Heathkit of the Month #105:
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Heathkit

AMATEUR RADIO - SWL

Heathkit KS-1
HV KW PLATE POWER SUPPLY.

Introduction:

The Heathkit SB-200/201 and SB-220/221 (HotM #33 & #49 respectively) were very popular linear RF amplifiers in their day. They still remain popular and most still remain in use. However, Heathkit's foray into the high-power RF amplifier field, began back in 1959 with the introduction of the KL-1 Chippewa HF Kilowatt Amplifier. This amplifier will be discussed in detail in an upcoming HotM article. The 61 lb. Chippewa is a full KW amplifier that operates both as a linear amplifier on AM and SSB and a Class C amplifier on CW. The power input to its pair of Eimac 4-400A tubes is 2,000 watts PEP on SSB and 1,000 watts on AM (linear) and CW. The Chippewa has a built-in bias power supply and also supplies all the filament current needed for the tubes. However the HV for the plates and screens must be provided externally. The Chippewa requires 3,000 V at 500 ma (1 amp peak). To supply this power Heathkit developed the 95 lb. KS-1 power supply (**Figure 1**). The open frame construction of the KS-1 on a 3" high steel chassis, while well shielded to prevent contact with dangerous high-voltage points, is designed to be located out-of-sight and not take up desk space.

Here is a link to the index of Heathkit of the Month (HotM) articles:

http://www.w6ze.org/Heathkit/Heathkit_Index.html

Figure 1: Heathkit KS-1 3,000 V Power Supply with its open frame construction. Rectifier tubes (A pair of 866A's) are in meshed cage at front left.

While designed to provide plate and screen power to the Heathkit amplifier, the KS-1 can also be used to power home-brew amplifiers of the sixties, and probably many people saw the KS-1 as an inexpensive alternative to a home constructed power supply. The KS-1 can supply either 3,000 VDC or 1,500 VDC, each at 500 ma (1 amp peak) by simple wiring changes. Heath recommends the power supply be run off 230 VAC but is also capable of running off the lower 115 VAC from a dedicated 20 ampere circuit.

The KS-1 was introduced a few months before the KL-1 in 1959. It sold for $169.95. In the May 1961 Heathkit catalog supplement the KS-1 and its companion the KL-1 were offered in a closeout special. (**Figure 2**) The close out price of the KS-1 was dropped to $129.95. The KL-1 was again featured in the April 1962 catalog closeout section without the KS-1 which had evidently been sold-out.

The KS-1 (as well as the KL-1) were not sold for very long and are considered rare today. **Figure 1** was obtained from the specification

sheet as no decent photo of a KS-1 could be found.

About the time the KL-1/KS-1 came out, Collins Radio started selling the 30L1 linear. While not a full 2 KW PEP amplifier it was tiny compared to the Heath amplifier and had a built-in power supply. The Collins design was based on an IVS (intermittent voice service) power supply[1] that takes into consideration the low duty factor of SSB and CW.

There is no question that the design of the KL-1/KS-1 was very conservative and overkill. Heath evidently realized this and had already started on its own IVS powered amplifier replacement - the HA-10 Warrior.

The KS-1 Power Supply:

The reason the KS-1 sold out before the KL-1 is likely because many were bought by home brewers. There is no question that this is a rugged, over-designed power supply, and probably a home-brewer could not purchase the individual components in 1961 dollars for the price Heath was selling it for in close-out.

The specifications for the KS-1 are given in **Table I**. Note that no duty factor is mentioned in the specifications or manual so the power supply could be expected run all day at the specified 1,500 maximum output rating.

