# Building and Using N7APE's NiCd Zapper

## *An update.*

by Marion D. Kitchens K4GOK

In the September 1992 issue of *73 Amateur Radio Today*, Ed Miller N7APE described a circuit for recovering NiCd batteries that have grown internal shorts. His article got my immediate attention because it seemed like a simple solution to a problem that plagues many of us. Most of us have numbers of just such NiCds. If you do much with NiCd batteries around the ham shack, then you will definitely want to build N7APE's circuit. Some hams have been known to burn out internal NiCd shorts by momentarily connecting them to an automobile battery. This can be dangerous, and is not recommended. N7APE's circuit can eliminate that danger and still recover the shorted NiCds. Furthermore, after clearing the short, the circuit will automatically switch into the charge mode and recharge the battery. A pretty neat circuit!

This article describes the experiences of two builders of N7APE's circuit, and relays the experience and knowledge they gained about recovering NiCds.

### Building The Circuit

Gene WØDLQ and I both built "Zappers" according to N7APE's article. The original publication contained one error in the schematic: The correct value of R5 should be 560k, as per the parts list, and not the 560 ohm value shown on the schematic. More on optimizing the value of this resistor later. The unit shown in the photographs used an under-the-bench power supply (12 volt auto battery on a charger), while WØDLQ used a built-in AC power supply delivering about 17 VDC to the circuit. The unmarked diodes in the original publication are 1N914 or similar.

Being experimenters, both of us made minor changes in N7APE's circuit. First, as an operating convenience, a "reset" switch was added to discharge an internal cap (C7) so the unit could be easily reinitialized after recovering a NiCd. Second, some voltage dividers and sensing circuits were modified to allow use of different supply voltages. Third, a fixed voltage regulator chip was used in place of the LM317 regulator. My unit used an active LM317 current-limiting regulator in place of resistor current limiters. If the LM317 current limiter is used, it requires a 1" x 2" heat sink. If you use the fixed resistor(s) at R1, they should be rated for 2 watts.

Gene and I could not resist adding a "zapping" LED to indicate that this function was happening. You have clear indications of the zap/charge mode via the red/green LEDs. We also added a switch to allow selection of 50 mA for charging AA size NiCds, or 100 mA for charging C or D size NiCds. The changes made in our circuits are shown in Figures 1 and 2.

### Checkout and Adjustments

Several adjustments need to be made after assembly. The sequence of checks and adjustments shown in the sidebar is recommended. This list provides a sequence that allows for easy resolution of problems, should they occur. Note that it is easy to get the circuit "locked up" in the charge mode, so follow the checkout instructions carefully! You can "unlock" the circuit by pushing the "reset" switch.

Adjusting R13 for about 0.500 volts on pin 6 seemed to help in recovering some of the very old NiCds. N7APE recommended about 0.300 volts, which should be fine for most users.

After getting the unit operating, optimization of the circuit is recommended. Optimization will result in the circuit delivering the maximum available energy to burn out the internal short, thus reducing the time necessary to recover a NiCd. The best method of optimization will depend on the resistor values and supply voltage in your particular unit. Try the easy way first.

### The Easy Way

Short pin 5 of the IC to ground, and short across the battery box for the following operations. Adjust R10 for maximum voltage on pin 2 of the IC. Measure and record that voltage. This may cause the voltage on C1/C2 to increase and stabilize at the supply voltage. Check with a voltmeter. If the voltage is steady, you can optimize the unit the easy way. (If the voltage ramps up and down, you'll have to do it a slightly harder


