

Heathkit of the Month #87:  
by Bob Eckweiler, AF6C



**ELECTRONIC TEST EQUIPMENT**

**Heathkit O-5 through O-8 Oscilloscopes.**

**Introduction:**

In the June RF Newsletter the first four Heathkit Oscilloscopes were discussed; the first of which was the very first kit Heathkit offered. These four scopes were very similar in their circuitry, all using the same five tubes plus CRT (Cathode Ray Tube). In September of 1949 Heathkit updated their line with the O-5 (Figure 1)<sup>1</sup>. This kit represented a big jump in Heath’s scope performance as well as being the first scope to have a real construction manual with step-by-step assembly instructions. The O-5 was followed by the O-6, the O-7 and the O-8, each being announced in the Heath September Flyer for 1950, 1951 and 1952 respectively. Each of these later models include circuit changes and frequently additional features. Heathkit often cycled kit updates in September in the early years of their business.

**The Heathkit O-5:**

In their September 1949 Flyer, Heathkit took a large step forward in advancing their ‘O’ line of scopes introducing the O-5 Oscilloscope with an ad that covered half of the front-page (Figure 2). They offered more specifications than for their previous scopes,

<sup>1</sup> Notes appear at the end of the article.

Here is a link to the index of Heathkit of the Month (HotM) articles:  
[http://www.w6ze.org/Heathkit/Heathkit\\_Index.html](http://www.w6ze.org/Heathkit/Heathkit_Index.html)



Figure 1: Heath O-5 1950 5” Oscilloscope  
Photo by Keith Greenhalgh (See Note 1)

though some remained vague. The biggest improvement was the use of push-pull amplifiers for the vertical and horizontal sections. This resulted in about a 10-fold increase in vertical gain and a claimed whopping 50-fold increase in vertical frequency response. Another change was the timebase generator. It changed from a thyratron gas tube to a 6SN7 dual triode operating as a sawtooth multivibrator. Also, the CRT shield discussed in the previous article<sup>2</sup>, that Heathkit was selling to O-2 to O-4 owners at \$2.95, was now incorporated as part of the O-5 kit. The biggest surprise of the O-5 was its price. With an additional two tubes and a change of the sweep oscillator tube to a two-section triode, the extra components needed to support the new

circuitry, as well as the CRT shield, the price remained the same as the four preceding scopes - \$39.50.

The O-5 uses eight tubes including the CRT. The additional two tubes provide the push-pull function for the vertical and horizontal amplifiers. **Table I** shows the tube lineup for the O-5 through O-8 oscilloscope models.

When Heathkit announced the O-5 scope the ad also included an "O-5 Conversion Kit No. 315". This kit allowed the owners of the earlier O-3 and O-4 scopes to update their scopes to include SOME of the new features of the O-5 including the push-pull amplifiers.

It did not update the sweep circuit nor did it include the CRT shield. Still, the modification kit was extensive, including a new chassis, tubes and all parts. Evidently there were actually two modification kits as Heath asked buyers to specify the scope being updated. The modification kits cost \$12.50.

**The O-5 Front Panel:**

From afar it is hard to tell the O-5 oscilloscope from the O-4 by appearance. There are just four changes the author noted externally between the two models; all are nomenclature on the front panel. First, and most obviously, the model number, displayed just below the CRT now totes a '5'; second, the

**NEW 1950 Heathkit  
PUSH-PULL . . . EXTENDED RANGE  
5" OSCILLOSCOPE KIT**

**FEATURES**

- \*The first truly television oscilloscope.
- \*Tremendous sensitivity .06 Volt RMS per inch deflection.
- \*Push-pull vertical and horizontal amplifiers.
- \*Useful frequency range to 2½ Mega-cycles.
- \*Extended sweep range 15 cycles to 70,000 cycles.
- \*New television type multivibrator sweep generator.
- \*New magnetic alloy shield included.
- \*Still the amazing price of \$39.50.

The new 1950 Push-Pull 5" Oscilloscope has features that seem impossible in a \$39.50 oscilloscope. Think of it--push-pull vertical and horizontal amplifiers with tremendous sensitivity only six one hundredths of a volt required for full inch of deflection. The weak impulses of television can be boosted to full size on the five inch screen. Traces you couldn't see before. Amazing frequency range, clear useful response at 2½ Megacycles, made possible by improved push-pull amplifiers. Only Heathkit Oscilloscopes have the frequency range required for television. New type multi-vibrator sweep generator with more than twice the frequency range, 15 cycles to 70,000 cycles, will actually synchronize with 250,000 cycle signal. Dual positioning controls will move trace over any section of the screen for observation of any part. New magnetic alloy CR tube shield protects the instrument from the outside fields. All the same high quality parts, cased electrostatically shielded power transformer, aluminum cabinet, all tubes and parts. New instruction manual now has complete step-by-step pictorials for easiest assembly. Shipping Wt. 24 lbs. Order now for this winter's use. Express shipment only.

**CONVERSION FOR OTHER MODEL HEATHKIT OSCILLOSCOPES**

A conversion for all O-3 and O-4 scopes is available changing them to the new push-pull amplifiers (does not change the sweep generator). Complete kit includes new chassis, tubes and all parts. For a small investment, add the latest improvements to your present oscilloscope (except CR Tube Shield). Shipping Wt. 10 lbs. Order O-5 Conversion Kit No. 315. Specify O-3 or O-4 .....\$12.50

*Everything you'd expect  
in a \$200.00 Scope . . . .*

**Only \$39.50**

Figure 2: Introductory ad for the O-5 Scope in the February 1949 Heathkit flyer.

O-5 to O-8 Tube Lineup

#	Function	O-5	O-6	O-7	O-8	
1.	B+ Rectifier	5Y3	5Y3	5Y3	5Y3	Full-wave diodes
2.	HV Rectifier	5Y3	5Y3	5Y3	5Y3	Parallel diodes
3.	Vertical Input Buffer	none	6J5	6J5	6J5	Triode
4.	Vertical Preamplifier	none	none	12AT7	12AT7	cascaded triodes
5.	Vertical Phase Splitter	none	none	6C4	6C4	Triode
6.	Vertical Deflection Amplifier	6SH7	6SH7	½ 12AT7	½ 12AT7	} 6SH7 pentode 12AT7 dual triode
7.	Vertical Deflection Amplifier	6SH7	6SH7	½ 12AT7	½ 12AT7	
8.	Horizontal Phase Splitter	none	none	6C4	6C4	Triode
9.	Horizontal Deflection Amplifier	6SH7	6SH7	½ 12AT7	½ 12AT7	} 6SH7 pentode 12AT7 dual triode
10.	Horizontal Deflection Amplifier	6SH7	6SH7	½ 12AT7	½ 12AT7	
11.	Sweep Multivibrator	½ 6SN7	6J5	½ 12AT7	½ 12AT7	All triodes
12.	Sweep Multivibrator	½ 6SN7	8J5	½ 12AT7	½ 12AT7	All triodes
13.	Cathode Ray Tube	5BP1	5BP1	5BP1	5CP1	5CP1 (PDA CRT)
14.	Alternate CRT	5BP4	5BP4	5BP4	none	
15.	Alternate CRT	5GP1	5GP1	5GP1	none	
<b>Total Tubes:</b>		<b>8</b>	<b>10</b>	<b>10</b>	<b>10</b>	
<b>Total Tube Sections:</b>		<b>11</b>	<b>12</b>	<b>16</b>	<b>16</b>	