HEATHKIT KS-1 SPECIFICATIONS

Maximum DC Power Output:	1,500 watts
Nominal DC Voltage Output:	1,500 or 3,000 volts*
Maximum DC Current Output:	Average: 500 ma Peak: 1,000 ma
Regulation:	
180 - 600 ma (Typical linear amplifier)	8%
0 - 300 ma (typical Class C amplifier)	10%
0 - 500 ma	15%
Ripple:	Less than 1%
Duty Cycle:	(Not given)
Tube Complement:	Two 866A mercury vapor rectifier tubes
Recommended Ambient Temp.:	50° - 100° F
Line Power Requirements:	115 V. - 20 amperes 230 V. 10 amperes
Line AC frequency:	50 / 60 cycles per second
Chassis Size:	17 ¾" W x 12" H x 13" D
Net Weight:	95 lbs.
Shipping weight:	105 lbs. (freight)

* 1,500 volt operation uses either 115 volts or a single leg of the 230 volt line.

TABLE I

The KS-1 Controls and Connections:

The The KS-1 power supply has no switches or controls, external or internal. The front of the chassis is adorned only with the raised plastic *Heathkit* signature emblem and a "Danger High Voltage" decal. Control of the power supply is accomplished in the KL-1 Chippewa amplifier via a six-wire cable. For those using the power supply with a home-brew amplifier Heath provides the needed wiring diagram for the control circuit. The control circuit consists of two **OFF/ON** switches, **POWER** and **HV** and three indicator lights, **POWER**, **READY** and **HV**. The READY light is controlled by the time delay relay and comes on after an allotted 60 second warm-up time.

The rear panel connections, from left to right as viewed from the rear, are: The HV connector, GROUND stud with wing-nut, octal CONTROL socket, 3-wire line cord with strain relief, FUSE B socket and FUSE A socket. The two fuse sockets take the standard screw-in fuses of yesteryear (**Figure 4**), and the HV connector mounted on the chassis is a UG-496/U[2] HN-coaxial connector. The mating male cable connector is the UG-59A/U[3].

[1] Notes appear on page 9.

Figure 2: Close out ad from the May 1961 supplement Heathkit catalog for the KS-1 and KL-1. In the same ad Heathkit announced the HA-10 Warrior 1 KW linear amplifier for $229 with built-in power supply.

Figure 3 (Right): Top layout of the KS-1 power supply showing major component locations and part numbers. The 17 ¾ inch width allows the power supply to be mounted in a 19" 'relay rack' if desired. One can imagine a 12¼ or 14" high rack panel with brackets attached to the front of the KS-1 and the power supply neatly mounted to it. One could move the Heathkit emblem and front High Voltage warning decal to the new front panel and add a window to show the glow of the rectifier tubes.
(Drawing is not to scale).

