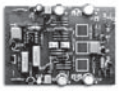


PHOTO 1: The modified HP test unit.

A First-Rate Audio Test Instrument, Part 1

A high-quality sine-wave generator, AC RMS voltmeter, and a worthy candidate for morphing into a reasonably high-power audio dummy load—all in one compact carry case and for a reasonable price!

By Todd Sharp

Recently a friend of mine asked me to put together a basic audio test bench. Other than scouting out a decent oscilloscope and DVM, I decided on an excellent candidate for modification: the HP 3550b transmission test set. The 3550b, with the following modifications, makes a downright sexy addition to any audio test bench. This endeavor proved so useful that I thought it worth sharing with *aX* readers (**Photo 1**).

FEATURES

If you have been to an electronics swap meet or surplus store in the past 20 years, I guarantee you have tripped over at least one of these sets. They also tend to be readily available on eBay, where the prices vary, from as little as $25 to as much as $150. On eBay search for "HP 204c," "HP 403b," or "HP 353a" rather than HP3550b.

The individual model numbers are those pieces included in the set, along with a sturdy steel case with IEC AC service connector, removable cover, and shoulder strap. These were obviously used for field testing of transmission lines of some sort, though with a little ingenuity you can transform yours into a first-class audio test set. They often come with a nice set of patch cables, to boot (**Photo 2**).

The **403b AC RMS voltmeter** (**Photo 3**) represents typical HP quality in a

PHOTO 2: The HP3550b before modification.

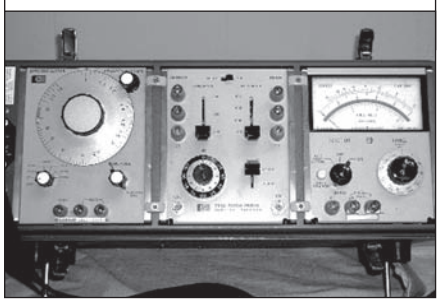
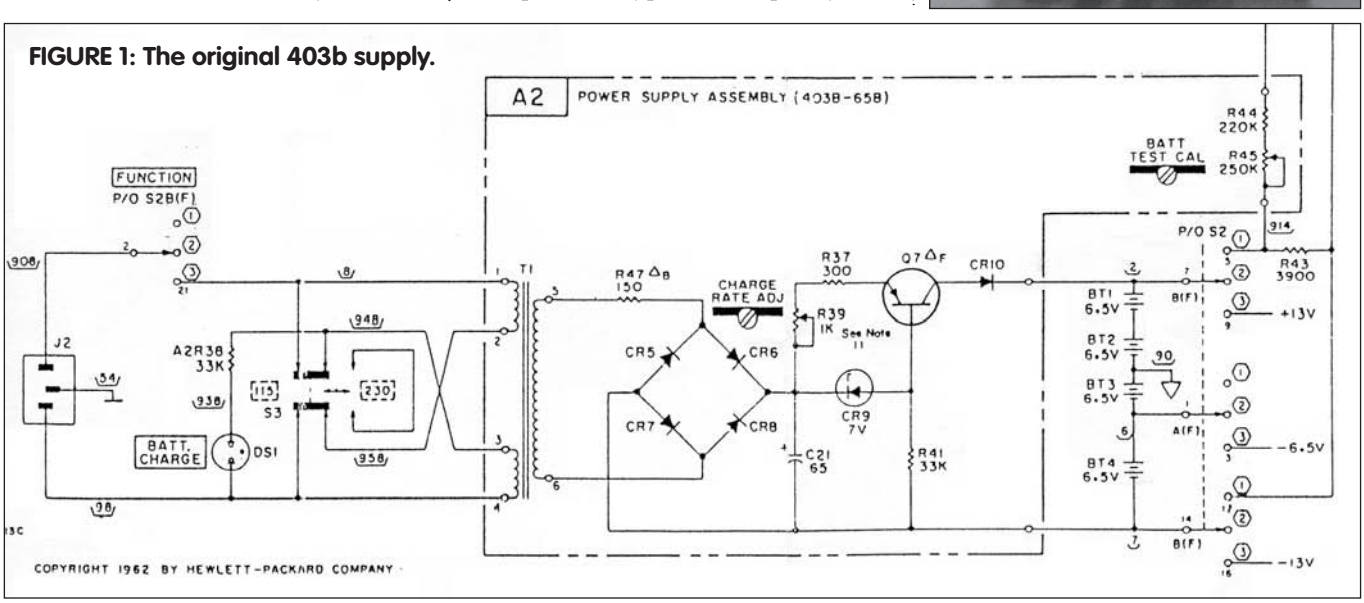


PHOTO 3: 403b voltmeter (front).

