Tech Note No. 1

by Pete Stark

Let me begin by introducing myself. I don't really consider myself an abandoned "Schober Orphan"; I'm more like the fellow who's on trial for killing his parents, and then begs for mercy because he's an orphan. I'm a "Schober Orphan" because I got myself into this on purpose. Let me explain.

Sometime around 1972, I heard and saw a Schober Theatre Organ and fell in love with it. I resolved to get one and even got some of the kits, but somehow got sidetracked. When I finally decided to go ahead, I discovered that, alas, Schober had gone out of business!

For the past few years, every now and then I'd look at the classified ads in my local paper, hoping that perhaps some day I might find a used one. And I almost fell out of my seat when I spotted the ad for one "as is" a few months ago.

To make a long story short, I'm now the proud owner of an "as is" Schober Theatre Organ. That's the easy part ... now I have to fix it! I started to correspond with Fred Henn, describing some of my repairs, and he suggested that perhaps my adventures might be useful to others. And so this column was born.

Here, and in the next few issues, I will bore you with the saga of my approach to making this organ play again. I have one advantage in this task -- I'm a college professor and an electrical engineer, and have been teaching courses in electronics and computers for some 25 years. That helps in trying to figure out what Schober did and why, and how to improve on it with more modern technology and today's components.

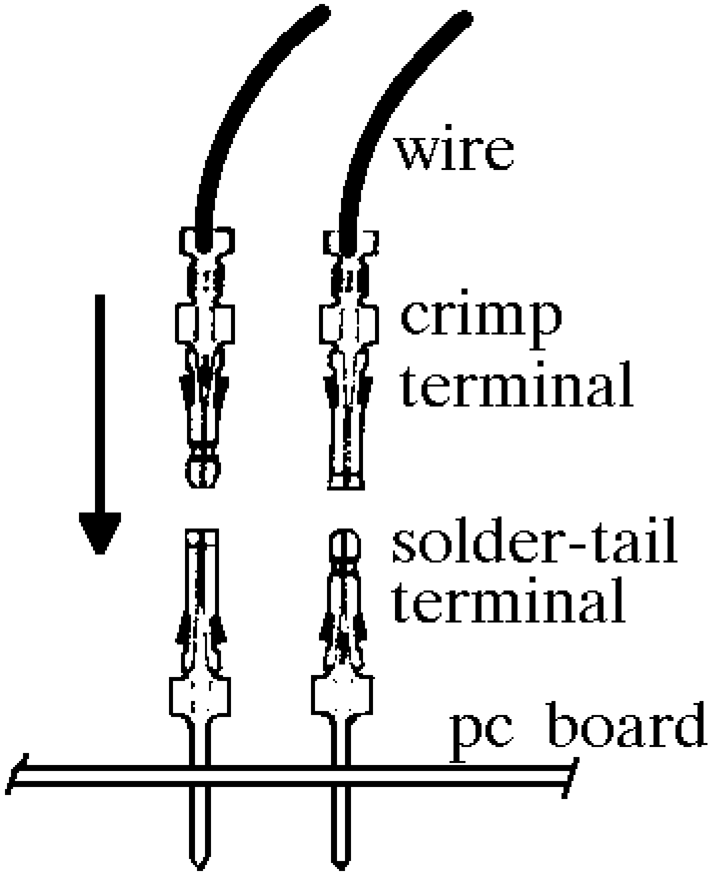
With that as an introduction, let's get going.

Connectors

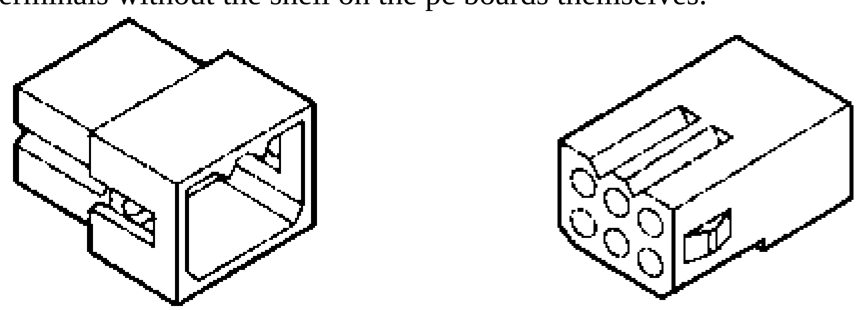
When I got my Theatre Organ, it had a lot of problems. Some of the notes did not play at all, but that was hardly noticeable because there was so much hiss and crackling that you could barely hear any notes at all. Obviously some major work on the printed circuit boards was in order.

