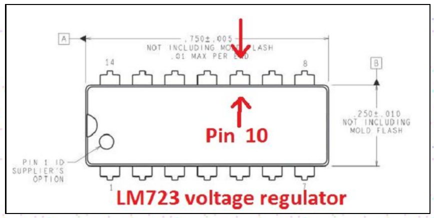
Putting the Power back into the Pyramid

Since the previous project on the bench featured a homebrew power supply, I decided to add another high current low voltage supply, a Pyramid PS-21KX that I purchased for cheap at a hamfest. The Pyramid was heavy as expected for a linear supply with a big transformer. As usual, my curiosity as to why it had failed got the better of me. Besides, for $5 it was worth buying for just the transformer, the case and the nice ammeter.

The supply provides 13.8 volts and is rated at 18 amps continuous and 20 amps surge. It is apparently still sold and the manual is available by clicking on the "manual download" icon to the right of the picture on this link.

The specification list features "Electronic Overload Protection with Auto Reset, Short Circuit Thermal Protection, Built-in Cooling Fan, and Crowbar Over-Voltage Protection".

Checking out the circuit.
I downloaded the 4 page manual from the link above. The voltage regulator in this supply, like so many other ham radio linear power supplies, is the little LM-723 fourteen pin integrated circuit, also written as uA-723. Its voltage output (pin reference 10) provides a maximum current of 150 mA which is then fed to the base of NPN transistor TIP41. The emitter of the TIP-41 feeds the bases of four parallel 2N3055 NPN pass transistors (by way of a diode in parallel with an 18 ohm resistor and through a thermal switch). It is a classic linear power supply circuit used by Astron and others. The collectors of the four 2N3055 are fed by unregulated DC from the combination of the power transformer, heavy duty diode bridge and capacitor filter bank (five 4700 uF caps in parallel). The unregulated power supply parts seldom fail. In each of these linear power supplies, the voltage at the bases of the four pass transistors determines the voltage at the emitters which provide the output of the power supply. Short circuit thermal protection is by way of the automatic reset thermal cutout switch.



Although the specifications mention a crowbar circuit, neither this Pyramid nor the manual schematic show the existence of one. A typical crowbar circuit is an SCR that is activated by over-voltage, short circuiting the output which then typically blows the fuse.