Table I

words “**PUSH - PULL**” and “**EXTENDED RANGE**” appear near the top under the “*Heathkit*” logo and “**OSCILLOSCOPE**” split by the CRT. Both of these are in a small font. The third change is the **VERTICAL** and **HORIZONTAL** gain nomenclature; the O-3 and O-4 **AMP.** and **PLATES** markings are gone, reverting back to the O-2 markings, as is the ability to connect signals directly to the CRT deflection plates. The final change is the marking for the five position coarse sweep **FREQ. SELECTOR** switch which shows the new sweep ranges. A table of the sweep ranges is shown in Table II

**O-5 Specifications:**

Heathkit was always a little obscure in the way they gave product specifications. One has to wonder if the specifications were chosen by the advertising department instead of engineering. One example is maximum al-

lowed input voltage to the vertical or horizontal amplifier. For the O-5 it is specified as 400 Vrms for both and then never mentioned again in the specifications or ads for the O-6 through O-8. Sometimes though, the maximum voltage is specified on the front panel.

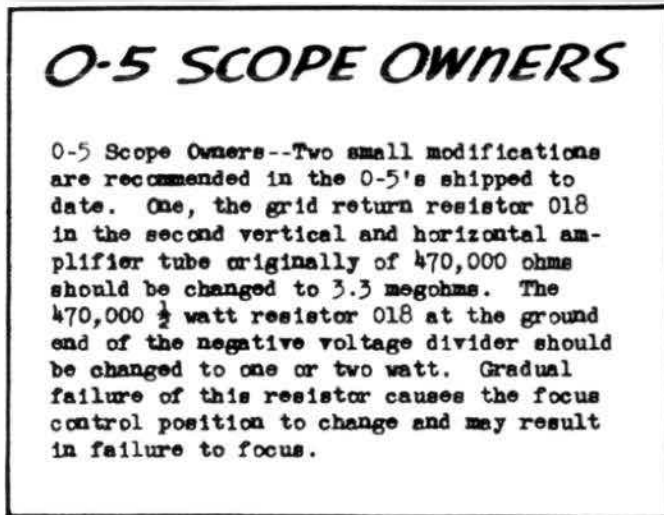
**O-5 Circuit Description:**

A lot of basic circuit discussion appeared in part I<sup>2</sup> of this soon to be triumvirate, and the reader may want to peruse it before proceed-

**SWEEP FREQUENCY SELECTOR RANGES**

	O-5	O-6	O-7 / O-8
1.	15 - 80	15 - 80	15 - 180
2.	80 - 350	80 - 450	180 - 1800
3.	350 - 2 kc	450 - 3 kc	1800 - 12 kc
4.	2 kc - 12 kc	3 kc - 15 kc	12 kc - 100 kc
5.	12 kc - 70 kc	15 kc - 100 kc	n/a

Table II



**Figure 3:** Early changes in the O-5 circuitry as announced in the December 1949 Heath flyer.

ing. Also the CRT workings are covered in a second article worth reading<sup>3</sup>.

Early in the production run of the O-5 two resistor values were changed, and a bit later the wattage of another resistor was increased to prevent focusing problems. Details first appeared in the December 1949 Heath Flyer (**Figure 3**). An updated manual with the changes appeared in early January 1950.

Again, the circuitry can be divided into five areas: The B+ power supply; the HV power supply with CRT; the vertical amplifier, the horizontal amplifier and the sweep generator:

#### **B+ Power Supply:**

Voltages are given on the schematic diagram for the first time. Also there is a tube voltage chart in the manual. The B+ supply provides two voltages to the scope, +350 VDC to the vertical and horizontal amplifiers and the sweep multivibrator, and +75 VDC to the screens of the vertical and horizontal amplifier tubes as well as the V and H positioning dual-potentiometers.

In order to add features to the O-5 without raising the cost, Heathkit removed the expensive filter choke used in the earlier mod-

els and replaced it with a resistor. The current drawn by the various circuits is not heavy so this seemed like a fair trade-off for keeping the price stable. The same three-section can capacitor used in the O-4 power supply is used in the O-5.

The tube voltages given in the manual show pin 2 of the B+ 5Y3 tube (the output to the filter network) to be at 450 to 550 V which is high for the 20  $\mu$ f 450 volt rated capacitor connected at that point. Assuming nominal line voltage and no transformer nor rectifier loss, the voltage would be about 495 volts if the secondary was right at 700 Vrms.

#### **HV Power Supply and CRT:**

The high voltage supply is almost identical to the O-4 HV supply. Two changes are the filter capacitor which is the last 'war-surplus' oil-filled capacitor used in the scope. It is rated for 1KV, but the voltage charts gives the voltage as "900-1300 V neg", stretching the ratings a tad. This is true of the 5Y3 rectifier tube in the HV also. However, since the tube sections are operating in parallel the plate-to-plate voltage is zero, and the tube seems to operate without problem. The second change is the final resistor in the CRT voltage chain which was changed to 100 K $\Omega$  from 1 M $\Omega$ . This is due to a new trace positioning circuit. The lower resistance caused excess dissipation on the 470 K $\Omega$  resistor in the chain so its wattage was increased as mentioned in the discussion of **Figure 3**.

#### **Vertical / Horizontal Deflection Amplifiers:**

The O-5 uses identical circuitry for the two deflection amplifiers. The biggest change for the O-5 is that the deflection amplifiers are push-pull. Instead of one deflection plate being held at a fixed voltage and the other plate voltage varied, each plate is actively driven, but 180° out of phase with each other. the result is that one plate goes more pos-

itive when the other plate goes less positive, creating a larger difference in voltage and doubling the sensitivity. Push-pull operation also has additional features. As discussed in Chuck DeVere's book "Cathode Ray Tubes"<sup>4</sup> push-pull operation of the deflection plates results not only in better display linearity, but also in more consistent focus over the screen area.

The deflection amplifier (see **Figure 4**) uses two 6SH7 sharp cut-off pentode tubes in cascade. The input signal is capacitively coupled through the gain control to the grid of the first stage. The plate is capacitively coupled to one of the deflection plates. The screen grid is connected to the 75V B+ supply through a 5.6 KΩ resistor. The amplified signal is also present at the un-bypassed screen grid and is coupled to the control grid of the second amplifier tube. The second tube has its plate coupled to the other deflection plate. Due to the phase shift in the tube, this signal is 180° out of phase with the signal to the other deflection plate. The main problem

with this cascaded push-pull type of circuit is the signals at the two plates, while correctly out of phase, are not quite identical in amplitude. This preempts directly coupling the tube plates to the deflection plates as the different amplitudes would also cause the trace position to change. Thus, on the O-5, a separate high impedance DC voltage is directly coupled to the deflection plates to set the trace position. This requires coupled dual potentiometers for each position control.

