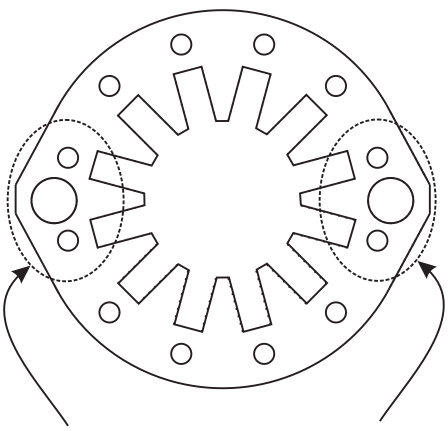
Fixing Broken Thomas Organ Vox Power / Standby Switches

OK, I admit it - I'm a little nutso about Thomas Organ Vox amplifiers. I've spent entirely too much of my adult life thinking about and messing about with them. I've pursued this obsession to the point that I can now recreate much of the Thomas Vox amplifier line from scratch, and have developed some ways to keep these oddities running.

One of the more difficult things to fix in these amps is the power/standby switch. The actual components are mildly archaic, and they do age and break. **There are no modern replacements that are both easy to find and reasonably priced.** That makes the power switch be a single point of failure for the entire amplifier. I have known of more than one of these amps which were junked solely because the power switch was not replaceable.

Here's the problem:
The rotary wafer switch was a masterpiece of easy semicustom design back in its day. It was based on a set of insulating wafers, each of which could hold a number of contacts that could be "programmed" to make and break by picking suitable-length switch contacts and matching contacts on rotary disks. The contacts were held to the wafer with rivets and were easy to make semi-custom; the wafers could be stacked on modular mounting posts.

The weak link was the wafer's mechanical strength. With aging, the phenolic-paper material of the wafer gets brittle and breaks easily. As with all mechanical devices, the breaking points were the points of greatest stress concentration.



This is an outline drawing I reverse-engineered from one of the switches I was repairing. There are 12 rivet holes and twelve slots on the inside diameter. The rivets hold switch contacts, which sit in the slots and interact with a rotating contact disk in the middle opening. The two bigger holes on the edges are the holes for the two support posts holding the switch together.

The stress on this wafer is greatest where there is the least material to withstand a bending force, and it's especially concentrated at sharp corners. That makes the two circled areas at the support posts be the primary break places. There can be others, but most of them break here.

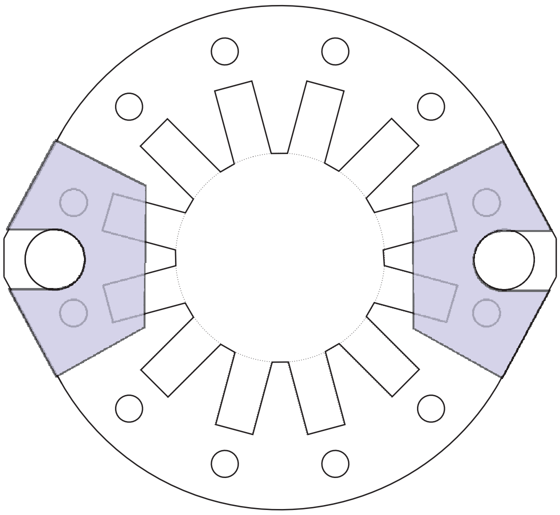
There are three ways to go about fixing this thing. One is to find a suitable modern rotary switch to replace it entirely. Another is to fix the broken wafers, and the last is to replace the switching function with something that acts the same but is made with available modern parts.

It is difficult to find a modern replacement because modern switches that will handle both the 125Vac line voltage and the 11-12A currents from the speaker contacts are expensive. I've found a few modern wafer switches that might work, but they're upwards of $50.00 each. If the switch is not too badly broken, it can be glued back together, which is method #2. I did a photo essay on a repair done this way which stars on page 8.

The general technique is to cut a reinforcing patch and glue it across the broken areas. No rocket science here. But it does require some careful attention to detail. If you're not careful, you can wind up with a switch that's not only broken, but no longer easily repairable. There needs to be a reinforcing patch across the break because simply putting glue into the cracks like you might with a broken ceramic cup is not likely to hold for very long. It broke where it was weakest and most stressed, and is likely to break there again.

For the most common breaks, it's smart to reinforce the other weak places where it didn't break this time, too. If you don't, it may break at the other weak spots in a month or two.

Here's how I did it. There are pictures of my repair technique at the end of the article.



From the drawing of the wafer and going cross-eyed staring at how the switch contacts move when they work, I figured out a "safe zone" where putting more patch material would not interfere with the switch operation. The two shaded areas at left show the two safe zones, one for each supporting post. The patch fits over some rivet holes and switch contact notches, but those are not used in the Thomas Vox power switches. It overlaps as much of the wafer area as I dared use.

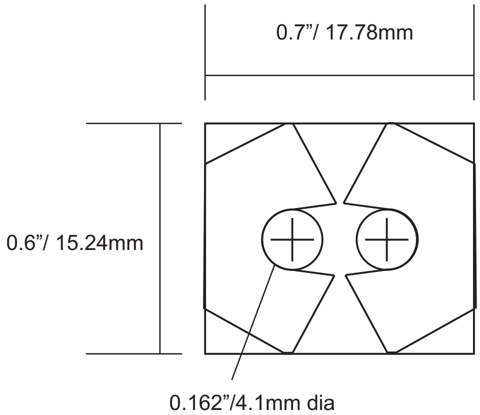
I found a scrap of 0.062"/1.6mm fiberglass/epoxy PCB material and cut out two reinforcements to match the pink areas, and then epoxied them into place on the switch wafer. The switch now works perfectly, and if it ever breaks again, the break will certainly not be there.