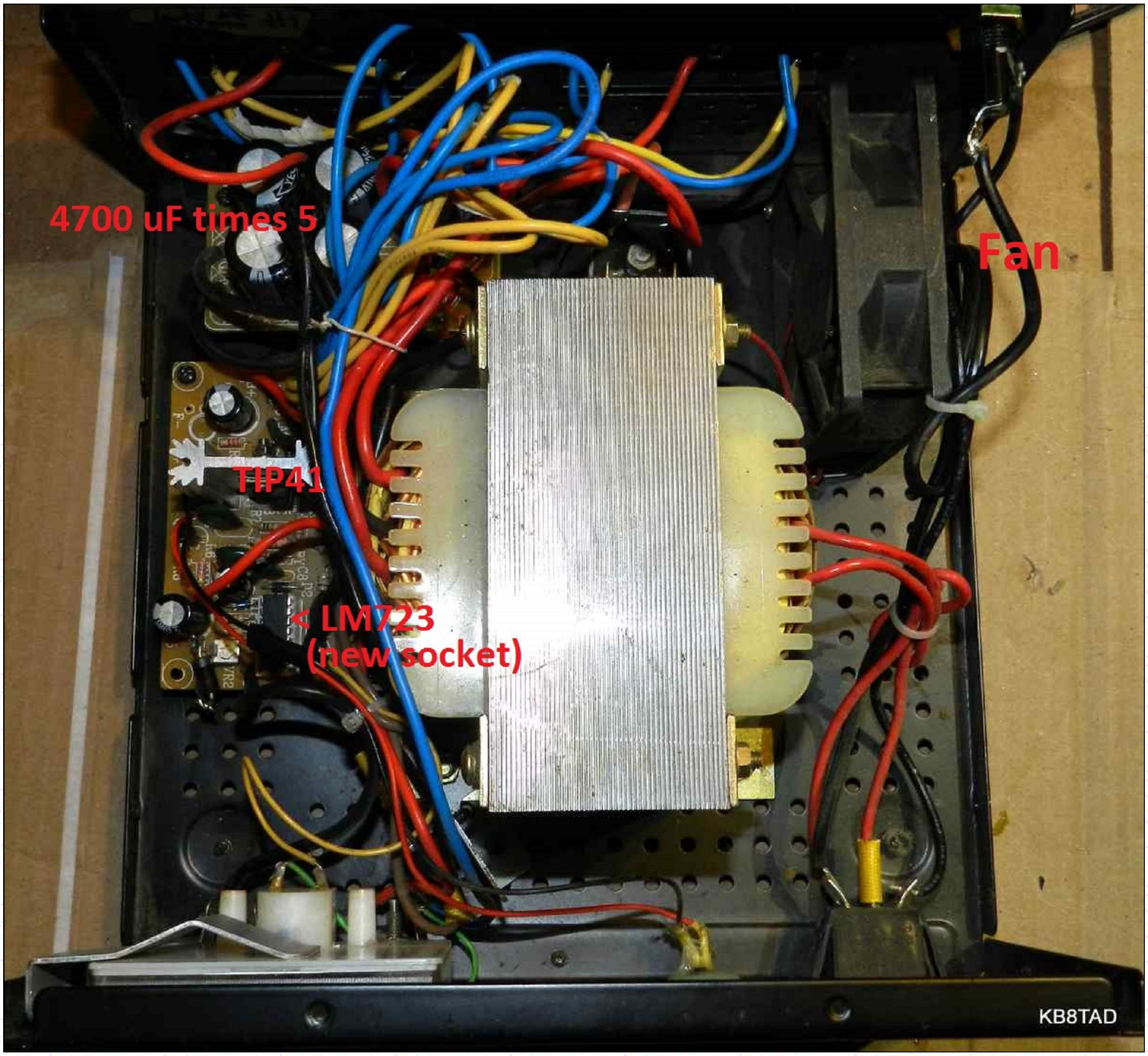
The LM-723

Texas Instruments has 21 pages of information on the LM-723 (uA-723) That information from TI is very useful for understanding the operation of the chip which is the heart of the Pyramid as well as all of the Astron linear supplies. I usually find the chip dead when the supply fails. If the non-regulated portion of the supply is working, a quick voltage check at pin 10 will verify whether the chip is in fact functional. That voltage would normally be the intended output voltage plus any voltage drops (of the PN junctions of the TIP41, the 2N3055 and the diode and resistors between the TIP41 collector and the 2N3055 base connections).

Repairs

The unregulated power of the Pyramid was in good condition. I found a failed reverse bias diode (D9 on the schematic), a dead LM-723 chip, and 2N3055 pass transistors that appeared to be leaky. Since the reverse bias diode had been blown open, about the only thing I could think of that would cause that is connecting the supply backwards while attempting to charge a battery. That would also explain failed pass transistors.

As expected, the LM-723 in the Pyramid was dead. It is soldered to the circuit board in the Pyramid which I consider a weakness of the design. In Astrons, the chip is mounted in a socket. One of the first things I did with this supply was to solder in a socket so I could more easily replace the chip if needed again. I next checked the 2N3055 transistors which was difficult because the emitter and base connections are also directly soldered. Three of the four had failed open and the fourth exhibited leakage. I replaced all four transistors. The TIP41 was in good condition. I replaced the reverse bias diode with a heavier-duty piece from the junk box.



I puzzled over the thermal switch but that part was working properly. It only sees the current from the TIP41 transistor fed to the bases of the pass transistors. On powering the unit up slowly, I found it working. I cleaned the voltage adjustment variable resistor (VR-2) and checked its setting to verify 13.8 volts output. A load test verified a fully functional power supply. Power had returned to the Pyramid.