**Sweep Circuit:**

The O-5 sweep circuit is an improvement on the earlier circuit that uses an 884 thyratron gas tube. The new circuit is a multivibrator using a dual triode 6SN7. This circuit continued to be used through the O-9, with minor component changes; however, different tubes were used, probably driven more by inventory than engineering.

The basic multivibrator circuit is shown in **Figure 5**. Let's follow it through one cycle starting where V1A has just turned on. CA,

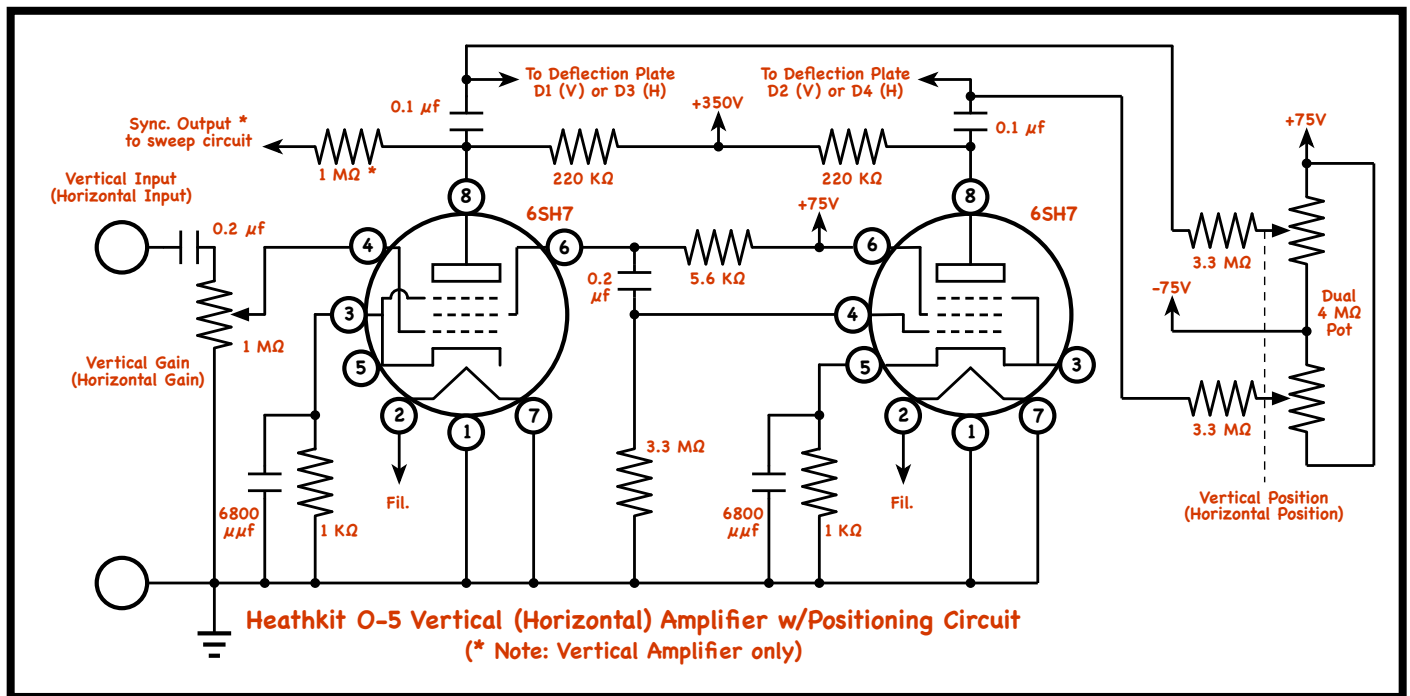


Figure 4: O-5 Vertical Cascading Push - Pull Deflection Amplifier (Horizontal amplifier is identical).

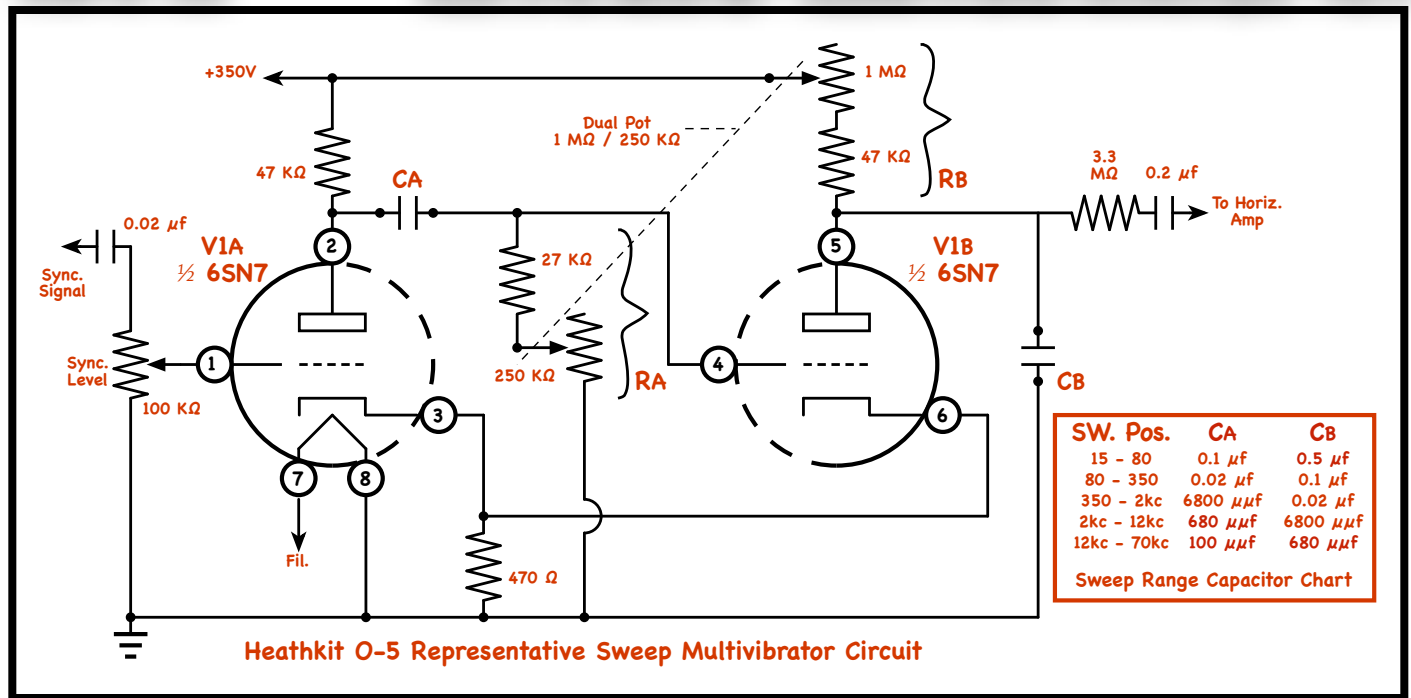


Figure 5: O-5 Representative Sweep Multivibrator Circuit. (The O-6 through O-9 circuits are similar, but not identical)

