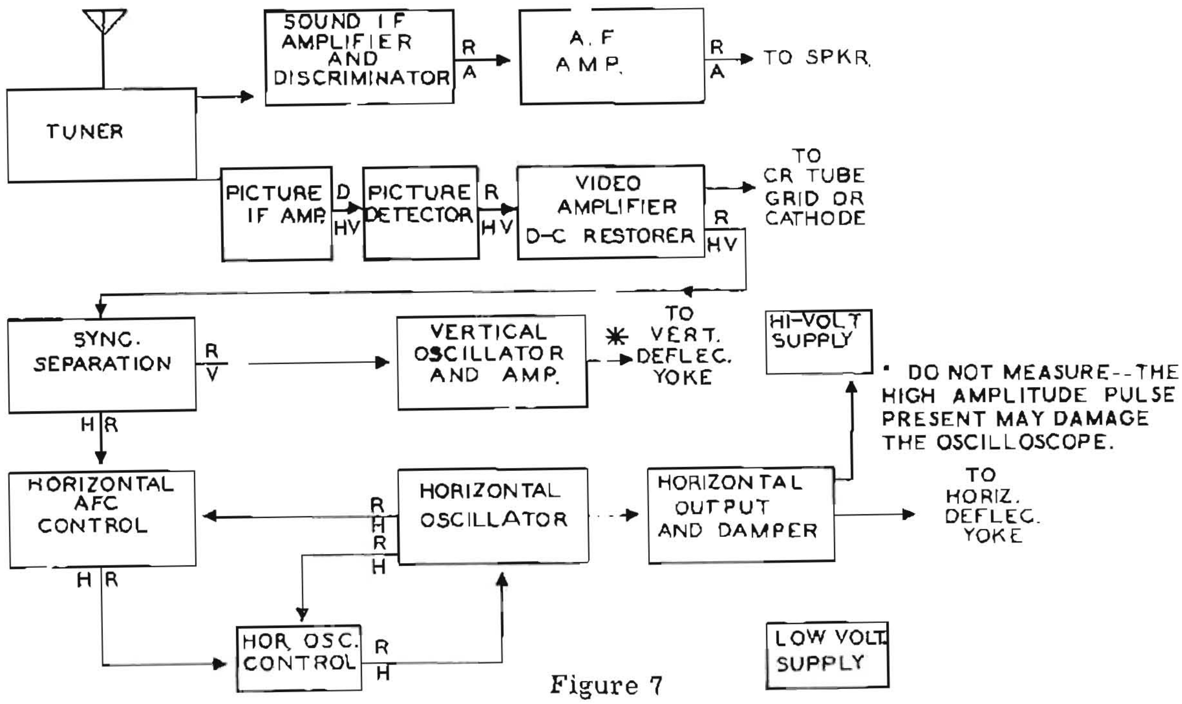


Figure 7

ferentiator network, and the horizontal amplifier stages, can generally be made using a sweep generator frequency of 20 to 30 cycles, thus showing two or three complete fields of the signal. In order to study the horizontal pulse shape, or the operation of the horizontal deflection system, it is generally necessary to operate the sweep generator at 15,750 or 7,875 cycles per second. This sweep rate will show the waveform of one or two complete lines of the signal. The use of PRESET ADJ. #1 and PRESET ADJ. #2 are especially useful in investigating these horizontal or vertical sweep circuits. See the PRESET ADJUST section on Page 33.

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. Plate circuits and cathode circuits are usually lower-impedance points, and more desirable for testing purposes. Also, bear in mind that the plate-circuit indication with respect to polarity will be exactly opposite to indications obtained on grid or cathode, since a phase difference of 180 degrees takes place within the tube. 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 as low as 20 cycles and as high as 4 or 5 megacycles, however, a more comprehensive test is required. Usually a 60 cycle check is made to cover low and medium-frequency characteristics. A second check at 25,000 cycles 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 oscilloscope. The signal-tracing technique can be used in these tests also. The squarewave generator is fed directly into the first video amplifier grid. Very low signal input will be required. Then the oscilloscope is con-