There are a few subtleties:
- The edges of the new reinforcement become new stress concentration lines. I put the edges of the patch over the places where the wafer is likeliest to be strong.
-I shaped the patch around the support post, so I could slide the reinforcement around the post to reinforce the weak inside edge as much as possible.
- The reinforcing patch does not extend to the inside edges of the middle opening, as there is a contact disk in the center of the operating switch that is not shown, and I wanted to be sure not to interfere with that.
- Using the right glue and right gluing process is IMPORTANT.
- Put the patches on the bottom side of the wafer, away from the switch contacts. This makes it much easier to put the patches in place when you're gluing.

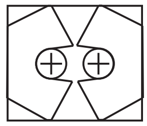
Making the patches was simple. I drew up the patch outlines on the PCB stock, drilled the holes for the support posts, then used a nibbling tool and a jeweler's saw to cut the outline to size, finishing the edges on medium grit sandpaper to smooth them. I removed the copper cladding and sanded the flat faces too, to give the glue a better grip on the surfaces.

With the patches cut, I spent about half an hour with my magnifying glasses and some needle files to refine the fit of the patches. I wanted to be sure that I could put them into place quickly and easily when it came time to glue. I also practiced placing the broken pieces of the switch back in place quickly. It is fortunate that the switch contacts actually slide onto the central conductor disk and will hold the broken wafer piece in position for most breaks. This is a huge help in assembling the switch when gluing, and in ensuring that the finished glued switch will actually work when the glue dries.

Here's how to make a pair of patches. The simplest thing to do is to print the actual size drawing on paper, then glue or tape it down onto your PCB stock. Center punch the centers of the drill locations and trace the outline of the finished patches. Drill the holes before cutting out the patch outlines in detail, and ideally before cutting the blank to 0.6"x0.7". When the holes are drilled, use a nibbler and/or jewelers'/Zona saw to cut the outlines. The actual outline is not critical as long as the finished patch is not significantly larger than the picture and can be placed on the wafer easily and quickly. Once the cutting and drilling is done, sand the edges. Spend some time making it fit well in the switch.



2x scale



Actual Size

Gluing is a critical step. You have to get this right.

First, use the right glue. You can try superglue if you insist. I have been very disappointed in superglues for applications like this in the past. I did a lot of reading about phenolic paper materials, and concluded that a good epoxy is the most useful glue here. Phenolic resin was an early form of thermoset gluing resin that made a crude kind of "fiberglass" to make these wafers. The switch wafers are a combination phenolic resin and wood fiber compressed into size and cured with heat into a solid sheet. Good grades of epoxy will bond solidly with phenolic-paper materials. If you do use cyanoacrylate superglues, you may be able to un-bond them by soaking the joint in acetone if it didn't work well, but I don't know what acetone does to phenolic materials.

Catalyzed polyester bonds less well, and stays sticky forever unless you block oxygen from it while it cures. Urethane glues might work, but they stay flexible forever in the ones I've seen, and that's not good for a mechanical setup like this. Epoxy it is.

I have also had bad luck with hardware-store "5-minute epoxy". This stuff is filled with plasticizers to make it give OK-ish results FAST. It's not optimized to hold and attach best.

I went to a local marine/boating store and bought some boat-repair epoxy. West Marine sells small packets of premeasured marine epoxy and hardener, and that's what I used, West Marine System 105 epoxy packets.

Once you have your glue, PRACTICE ASSEMBLING THE PIECES. Unless you are using a superglue to wick into the cracks, you will be mixing and applying glue, then putting the pieces into position and holding them there. You do NOT want to be figuring out how to assemble and hold the pieces in place while the working time of the catalyzed glue is ticking off. Practice assembling the pieces, which includes gathering a kit of tweezers, probes, whatever is needed for you to put them in place quickly and accurately.

Also figure out how you'll hold it in place while it cures. I am fond of clothes pins and paper clips for many gluing procedures, but there's not room in there for clothespins and most paper clips. For this work, I made special spring clips for the process. I took #1 wire paper clips, straightened them out and wound them into a spiral on a tool shaft, leaving about 3/8" to ½" (8-12mm) straight on each end, then bent the free ends into shapes that could serve as a temporary clamp to prevent the patch from sliding around while the glue cured. There are pictures of my clamps at the end of this article.

For any glue to work you have to get the surfaces clean. The switch wafer will have an unknown layer of gunk on it. That has to come off. I used cotton swabs and denatured alcohol to get the dirt and most of the greases and oils off the area to be glued, then lacquer thinner to remove any remaining grease or oil. I also cleaned the patches the same way. Needless to say, either completely degrease your hands before doing the cleaning, or wear plastic gloves during the whole process. A fingerprint has enough oil in it to destroy glue adhesion, and neither lacquer thinner nor epoxy is good for your skin.

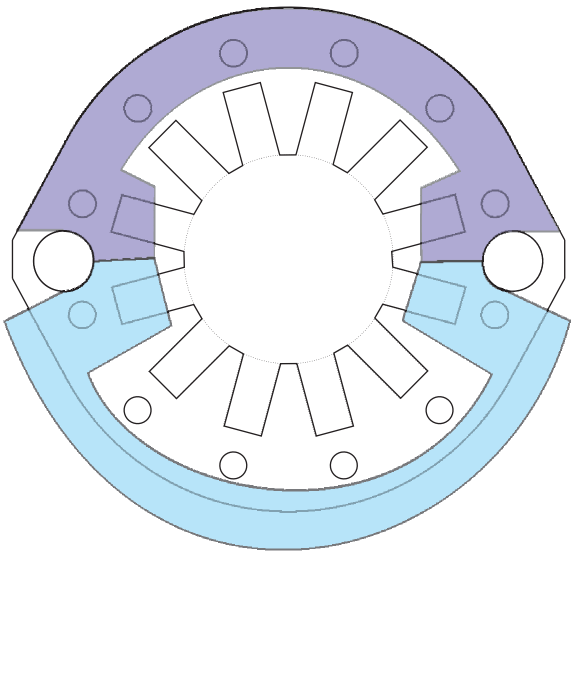
When you are sure you can put it together quickly and accurately, when you have all the tools and pieces you need (like... newspaper or other disposable covering for the work surface, as some glues are very hard to remove from the kitchen table), then get ready for the gluing. Run the cats, dogs, ferrets, parakeets, kids, and other interruptions out of the work area for a few minutes. This won't take long - it can't, as good epoxies are only workable for about 5-10 minutes max. If you're not done in 10 minutes, the glue will be unusable, and you have a huge cleanup and re-preparation task ahead of you before you can try again. The more prep work and practice you do before the catalyst hits the resin, the less chance you'll have to do the cleanup and re-preparation, or lose the switch entirely.