which had charged while V1A was off, discharges through the tube and RA, applying a negative grid voltage to the V1B turning it off. CB starts to charge through RB. When CA has discharged sufficiently, V1B begins to conduct causing CB to discharge through the tube and cathode resistor which turns V1A off. CA immediately starts charging through RA. As CA charges grid voltage on pin 4 drops finally turning V1B off which removes the cathode bias on V1A turning it back on and completing the cycle. Thus CB charges slowly through RB and discharges rapidly through V1B producing a sawtooth voltage that is fed to the horizontal amplifier when in sweep mode. Since the charge discharge voltage of CB is only a small fraction of the 350 volt B+, the sweep ramp is very nearly linear.

A large positive pulse on the sync input turns V1A on if it was off, forcing the sweep oscillator to sync at the frequency, or sub-harmonic of the frequency, of the sync pulses. When internal sync is selected these pulses come from the vertical amplifier signal.

### The Heathkit O-6:

The O-6 was announced in the September 1950 Heath Flyer. Featured in the flyer were twelve improvements that were made in the new oscilloscope. Four of these improvements involve the amplifiers, two the sweep and sync circuits, two the CRT and associated circuit, two the new vertical attenuator and the last two the power supply. These will be touched on in the circuit descriptions.

### The O-6 Front Panel:

Figure 6 shows the front panel of the O-6. Two changes stand out: Another control has been added to the front panel as has a binding post to the right and between the horizontal position and gain control. The added control is a switch that controls the new vertical attenuator. This **VERT. INPUT** two-position switch selects either x100 attenuation (**600 VOLT MAX.**), or x1 attenuation (**10 VOLT MAX.**). The added binding post is marked **DC** and allows direct DC input to the horizontal amplifier, which is DC coupled to the deflection plates.



The cathode follower uses a 6J5 triode and provides the needed high impedance to the output of the attenuator. The output of the cathode follower is AC coupled through the vertical gain control at a low impedance point to the push-pull deflection amplifier. (#10 of 12)

**O-6 Vertical/Horizontal Deflection Amplifiers:**

Like the O-5, the O-6 uses identical circuits for the two deflection amplifiers. However, the circuit is improved. Instead of cascading amplifiers, the first driving the second, a differential amplifier is used. This offers a lot of advantages. First, the tube plates are directly connected to the CRT deflection plates (#4 of 12), second, the balance control is a simple pot in the cathode circuit adjusting the quiescent current in each tube and hence the deflection voltages. The only capacitor in the circuit buffers the position potentiometer, hence the circuit can operate from DC to a high frequency (#4 of 12).

The differential amplifier circuit is shown in Figure 7. With no input, the grid of each tube

is at ground, and an equal current from each tube flows through the common cathode resistor (with the position pot centered). Since each plate is drawing the same current, the drop across the 220 KΩ load resistors are identical and the voltage on the deflection plates are identical. When a signal causes the input to go positive, current increases in V1. Since the cathodes share the same resistor the increase in cathode voltage causes V2 to reduce its current keeping the cathode current constant. Thus for the vertical amplifier, the D1 deflection plate (upper) becomes less positive and D2 (lower becomes less positive) deflecting the CRT beam up. When the input signal goes negative the reverse happens and the CRT beam is driven down. The horizontal deflection amplifier works similarly. The high gain of the differential amplifier produces a sensitivity of around 0.04 Vrms for one inch of deflection. While this number holds for the horizontal amplifier, the attenuator circuit and cathode follower section reduce the vertical sensitivity to 0.09 Vrms (#5 of 12).

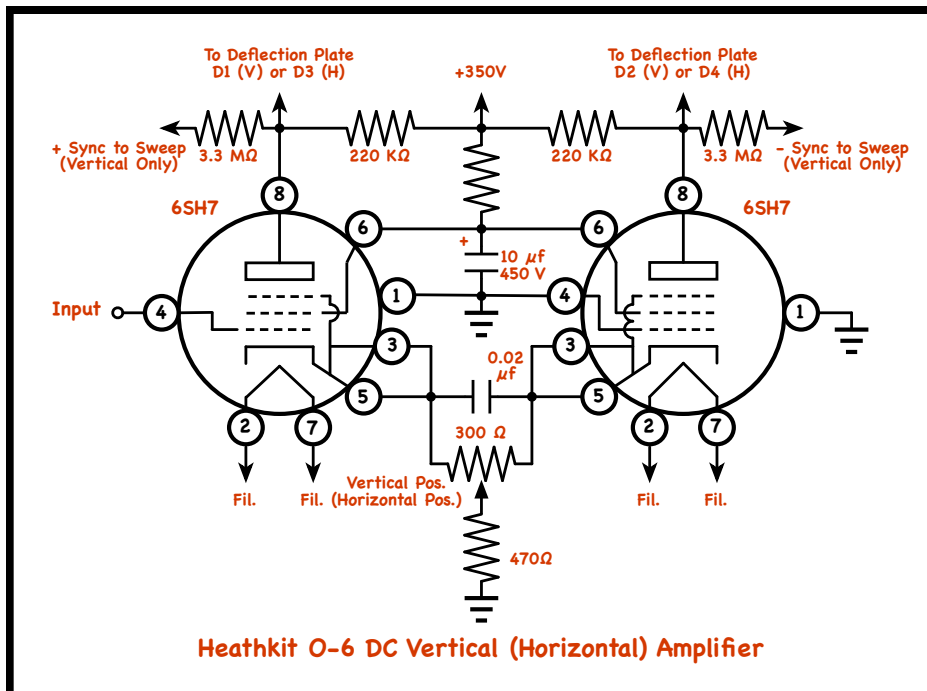


Figure 7: O-6 Deflection Amplifier

A binding post on the front panel named DC is DC coupled through the horizontal gain pot to the horizontal amplifier input, allowing DC input to the horizontal amplifier. (#2 of 12). Evidently Heath added this as a last minute thought. Some early ad photos show the O-6 without the binding post.

**O-6 Sweep and Sync Circuit:**

The sweep circuit is very similar to the O-5 circuit. For reasons unknown, the 6SN7 was changed to two separate 6J5 triodes, and new frequency determining components were



chosen to increase the five ranges of the sweep multivibrator to cover 15 cps. to 100 kc. (#7 of 12).