One of the major headaches with working on my organ is caused by Schober's method of mounting and wiring the pc (printed circuit) boards. Since the boards are soldered in place, and some of the wires are quite short and tight, it's difficult to work on them. So my first task was to devise a system of connectors to make the job easier. It turns out to be an almost trivial, and relatively inexpensive, task. I stocked up on the parts needed, but only modify each pc board as I need to remove it; no need to put connectors on a board until you need to pull it out.

As you know, Schober used small tubular terminals, which were soldered to the pc board and then filled with solder. Once the board was screwed into the organ, wires were slipped into the terminal and soldered. My approach is to replace the tubular terminals with Molex connector terminals. Figure 1 shows the basic idea.



Waldom/Molex manufactures a series of cable connectors, which come as nylon shells (see Fig. 2) and separate terminals. In normal use, the wires are first attached to the terminals, and then the terminals are inserted into the shell to make the connector. I have used the shells in some of the cables in my organ (such as those leading back from the stop switches), but I use the terminals without the shell on the pc boards themselves.



The terminals come in several types. Some crimp onto wires (the ones on the top of Fig. 1), some have "solder tails" for soldering (the bottom of Fig. 1); there are male and female types, and they come in two diameters: 0.62 inch, and 0.93 inch. Radio Shack carries complete connectors (shells and terminals) in the 0.93" size, but does not sell the solder-tail terminals, and charges a lot more than the industrial distributors do. I decided to use the 0.62" size, and ordered them from Digi-Key (1-800-344-4539). I'd suggest calling Digi-Key for their catalog before ordering. I will give the Molex part numbers and Digi-Key prices below; they are comparable to other suppliers, and I have found Digi-Key to be very happy to handle small orders. (In retrospect, I probably should have used the 0.93" size, so I could use Radio Shack parts if I ran out of Digi-Key parts.)

First, whenever I remove a board from the organ to work on it (except for some special cases discussed below), I pull off all of Schober's tubular terminals; instead of each terminal, I install a 02-06-8103 solder-tail male terminal ($13.26 per 100). The solder tail just fits into the hole on the pc board.

Onto the matching wire, I crimp a 02-06-1103 female terminal ($7.80 per 100), using the Waldom-Molex HT-1921 crimp tool ($12.95). The female terminal then simply slips over the male terminal on the board for a secure, yet easily removable, connection. (You can also do it the opposite way, and Fig. 1 shows both approaches. The left shows the female terminal soldered to the board while the male terminal is crimped to the wire, while the right shows the male on the board and the female on the wire. Either method will work; in fact, it might be a good idea to wire adjacent boards in opposite ways so you can't accidentally connect a wire to the wrong board.)

The exception is those wires which go forward to the stop switches. Since I eventually will have to remove the entire stop switch horseshoe (in order to clean the keyboard contacts), I am treating these wires a bit differently. Rather than remove the wires at the printed circuit board, I am installing connectors in the wire harness itself. For example, the right side of the stop filter PC board has 15 thin wires, in two harnesses, that go to the stop switches. I am putting in a 15-pin connector, making sure that the wires are routed so that both the PC board and the horseshoe can be removed without problem (meaning that I had to pull the wires out of the hook eyes.) These connectors are also made up from Waldom/Molex crimp-on terminals, which are then inserted into the nylon shell housing to make a multi-wire connector assembly.

The fact that the terminals crimp on to the wire makes it relatively easy to work on the wires and cables while they are still in the organ (even though my eyesight is not the best). Digi-Key sells a convenient cable connector designer kit (for $39.95) which contains enough parts to make up 28 pairs of connectors, as well as the crimping tool you need and a terminal removal tool (for pulling a terminal back out of a connector housing if you make a mistake.) The connector kit is handy as a starter, but most of the connector shells in it are just for 1 through 6 wires, so I had to order extra shells for 15 and 24 wires. It's probably a good idea to start with the Digi-Key catalog first and choose the individual parts needed, rather than buy the designer kit.

The only problem I've run across here is that the new terminals extend a bit higher above the board, and can easily be bent. This is really only a problem in those places where a -30-volt power pin is right next to a ground or signal pin; in these cases, I slip a 1-pin housing shell over the terminal to make sure that it cannot touch an adjacent wire.