Get the catalyst and resin thoroughly mixed, then apply microscopic bits of glue to the original break lines; fit the broken switch wafer back into position, and let the metal switch contacts hold it in position; apply a thin layer of glue to the flat area of the wafer where the patch will go, and place the patch in position, and apply the clamps. Don't use too much glue and get excess squeezing out where it will interfere with the switch operation when it hardens.

I used a wooden toothpick as an applicator. Dipping anything into catalyzed epoxy results in a layer of epoxy on the anything, and a small toothpick can transfer just a bit of glue into the right places in a controlled fashion. You do not want a lot of excess glue flowing around to get onto the switch parts you don't want to glue. Apply just a little glue onto the surfaces that will be glued, place the patches in place and clamp them. Check your work while the glue is still workable enough to be removed if something is wrong, and when you're sure it's right, leave the switch assembly where it won't be moved for several hours. It's better if it's undisturbed for 24 hours.

If you've prepared well, the switch will be fully workable when the glue is hard.

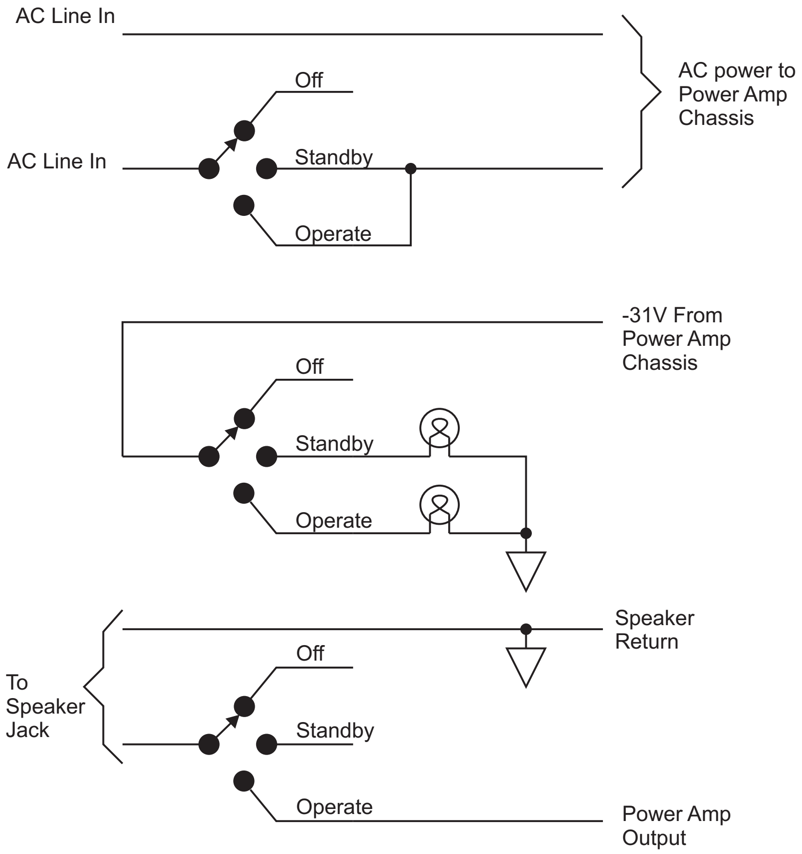
An ugly question is - what happens if the break(s) are not at the support posts, but out in the ring around the wafer.



That's harder to fix. I've never done that. But given how this went, I'd try something like the picture at left. I'd make a patch that supported the entire half of the switch that was broken, the upper shaded area as shown at right. This is considerably more complicated, and carries a greater risk of the fix interfering with the switch operation. I might try to drill out holes in the patch where the rivets are so that the patch could lie flat on the phenolic, or use a filled epoxy paste that would let the patch lie on top of the rivets so that the filled epoxy would hold patch and wafer together.

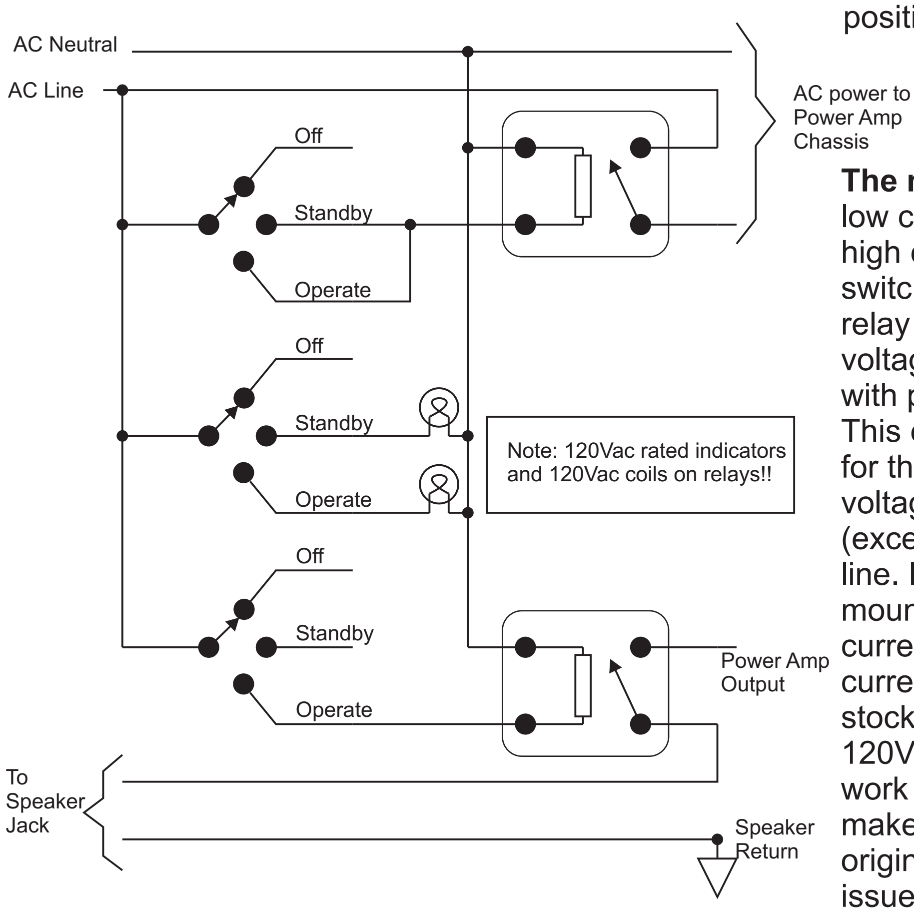
Another possibility is an external brace, just outside the circle of rivet holes, as shown in the lower shaded area. Both of these are complicated. I'd probably go to the third method.

