TITLE: The Battery Sulfate Buster

ISSUE: April '02

By Jim Weir
Humble Tinker, RST

"Johnny took a little drink; Johnny drinks no more; 'cause what Johnny thought was H_20; was H_2SO_4."

Most of us learned this little ditty in high school chemistry. The furthest thought in my mind back in those days was how this particular nasty acid was going to be a real problem for my airplane. 's funny, just thinking back to those halcyon days in my junior year I *did* have a battery sulfation problem but I was too young and naïve to realize it. (It all had to do with a young lady, an old '51Chevy with a vacuum tube radio, too long parked in the local lover's lane in San Diego, and having to call her parents at midnight to come give me a jump start…ah, those were the days…).

At any rate, battery sulfation has been with us for a very long time. The problem is that in a typical wet (sulfuric acid) battery, the lead plates want to be exercised. That is, they want to be charged and discharged on a regular basis. If they just sit there, the acid slowly, slowly builds up a film of sulfide that eventually causes the battery to "go weak". This "weak" has everything to do with the fact that lead sulfide is a fairly good insulator, and as the sulfide layer builds and builds over weeks and months of disuse, the internal resistance of the battery goes up and up. Finally it gets to the point where most of the voltage of the battery is dropped in the internal resistance of the battery and darned little gets to the point of intended use…like the starter motor.

Now I don't pretend to be a chemist, nor do I pretend to have invented the pulse system for desulfation of batteries. For those of you who wish to dig deeper into the whys and wherefores of the process, I can recommend this website to you: http://www.shaka.com/~kalepa/desulf.htm This is by far and away the most comprehensive treatment of the subject that I've been able to find. Moreover, it goes deeply into the reasons why pulse charging is so effective in combating the sulfation process.

Let's see what we might do about this problem. Let's also get a couple of caveats out of the way right from the getgo:

1. You are playing around with a chemical container that holds a quart of the nastiest acid known to man. It is entirely possible that the container may rupture and/or the acid be forcefully ejected from the container at some point in the process. Take all necessary precautions to prevent harm to persons, pets, or property.

2. You are playing around with an electrical system that has half a hundred volts at several dozen amperes available. Half a hundred volts HURTS when you get across it, even for a split second.

3. Do not be deceived by the fact that the transformer "only" puts out 18 volts. The circuit design takes that 18 volts and makes about 55 volts DC out of it. Just like a strobe power supply "only operates from 12 volts", you can get a kilovolt whap from the strobe circuit if you are not careful.

4. There are going to be some batteries that are so far gone that leaving the desulfator on charge for a month will only get you four weeks and change. In my experience with these circuits, if you get the battery right when you notice that it is laboring to turn the starter, you have half a chance to make the desulfation process work. If it is so far gone that it won't even pull in the master switch relay, the odds of being able to save it are slim to none at all. See photo 976 for an example of a battery that will probably never be able to be brought back to life.

5. The sulfation process took weeks or months to develop. The desulfation process will take the same order of magnitude of time. Don't expect to put the battery on desulfate today and back in the airplane tomorrow. I've left batteries on this system for a month before I was happy with the end result.

6. The desulfator will work on any 12 volt battery that uses sulfuric acid as the electrolyte. It doesn't really matter whether the acid is a liquid or a gel. However, don't plan on using the desulfator on nicad, NiMH, or other chemistries without a *lot* of research and experimentation on your part.

Given that you want to proceed with a battery desulfator, the circuit with C103/104 as shown will perform quite adequately on most "small" batteries -- say anything up to and including the 35 amp-hour units that come stock on most large singles and a few light twins. (Sorry, 24 volters, the design has to be doubled in voltage to do you much good, and I just don't have those parts available at the local stores.) The design has also worked well on some moderately sized automobile and marine batteries, and I can't really give you a limit other than to say the larger the battery, the longer the desulfation process will take.

The basic circuit uses either a standard wall-wart ac power supply or a doorbell transformer from the handyman shop. Actually the bell transformer is a little more rugged than the wall wart and if you intend to use this unit for some years to come, I might recommend the bell transformer. The downside to the transformer is that you have to pipe 110 volts into the circuit chassis box, supply a fuse, and all that stuff. I've used the wall wart for about five years now and have not had to replace it once. I do keep one spare on the shelf for the day when the original supply is going to go Tango Uniform, although I've never had to use it.

It is actually a pretty simple circuit. C101-104 and D101-102 form what is called a "voltage doubler" circuit. This was all the rage back in the days of tube-type TV sets, where you could get plate supply voltage of 330 volts or so of dc right directly from the 110 volt ac line. In our case, we take the 18 volts ac and get 50 volts dc ("doubler" is an inaccurate term…the actual multiplier is 2.83) out of the power supply. This voltage goes directly to Q101 and then out Q101 to the battery being desulfated.

Note that I've used TWO capacitors for C101/103 and C102/104. If you only intend to desulfate very small batteries such as the small 6 amp-hour gelled-cells found in a lot of the smaller electronic devices, you don't need the large 2200 uf C103/104. If you plan on using the unit for "real" batteries such as the 25/35 amp hour units used in most aircraft, you can delete the small 100 uf units and use only the 2200 uf capacitors.