Thanks to the differential amplifier it is possible to obtain sync pulses from each plate of the vertical amplifier. One can be used for positive syncing and the other for negative syncing. The signals from each plate are isolated with 3.3 M $\Omega$  resistors and AC coupled to an end of the **SYNCHRONIZING** center tapped potentiometer. The center-tap is grounded and over one half of the rotation positive syncing is available and over the other half negative syncing is available (#8 of 12). Heathkit continued to use the same center-tapped sync circuit through the O-9.

### The Heathkit O-7:

The New 1952 Heathkit O-7 Oscilloscope kit was announced in the September 1951 Heath Flyer. It was the first of the 'O'-scopes to use miniature 7 and 9 pin tubes. No more "high-gain pentode" claims; other than the rectifiers and CRT, all the tubes are triodes. Instead of trying to get the gain from one tube, four triode stages precede the vertical deflection amplifier. The O-7 also adds an astigmatism control. It is a set-and-forget pot that adjusts the circularity of the dot. To help increase bandwidth, the deflection amplifier and phase splitter tubes now reside on the rear CRT support to keep the lead capacitance to a minimum. Another nice feature is the sweep vernier control. The sections of this dual pot are coupled so they can turn independently over a few degrees of rotation before following each other. This allows one to turn the control to just past the desired point, moving both sections, and then go backwards moving just the fine pot, making adjustment easier.

These improvements finally "broke the bank" and for the first time since the O-1 Heath raised the scope price by 10% to \$43.50.

### The O-7 Front Panel:

**Figure 8** shows the front panel of the O-7. The **INTENSITY** and **FOCUS** controls have been moved to the top, and the **VERTICAL CENTERING** and **HORIZONTAL CENTERING** controls have replaced them. The **VERT. GAIN** and **HORIZ. GAIN** controls have been moved to where the position controls were. The **VERT. INPUT** (attenuator) switch has been moved to the former VERT. GAIN position and the **SYNCHRONIZING** pot to the former HORIZ. GAIN position. The short-lived DC binding post is gone. Along the bot-



**Figure 8:** Heath O-7 1952 5" Oscilloscope  
Photo by Keith Greenhalgh (See Note 1)

tom the two rows of slide switches, binding posts and pilot light remain as they have been since the O-2 with the exception of the switches changing from toggle to slide switches during the O-3 production.

**The O-7 Specifications:**

Table III covers the O-7 specifications. Notable is that the sensitivity of the vertical amplifier increases to 0.03 Vrms per inch of deflection, the less critical horizontal amplifier drops way down to 0.6 Vrms. For the first time Heath actually specifies quantitative data for the frequency response as: +2 db at 10 cps and -24 db 2 MHz (1 kc ref.). They also say the scope is usable up to 5 mc.

**O-7 Circuit Description:**

The O-7 is the first O-scope to use the new Heathkit parts number system. This makes it difficult to determine if a part is new or not. Again, let's look at the circuit one section at a time:

**O-7 B+ Power Supply:**

The ads refer to a 'special', but not 'new' transformer with reduced magnet and electrostatic fields, internal shield with ground lead. This is probably the same part as used in the O-6, and it must have worked well because the O-7 no longer comes with a CRT shield. The B+ uses the same four-section capacitor, but now producing three B+ voltages, +350 V and two lower unspecified voltages. These two lower voltages supply power to the two phase splitters, everything else is powered by the +350 volts.

**O-7 HV Supply and CRT:**

The HV filter capacitor was changed back to 1 µf oil-filled, but the HV CRT resistor chain remains the same except the astigmatism control replaces two of the fixed resistors with the wiper going to the CRT acceleration electrode.

**O-7 Vertical Attenuator:**

Figure 9 is a schematic of the O-7 attenuator it is identical to the O-6 attenuator except for a couple of values. While the O-6 provides an attenuation of 100:1, the O-7 attenuator has an attenuation of 70:1. A cathode follower with a gain less than one, but a high input impedance to isolate the attenuator, and a low output impedance to prevent distortion in the vertical gain control, follows the attenuator.

**O-7 Vertical/Horizontal Deflection Amplifiers:**

The vertical and horizontal deflection amplifiers both use a 12AT7 dual triode to directly drive the CRT deflection plates. However, the vertical amplifier has two stages of triode pre-amplification, also using a 12AT7, prior to the deflection amplifier. Each of the deflection amplifiers use a phase splitter to provide 0° and 180° to the two amplifiers driving the CRT deflection plates. The vertical circuit uses a 6C4 seven-pin miniature triode while the horizontal circuit uses a 6J5 octal triode. The O-8 is almost identical and further discussion will be waived till then.

**O-7 Sweep and Sync Circuit:**

The sweep circuit is the same multivibrator circuit discussed for the O-5 with minor changes. The O-7 uses a 12AT7 miniature tri-

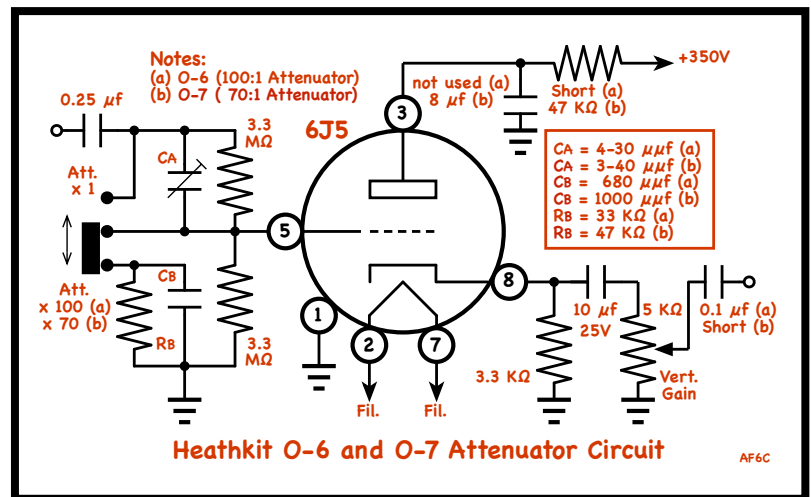


Figure 9: O-6 and O-7 Attenuator Circuit

ode and the sweep range switch now has only four ranges. (see table II), however the new sweep vernier control makes adjustment easy. One Heath ad claims the sweep is capable of going as high as 135 kc. Positive and negative sync pulses are now taken from the vertical phase splitter outputs.

**The Heathkit O-8:**

The September 1952 Heath flyer is missing from the author’s collection, however a check of the September 1952 issue of Radio News. included the “New Heathkit Oscilloscope Kit; Model O-8”. By then Heath and Heathkit were well established; the Radio News ad

ran for 11 pages and included 47 Heathkit items on the order form. Chuck Penson sent a page from the October 1952 Heath flyer (Figure 10) which is likely identical to the September flyer ad.