The third way: replace the whole switch assembly with modern parts that do the same job.



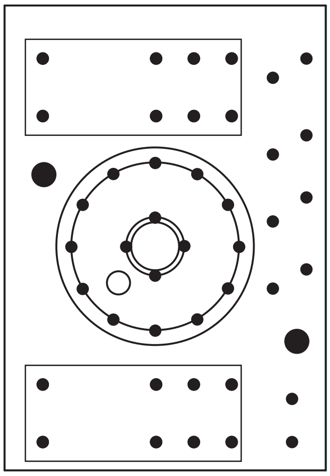
Original Circuit Function (left)

The power switch on Thomas Vox solid state amps mimics the off/standby/on function of conventional tube amps, and prevents a turn-on/off thump from the power amp. At left is the conceptual diagram of how it works. One throw is all off. The next, ‘standby’ turn power on to the power chassis, lights the standby indicator, but does not connect the audio output. The third position leaves AC power to the power chassis, turns on the operate indicator, and connects the power amplifier output to the speaker jack. The indicators run from low voltage DC. One big problem is that the speaker currents can be 12A on the Beatle. This prevents us from using low-current rotary switches for repairs.
This is only a conceptual view. The actual switch has one wafer switch and a mechanically attached power switch that only switches to two positions, on and off, and not two different on positions.



The modified version allows use of a low current rotary switch instead of the high current original. The actual power switching is done with two relays. The relay coils are rated for the AC power line voltage, and the indicators are replaced with power line voltage rated indicators. This eliminates the need to run DC back for the indicators and keeps all the voltages on the power switch board (except the speaker output) at power line. I found 120Vac miniature PCB mount relays rated for 16A of contact current, enough for the 12A speaker currents on the Beatle. Notice that the stock indicators have been replaced with 120Vac indicators! The old ones won’t work with this circuit. It is possible to make a setup like this work with the original indicators, but it increases the issues with safety clearances.

As usual with my electronic exploits, making things fit mechanically is a lot harder than making them work electronically. The replacement has to fit in the existing chassis space. This is not a problem for the original, because it used multiple sections of the original switch, using 3-D space for the wiring. I wanted more circuitry (the two relays) on a single PCB, so space was at a premium. Worse, both hazardous primary AC power and the secondary speaker output would be on the same PCB which can be a safety hazard unless it's done properly.



Top/Component View

First, I pored over the chassis with calipers and rulers to find out how much space I really had. The result is shown at right. I plotted the location of the centers of the rotary switch hole, the two indicator holes, and the semi-interfering fuse holder so I could see how much room I had. After that, it was off to the parts suppliers on the internet to find suitable electrical parts that would fit the space.

I found a cheap rotary switch which was rated for power line voltage and enough current to run relays. I also pored over relays to find small, high current, PCB mount relays that would fit in the available space. As luck would have it, these were also affordable, which does not always happen! The switch was actually 4P3T switch, which was fine, as one section would be unused. Even better, the PCB-mount relay height was less than the PCB-to-panel height of the rotary switch, so they could go on the same side of the PCB.

I wanted the whole PCB to attach to the back side of the rotary switch, and to carry the relays. The idea was that all the electronics would be on one PCB, with only the wires to/from the power amp chassis going to the board. This preserved the original plug-in wiring cabling.

This provides all the necessary switching and indication. It requires replacing the stock indicators with power-line voltage rated lamps. This can be done by replacing the bulbs inside the indicator lamp holders with 120Vac bulbs if you can find them. However, I found 120Vac rated replacement lamp holders which closely resemble the originals and even fit the same holes, so I just replaced them.

I wanted to NOT have to run DC power back to the AC power switch board. It simplified the wiring.

Here's the parts I wound up using:
Rotary switch : Lorlin CK1461, Mouser part number 105-14574, $4.76 (when I bought it)
PCB relays: TE Connectivity / Schrack P/N RT314615, Mouser P/N 655-RT314615, $2.98 ea.
Green Indicator: Chicago Miniature 1052C5, Mouser P/N 607-1052C5m $3.51
Red Indicator: Chicago Miniature 1050C1, Mouser P/N 607-1050C1, $2.33
This all comes up to $16.56, which is expensive enough, but it can be bought at any time from in-stock items. You'll also need a bit of PCB stock, some etch resist and some etchant.

As a final note,

THIS STUFF IS AC POWER LINE VOLTAGES!! IT'S **DANGEROUS** TO MESS WITH!! **DO NOT** TRY THIS UNLESS YOU ALREADY KNOW HOW TO DO IT SAFELY. THIS NOTE DOES NOT HAVE ENOUGH INFORMATION TO WIRE AC MAINS POWER SAFELY.