FIGURE 1: The original 403b supply.



compact package with a large viewable meter face. The full-scale meter range is from 0.001V AC RMS to 300V AC RMS. Input impedance is 2MΩ, and the bandwidth is from 5Hz to 2mHz. Frequency response is extremely flat (0.2dB 10Hz to 1MHz) through the audio band, dropping off to –3dB at 2MHz.

The scale is gradiated in typical analog VM fashion in 0-3, 0-10, and dB (ref. 1mW into 600Ω) scales. The dB scale is particularly handy in tracking frequency-response relative measurements. I have probably repaired about a half-dozen of these units and have found them to be easy to service and calibrate. Two of them have been in daily service at our shop for nearly eight years.

The one problem that they all seem to suffer is in the power supply, but fixing this is usually all there is to resurrecting them. They were originally fitted with 6V nicad cells and a charging supply. The nicad cells were configured as 6V ("C" cell size) batteries. I would guess that these are all at least 15+ years old at this point and the nicads are shot. I have tried rejuvenating them, but this is pretty much a lost cause, and finding 6V replacements has proven nearly impossible.

The idea of using batteries to operate gear like this is a good one, because battery-operated test equipment offers a few fringe benefits such as ground isolation, virtually ripple free supply, and otherwise unaffected by line noise and/or potential differences between chassis. But, you can easily resurrect them for AC line operation by simply replacing the batteries with electrolytics and a few zener diodes for regulation. Add a few resistors and voila—you are in business. Both the 403b and the 204c use the same 6V nicads and almost the same supply configuration.

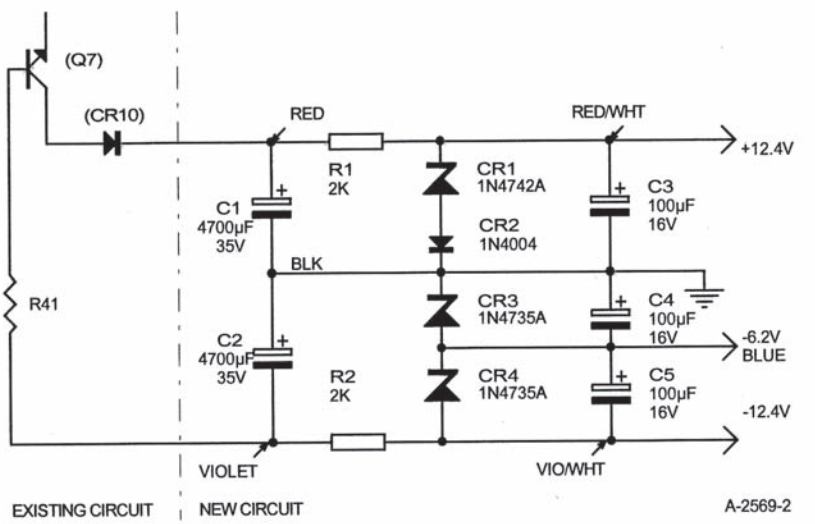
To save space in this article I will show only the power-supply schematics that the proposed modifications deal with. I will upload more complete info from the HP manuals on my website (www.amprepair.com) for those who might need or want it.

403B MODIFICATION

This mod is dead simple. You have a +13V DC supply and a –6.2V DC and a –13V DC supply, all of which you can easily achieve with a tapped series string of zener diodes. I suggest that you leave all of the chassis components in place (**Fig. 1**), even though some of them are no longer needed because you are no longer charging batteries. They don't hurt anything, and leaving them in place really makes this a simple modification.

I must confess that I did not go to the extent that most *aX* authors usually do with massive filtering, bypassing, and other such "POOGEing." I just made a nice power supply that works well without having to design PC boards and so on. Go crazy if you prefer with bigger caps and film bypass if you think it will matter—and if you can fit it all in. The modified supply circuit is shown in **Fig. 2**. The new circuit components will re-

FIGURE 2: The modified supply.



place the nicads.