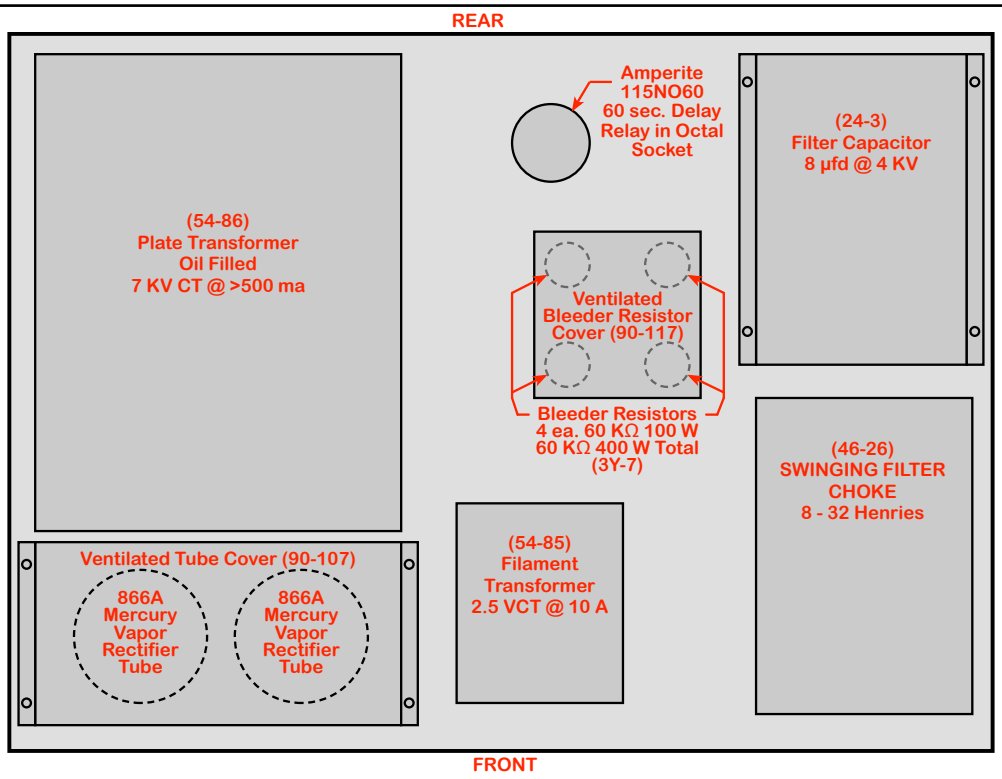


Figure 4: Old style screw-in fuse as used in the KS-1. Two 15 A fuses are required for 230 volt operation and one 25 A fuse is required for 115 volt operation.

The KS-1 Major Components:

Figure 3 shows a top-view layout of the major components of the KS-1

The Plate Transformer

The heart of this power supply is the plate transformer. It is an oil filled hermetically sealed unit rated at 7,000 volts center tapped and capable of at least 500 ma. The manufacturer and specifications are not given in the parts list or other available information.

The Rectifier Tubes

The rectifier tubes are a pair of 866A mercury vapor tubes. These bring back memories. In use they provide a brilliant blue glow, dependent on current draw, that is so impressive that hams in the fifties and sixties actually located the tubes near the front of their home-brew power supply's front panel and cut an opening filled with a sheet of glass (often backed with a shielding screen) so they could monitor the glow which brightened with each press of the key and danced with each syllable of their voice.

The 866A has some quirks that a user should be aware of. First, the tubes need to be warmed up prior to the high voltage being applied. This is done in the KS-1 with a 60 second delay timer that prevents the high voltage from turning on until the filaments are warmed up. There is another requirement that is mentioned in the manual. If the tubes are new, have not been used for a long time or have been laying on their side in storage, (In use the tube must be positioned vertically with the base down) it is required that the tubes be excited with filament voltage only for a period of 20 to 30 minutes to fully vaporize the mercury and make sure there is no residuals on the cathode that can cause flash-over and resultant damage to the tubes.

The rectifier tubes are mounted on a subchassis below the main chassis to keep their height low and provide some cooling room under the ventilated tube cover.

Filament Transformer

A 2.5 volt filament transformer provides 10 amps of filament current to the two 866A rectifier tubes (5 amps each). It is designed to handle high peak voltages and is center-tapped, which is where the HV is taken from to go to the filter.

Swinging Choke

The KS-1 uses a single stage choke input filter for regulation and ripple filtering. The choke is a swinging choke in that its inductance is high with low current draw and low with high current draw.

Of importance in a choke input filter is the "critical" inductance of the choke itself. If the choke's inductance is below the critical value the filter will act as a capacitive input filter. At low currents the voltage will rise significantly, up to 1.4 times the secondary value. This puts a burden on the filter capacitor due to an over voltage condition. At high currents it puts a burden on the transformer and rectifier tubes due to the higher peak current drawn. At the same time regulation and ripple filtering suffer.

The KS-1 uses a swinging choke that is rated at 32 henrys at low current and 8 henrys at high current. The equation for critical inductance is:

$$L_h = \frac{E_{out}}{I}$$

where L_h is the critical inductance of the choke in henrys, E is the output of the supply in volts, and I is the current in mA being drawn through the choke. Solving the equation shows the minimum required current being drawn must be a bit under 95 mA. The bleeder resistors draw just over half of that (50 mA) and the rest is assumed to be the idling current of the device the power supply is supplying. At the high end 8 H is more than enough to meet the critical inductance. Notice it would not be good to leave the power supply on with no load for long periods.