THERE MAY BE UNINTENTIONAL ERRORS OR OMISSIONS IN THIS INFORMATION!!

BY USING THIS INFORMATION, you positively indicate that you accept all risks of damage to people or property of any kind whatsoever, and irrevocably agree to indemnify and hold the writer harmless, and to defend him from any legal issues arising from your use of the information whatsoever, and that this agreement is forever binding on you, your heirs, successors, and assigns.

Sorry, but that's necessary. AC mains power is dangerous. I cannot accept any responsibility for it if you mess up and get yourself hurt. Think before you act.Here's my board layout. I recommend that you find parts that YOU can get, and adjust your layout to fit your parts, keeping only the location of the rotary switch and overall size/position of the PCB the same. This will ensure that your parts fit your PCB.

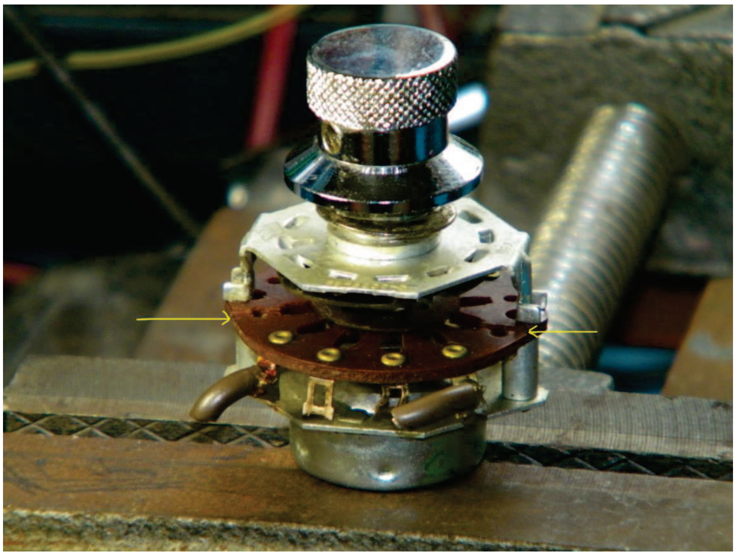
Notice that there are critical safety clearances and spacing distances involved.
While the AC power wiring sections of this are all assumed to be hazardous, and so only need to clear each other by the working voltage (i.e. 120Vac or 240vac, etc.) the speaker output connections are secondary and must be spaced away from all other conductors on the PCB. I did this to my satisfaction. You MUST ensure that whatever you do is safe to your own satisfaction.

I made a second, blank board of the same size and spaced it away from the bottom/solder side of the PCB to ensure me not being able to touch the AC mains circuitry in a moment of inattention. The instructions tell you how to do this if you decide you want to do so.

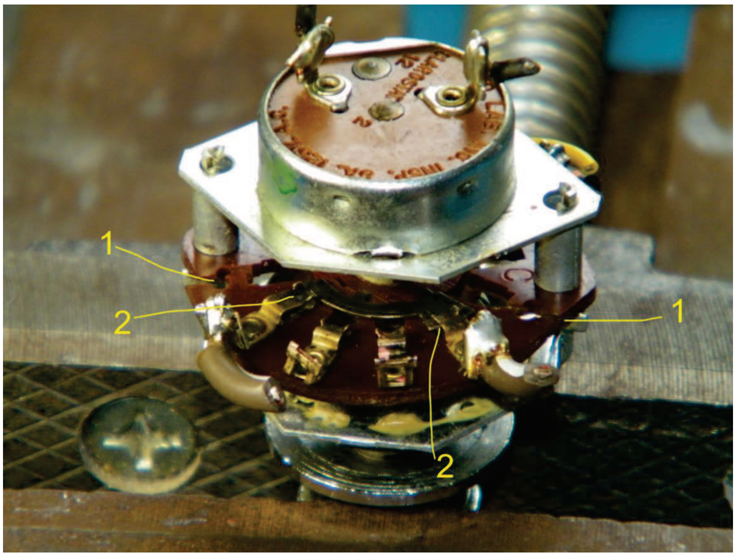
Patching a broken wafer switch

The photo at right shows the switch as received. The two yellow arrows point to the breaks in the wafer.

The broken section is actually completely loose from the main part of the switch and would fall off if disturbed.

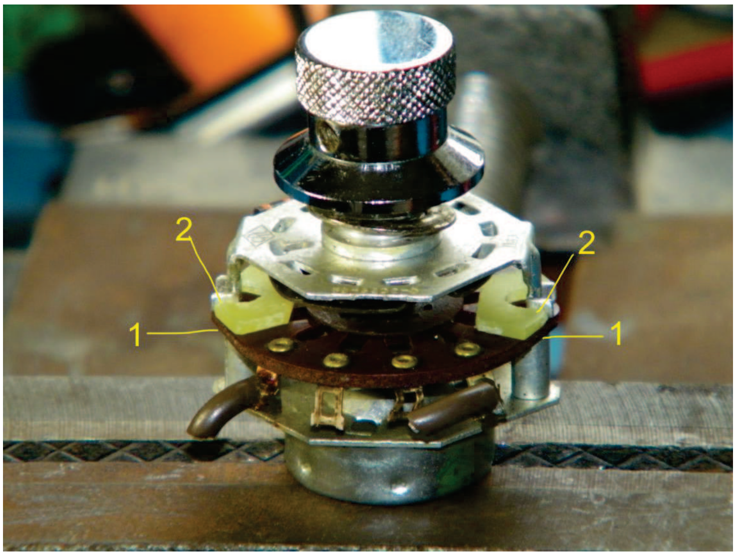


In the middle photo, the switch has been flipped over to show how even with the breaks (1), the switch contacts (2) will hold the broken section in place as long as there is no force on the broken section at all. This is really fortunate, as it gives some help in aligning the switch for gluing so that the switch will still operate when the glue dries.