Remove the left side and top panels (**Photo 4**). You might as well plug it in and see whether it works at this point. Locate the batteries and the red, violet, blue, and black wires attached to the batteries. The black (or perhaps white with black stripe) is ground. Red is +13V, violet is –13V, and blue is –6.5V.

See whether these voltages are present. If you are lucky enough to have something close to a power supply, then go ahead and see whether the meter responds properly to input. Usually the supplies are barely there at all—hence the reason for the mod.

Make a drawing/legend of the push-pin connections to the top board. Remove the push-on connections and remove the top board. Remove the left side frame. The batteries should now be exposed. Clip the (red, violet, blue, black) wires from the Nicad cells and remove the batteries. Clean up any leaked battery goo (**Photo 5**).

There were various-size cells used in these units, though I always seem to find a way to adapt the battery mounting apparatus to mount up the filter caps and secure them to the chassis. Arrange the two 4700µF/35V caps to the chassis so that they are joined at the center (ground) with a positive lead from one and the negative lead from the other. You can then simply tack-solder the remaining components to these cap leads (**Photo 6**).

Re-attach the wires you removed from the batteries as follows:

Red to the positive input terminal of the 4700µF positive filter. Violet to the negative input of the 4700µF negative filter. Black to the joined ground node, and blue to the node where CR3 and CR4 are joined.

Clip off the red/white and violet/white wires from the front panel three-position power switch and attach them instead to the zener-regulated nodes—red/white to the cathode of CR1, violet/white to the anode of CR4 as indicated on the modified schematic (**Photo 7, Fig. 2**).

Remove the bottom cover and locate the AC inlet terminal, which has only one wire coming off it. Break this connection and insert the ⅛A fuse in series with this line, making sure to insulate with shrink tubing. That should be all there is to it.

Plug in the power cord and check with a DC voltmeter that all three supplies (+12.4V, –6.2V, and –12.4V) are there. If the supplies are good, you should have a functioning AC RMS voltmeter. Visit www.amprepair.com for links to further calibration information.

The specs for the **204c sine-wave generator** (**Photo 8**) are as follows: (modified unit) maximum output is 5.4V RMS unloaded, 5.4V RMS into a 10k load, and 2.7V RMS into 600Ω. THD is 0.08% (1kHz at full output). Frequency response is virtually flat throughout the audio band. It does become a little wobbly at line frequency (60Hz), but this 60Hz beating will nearly disappear if you lift the AC ground. Flatness is otherwise within 0.2dB from 5Hz to 200kHz, –1dB at 500kHz, and –3dB at 1MHz.

PHOTO 4: Uncovering the 403.

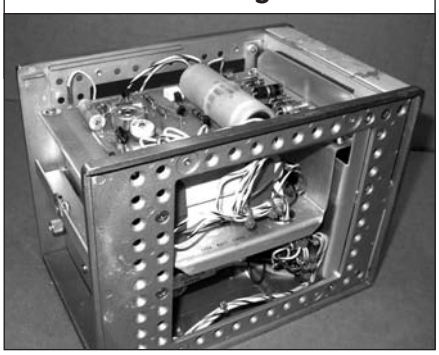


PHOTO 5: Exposing 403 innards.

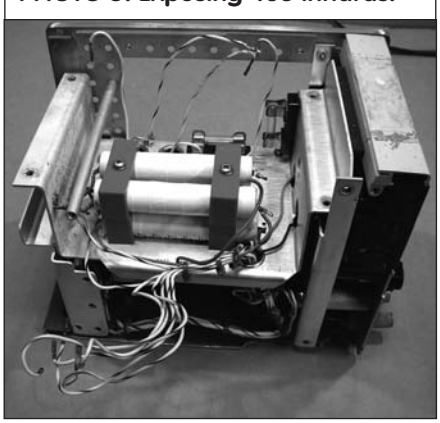


PHOTO 6: 403 wiring.

PHOTO 7: Re-attaching the wiring.