Not too long after the KS-1 was released Heathkit changed the choke in a special Notice**.** Heath stated: *"The KS-1 filter choke (#46-26) has been modified to improve its performance and now features ceramic insulated terminals instead of wire leads…"*. The modification announced two new versions of the #46-26 choke with different layouts of the new ceramic terminals. the new chassis were drilled to accommodate either. Electrical changes to the choke, if any, were not mentioned. This note is available online [4].

Filter Capacitor

A high voltage (4KV) 8 µf oil filled hermetically sealed capacitor is used after the choke to reduce ripple and provide further voltage regulation. The two capacitor terminals are ceramic feed throughs and the capacitor mounts using two hooked brackets that fit over the top lip of the capacitor and bolt to the chassis. This is a non-electrolytic capacitor.

Bleeder Resistor Array

The bleeder array consists of four 60 KΩ resistors – two pairs of parallel resistors in series. Each resistor is rated at 100 watts. The total resistance is 60 KΩ at 400 watts. At 3,000 volts the array draws 50 mA (150 watts) with each resistor dissipating 37.5 watts. Bleeder resistors help keep the choke input filter above the critical inductance, but they also play a major safety factor; they discharge the HV filter capacitor in a short time. Otherwise the capacitor can hold a lethal charge for a long time; this is especially true for oil capacitors which have low leakage rates. While Heathkit could have profited by using 50 watt resistors, in foresight they must have realized that if one resistor fails, its shunted mate would have to dissipate 67 watts which would have quickly caused that resistor to fail too. Dead hams don't buy Heathkits!

115 VAC Mains Operation:

While it is recommended that the KS-1 be operated from 230 VAC mains, the supply can be wired to operate from 115 VAC and still supply the full 3,000 V at the rated current. This may require a separate circuit since the power supply will draw up to a full 20 amps.

If the KS-1 is wired to produce 1,500 volts at 500 mA the 115 VAC current requirement drops to 10 A. When wired for 230 VAC and using the 1,500 volts output, the power sup-

Figure 5: Screw-in receptacle recommended to replace FUSE B for 115 volt operation. The receptacle may be used as a switched AC outlet.

ply draws its power from only one leg of the 230 volt line (effectively 115 volts).

Modification for use with 115 VAC involves removing FUSE B and connecting a 14 gauge jumper between lug one of FUSE B socket and pin 3 of the octal CONTROL socket. After this modification is made the power supply will provide 1,500 VDC at 500 mA. (See **Figure 6**). To achieve 3,000 volts @ 500 mA the two primary windings must be rewired so the windings are in parallel. (Terminals 1 and 3 wired together and terminals 2 and 4 wired together). (See **Figure 7**).

When wired for 115 VAC mains no fuse should be placed in FUSE socket B. Instead Heath recommends one purchase a socket outlet (**Figure 5**) and install that in FUSE socket B. The power cord may still be wired and connected to 230 VAC but current will only be drawn from one leg of the 230 volt line. In that case the socket outlet may be used as a "convenience" 115 VAC outlet. If wired to a 115 VAC line a jumper can be installed as shown in **Figures 6** & **7** to activate the socket outlet; just be aware the available current will be limited due to the heavy draw by the KS-1. It is recommended that this jumper be placed external to the KS-1 as part of the power 115 VAC power cord so it won't be overlooked if the power supply gets converted back to 230 VAC operation. **Table II** shows the fuse choices for the KS-1.

HEATHKIT KS-1 FUSE INFORMATION

Mains Voltage	Output Voltage	Fuse A	Fuse B
230 V	3,000 V	15 A	15 A
230 V*	1,500 V	15 A	n/A**
115 V	3,000 V	25 A	N/A**
115 V	1,500 V	15 A	N/A**

* Draws power from only one side of the 230 VAC line.

** NEVER PUT A FUSE IN FUSE SOCKET B WHEN THE KS-1 IS WIRED FOR 115 VAC or 1,500 VDC. Instead, place a screw-in receptacle in the socket.