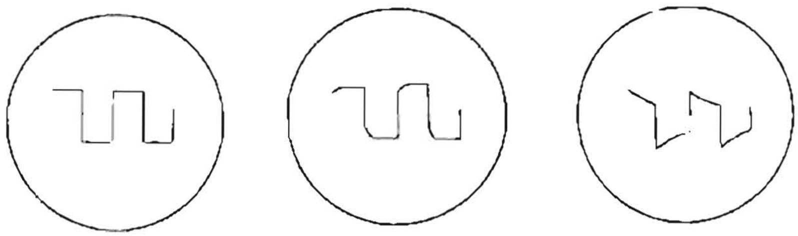


Figure 8

nected to various tube plates, starting near the output end and working back until any distortion is isolated. Patterns such as Figure 8B are responsible for poor picture detail, or "fuzziness," while distortion of the form shown in Figure 8C can cause shading of the picture from top to bottom.

Miscellaneous Waveform Measurements

In this category, we can place such waveform investigations as measurement of modulation percentage, studies of noise and vibration, subsonic and ultrasonic applications and hundreds of others. Each of these fields is highly specialized, and it is obviously impossible to cover each here. We again refer you to the BIBLIOGRAPHY for further reading.

AC VOLTAGE MEASUREMENTS

Because of its peculiar characteristics, the oscilloscope is particularly suited to the measurement of AC voltages. With the advent of television, it has become imperative that such measurements be made accurately without respect to waveshape. Most television service bulletins specify peak-to-peak voltages which appear at varous points of the circuit. Other applications for such measurements are becoming more common every day.

The oscilloscope was designed to accurately measure and display these voltages. Former instructions have shown how to calibrate the instrument for direct measurement of peak-to-peak amplitudes. 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 grid screen for AC voltage measurements, it is sometimes helpful to use the EXT. INPUT setting for the HOR./FREQ. SELECTOR switch. This produces a vertical line which can be focused and centered exactly for the most accurate readings.

The following relationships exist between sine wave AC voltages:

rms times 1.414 = peak voltage.
rms times 2.828 = peak-to-peak voltage.
Peak voltages times 0.707 = rms voltage.
Peak-to-peak voltage times 0.3535 = rms voltage.

AC CURRENT MEASUREMENTS

To measure AC currents, the unknown current must be passed through a resistor of known value. The voltage drop across this resistor is measured as described above. From Ohm's law, I equals E/R, the current can be calculated. It is important that the resistor be non-reactive at the frequency involved. It should also be relatively small with respect to the resistance of the normal circuit load.

FREQUENCY MEASUREMENTS

Frequency measurements can be made with an accuracy limited only by the reference frequency source available. In most cases, this can be the 60 cycle line frequency which is usually controlled very closely. The unknown frequency is applied to the vertical input, and the reference frequency to the horizontal input. (Sweep generator input is not used.) The resultant pattern may take on any one of a number of shapes. Typical patterns are shown below:

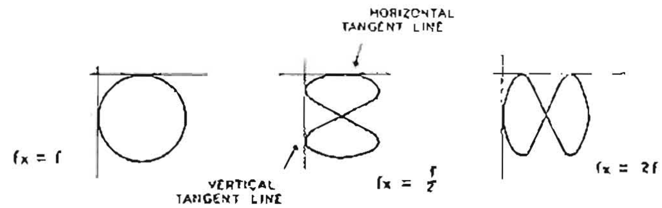


Figure 9

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 patterns, as these curves 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 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 AC 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 Figure 10.

To calculate the phase relationship, use the following formula:

$$\sin \theta = \frac{A}{B}$$

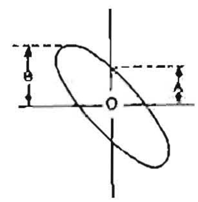


Figure 11

The distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance B represents the height of the pattern above the X axis. The axis of the ellipse must pass through point 0.