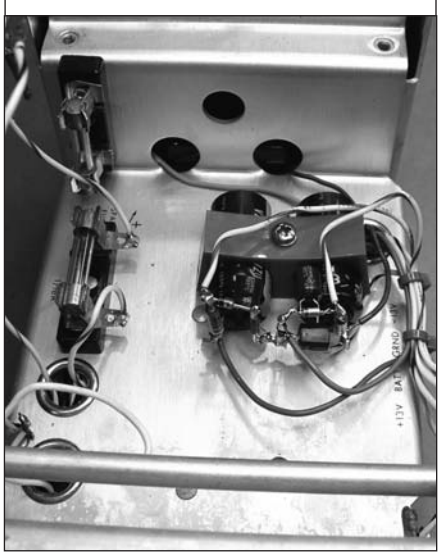
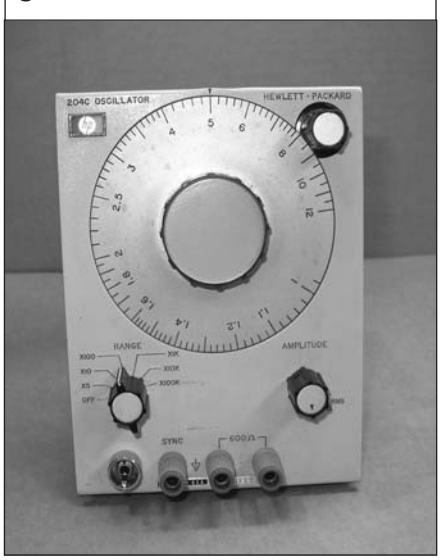


PHOTO 8: 204c sine-wave generator.

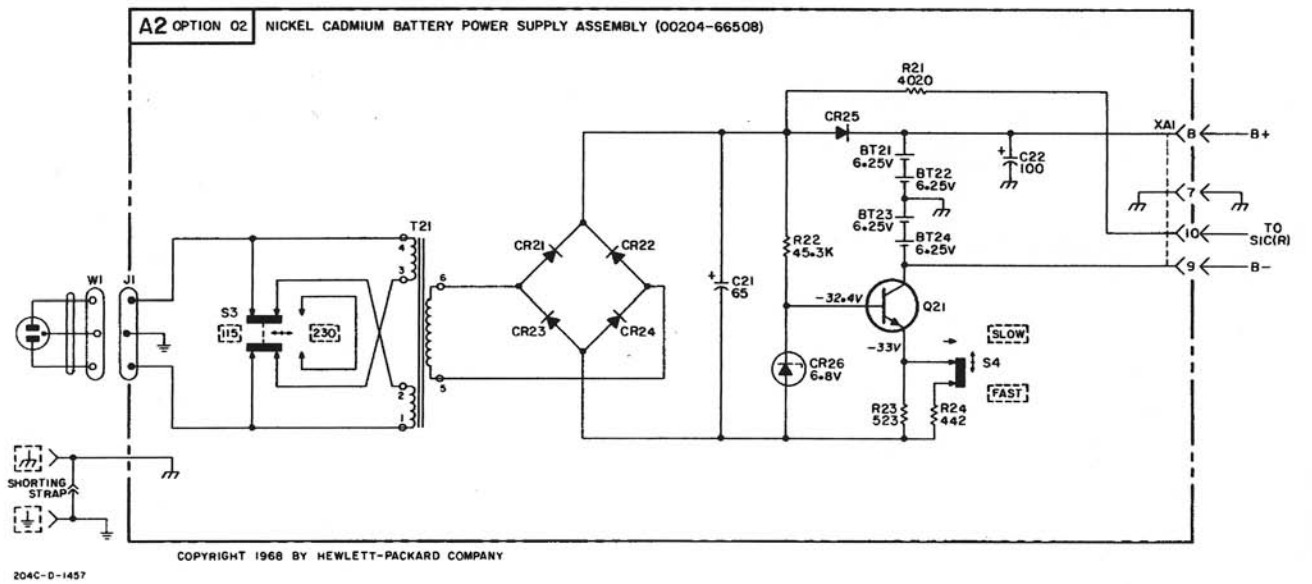


POWER-SUPPLY MODIFICATIONS

You have almost the same supply as the 403b (**Fig. 3**). You need +12V and –12V to achieve a 5V RMS output. I opted to go with the same basic design utilizing a simple zener-regulated supply. Again, feel free to beef up the caps, although the specified parts used here work just fine.

Though the 204c has an off position on its range switch, the stock supply is "on" as long as the AC is plugged in (unlike the 403b) due to the original charging circuit. I don't like the idea of leaving things on when I leave the bench, so I will add a

FIGURE 3: Original 204c power supply.



power switch to the front panel as well as a line fuse.

Note the original power supply and the modified supply. Remove the nicads and find plenty of space to replace them with your new components. Again, you may need to do a little cleaning on the nicads, which often leave leakage residue on the board.