TABLE II

Circuit Description:

Figure 8 shows the KS-1 power supply schematic as wired for 230 VAC and 3,000 VDC output operation. The schematic also shows the wiring of a typical control circuit – this one is the circuit in the KL-1 Chippewa amplifier. Note that the amplifier gets the 115 volts AC needed to power the filaments and bias supply in the amplifier from the CONTROL socket.

Primary Circuit

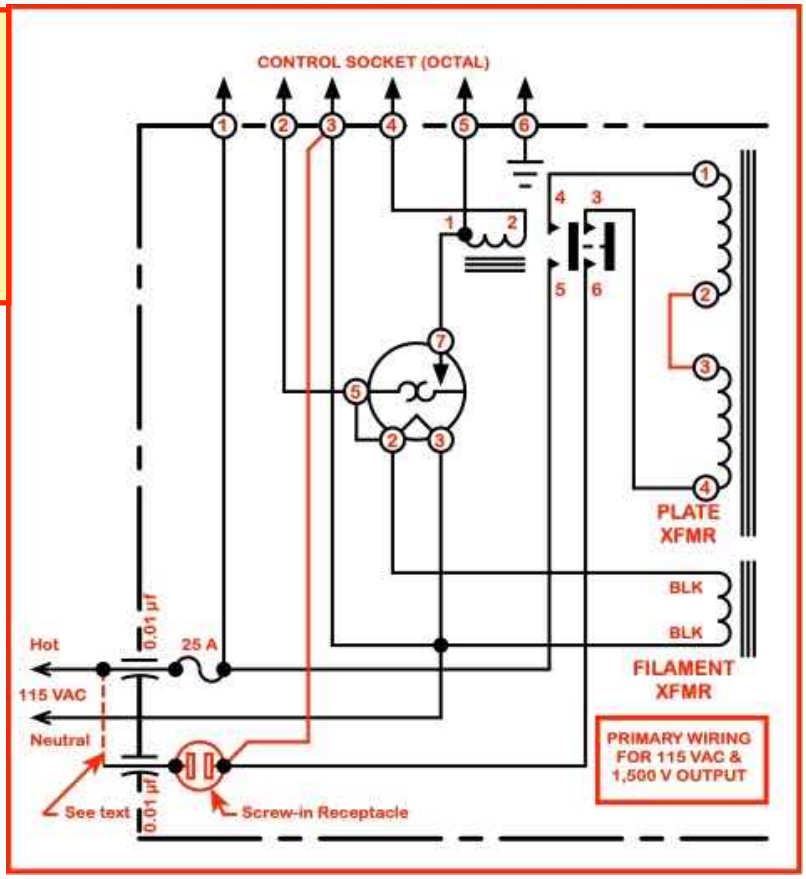
Power is applied to the control circuit whenever the KL-1 is plugged in – hot 115 volts through pin 1 and neutral through pin 3 of the control socket. When the control circuit POWER switch is closed, the 115 VAC power is applied to the amplifier and the POWER lamp illuminates. Power is also applied through pin-2 of the control socket to the KS-1 filament transformer and to one contact of the time delay relay. Power is also applied to the filament of the time delay relay, initializing the timer.

After a nominal 60 seconds, the delay relay closes; power is connected to one side of the plate relay and to pin-5 of the control socket. In the control circuit the READY light illuminates. When the HV switch is closed neutral is applied to the other side of the plate relay through pin 4, activating it and the HV lamp. The plate relay applies power to the primary of the plate transformer.

Secondary Circuit

The secondary of the plate transformer produces a-voltage of 7,000 volts center tapped. The two 866A rectifier tubes (discussed previously) are wired as a full wave rectifier. The

Figure 6 (To the right): shows the wiring for running the KS-1 from 115 VAC with 1,500 VDC output. The dashed jumper shown in the lower right allows the screw-in receptacle to be powered. If the power cord is wired to 230 VAC per drawing 8 the jumper should not be used and the receptacle will be powered by the other leg of the 220 VAC.