*Photo A. K4GOK's NiCd Zapper.*

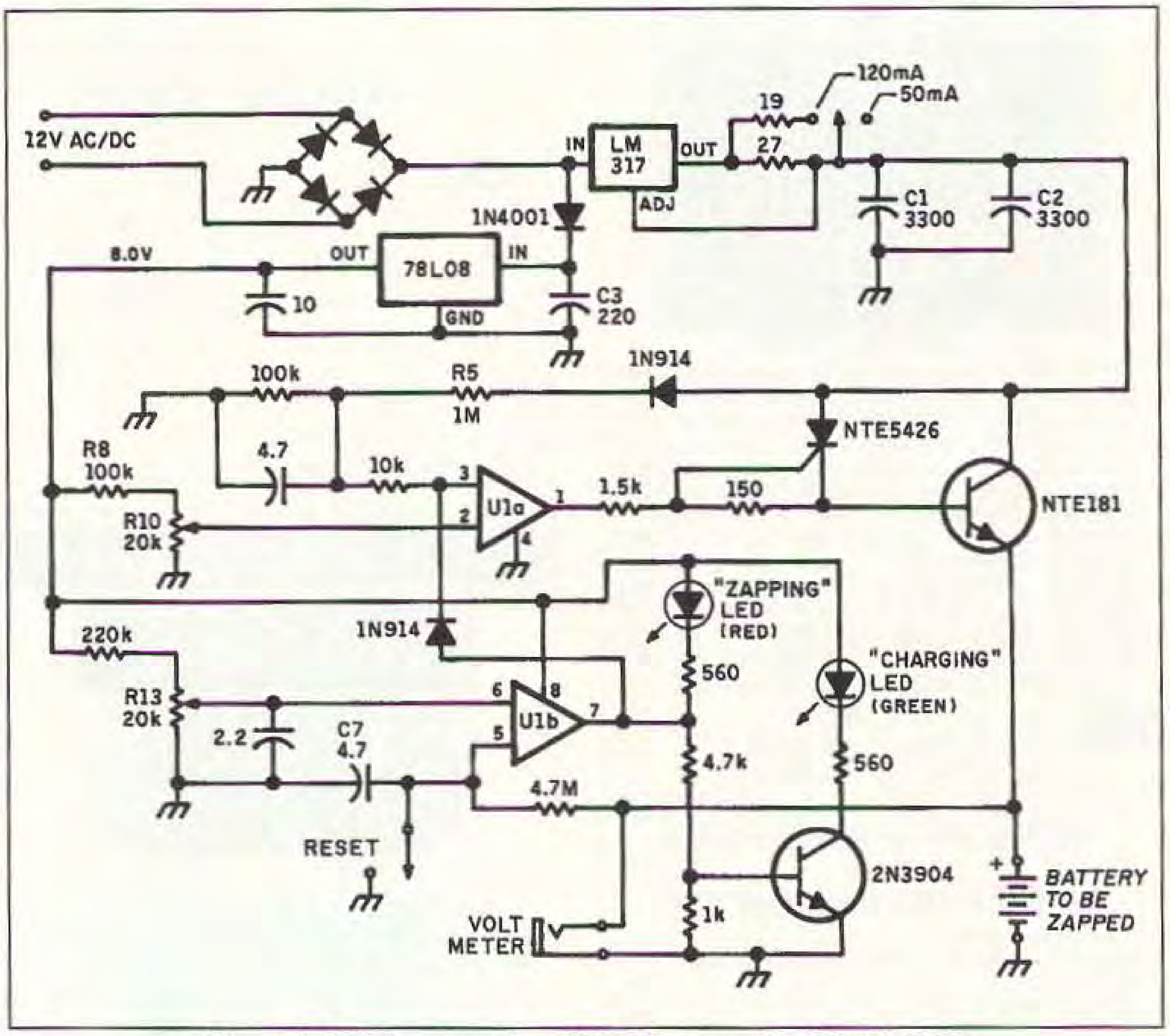


*Figure 1. NiCd restorer from N7APE, as modified by K4GOK.*

way, described below.) Once the voltage on C1/C2 is stable, measure and record the voltage on pin 3 of the IC; it should be less than that on pin 2. The voltage on pin 1 should be less than 1 volt. Next, adjust R10 until pin 3's voltage is just slightly less than that on pin 2. At this point, the voltage on pin 1 should be pulsing with very short pulses, and the voltage on C1/C2 should be ramping up and down.