Remove the top, bottom, and both side panels. Plug the unit in and power it up to see whether you have a supply. There are test posts available at the side marked B+ and B-. If your batteries are in reasonable shape, you may see +12 and –12V DC with reference to ground. More than likely the supply is not functioning properly due to defective nicads. The power-supply module is attached with four screws through the side frame brackets. Remove these screws to pull the supply portion away from the back of the oscillator (**Photo 9**).

Disconnect and remove the four nicad cells. If they are mounted in with friction clips, unsolder and remove these too, so you can use their PC throughholes for the new components. Notice that there is a 10-contact bifurcated plug at the card edge that interfaces to the main part of the unit. Use contacts #2 and #4 to run one side of the AC line up to the newly added power switch. In order to do this, you will need to remove any connections at these two places—on both the PS card and its mate connection traces on the main unit board.

There are different versions of the 204c out there, so I am not sure that yours will exactly match the specimen in this article, but I have yet to open one that did not have the rechargeable battery option. In any case, you will need to make sure that contacts #2 and #4 are "free" if you are to utilize them for your power switch AC line interrupt.

There is a PC trace connecting a rear panel ground post marked with a flat line (as opposed to the one next to it, which is marked with the ground "arrow" symbol). This rear post connects to the #4 contact at the rear of the PC board connector via a small jumper. Remove this jumper and then open up this trace where it connects to the chassis. I use a Dremel with a little router bit for this, which works like

a charm, though a good sharp knife along with a scraping edge of some sort will do just fine. See lower left corner of **Photo 10**.

Interrupt one side of the AC connector where it goes to the voltage selector. It is the gray wire in **Photo 10**. Attach a wire from this side of your AC inlet to the PC pad where you removed the jumper from the rear panel ground post. Verify with an ohmmeter that this pad is in fact connected to the #4 contact and also that it is no longer at chassis potential. Be sure to run this and all other wires under the PC board so they will not be crimped when you re-install the power module on final assembly.

Next attach a wire to the #2 contact underneath the board. This is currently an unused contact, so you will just carefully tack on to it. Just to be sure—verify that this is not attached to anything before proceeding. The other end of this wire that you tacked to #2 goes to the line selector switch. This would be what you disconnected from the AC inlet in the last step.

Now you should look at the main oscillator unit card edge #2 and #4. Remove

PHOTO 9: Disassembling the 204c.

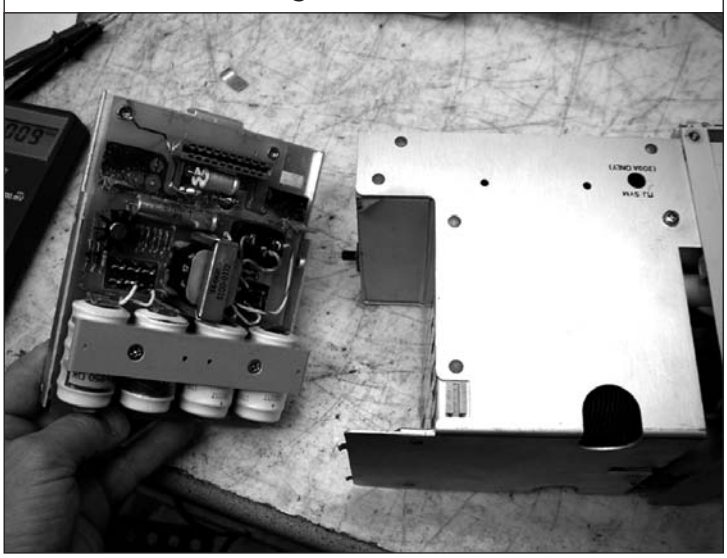


PHOTO 10: Exposing 204 innards.