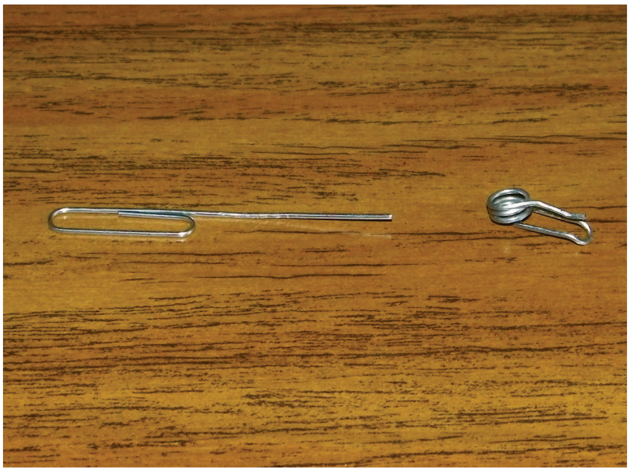


Taken immediately before gluing, this photo shows how the shaped patches (2) cover the breaks (1) and the possible breaks that could happen in the matching weak places on the back side of the mounting posts.

Also, this shows placing the patches on the side of the wafer opposite to the metal switch contacts.



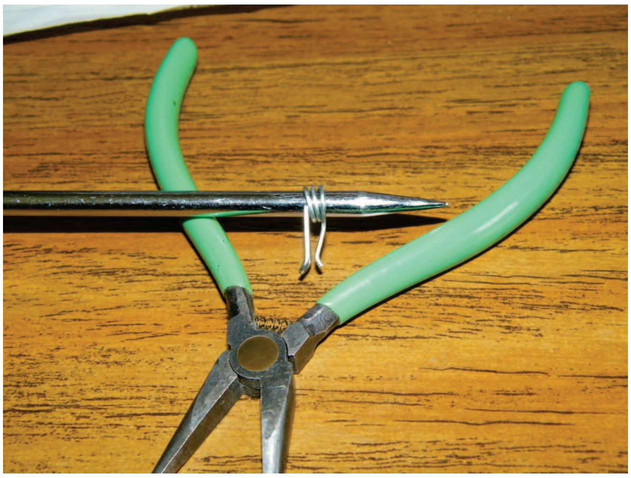
When gluing patches on the wafer, the patches need to be clamped in place just to hold them steady. I normally use clothespins and/or spring-clamp paper clips for such tasks, but the setup of the switch didn't allow for getting them onto the patch.

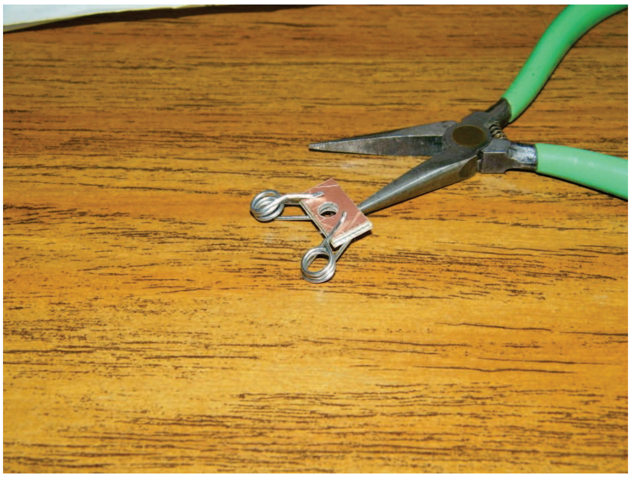


As an alternative, I sacrificed a couple of #1 size wire paperclips for the task. In the photo at right, I show a completed clip, and the beginning of another. I have straightened out the first bend in the clip, and will straighten the second bend, leaving only the third bend as is.

I then took the straightened clip and held it against the shaft of an awl with the open end of the third bend against the shaft. I wound the straightened section around the shaft three times, bending the straight part over the space in the middle of the third bend.

In the third photo, you can see how I bent very tip of the third-bend-section down, and also bent the straightened wire over it up so that they formed lips that let me slide the clip over the patch and wafer.



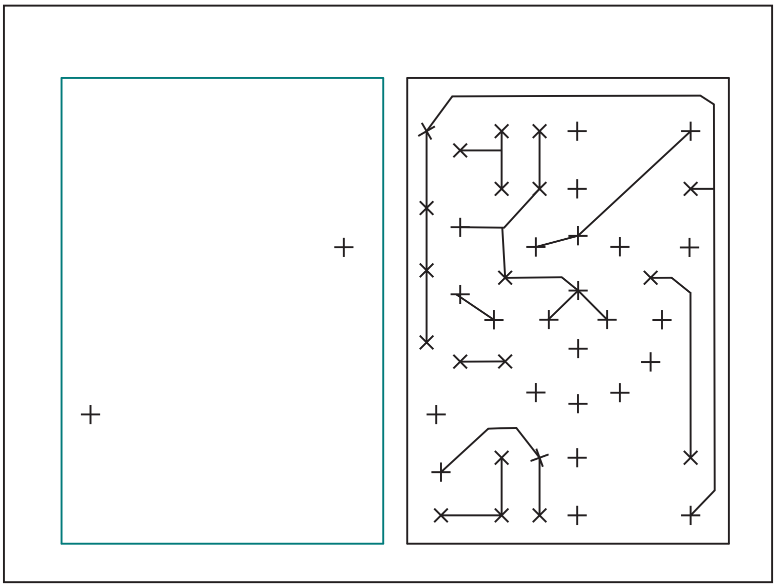


Here's the finished result, holding two of the spare patches I made (just in case!) together. They actually slid onto the patches easily. I practiced putting them on to the wafer and patch I used so I could be sure this would work without having to worry about the elapsing catalyzed-glue time.