The O-8 came out with a new style. For the first time there are ventilation holes in the cabinet along the top and bottom on each side. Also the cabinet is formed with rounded corners and a formed front panel. The maroon pin-striping around the front panel is gone, and Heathkit introduced its new 5-way binding posts (See Figure 11). Probably the most significant change is a new PDA CRT,

**NEW Heathkit**  
**OSCILLOSCOPE KIT**

Direct connections to deflection plates.  
New wide band vertical amplifier  $\pm 2$  db 10 cycles to 1 Mc.  
3 step vertical input attenuator.

The 5" Heathkit O-8 Oscilloscope has tremendous NEW FEATURES AND VAST IMPROVEMENTS in addition to the many desirable features of previous models. New vertical amplifier circuitry gives improved frequency response — amplifier within  $\pm 2$  db from 10 cycles to 1 MC — useful beyond 5 MC. This excellent frequency response allows observation of TV Sync. pulses with front and back porches clearly displayed. Ideal for all radio and TV servicing.

Greatly increased vertical sensitivity of .025 V RMS per inch gives you that extra sensitivity needed for lower level signal observations. Now you can clearly observe weak signals. A fine feature for schools and laboratories.

Direct connections to CR tube deflection plates easily made on special terminal board accessible through removable plate in back of cabinet. Hams like this arrangement for checking percent modulation in transmitter tests, etc.

Note the beautiful newly designed cabinet with its rounded corners and fitted panel. The new baked enamel panel is really tough for taking laboratory and service bench abuse.

5CP1 CR tube with intensifier gives greater trace brilliance. Special 3 step input attenuator is convenient when working with input levels of greatly different magnitudes. Scope has internal synchronization which operates on either positive or negative peaks of input signal — Z axis modulation (intensity modulation) — provisions for external synchronization.

Comes complete, detailed instruction manual has step-by-step instructions, pictorials, schematic, circuit description and uses of scope. All parts furnished — tubes (including CR tube), chassis, cabinet, transformer, etc.

**\$43<sup>50</sup>**  
**MODEL O-8**      SHIPPING WEIGHT 29 LBS.

**INTENSIFIER KIT:** For extreme trace brilliance in special applications such as photography, group demonstrations or operation in brightly lighted areas, an optional Intensifier kit providing 2200 volt operation of the CR tube is available. Kit includes high voltage filter condenser, high voltage selenium rectifier, etc. **\$7.50**

Figure 10: O-8 Oscilloscope ad from the October 1952 Heathkit Flyer, courtesy of Chuck Penson - WA7ZZE



**Figure 11:** Heath was so proud of their new 5-way binding post they offered them separately in packs of 10 pairs for many years (1953-54 Winter Flyer Ad).

the 5CP1. PDA, as explained in the CRT article<sup>3</sup>, stands for Post Deflection Anode. The faster the beam passes between the deflection plates the more voltage is needed to deflect the beam the same amount. By accelerating the beam after deflection a much brighter spot is possible without compromising sensitivity.

**The O-8 Front Panel:**

**Figure 12** shows the front panel of the O-8. Note the change in style from the earlier scopes. Chuck Penson refers to this style as Late Pre-Classic<sup>6</sup>. The control layout is identical to the O-7 with the single difference being the attenuator now has three positions. The FREQ. VERNER potentiometer is the same specially coupled dual one used in the O-7, allowing good vernier action.

**The O-8 Specifications:**

The O-8 specifications are shown in Table III. The vertical amplifier sensitivity has increased by 20%, and direct access to the de-

flection plates is available again (for the first time in a push-pull scope); but now the connections are made to a terminal strip behind a removable plate at the rear of the scope. Heath also continued to refine the frequency response specifications, giving  $\pm 2$  db and  $\pm 6$  db ranges.

**O-8 Circuit Description:**

The O-8 circuit is very close to the O-7; for the first time, since the O-1, peaking coils are used on the vertical amplifier. They will continue to be used through the O-12. The other big (but very simple) change is the PDA CRT circuitry that is covered in the HV section.



**Figure 12:** Heath O-8 1953 5" Oscilloscope Photo by Keith Greenhalgh (See Note 1)

**O-8 B+ Power Supply:**

The O-8 B+ power supply is identical to the O-7 with the exception that it uses a new power transformer. The B+ windings, however, remain the same.

**O-8 HV Supply and CRT:**

The new transformer's HV winding current has been increased from 3 mA to 5 mA to supply the extra beam current due to the PDA. With the new 5CP1 CRT, the HV divider chain has had its resistor values tweaked some to provide the proper intensity and focus voltage ranges. The astigmatism (spot shape) control remains. The PDA is powered directly from +400 volt B+.

Heath provided an optional "Intensifier Kit" for the O-8 for an additional \$7.50. This kit increases the overall acceleration voltage

from around 1.4 KV to 2.2 KV. No information has been found by the author on this accessory kit<sup>7</sup>, however it appears to add a voltage doubler off the B+ supply using a HV selenium rectifier and additional filter capacitor to increase the PDA voltage to around +800 volts. This results is a much brighter spot, especially at the faster sweep rates.

**O-8 Vertical Attenuator:**

Heath improved on the O-6 and O-7 attenuator by adding a third attenuation. The O-8 offers x1, x10 and x100 attenuation.

**O-8 Vertical/Horizontal Deflection Amplifiers:**

The vertical and horizontal amplifiers are almost identical to the O-7. Figure 13 is a schematic of the O-8 vertical amplifier including the cascaded preamplifier and phase splitter. The only difference between the O-7