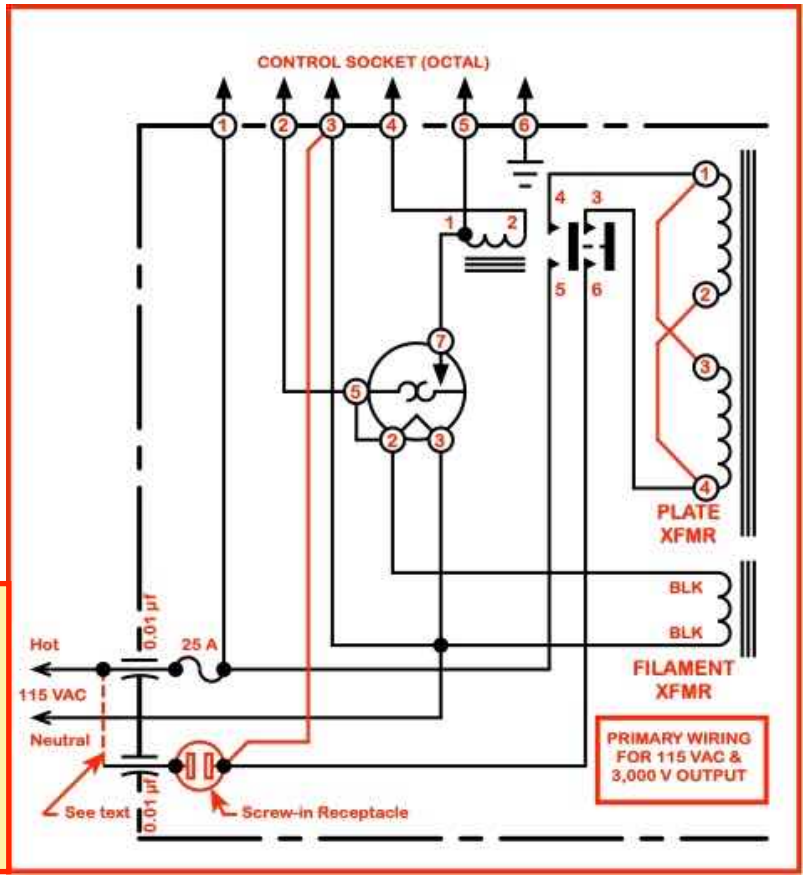
resulting DC voltage is taken from the center tap of the filament transformer secondary and filtered by the swinging choke and 8 µf capacitor. The output is connected to the HV connector on the back of the chassis. A bleeder resistor array sits across the output voltage and ground to act as a minimum load as well as assuring for safety that the capacitors are rapidly discharged after the power is turned off. **Figure 9** shows an under chassis view.

Final Comments

The KS-1 is a very well designed power supply. In the 40's and 50's it would have been an example of conservative engineering. But, with the emergence of SSB, resulting in the steep decline of AM, one has to wonder if the KS-1 was initially designed for AM? The power supply could easily provide plate power to an AM Class C 1-KW amplifier and still have enough power left to easily drive a 500 watt AM modulator.

A major change in technology for HV power supplies was the development of

Figure 7 (To the right): shows the wiring for running the KS-1 from 115 VAC with 3,000 VDC output. The dashed jumper shown in the lower right allows the screw-in receptacle to be powered. If 230 VAC power is available there is no reason to run the KS-1 off 115 VAC though it is possible mentioned in the Figure 6 caption.



the silicon rectifier diode. Not long after the development of the KS-1 the pair of 866A tubes and 25 watt filament transformer, along with tube sockets, extra needed space, additional heat, etc. could be replaced by a string of solid-state diodes costing just pennies.

Next month is April, and with it we will once again be looking at one of Heath's more unusual kits. A lot depends on whether I can get a manual for the kit I'm thinking about featuring. You'll just have to wait until next month to find out the kit I'm thinking of But here's a clue; it's based on a song by *The Who*!