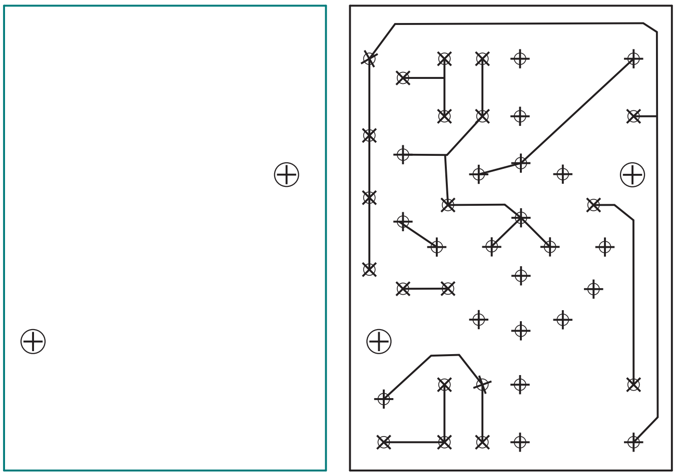
They worked GREAT!

Board Making

Obtain a piece of FR-4 glass-epoxy PCB stock 1/16” (0.0625”/1.6mm) thick with copper on one side only. Print the pattern shown at right on your printer and measure, adjusting your printing to make the outer rectangle come out to as close as 3.00” by 4.00” as you can. Cut the pattern out of the printed sheet and tape it over a rectangle of carbon paper onto the copper side of your PCB stock with masking tape, getting it smoothed and flat on the copper side.

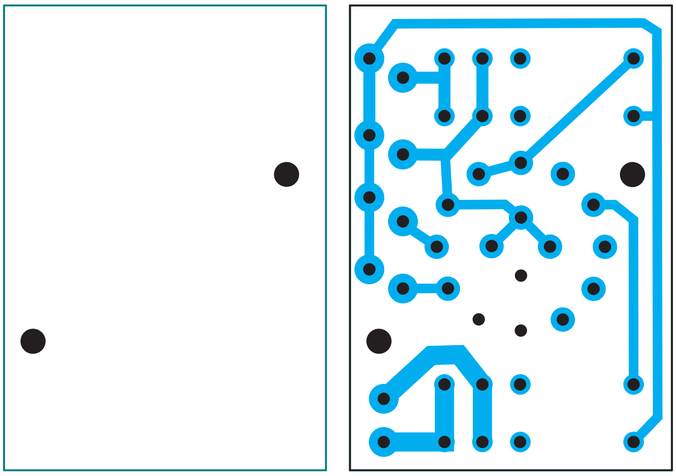


Using a ball point pen, mark the rectangular outlines of the two smaller boards to be made from this, and also the lines between “X”s. It’s OK, and a good idea to use a small straightedge to help you draw the lines. Then punch the centers of each of the “X”s with an ice pick, awl, or sharpened nail or screw to leave a tiny dent in the center of each “X”. Do this carefully - the relays and switch won’t fit if you get the holes too far off center.



Remove the masking tape, paper pattern, and carbon paper. Inspect your work, being sure you have every hole marked with a center punch and every line marked in carbon. It may help to deepen the center punch marks if they’re too shallow for the drill bit to center on and bit into. Also, it may help to scratch along the carbon-trace lines so they’re easy to follow after you clean the board for painting and etching.

Drill all the holes with an 0.060”/1.6mm drill. Then use a 0.125”/3.5mm to enlarge the four holes with the large circles around them to 0.125” diameter holes. It’s a good idea to see if your relays and rotary switch fit in the holes at this point.

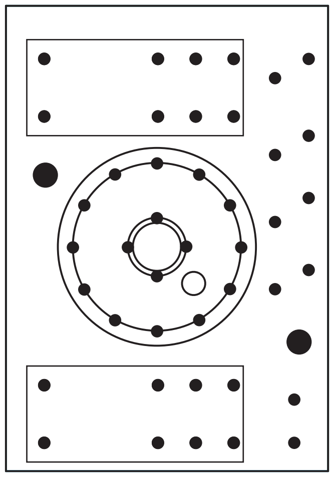


Clean the copper side with kitchen cleanser, then dish detergent and hot water until water runs off the copper in a smooth sheet, not rivulets. It must be totally oil free.

Cover the copper side with plastic kitchen film or paper or some such to keep oil from your hands from re-contaminating the copper with oils, resting your hands on the film or paper and moving it as you draw, and draw the pads and traces as shown at right onto the copper in nail polish or Sharpie marker. Get the pad diameters and trace widths as close as you reasonably can. There are seven holes shown with no pad around them; leave them with no pad. Again, check your work.

If you’re satisfied with the paint job, let it dry a minute or two, then dunk the board into your favorite PCB etchant and etch until the copper clears entirely between pads and traces. Rinse with running water until the board is completely clear of etchant, then dry it. Clean up your etching setup.

When you're done with the etching and cleanup, place the relays and rotary switch into the holes on the board and solder them in. Notice that the relays will only go in one way (that is, if you got your holes close to the right positions), but the relay can go in four different positions. Technically, the index pin on the switch should go over the little circle to the lower right of the center circle of pins as shown at right, but in fact, the center pins force the relay to go in a workable position any way you can make it fit in all the center holes and outer holes at the same time.