Figure 10

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 reccommended, we also suggest the following excellent books:

Ruiter; Modern Oscilloscopes and Their Uses.
Hickok; How to Use the CR Oscilloscope in Servicing Radio and TV.
Rider; The Cathode Ray Tube at Work.
Turner; Basic Electronic Test Instruments.
Editors and Engineers; Radio Handbook.
ARRL; Radio Amateurs Handbook.
Rider and Uslan; Encyclopedia on Cathode Ray Oscilloscopes and Their Uses.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored 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.

2. It is interesting to note that about 90% of the kits that are returned for repair, malfunction due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as illustrated in the Figures found in the SOLDERING TECHNIQUES section of this manual.

3. Check to be sure that all tubes are in their proper locations. Make sure that all tubes light up properly.

4. Check the tubes with a tube tester or by substitution of tubes 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 out 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 on the Schematic Diagram. NOTE: All voltage readings were taken with an 11 megohm input vacuum tube voltmeter. Voltages may vary 10% due to line voltage variations.

8. A review of the Circuit Description and Block Diagram will prove helpful in indicating where to look for trouble

9. If the dot moves off the face of the CR tube right after the oscilloscope warms up, and cannot be brought back by adjusting the positioning controls, it is generally caused by a defective deflection amplifier tube. If the trace drifts up or down, check the 12BH7 at V3. If the drift is right or left, check the 12AU7 at V7. Other probable causes are incorrect or defective plate load resistors for these stages, the 2.7 K 2 watt and 1 K 1 watt resistors to V3, and the 33 K 1 watt resistors to V7.

10. If you are unable to obtain straight diagonal lines when adjusting the vertical trimmers, please refer to Figure 2 on Page 31. The patterns shown there present a perfectly straight line between points B and C on the traces. Some users 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 the 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 wavefront of the sawtooth generated by the sweep oscillator. If the remaining portion of the line bellies up or down, a readjustment of the sweep oscillator 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 compensating.

11. 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 terminals, increase the VERT. GAIN control to 100, and set the VERT. INPUT 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 several 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 CRT6 and CRT7 on the cathode ray tube socket. This will eliminate any electrostatic 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 CRT6 and CRT7 shorted, the vertical width of the trace exceeds 1/16", the deflection or ripple is caused by magnetic 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 power transformer, but the relative position of 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 power-line frequencies creates a certain magnetic field. The worst offenders are those devices which draw a considerable amount of current such as soldering irons, soldering guns, AC motors, electric heaters, and other similar items.

Figure 12A 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 12B, 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 30% of its cycle or so.

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 oscilloscope 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 at least $15.00 for the 5UP1, and is an obvious impossibility in a kit selling for as low a price as this oscilloscope.