Errata:

In HotM #30 **(SB-Line - Overview)** in the discussion of older and newer style filters, it was stated: "

"The later filters are narrower, but the mounting and terminals are reported to be the same so you should be able to use the smaller filter in an older radio but not the other way around without modification."

The mounting and terminals are different, so while the new filters will fit size-wise, new holes must be drilled in the chassis to accommodate the relocated mounting studs and terminals. Thanks to Chuck Penson WA7ZZE for pointing that out.

73, from AF6C

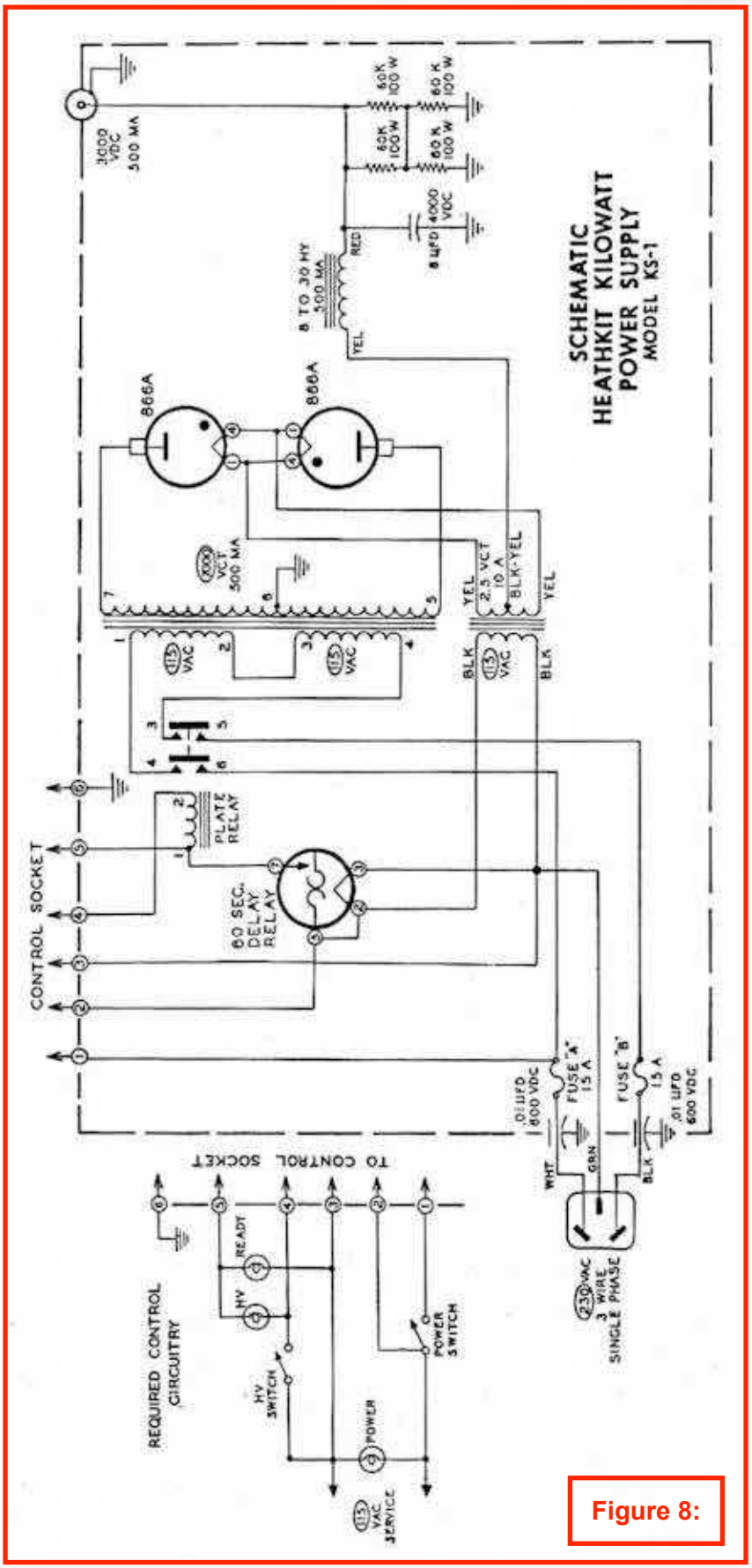


Figure 8:

