Method: Salvaging LCD polarizers

Why

Polarized light is a pretty useful tool. Not only the two polarizers make a nice effect of going dark/transparent depending on their relative angle, they can be also used for many actually useful things, e.g. visualisation of strain in transparent plastics and glass.

New polarizer sheets are either small and expensive, or larger and VERY expensive. But each LCD panel usually has two, in the form of a glued-on plastic foil, one on each side of the glass sandwich. It's just about sourcing a cracked or otherwise useless display panel of a suitable size and prying the sheets off.

One LCD panel will yield two polarizers. Depending on the design, both can be fully transparent, or one of them, the front one, can have matted surface (for non-glossy displays). The bottom one may or may not be matted, but in the tested case it was found to be glossy and transparent.

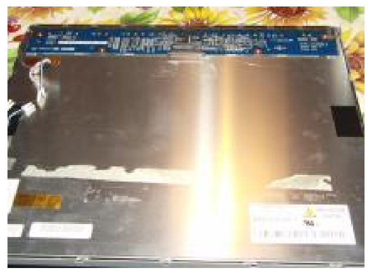
How

The adhesives and sealants used in electronics often become softer at higher temperatures. This is exploited for example for salvaging ferrite cores and bobbins from discarded power supplies.

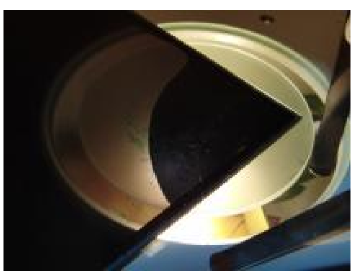
The display panel is removed from the backlight plate (which is useful too). Note the electronics on a flexible substrate, with directly bonded long narrow silicon chips; these are the row and column panel drivers, sending signals to the pixels themselves. In some cases these become gradually unbonded and cause failures involving a band of bad colors or failed pixels affecting an entire row or column. The isolated display is a thin layer of liquid (the liquid crystals themselves, usually a cholesterol ester but can be also another suitable organic chemical), on each side with a thin glass panel (about 1mm thick, fairly fragile glass). The sandwich's outer sides are laminated with plastic polarization filters.


LCD panel, front side


LCD panel, back side


LCD panel, back, electronics exposed


LCD panel electronics, column driver chips

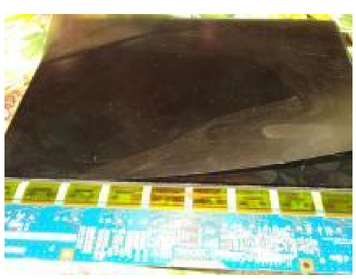

Cracked panel, backlit


Cracked panel, backlit

The glass-and-plastic sandwich is placed next to the nozzle of a hot air generator (like the Hot Air Blower or a hairdryer. Beware of too high temperatures, the plastic itself should not soften nor undergo any other damage. Allow enough time for the heat to soak through the plastic and warm the glass and the glue layer between the plastic and the glass. Avoid direct touch of the panel and the nozzle or other excessively hot material; the plastic could warp or discolor or partially melt or lose the polarization properties or undergo other kind of damage.

Gently pry the plastic from the glass. Use a blunt tool. A table knife or butter knife will do a good job. Be gentle and patient, push the blade between the glass and the plastic in parallel, avoid prying - you'd risk damage of either the foil or the glass. Avoid pulling on the foil itself, however tempting it is to just tear the foil off the glass; the adhesive is fairly good and you'd risk either cracking the glass or forming a sharp kink on the foil and damaging it. The foils don't cope well with sharp bends. The adhesive tends to stick to the blade; it's annoying but can be lived with. It can be alleviated with a bit of a suitable solvent (more later).


Ungluing the sheet


Ungluing the sheet


Ungluing the sheet


Unglued sheet, minor heat damage visible on the edge

Once the sheet is removed from the glass, the icky part begins. The sheet is still full of the adhesive . Which attracts dust and fibers and sticks to everything and wrecks the transparency. So the glue has to go. Preferably with a solvent.