The rest of the problem resolves itself to pulsing Q101 on and off at a "rapid" rate. "Rapid" is a relative term, and to keep power dissipation within bounds and use "cheap" parts, I chose a repetition rate of about 75 pulses a second with a pulse "on" width of 10 microseconds.

Speaking of "cheap parts", the only things you will have to go to a good electronic parts house (Digikey) to get are Q101, the p-channel field effect transistor and C103/104, the large electrolytic capacitors. The rest of the parts are readily available at The Shack.

U101A is configured as a 75 Hz. square wave oscillator. C108 takes the leading edge pulse of this square wave and turns U10B on for a time determined by the value of C108 and R108. The output of U101B is a 10 microsecond wide pulse with a 75 Hz. repetition rate.

This pulse turns on Q103, which in turn causes Q101 to turn on for 10 microseconds at a 75 Hz. rate. D107 keeps the battery voltage from bleeding back through Q101 and upsetting the voltage doubler power supply.

Were we to stop right here, we'd certainly have a good desulfator, but there is every chance that our by-guess-and-by-golly method would overcharge a good battery and destroy it with a severe overcharge. What we'd really like to know is what voltage the battery is at during periods where the desulfator isn't pulsing the battery.

R114 charges C109 to whatever voltage is across the battery. It charges it slowly, with a 1 second time constant. Were we to leave the measuring circuit here, we would read the average of the battery plus the desulfation pulse. However, D106 discharges these peak pulses from C109 and leaves only the unpulsed battery voltage.

R115-116 and C110 further eliminate any ripple from the measured battery voltage with a 5 second time constant and pass through unity gain amplifier U101C. U101D is set up as a comparator that turns on D108 to alert you that the battery has reached its limit for voltage and should be removed from the desulfator. To set this circuit properly, put a known good and fully charged battery on the desulfator output and adjust R118 until the light just barely comes on.

Of course the problem will present itself when the battery has reached full charge voltage, and yet there is still a significant amount of sulfation on the plates. My remedy to this is to put a small load (say, a small light bulb) on the battery and discharge it down to 12 volts or so, then repeat the desulfator routine. Back and forth until the battery tests good under load.

Oh, "tests good"? You want a battery load tester now? Come see me in the June issue and I'll have the darndest design for a load tester you've ever seen. May issue, I promise, I'll go back and do the little pager-relay I told you I'd do soon.

(A note for those of you actually attempting to build this device…a full drawing package for the chassis-box from The Shack and a full pcb layout drawing in Circuitmaker/Traxmaker format is posted on the archive website at www.rstengineering.com/kitplanes If there is sufficient interest generated, I might be persuaded to put this little jewel out as a "sortakit" with all the electronic parts and an etched, screened pc board.)

Author's Note: Jim Weir is the chief avioniker at RST Engineering. He will be glad to answer avionics questions for this article or on any avionics subject in the Internet newsgroup rec.aviation.homebuilt. If you are having trouble with newsgroups, go to www.rst-engr.com and click on the "How To Use The Net" link.

PHOTO LOG:

(all photos start with dcp00 and end with .jpg)

dcp00965.jpg The waveform at the X105 terminal when at the beginning of the desulfation process. The horizontal scale is 2 msec/cm and the vertical scale is 5 volts/cm. Note that the battery voltage between pulses is about 12 volts and the pulses are about 35 volts by the time they get to the battery. Calculated current is about 30 peak amps in each pulse.

970 The desulfation pulse expanded out to 1 microsecond/cm. Note how the voltage peaks to 35 volts and then slowly lowers to about 25 volts. This sloping pulse is indicative of relatively high internal battery impedance. Note the "ringing" at the end of the pulse. This is the "battery resonance" noted in most of the desulfation articles in the reference.

967 This is the "ringing" part of the waveform expanded out so that you can see the exponential decay of a fairly constant frequency. (The upper trace is an unavoidable ghost trace that is necessary to see the ringing clearly. It means nothing; disregard it.)

973 The waveform at X105 for a "good" battery that has gone through a complete desulfation process. Note how the pulses are limited by a good low impedance battery to 20 volts versus the 35 volts of a fairly well sulfated battery in photo 965.

974 The desulfation pulse expanded out to 1 microsecond/cm. This is a "good" battery. Note how flat the top of the current pulse is. This is indicative of a good battery with low internal resistance. Battery ringing is still quite evident for this battery.

976 A completely trashed battery. The vertical scale is now 10 volts/cm. Note how the desulfation pulse goes all the way up to 50 volts and then rapidly decays to near zero. The odds of recovering this battery hover somewhere around the odds of winning a shouting match with an FAA inspector.

977 The same pulse expanded out to show that there is practically no current being driven into this trash battery. No ringing, no real chance at saving the battery unless after a few weeks of treatment something inside starts breaking down and begins allowing the desulfation pulses to drive current into the cells.