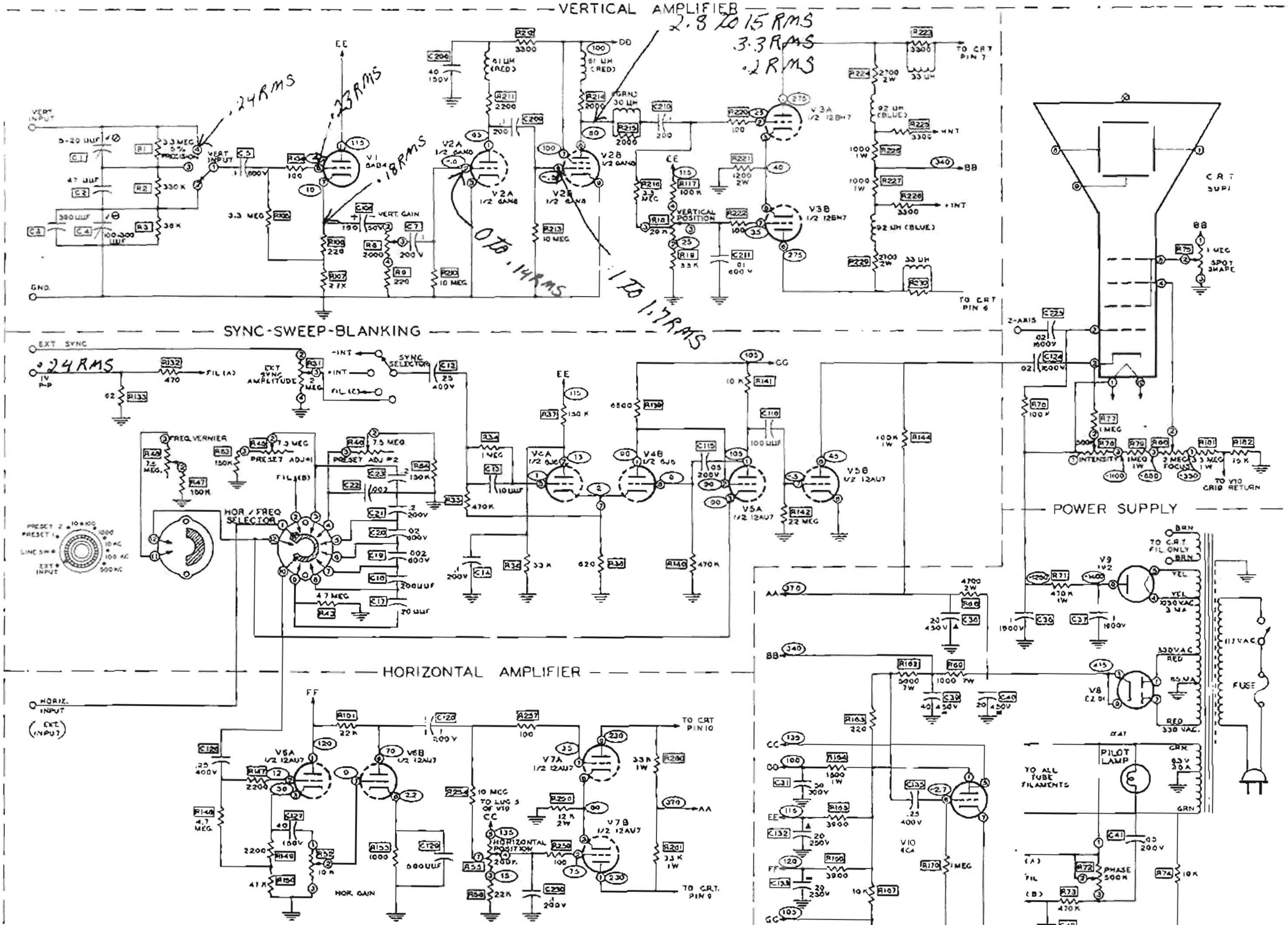
Fortunately, interference of this kind is usually small in amplitude and presents no problem to the average user. A little judicious experimenting will isolate the principal offender creating the field. Physical separation is in general a quick and easy solution to the problem.

Should the procedure as outlined fail to correct your difficulty, refer to the SERVICE INFORMATION section of this manual.

A


B


Figure 12



R AND C NUMBERS ON LARGE FRONT CIRCUIT BOARD = 100-199
R AND C NUMBERS ON SMALL REAR CIRCUIT BOARD = 200-242
ALL OTHER R AND C NUMBERS = 1-99

HORIZONTAL FREQUENCY SELECTOR SWITCH VIEWED FROM THE FRONT AND IN THE POSITION SHOWN BY THE FRONT PANEL MARKING.

ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE SHOWN.
ALL RESISTOR VALUES ARE IN OHMS, 1 K = 1000 Ω, 1 MEG = 1,000,000 Ω
ALL CAPACITOR VALUES ARE IN μfd UNLESS OTHERWISE SHOWN.

ALL VOLTAGES ARE FROM POINT INDICATED TO CHASSIS GROUND EXCEPT AC VOLTAGES ON POWER TRANSFORMER WINDINGS. READINGS WERE TAKEN WITH AN 11 MEGOHM INPUT VTVM.

SCHEMATIC OF THE HEATHKIT® 5" LABORATORY OSCILLOSCOPE MODEL IO-12