Top/Component View

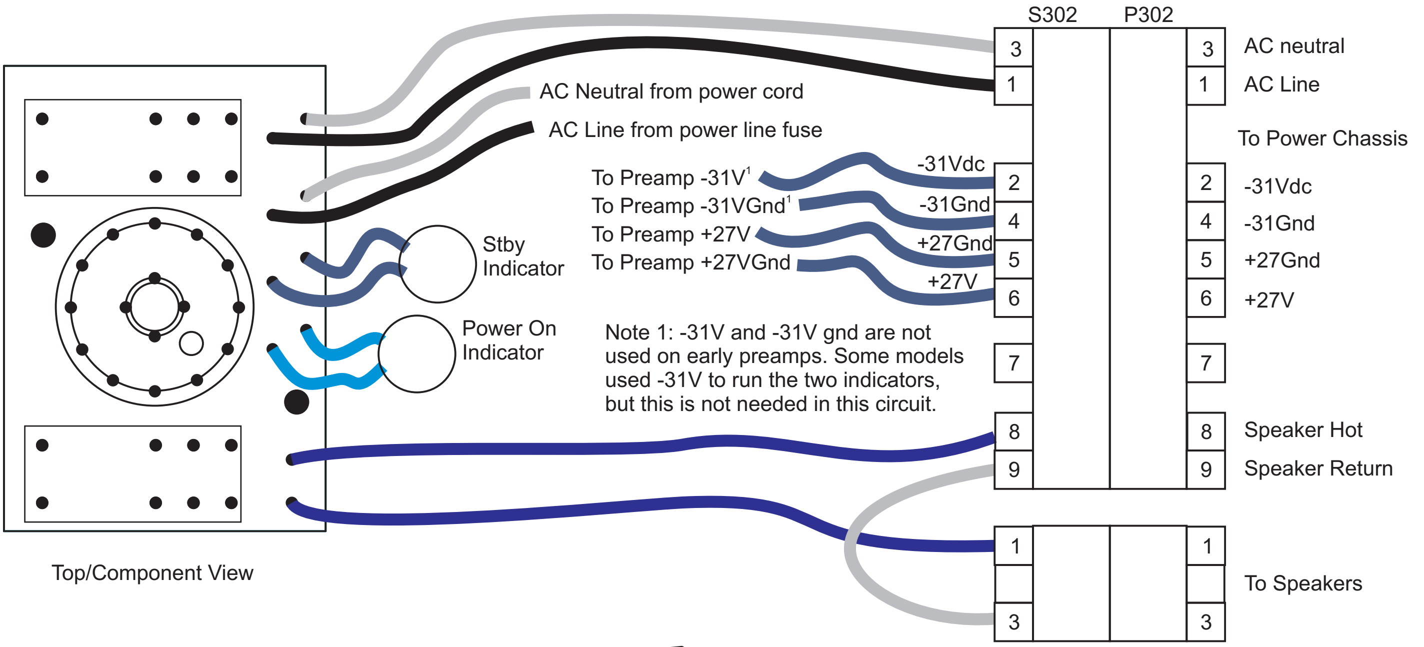
The holes without pads for solder on the rotary switch were left that way to get more safety spacing between the AC-line voltage and the speaker-relay pins. Again, I did this for my own purposes, and it may or may not be safe according to official standards. You will have to take responsibility for your own safety in deciding whether to do this or not. If you have doubts, don't do it.

If you have chosen to build this, I recommend that you do the following checkout procedure, as I did to mine.
First, check the fit in the chassis. Place it temporarily in place and verify that the rotary switch fits properly into the hole in the chassis, and that the new indicators can be inserted into the chassis holes and not interfere with the new PCB. The PCB should also not interfere with the fuse holder - barely.

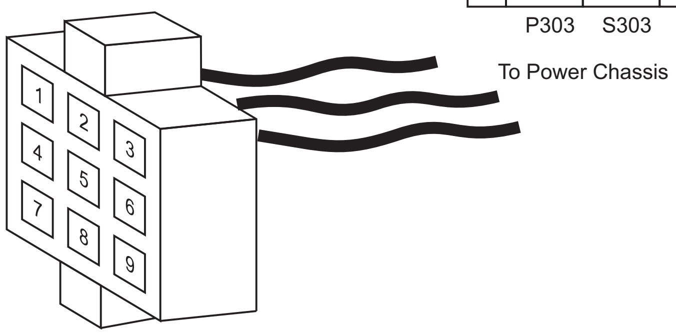
If all is well mechanically, check out the PCB with an ohmmeter before trying to wire up the line voltage wires to it. Hook one lead of the ohmmeter to the pad indicated for the AC neutral wire, and the other to the pad for the AC Line wire.
You may want to solder a bit of wire onto the pad temporarily to connect your meter leads.

With the ohmmeter between the AC line pad and AC neutral pad, measure resistance in all three switch positions. These should be :
- Off position: open circuit
- Standby position: about 7.5K - 8.5K, which is the coil resistance of the relay switching power to the power amp chassis
- On position: about 7.5K - 8.5K, which is the coil resistance of the relay switching the speakers
If you get other readings,
Verify that in the CCW position, the meter shows open circuit, and in each of standby and on positions, the meter reads about 8K +/-, that being the resistance of one relay coil. If you get any reading less than this, there is a short on the PCB. If you get much higher than 8K in either on or standby, check the one top-side wire and relay soldering. Next check for zero ohms from AC neutral to one pad of each indicator.

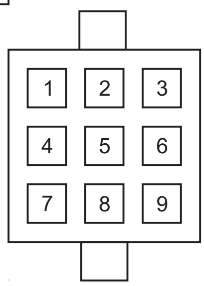
This is how I wired my AC switch board into my amplifier, with some notes about how it might be wired into other amps in the same model line. The original wires coming from S302 are unsoldered from the original switch assembly and re-soldered onto the new switch board. The DC connections from S302 to the switch board are not used, as the new indicators run on 120 Vac. I insulated the wires carrying -31Vdc and its ground return after removing them from the old switch assembly.



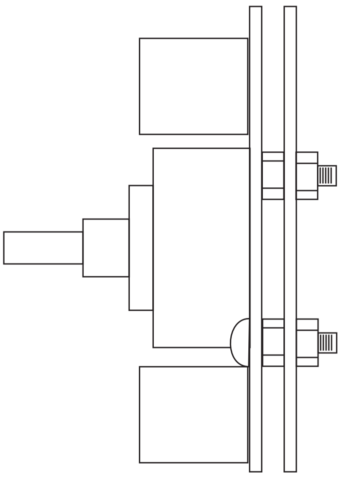
Top/Component View



P302



P302
Looking into holes



Blank bottom board mounted on insulating nylon screws and nuts to prevent touching the live voltages on the bottom of the PCB.