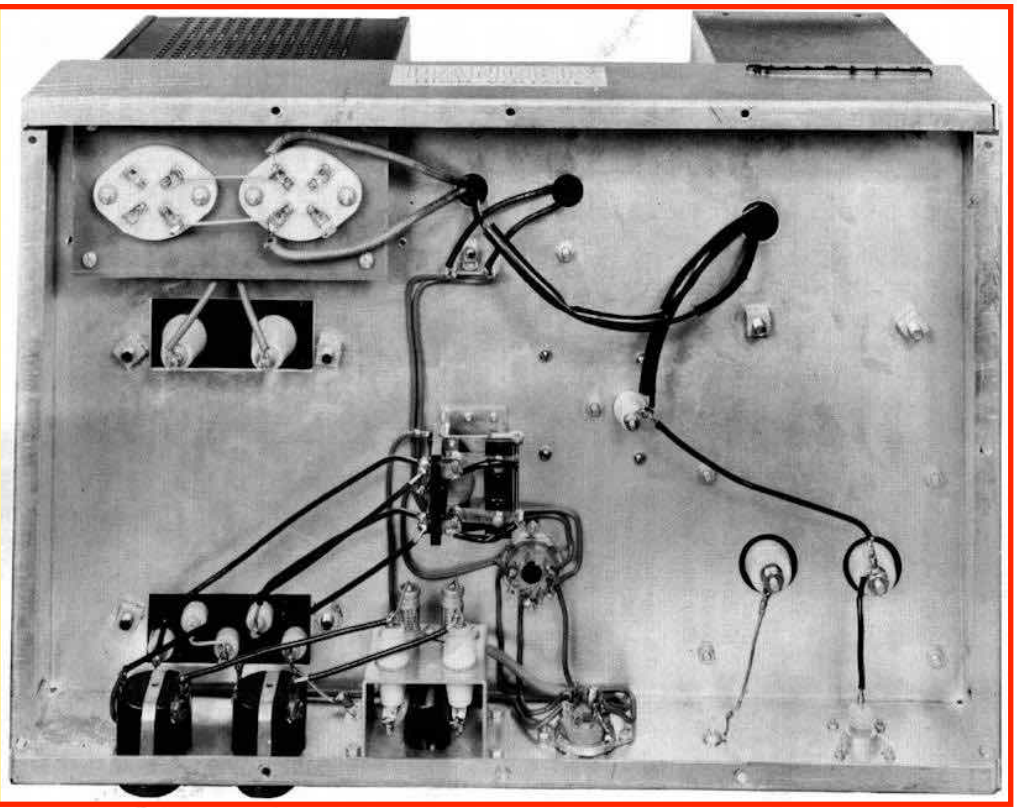


Figure 9: An underside view of the KS-1 Power Supply. On the upper left are the two sockets for the 866A rectifier tubes. Directly below them are the porcelain feed-throughs from the plate transformer secondary that go to the tube plate caps. In the center is the plate relay and to its lower left is the time delay relay. The feed through just right of center goes to the bleeder resistor assembly. The two feed throughs near the lower right are the filter capacitor. Along the bottom lip are the two fuse sockets, AC power feed-through caps, the octal control socket and on the right is the HV connector.

Notes:

1. Radio Handbook (21st Ed.) Bill Orr W6SAI Section 23-7 “Solid State Supplies for SSB”.
2. UG-496/U Female chassis mount, Amphenol 82−92, (Heath 436-15)
3. UG-59A/U Male cable connector, Amphenol 82−38, (Heath 438-21)
4. Heath KS-1 Special Notice is available at http://www.w6ze.org/Heathkit/TN/KS1Choke.pdf

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

Thanks - AF6C