Problem 1: Dead Notes

Once I figured out how to make the work easier, it was time to tackle my problems one by one. First, I had some notes that did not play at all. For example, every F on the entire organ was dead. I decided that the master F tone generator oscillator had to be dead. From long experience, I know that electrolytic capacitors tend to dry out after many years, and so on a hunch I went after the 5 uf capacitor in the oscillator circuit (the one that connects from the oscillator coil to the base of the first transistor). Replacing it fixed the problem.

Let's talk electrolytic capacitors for a bit, since I've so far found almost a dozen bad ones -- and I'm not done yet.

Electrolytic capacitors are rated in their capacitance (measured in microfarads or uf; actually, the u in uF should be the Greek letter "mu", but u will have to do here) and their voltage. Most electrolytics range from 1 to several thousand uf, though capacitances of 100,000 or more uf are not uncommon, especially in power supplies. But since the tolerance of many electrolytics is something like -50% to +100%, a unit rated at 5 uf could actually be anywhere from 2.5 to 10 uf. Since the designer is never really sure what value the particular unit will have on a production sample, he usually puts in an oversize value. This is OK, since electrolytics are usually used in places where a too-large value causes no problem.

That means that in most places you do not have to replace an electrolytic with its exact value.

For example, replacing a 250 uf unit with a 220 or 470 is OK. But a 150 or 100 uf unit might be marginal -- it depends on how much overkill the original designer went for.

As to the voltage rating, that specifies what voltage the capacitor can withstand in a working circuit. For example, the largest power supply in the Theatre Organ is 30 volts, so using 50-volt capacitors everywhere would ensure that no capacitor will have more voltage on it than it can withstand.

But there are many places where an electrolytic will only be subject to 2 or 3 volts; putting in a 50-volt unit is overkill, and so the designer may have specified a cheaper (and smaller) 6-volt or 10-volt capacitor. But replacing it with a 50-volt (or even more) capacitor is no problem, as long as you have the room.

How do you test an electrolytic? Capacitor testers are expensive, but an ohmmeter (the old fashioned kind that has a meter with a needle, not a digital one) works almost as well, especially if it has a polarity reversal switch (a switch labelled + and -). If the meter has several ohms ranges, choose one of the middle ranges, and connect the meter across a loose electrolytic capacitor (one that is disconnected from its circuit). The meter needle should kick up to the right, and then slowly settle back to the left. Reverse the connections to the capacitor, and the needle should again kick up and settle back left. Each time you flip the connections (this is where the polarity switch makes the job easy because you just flip the switch back and forth) the needle will flip right and then back left. The larger the capacitor value (in uf) the further the needle kicks. With a bit of practice, you can judge the approximate value of the unit by how far it kicks the needle. Practice a bit with a new capacitor to get the feeling for what should happen.

If the needle stays at infinity (looks like a sideways 8) and doesn't move, the capacitor is open and should be replaced. If it stays at 0 ohms, it is shorted and also needs replacing. Finally, when the polarity of the meter matches that of the capacitor, the needle should kick up and then go all the way back to the infinity reading within a minute or two at most. If it doesn't do that, then the capacitor is leaky and should also be replaced.

The foregoing discussion assumes that the capacitor is disconnected from its circuit. If it is still in the circuit, then the test is not as clear-cut. The meter needle may not go all the way to the left, but it should still kick a bit as you connect the meter to the capacitor. If you don't want to disconnect each capacitor for testing -- which can get very lengthy and boring -- you need another way of testing the cap while it is in circuit.

As a capacitor ages, it usually becomes either leaky or it opens up. A leaky capacitor will usually mess up the voltage readings in the circuit; since Schober gave the voltage readings in their service instructions, this can usually be spotted by checking voltages in the circuit. But an open capacitor can't be detected this way.

The easiest way to spot an open capacitor is to temporarily connect a good one across it and see whether this fixes the problem; that's how I found the problem in my F tone generator. The test capacitor need not be the same value; anything close will be OK for testing. Just be sure to observe the polarity -- electrolytics have a nasty habit of occasionally blowing up if you connect the negative voltage to the + terminal, so watch how you connect it.

Most of the bad capacitors in my organ so far have been small 5 uf units; maybe Schober got a bad run of these. For these, a good test unit is Radio Shack's 272-998, which is a nonpolarized unit so you don't have to watch your polarity as you test.

At $0.13 each, electrolytics are cheap enough that I've ordered 100 of the 5 uf ones (and some other sizes) from ALL Electronics (1-800-826-5432). As I pull out a pc board, I replace all the electrolytics on it without even bothering to test them. If the old ones are not bad now, they probably will be by next year, and I don't want to have to do it again.

Next Time...

...we'll tackle the problem of transistor replacement. It did wonders for my noise problems!