The first solvent to test was toluene, on the basis of educated guess and availability (the workshop's supply of solvents was found to be grossly inadequate). The compatibility with the plastic was tested by putting a drop on its edge, waiting for several seconds, then wiping it off; no attack on the material was observed. Same was performed on the glue, where a somewhat satisfying interaction was observed.

The glue did not dissolve, but swelled and got somewhat less sticky and could be scraped off. The material is a "supersnot" - a gooey gelly stuff with absorbed solvent, like what a god of glues blows from his nose. Work on old newspapers or other disposable substrate, as it will get everywhere. (Beware on the tendency of the printing ink to dissolve in some solvents, you could inadvertently transfer some onto the table below. Oops.)

The performance of the solvent was less than hoped for, the adhesive was fairly resilient and toluene stinks. The next day more solvents were bought under the guise of paint thinners - a light petroleum fraction[YI] and a xylene[YI]. (Various solvents and their combinations are available for different paint formulas; they usually contain one or more of aliphatic and aromatic hydrocarbons, aliphatic ketones and esters, usually listed in small print on the can.) Other solvents sourced were turpentine["(] and the citrus oil (a mixture of terpenes) based sticker remover in the form of spray. Ketones-containing solvents weren't tried out of concern for the incompatibility with the plastic sheet.

All the solvents tested shown similar performance. The citrus oil sticker remover won on the basis of ease of dispensing (just spray it on) and least-bad smell; turpentine, with its distinct smell of pine trees, was the second choice. Light petroleum and xylene, while also possibilities, were decided against on the basis of stink.

The solvent was sprayed on the adhesive layer and given a few minutes to soak in. The thin layer of adhesive turned into a thicker layer of swelled snot. A piece of tissue was then used to wipe the snot off the surface; it does not go well, the goo tends to recontaminate the surfaces and there is a lot of it. The layer also tends to stick fairly well, and needs to be mechanically scrapped; a fingernail does a good job.

It is tempting to scrape the goo off with a knife. Avoid it if you can; even a dull dinner knife turned out to be hard enough to scratch the soft plastic. The scratches then will be very well visible in dark field due to absence of polarization effect. Stick with slow, patient wiping, use copious amount of solvent, and do the work in several passes; first get rid of most of the glue, then of most of the rest, and only then go for removal of all the residues and smudges. A scraper made from a suitably soft material (softer than the foil but hard enough to not deform much under the force needed to separate the snot from the substrate) could be very helpful.

The polarizer is often present as a thin coating on the plastic substrate, on the glue side. As such, it is fairly sensitive to scratches and other mechanical damage. Be very careful if you want to minimize introduction of such defects.

The work is messy and takes a long time. A rerun of something on TV is a good companion for the job. Awareness of the price of the equivalent new polarizer sheets off-the-shelf is also helpful to keep the morale up.

It is advisable to perform the final cleaning using an antistatic-enhanced cleaning solution/foam. The cleaned and solvent-wiped foils were found to get electrically charged and attract dirt and stick to things before such treatment.

Washing off the adhesive

Removed adhesive, "supersnot"

Other useful parts

The LCD screens have more useful components. In addition to standard electronics, there is the backlight panel, useful for e.g. light table or a large-area room light. The glass layers from the display itself are coated with a matrix of transparent electrodes, which may find their own use in some exotic projects. One of the glass panels also contains the RGB color filters deposited under the electrodes.

Hot air blower

Instrument

In a lab, like in politics, there is often a need for hot air; sometimes for a gentle preheating of something, sometimes for drying paint or other water- or solvent-based substance.

A salvaged hairdryer was originally intended to be satisfying. However, it turned out that the airflow is too high (enough to damage more sensitive components or paint layers). More seriously, the noise of the running hairdryer was unbelievably L-O-U-D, resembling a jet engine during takeoff. (Who can ever be comfortable running that next to one's head?) Therefore it was decided to design a modified hot air source.