### The Harder Way

If adjusting R10 for maximum voltage on pin 2 does not stop the voltage ramping up and down on C1/C2, you'll want to make some changes in resistor values. The idea is to change either R5 or R8/R10 until you can get the ramping up and down to stop. In my unit I increased the value of R5 to 1.2 megohms, while Gene made R10 a 100k pot and replaced R8 with a jumper soldered permanently in place. The changes required will depend primarily on the supply voltage you use. In general, the higher your supply voltage, the larger the value needed at R5 or the smaller the resistor needed at R8. Make changes until you can get the voltage on C1/C2 to come up to the supply voltage and stabilize (no pulsing or ramping up and down) by setting R10 to maximum voltage at pin 2. Then adjust R10 as described above so the voltage on pin 3 is just slightly less than that on pin 2.

Check that the voltage on C1/C2 now ramps up and down. The unit will deliver the maximum energy to zap the NiCd when adjusted as described above. Remove the jumpers from pin 5 to ground and from across the battery box. Now you are ready to put the zapper to use.

### Zapping Some NiCds

Using the zapper is very easy. Put in the bad NiCd and turn on the power. The "charging" LED will flash very briefly and the "zapping" LED will come on. If the power is already on when the NiCd is inserted, or if a recovered NiCd has just been removed, you will have to push the reset switch to reinitialize the circuit. The "zapping" LED stays on until the short is burned out. Then the zapper automatically switches to the charge mode and the "charging" LED comes on. Leave the NiCd in the zapper for the recommended charge time, or remove it and place it in a standard charger.

We had 16 very old NiCds on hand for learning to use the zapper. Eight of these were more than 20 years old, a good set to see just what the zapper would really do. All of these NiCds measured 0.000 volts, and obviously had internal shorts. We tried all eight NiCds for an hour or so without any signs of recovery. Additionally, we zapped all of them with the automobile battery technique, without success. The automobile battery technique had never failed before—it puts quite a large jolt of current through the cells. These NiCds were more than dead!

Finally, a NiCd was left overnight on the zapper, and the "charging" LED was "on" the following morning. Eventually, four of these eight NiCds were recovered by overnight treatment with the zapper. Let the zapper do its job, and don't give up on the NiCds too soon. Four of them never recovered, even after 24 hours on the zapper. We set those aside.

All eight of the remaining NiCds were recovered. These were not as old as the eight described above, but they were 10 or more years old, and unkept for most of that time. These recovered in varying time. Some in a