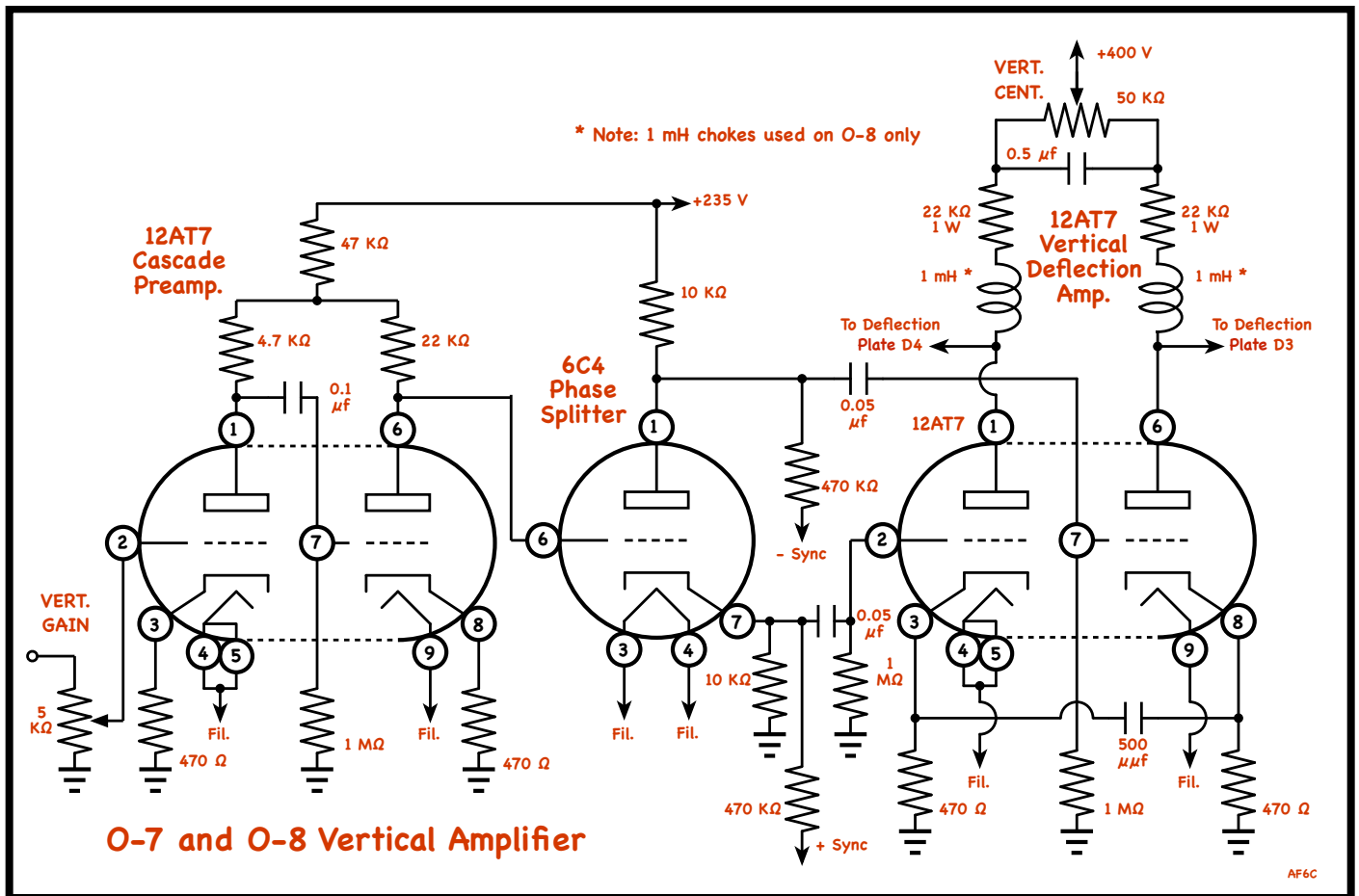


Figure 13: O-7 / O-8 Oscilloscope Vertical amplifier

and O-8 is the addition of peaking coils in the plate circuit of the deflection amplifier for added frequency response. The phase splitter has equal resistances in the plate and cathode circuit and the signal amplitude appearing across them are identical but 180° out of phase. These two signals each drive a section of the deflection amplifier. They also provide sync signals to the sweep circuit. Either may be selected by the sync pot to allow syncing on positive or negative waveforms.

The horizontal amplifier doesn't have the preamplifier, and it has a different phase splitter circuit (Figure 14). To provide a horizontal gain control Heath uses a dual-5 KΩ potentiometer that adjusts the gain of each phase of the signals going to the horizontal deflection amplifier. The horizontal deflection amplifier is identical to the vertical circuit with two exceptions, first there are no peaking coils, and second, the tube sections are reversed, probably to reduce lead length.

Figure 15 shows the rear of an uncased O-8. Note the four miniature tube sockets on the vertical CRT support. The single tube socket on the left is the horizontal deflection amplifier. Its 6J5 phase splitter is on the main chassis. The three tube sockets on the right are (from bottom to top) the preamplifier, the 6C4 phase splitter, and the vertical deflection amplifier. The two peaking coils are the brown components located below, and partially behind, the large screw-type terminal strip. this terminal strip is available behind a metal plate on the rear of the scope and allows direct connection to the CRT plates.

**O-8 Sweep and Sync Circuit:**

This circuit is identical to the O-7. Refer to the O-7 section for details.

**Summary:**

A lot of ground has been covered in this article. There remain four more O-series scopes

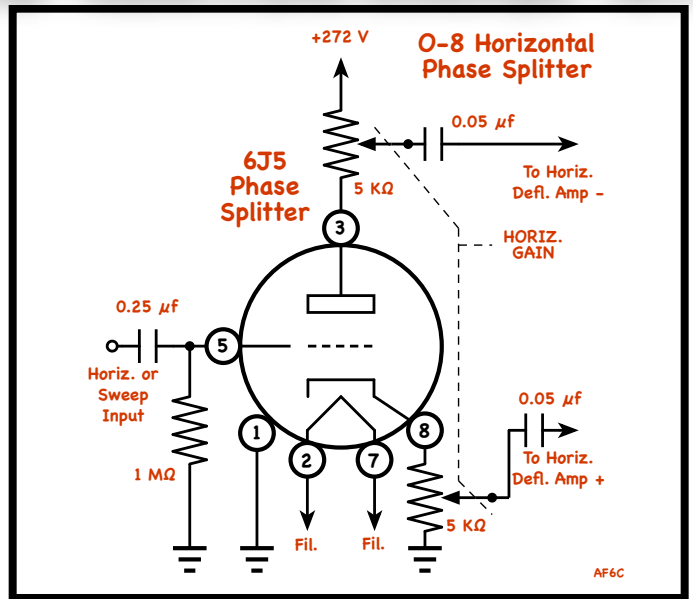


Figure 14: The O-7 and O-8 use a different phase-splitter for the horizontal amplifier than is used in the vertical amplifier.

that Heathkit sold. The third part of this trilogy is still a few months off. Meanwhile we'll touch on some other kits, and hopefully shorter articles!

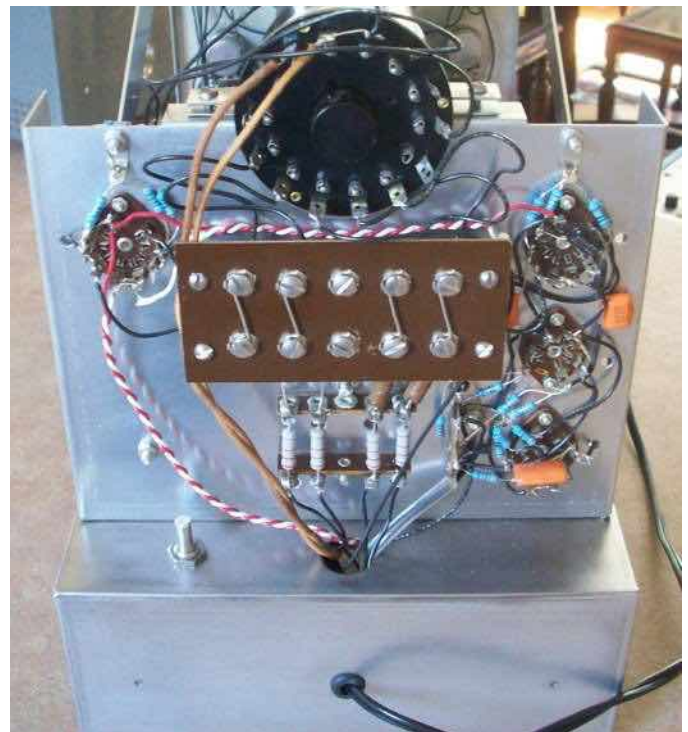


Figure 12: O-8 rear view showing CRT socket and terminals for deflection plate access. Photo by Keith Greenhalgh (See Note 1)