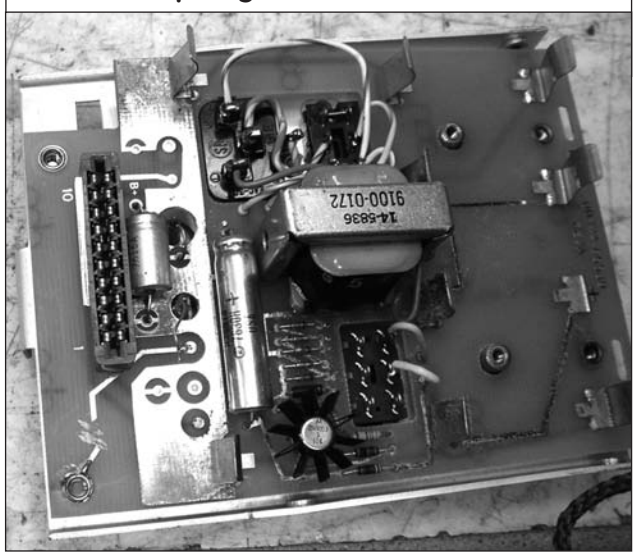


PHOTO 11: Uncovering the 204.

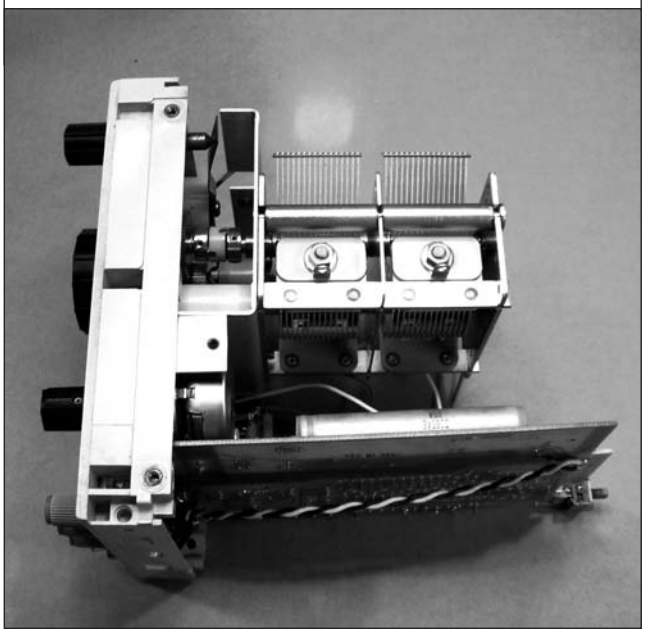


PHOTO 12: Notch in cover accommodates power switch.

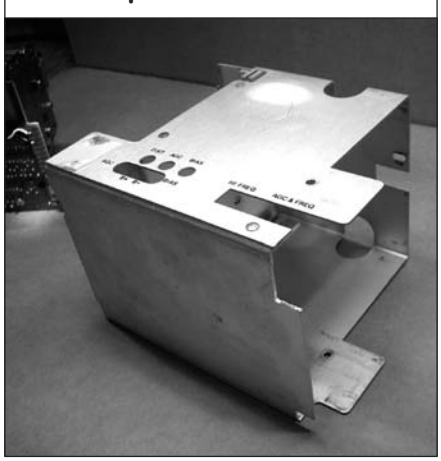
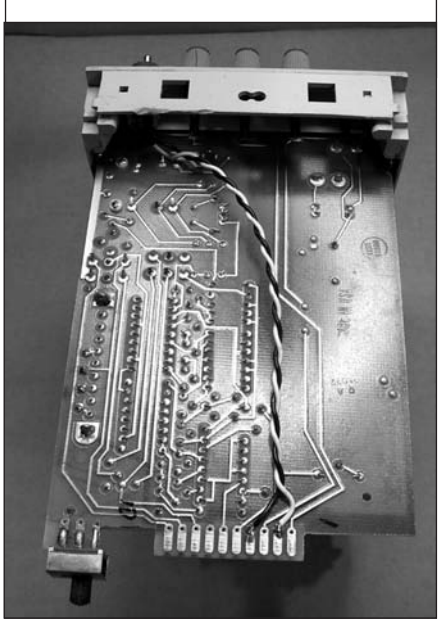


PHOTO 13: New 204 connection.



both side panels and then one screw in each side of the cover and the one nylon screw at the top. Pull the cover away from the oscillator unit (**Photos 11** and **12**).

Now that both sides of the main board are exposed, remove any connections to #2 and #4 card edge and affix a twisted pair as shown in **Photo 13**. There is a spot to install your AC switch—just below the range switch. Use shrink tubing to insulate these connections.

Note that you will need to cut a slight notch in the cover. You can see this right about in the middle of **Photo 12**. This will make room for the newly installed power switch.