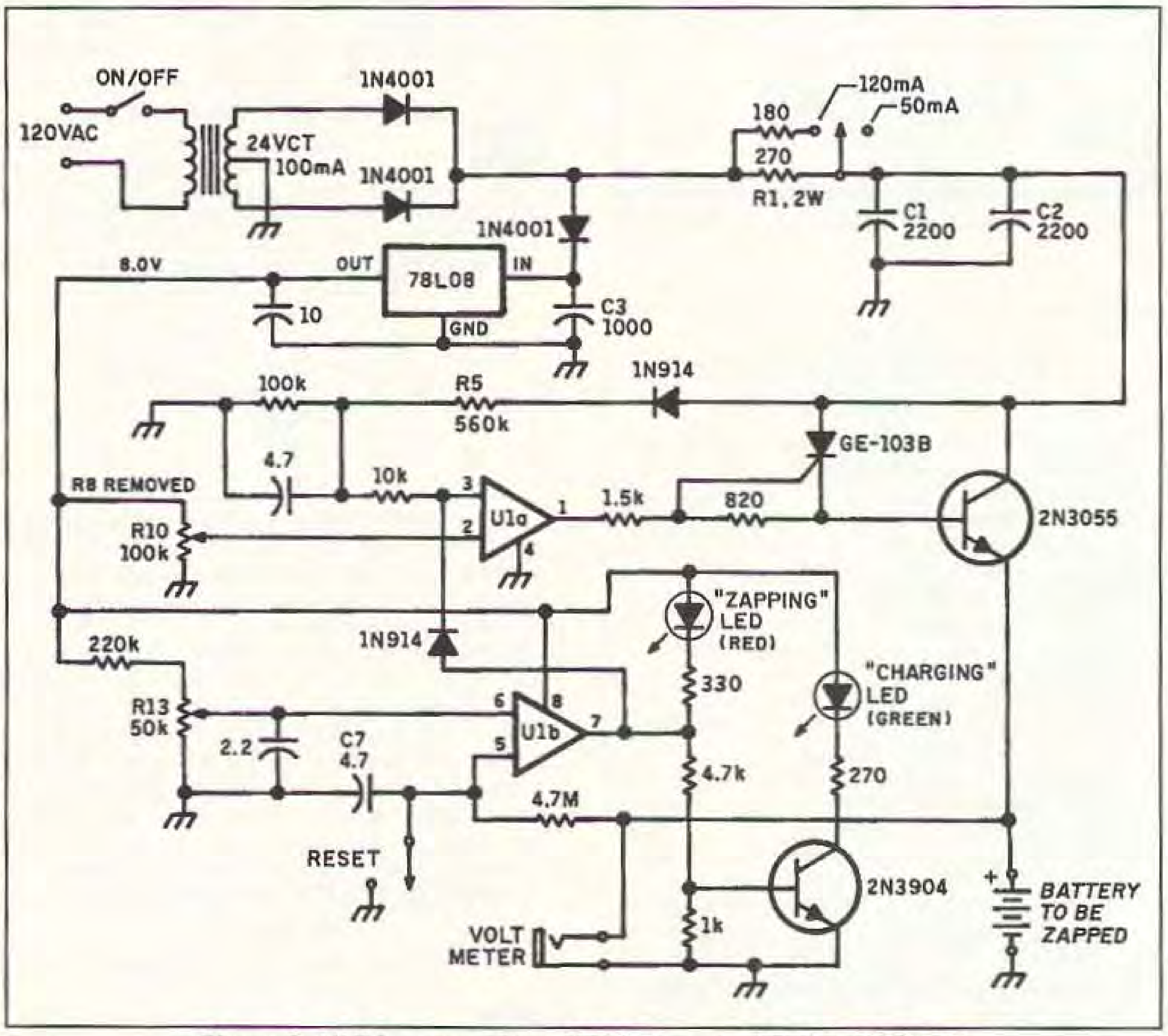


*Figure 2. NiCd restorer from N7APE, as modified by WØDLQ.*

matter of an hour or so, and a few required four or five hours to recover.

After recovery and charging, a number of the NiCds regrew their internal short. Some regrew the shorts while on a charger, unexpectedly. A short treatment on the zapper recovered these again, usually in minutes, instead of the overnight or several hours as initially required. All of those NiCds that initially regrew their internal shorts did so repeatedly. As they were re-zapped, it required less and less zapping time each cycle. It appears that with enough runs through the zapper they all might be fully recovered to hold a charge, although this has not been confirmed as of the writing of this article.

Several of the recovered NiCds displayed symptoms suggesting they had internal discharge paths, as opposed to internal shorts. This result exhibited itself when a zapped battery would recover in half an hour or less and would accept a charge, but would discharge to a low (not zero) voltage in less than 24 hours. About half to two-thirds of the 20+-year-old batteries had these symptoms.

More recently purchased NiCds (four to five years old) recovered nicely. I had only three NiCds in this category. They all recovered quickly and would hold a charge. No energy storage capacity test of these NiCds was done.