Pumping out 16 amps at 13.8 volts

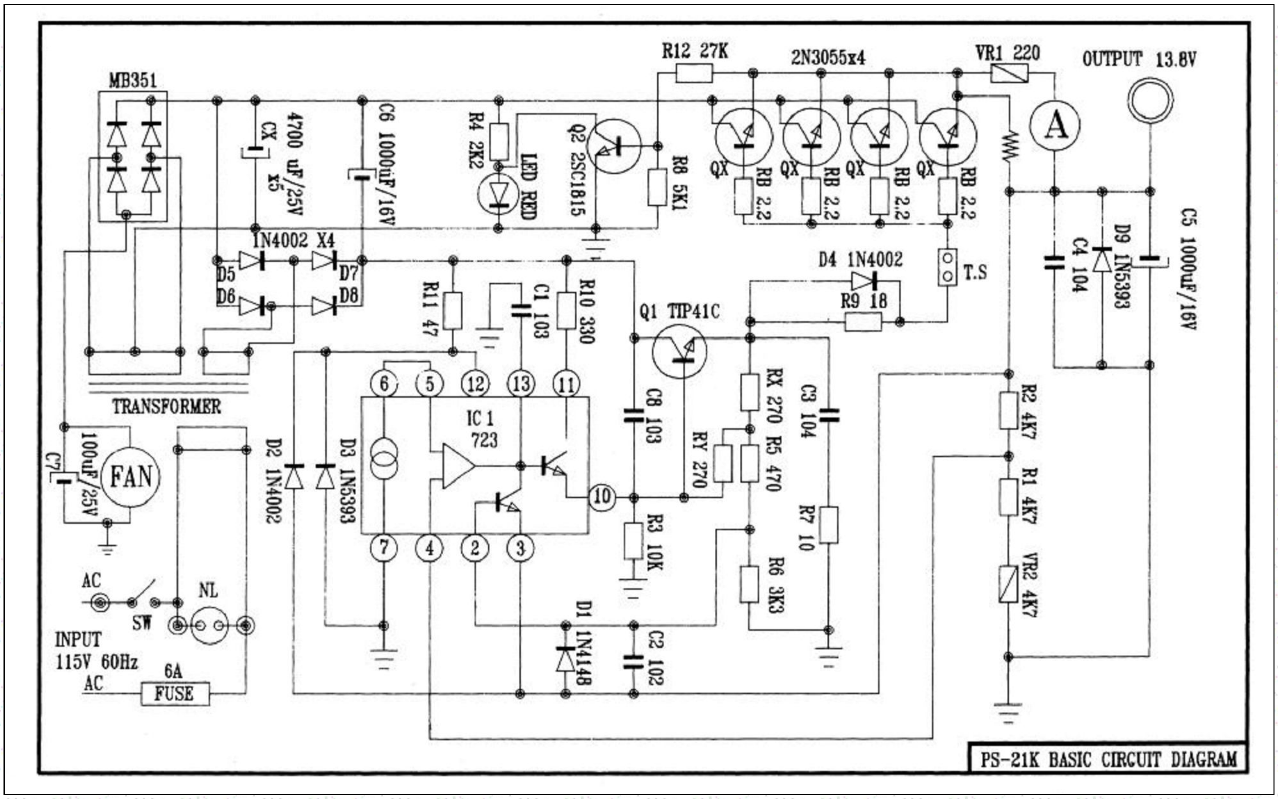
Pyramid Design

I consider the soldered-in chip and pass transistors as a design weakness that makes repairs difficult. The lack of a crowbar circuit is another weakness. Also, comparing the schematic to that of Astrons, the Pyramid inserts a 2.2 ohm resistor in series with each pass transistor base. The Astrons and most other supplies use a resistor such as a 0.1 ohm in each emitter leg. The purpose of those resistors is to balance the load of the four pass transistors. I prefer the use of a balance resistor in the emitter side rather than the base. However, the Pyramid includes a fan which its Astron competitors do not have and the nice large ammeter with accuracy adjustable by variable resistor VR1.

The Pyramid leaves out the MOVs (metal oxide varistors) typical in many other later model linear supplies. A MOV clamps input voltage such as spikes on the power line. A nearby lightning strike can send a spike on the power line which at the very least can knock out the LM-723 chip. Many later model linear supplies include at least one MOV across the AC input rail (after the fuse and power switch). Three would be better, adding one from each side of the power line input to safety ground as well as one across the power line. A simple solution is to plug the Pyramid into a late-model UL and CSA approved surge protector. (My two older APC "Surge Arrestors" were recalled and replaced by APC. MOVs can themselves fail drastically and must be fused accordingly as done in later models of approved surge protectors.)

If I were to use the Pyramid to charge batteries, I would use a high-current diode in the feed-line so that the battery could not feed power back to the supply in the event the supply was shut off. A low-loss schottky diode recycled from a dead computer power supply would meet the need nicely along with a fuse on the output and perhaps another heavy-duty diode as an additional external reverse bias diode to blow that fuse in the event of an accidental reverse battery connection. A resistor in parallel with the schottky could be used for trickle charging to overcome the small voltage drop introduced by the diode. The resistor would be sized for a minimal trickle charge current level.

Pyramid PS-21KX schematic



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A [High power low voltage variable DC supply from recycled parts]was the previous item "on the bench".

[Go back to the BA Pix Homepage.]