REMAINING MODS

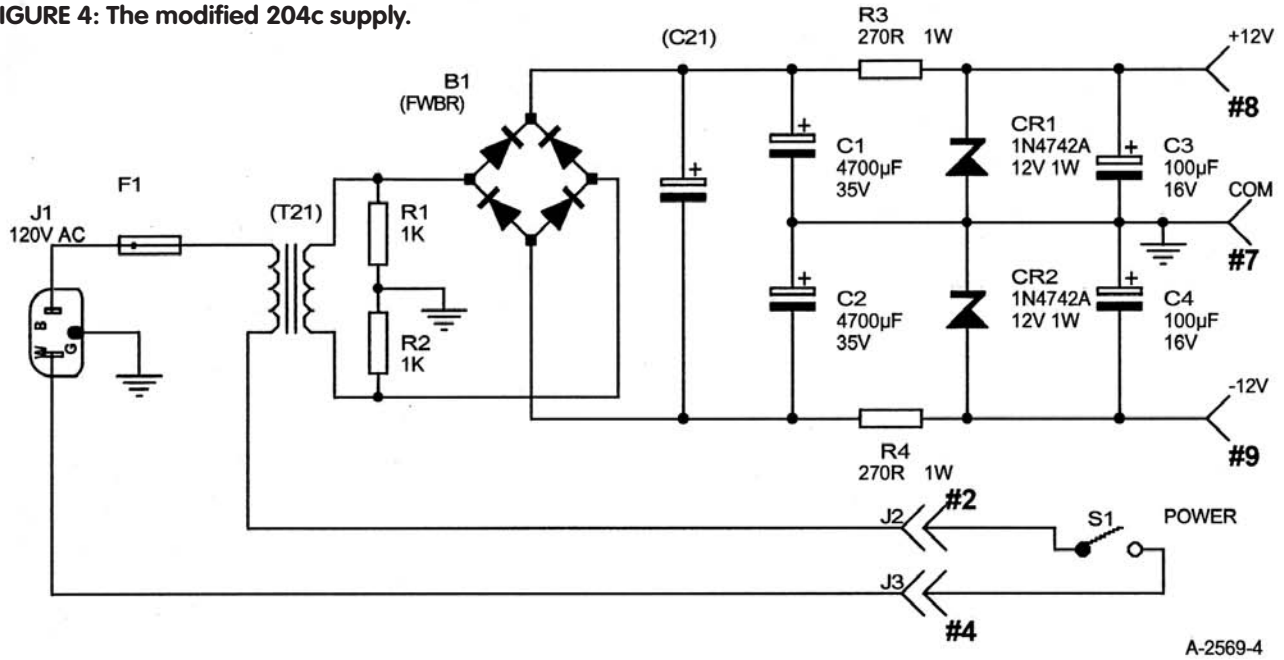
Remove Q21, CR26, R22, R23, R24, and jumper across CR25 (see **Fig. 3**). Once you have done that, you will need to install a jumper between the negative FWBR output (the negative end of C21) and where the collector of Q21 used to be (the input side of R4, **Fig. 4**).

As you can see, you are simply replacing the batteries with filters, current-limiting resistors, and 12V zeners. You will also need to install a quasi center tap at the secondary of the power transformer (T21) with a pair of 1k, 2W resistors as shown. You can wick out the PC traces and pads where the battery clips used to be and use these pads for your new components.

You will also need to interrupt the existing PC trace connections to the card edge connector #8 (+12V) and #9 (–12V), so you can insert the series resistors (R3 and R4). This will require that you run a wire from the output of the +12 rail to pin #8 and another wire from the output of the –12 rail to pin #9. Again, run these wires under the PC board. The ground is already intact at pin #7 (**Photo 14**).

I used a dab of glue underneath the big electrolytics to hold them in place

FIGURE 4: The modified 204c supply.