In recovery of old, shorted NiCds be wary of those that show unusually high or low voltages after charging. Experience suggested that those with fully charged voltages of more than 1.45 or less than 1.15 volts would eventually be "bad actors." They would either revert to internal shorts quickly, or would refuse to hold a charge for any significant time.

Note that the zapper will revert to the zapping mode if the NiCd voltage drops below the trip voltage set on pin 6. This allows you to leave a recovered NiCd in the zapper, and should it regrow its internal short while being charged, the zapper will automatically switch back to the zapping mode and re-zap the NiCd. This was observed a number of times on the 20+-year-old NiCds. This feature of N7APE's circuit was not recognized until it was experienced in practice. A nice feature indeed.

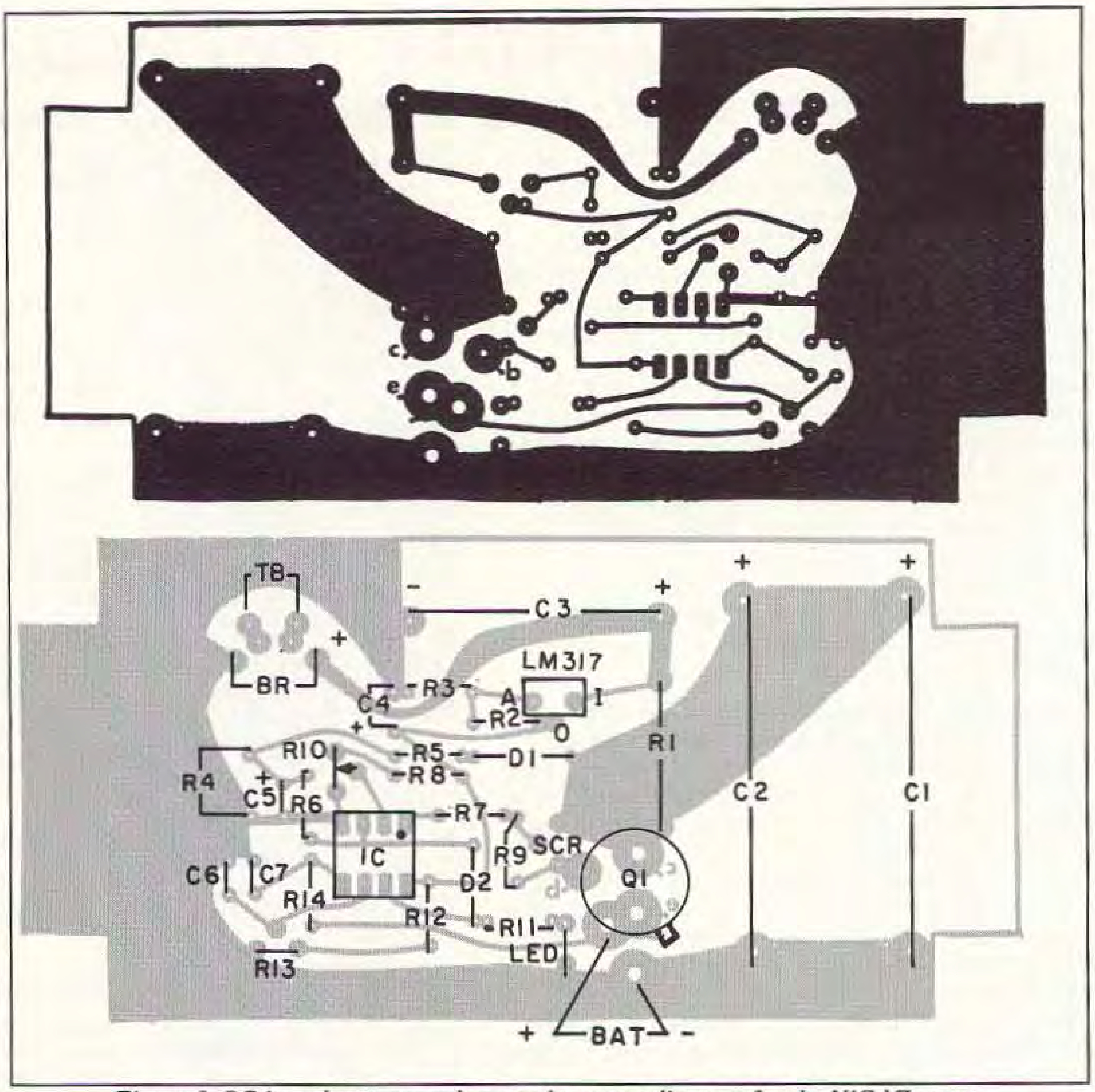

*Figure 3. PC board pattern and parts placement diagram for the NiCd Zapper.*

### Checkout Sequence

1. Remove all power from the unit.
2. Discharge C1/C2, C4, C5, C6, and C7 completely by temporarily shorting them to ground.
3. Remove the LM358 IC from its socket.
4. Put a shorting jumper wire across C1/C2 to ground, and leave it there until step 10 below.
5. Turn on power and verify that the voltage at the regulator output is correct.
6. Verify that the voltage across C3 is at least 2 volts higher than the regulator output voltage. If not, the supply voltage must be increased, or the value of R1 must be increased.
7. Measure the the voltage across R1 (same as across C3) and calculate the current through R1. This current needs to be 50 mA for charging AA cells and 100-120 mA for charging C and D cells. If it is not correct, either the supply voltage or the value of R1 must be changed. The conditions of #6 above must still be met after any changes here.
8. Verify that pin 4 is at ground potential, and that pin 8 is at the regulator output voltage.
9. Adjust R13 for about 0.3 to 0.5 volts on pin 6, and set R10 to its midrange.
10. Turn off the power and remove the jumper from across C1/C1.
11. Discharge the capacitors as described in 1 and 2 above.