The motor with the fan blades was quickly determined to be the root cause of the noise. (Well, duh.) So it was removed and another airflow source was located. A 120x120 mm 220V AC cooling fan was picked up as the best cost/performance option. While still not entirely quiet, it was MANY decibels less and it was actually possible to withstand longer periods of working right next to it without turning mad.

First, to test if the airflow is sufficient for cooling of the heating spirals, a mockup was made, using aluminium foil and sellotape to channel the airflow from the fan through the heater block. The test results were satisfying.

An old ATX power supply case was determined to be the best and easiest option, due to being metal (and therefore fireproof), easily available, and already with a precut hole for the 120 mm fan. The storage compatibility with the Spot Welder was another plus. A hole was cut in its side (by drilling a lot of adjanced holes, then cutting out the disc and filing off the ragged edges, ufff) and the heating element from the hairdryer was affixed in it.

The airflow in the new assembly was a bit lower than expected from the mockup tests. The box was apparently creating more air drag than the aluminium foil structure, increasing the pressure gradient inside and lowering the efficiency of the fan. The impact was however less than critical.

The resistive wire turned out to be more fragile than expected. It was damaged on two more places during handling, and a repair had to be performed. The same approach, brazing with brass and borax, was used as with the original hairdryer repair.

The holes in the casing were covered with sticky tape, in order to channel all the airflow through the heater. The mesh on one of the sides was covered with aluminium sheet.

The electrical wiring was simple. The main switch powers up the fan and enables the heaters. Two other switches power up (if enabled) the two heater segments. Originally there was a plan to add diodes in series with the heaters, with a switch to allow reducing the energy by half, however at the end it was decided to hardwire the diodes there without the switch, as the airflow was too low and the heaters were quickly overheating at full power. (Fortunately there is a bimetal-based thermal fuse in the heater assembly, which cuts the power to the heater when it overheats, preventing lasting damage.)

The heater assembly was secured in place using silicone caulking.

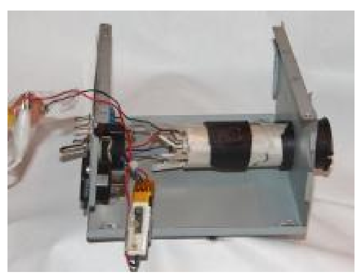
It was measured that the air temperature at the outlet at full power is around 250 °C, which is just about right ceiling to not damage most things. The temperature drops with distance from the vent.

The unit proven to be useful for gentle drying of paints, melting of some compounds (e.g. wax), and softening adhesives and plastics. Its relatively low noise is a definitive plus in comparison with the original hairdryer; that goddamned thing was AWFULLY loud.

Images


Fan test


Fan test


Inside view, testing


Inside view, testing

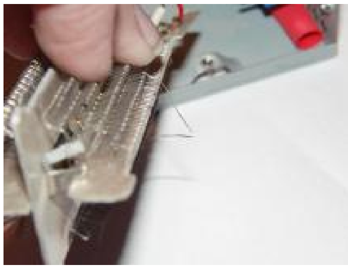

Preassembled unit


Preassembled unit, slightly overheating


Inside view, electronics


Inside view, heater mount

Hot air blower, control panel



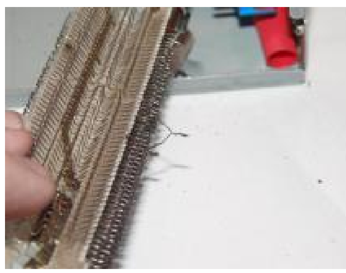
Broken wire

Broken wire, twisted together

Broken wire, added brass and borax, foamed up

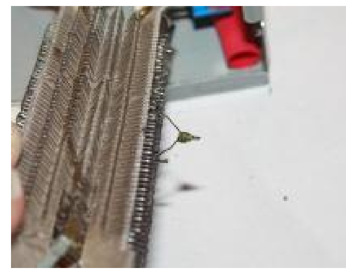
Broken wire, soaked with molten flux

Broken wire, brazed together, before flux removal



Broken wire, twisted together

Broken wire, added brass



Broken wire, brazed together, before flux removal