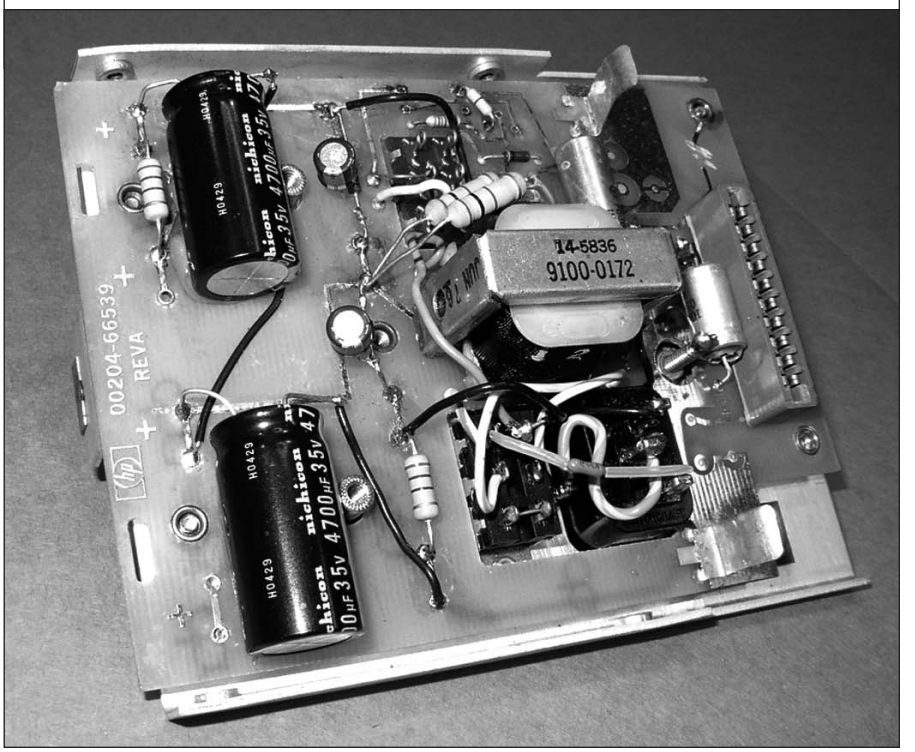


and wired the 100µF caps directly across the zeners, which is why they are somewhat obscured in the photo. Finally, replace the wire connecting the other side of the AC inlet to the voltage selector switch with the 1/8A fuse. I think everything ought to have a fuse.

After checking all your connections and polarities, temporarily jumper the switched side of the AC line straight to the voltage selector and fire up the supply. I have the luxury of using a Variac with current metering to gently power up my work. This is very handy and often reveals the bonehead mistake before . . . smoke. So if you are just plugging in, then check your connections again and let 'er rip.

You should have +12 and –12V at pins 8 and 9 with respect to pin 7. Check to see that you have about ±20V

PHOTO 14: Re-wiring the 204c.



at the inputs of each 4700μF filter. If all looks well, tighten down the screws that attach the PC board to the rear panel (make sure nothing is crimped under there) and plug it into the oscillator. Turn it on and check your ±12V again at the test points at the side of the oscillator.

If all is well, you should have a nice-looking sine wave at the output. The front panel middle post is ground. If your oscillator needs calibrating, you may find links at my website: www.amprepair.com. It's very simple, requiring only a scope, DVM, and a frequency counter. Next month, in Part 2, we will go to work on the HP 353a unit. *aX*

SOURCES

Mouser
www.mouser.com
800-346-6873

Digi-key
www.digikey.com
800-344-4539

Allied
www.alliedelec.com
800-433-5700

403b Power-Supply Mod Parts

Component	Description	SOURCE
CR1	12V 1W (1N4742A) zener diode	Mouser # 78-1N4742A
CR2	1N4004 diode	Mouser # 512-1N4004
CR3, CR4	6.2 1W (1N4735A) zener diode	Mouser # 78-1N4735A
C1, C2	4700μF/35V radial electrolytic cap	Mouser # 647-UVZ1V472MHD
C3, C4, C5	100μF/16V electrolytic cap	Mouser # 647-UVZ1C101MDD
R1, R2	2k ½W resistor 5%	Digi-key # 2.0KH-ND
F1	⅛A micro fuse	Mouser # 504-MCRW-125MA

204C Power-Supply Mod Parts

C1, C2	4700μF/35V radial electrolytic cap	Mouser # 647-UVZ1V472MHD
C3, C4	100μF/16V electrolytic cap	Mouser # 647-UVZ1C101MDD
R1, R2	1K 2W FP metal oxide resistor	Mouser # 282-1.0K
R3, R4	270R 1W CF resistor	Mouser # 294-270
CR1, CR2	12V 1W (1N4742A) zener diode	Mouser # 78-1N4742A
Sw1	power switch Alco SPDT	Mouser # 506-MTA106D
F1	⅛A micro fuse	Mouser # 504-MCRW-125MA
Misc	power switch protective guard	Allied Electronics # 948-0002