12. Put a shorting jumper across the battery box, insert the LM358 IC in its socket, and apply power.
13. The "charging" LED may flash very briefly, and the "zapping" LED should come on.
14. Connect a voltmeter across C1/C2 and adjust R10 for the maximum voltage on pin 2 that still lets the C1/C2 voltage ramp up and down, as seen on the voltmeter.
15. Remove the jumper at the battery box. After about five seconds the "zapping" LED should go off and the "charging" LED should come on.
16. Push the "reset" button. The "zapping" LED should come on immediately, and after about five seconds should go off and the "charging" LED should come on.
17. Re-connect the shorting jumper at the battery box. The "charging" LED should stay on for five to 10 minutes, or until the "reset" button is pushed.
18. See the text for information about optimizing the zapping energy.

NOTE: It is safe to verify the battery charge current via a mA meter at the battery box as long as the "charging" LED is on. But do NOT try to measure the current when the "zapping" LED is on!

### Conclusions

The N7APE designed circuit works and works well. It does indeed recover internally shorted NiCds in a safe and effective manner. N7APE did the ham community a fine service in designing the zapper circuit. NiCds as old as some investigated here could not be permanently recovered. However, those NiCds of more recent vintage were successfully recovered. Any ham who uses NiCds should construct this device and put it to use.

Acknowledgments: Thanks to my friend Gene WØDLQ for building a zapper as I was building mine, and for numerous exchanges of ideas, comments, and discussions. Without his involvement it is unlikely I would have tackled this fun and useful project. And, of course, many thanks to N7APE for designing and publishing the circuit!

*[Ed. Note: Reprints of the original article, "NiCd Restorer/Charger" by Ed C. Miller N7APE, are available for $3 each from* 73 Amateur Radio Today, *70 Route 202 North, Peterborough NH 03458. Circuit boards for the original project are available for $5 plus $1.50 S&H from FAR Circuits, 18N640 Field Court, Dundee IL 60118.]*