Specification	O-5	O-6	O-7	O-8
Announced Date: Discontinued Date:	September 1949 August 1950	September 1950 August 1951	September 1951 August 1952	September 1952 August 1953
<b>VERTICAL AMPLIFIER</b>	Push - Pull	Push - Pull	Push - Pull	Push - Pull
Input Impedance	1 MΩ	3.3 MΩ / 35μmf	2 MΩ / 30μmf	2 MΩ / 47μmf (x1) 2 MΩ / 35μmf (x10/x100)
Sensitivity (volts per inch)	0.06 Vrms	0.09 Vrms	0.03 Vrms	0.025 Vrms @ 1kc
Maximum Input Voltage	400 Vrms	(x100) 600 V, (x1) 10 V	(x70) 400 V, (x1) 6 V	(x100/x10) ?, (x1) 5 V
Freq. Response.	Useful to 2.5 MHz (at maximum gain)	Useful to 2 MHz	+2 db / 10 cps -24 db 2 MHz (1kc ref.)	±2 db 10 cps to 1 mc ±6 db 5 cps to 2 mc
Attenuator	none	x1 / x100	x1 / x70 (b)	x1 / x10 / x100
<b>HORIZONTAL AMPLIFIER</b>	Push - Pull	Push - Pull (w/DC input)	Push - Pull	Push - Pull
Input Impedance	1 MΩ	250 KΩ / 50μmf	2 MΩ / 30μmf	1 MΩ / 25μmf
Sensitivity (volts per inch)	0.06 Vrms	0.04 Vrms	0.6 Vrms @ 1kc	0.6 Vrms @ 1kc
Freq. Response H Amp.	Useful to 2.5 mc (at maximum gain)	Useful to 2 MHz	+2 db at 10 cps -12 db / 2 mc (1 kc ref.)	± 6 db 10 cps to 1 mc
<b>SWEEP CIRCUIT</b>	Multivibrator	Multivibrator	Multivibrator	Multivibrator
Horizontal Sweep Range	15 cps to 70 kc	15 cps to 100 kc	15 cps to 100 kc (c)	15 cps to 100 kc
Range Switch Positions	5	5	4	4
60-cycle Test Voltage Post	Yes	Yes	Yes	Yes
<b>SYNCHRONIZATION</b>	From Vert. amp plate	from vertical channel	from vertical channel	from phase splitter
External Input	Yes	Yes	Yes	Yes
Sync. Polarity	Positive only	Positive & Negative	Positive & Negative	Positive & Negative
Power - 50/60 cps	105/120 VAC 60 W	105/125 VAC 60 W	105/125 VAC 70 W	105/125 VAC 70 W
Fuse	Dual @ 1 amp (internal)	One @1 amp (internal)	One @ 1½ amp (internal)	One @ 1½ amp (internal)
Electrostatic CRT Shield	Yes	Yes - Improved type	No	No
Astigmatism (spot) Control	No	No	Yes	Yes
Direct Input to CRT Deflection Plates	No	No	No	Yes
'Z' Intensity Modulation Input	Yes	Yes	Yes	Yes
Size H" x W" x D"	13 x 8-1/2 x 17	13 x 8-1/2 x 17	13 x 8-1/2 x 17	14-1/8 x 8-5/8 x 18
Shipping Weight (lb.)	25 (a)	30	29 (a)	29
Price US\$	\$39.50	\$39.50	\$43.50	\$43.50
<b>COLOR KEY:</b>	From manual specs.	From flyer ads	From scope photos or schematic	

Table III: Heathkit O-5 through O-8 Specifications (Table notes on next page)

As time permits a page will show up on the Heath of the Month website with links to a short pdf with each kit's schematic, parts list, specifications and introductory ad when available. Parts lists for the O-1 and O-2 have not been found, nor have any specifications other than that found in ads. If you have any of this information please get in touch using the link at the end of this article.

### Acknowledgements:

Obtaining information on twelve different Heathkit oscilloscopes, only one of which I own, seemed a daunting task. Luckily I had help, especially from the following people:

Chuck Penson - WA7ZZE, who is the author of three Heathkit books; *Heathkit - A guide to the Amateur Radio Products*; *Heathkit Test Equipment Products*; and his new book *Heathkit Hi-Fi and Stereo Products*. Chuck supplied me with schematics, specifications, ads from old Heathkit flyers and more.

Keith Greenhalgh, a collector and restorer of many electronic products, who has a large album of excellent high resolution photos of his equipment in and out of the cabinet on Flickr. Many photos include details that helped fill in a lot of questions I had on the Heath O-series kits. Keith has graciously allowed me to use his pictures in this article.

No topic for next month has been set yet. However I hope do a short book review on Chuck's new Heathkit Hi-Fi book.

73, from AF6C



### Specification Notes:

- (a) 24 lb. in early ads.
- (b) calculated - attenuation ratio not given.
- (c) sweep up to 135 kc. claimed in Sept. 51 flyer ad.
- (d) obtained from schematic and/or front panel text.

### Notes:

1. Keith Greenhalgh has an extensive photo album of electronic hi-fi and test equipment on Flickr, many of them Heathkits. You can reach his albums here: <https://www.flickr.com/photos/keithgreenhalgh/albums>
2. [http://www.w6ze.org/Heathkit/Heathkit\\_Index.html](http://www.w6ze.org/Heathkit/Heathkit_Index.html) HOM #85 article (From *RF Newsletter* June 2018)
3. The 5BP1 CRT and others are discussed in detail in *Bob's TechTalk* article #51 published in the May 2018 *RF Newsletter* and available right below the article linked to in the preceding note.
4. Chuck DeVere's book *Cathode Ray Tubes* part of the Tektronix library is available on line at: <http://w140.com/tekwiki/images/6/62/062-0852-01.pdf>
5. The 33 K $\Omega$  resistor is in parallel with the 3.3 M $\Omega$  resulting in 32.7 K $\Omega$ .
6. *Heathkit Test Equipment Products* by Chuck Penson WA7ZZE, 2014 ISBN978-0-615-99133-7 page iv.
7. The "Intensifier Kit" is mentioned briefly in the October 1952 flyer (Figure 10).

*This article originally appeared in the August 2018 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.*

*Remember, if you are getting rid of any old Heathkit Manuals or Catalogs, please pass them along to me for my research.*

*Thanks - AF6C*