# Important project notes:

- **THE OEM CIRCUIT IS WIRED WITH A *POSITIVE* GROUND! THE NEW PHOTOELECTRIC CONTROL CIRCUIT RETAINS THE *SAME* OEM POSITIVE GROUND CONFIGURATION.**
- **Circuit values were designed based on operating from a *regulated* 5 Volt DC supply. 5 Volts DC was chosen because surplus 5 Volt DC cell phone chargers are readily available, or use a PS based on a generic LM7805 regulator circuit. The circuit and will draw around 30ma in operation. Before connecting, test that the output of the charger stays regulated at 5.0 Volts down to no load.**
- **+5 Volts DC (positive) connects to the grounding post on the battery housing.**
- **-5 Volts DC (negative) connects to the red wire that goes to the negative battery spring terminal.**
- **Component reference names are my designations, not from the OEM schematic.**
- **Take special precautions during the "Photo 19" work to avoid melting the insulation on the carriage 'umbilical' cables. Either unwrap the ground wire anchoring the cables or attach an effective heat sink before soldering to the ground turret terminal 1.**
- **Transistor Q1 in the drive/battery housing need not be replaced. Transistor Q2 on the carriage gets replaced with a 2N3903 (or 2N4123) which has a different lead configuration than the OEM 2N3705. Follow the lead connections shown in this mod, not the OEM schematic.**
- **It is recommended that you follow these steps in sequence, even though some of the photos get referenced out of numerical order.**

Photo 1:

- Everything gets stripped out, except for the ground wire to the brass axle stake and the umbilical cable assembly which includes the red/white/black unshielded control cable and the shielded tonearm cable.

Photo 2:

- Unsolder the white wire from turret terminal 4.
- Unsolder the two green wires from turret terminal 3, and re-solder both green wires to turret terminal 4.
- Do not disassemble the multi-wafer yellow cue switch & lift motor cam switch assembly. There is no reason to do this and it is a royal headache to re-assemble.

Photo 3:

- Unsolder the catwhisker contact assembly from the carriage side of the turret terminals.
- Unsolder the transistor and resistor from the carriage side of the turret terminals. Don't try to salvage these. Replace them with new parts.

Photo 4:

- Install a minimum 10mm high by 5mm deep 'flag' on the contact post with the 'tail' pointed towards the front. The easiest way to make the flag is to cut a 10mm square piece of aluminum duct tape (*not* silver color fabric "Duck" tape) and fold it in half over the post. Note: the adhesive on the aluminum tape is very sticky and makes it difficult to handle and position properly. The height of the flag needs to be able to completely block the bottom carriage drive sensor and the upper lift motor sensor simultaneously.
- Note that everything has been removed from the carriage side of the turret terminals except for the 'ground' post wiring and cartridge signal wiring. Replacing the cartridge signal wiring is not part of the modification, unless you have planned a total re-wire of the arm (which is off-topic).

Photos 5 – 11:

- Miscellaneous details. The microswitch and mounting hardware shown in Photos #5, 6, and 8 has been deleted from the project (long story). Ignore the switch in all photos. Consider the switch to be replaced with a jumper wire in all schematics.
- Note in Photo #8 that the sensor support includes selectable depth spacers under the sensor mounting tabs. The total depth of the front edges of the sensor mounting tabs from the front edge of the carriage frame is set to position the run sensor aperture near the center of the OEM moving contact hole opening. The total depths are determined by the depth (thickness) of the sensor support plus the individual spacer depths. The total depth for the run sensor is 0.599". The total depth for the lift sensor is 0.643". The 0.044" offset between the run and lift sensors works out to about 0.16 in (4 mm) runout to trigger an end-of-record lift. Of course, you should round off the decimal places to realistic, buildable values. I elected to make the sensor mounting undersized and then add different thicknesses of spacers to optimize the sensor positioning. This proved to be easier than trying to make the mounting from one piece and having to get the dimensions right the first time. Final adjustment for zero tracking error is via the hex-head setscrew using the same OEM procedure outlined in the service manual.

Photos 12 – 18:

- Miscellaneous details.
- It is easier to preassemble Q2, D2, & R4 and install as a sub-assembly in a later step. Hold the parts bundled together with heat shrink tubing.

Photo 22:

- Install the opto sensor sub-assembly. Line up the sensor sub-assembly so that the aluminum tape flag ends up in the middle of the gap. Adjust/bend the flag to make sure it moves freely in the gap. Remember that the wire post end of the tape is the leading edge that controls the servo action.
- Position the resistor bundle R5-R6-R7 as shown. It must not interfere with the free movement of the cartridge wires. Tape the bundle down so that it doesn't hit the beaded chain tension pulley when the carriage is moved to the 'home' position.

Photos 19 & 21:

- Solder one end of resistor R2 (160 ohms, Brown-Blue-Brown stripes) to turret terminal #3 (Photos #19 and #21). Leave the other end hang down for connection later.

Photos 7, 20, & 21:

- Details show backside wiring of the opto sensors (Photo #7). Wires on the left go to resistor bundle R5-R6-R7. Bottom sensor wire on the right goes to turret terminal #2 with the red wire (-5 Volts, Photo #20) that goes back to the battery housing. Middle sensor wire on the right (the one with the red dots) goes to the white wire to the carriage (Photo #21). This is a 'flying' splice with an insulating sleeve.

Photo 20:

- Bend the free end of R4 on the Q2-D2-R4 sub-assembly around to be inline with the C and E terminals of Q2, and tack solder the three leads to turret terminals 2 (emitter), 3 (collector), and 4 (resistor R4 free end).

Photo 7:

- Top sensor wire on the right goes to the free end of diode D2 (the end without the stripe, Photo #20).

Photos 11 & 19:

- The free wire from the R5-6-7 bundle (Photo #11) goes to turret terminal 1/frame ground/black wire to the carriage (Photo #19).
- **NOTE: Un-wrap the ground wire from the carriage cable set or use an effective heat sink on the ground wire to prevent melting the cable insulation when you solder to turret terminal #1. This would be a lot of work to fix!**

Photo 21:

- Connect the red wire from the lift motor to the free end of resistor R2 (160 ohms, Brown-Blue-Brown stripes).
- The 160 ohms value for R2 was chosen to make the lift motor run at the same speed as the OEM control operating from a C cell power source. A smaller value for R2 would make the cue action faster, but that will result in overtravel of the cam switch and cause the lift motor to cycle continuously.

Photo 22:

- Carriage modification and wiring should look complete.

Photo 23:

- Unsolder the carriage run motor red wire from transistor Q1 collector lead (middle). Take care not to damage the transistor as it will remain in the circuit.

Photo 24:

- Solder in resistor R1 (620 ohms, Blue-Red-Brown stripes) in series with transistor Q1 collector lead (middle) and the carriage run motor red wire. Position the resistor so that it doesn't interfere with the cartridge signal wires to the RCA sockets.

Photo 25:

- Run a cloth sewing thread through the center hole above turret terminal #3 and tie down/secure the wires so that they will not interfere with the beaded drive chain.

Photo 26:

- Tie a cloth sewing thread loop to secure the green and black cam/lift switch wires and position them so that they will not interfere with the free movement of the flag trip arm.

Photo 22:

- Top view of the completed carriage – it's done!

Final Notes:

- The circuit is designed to operate from a *regulated* 5 Volt cell phone charger as the power supply and will draw around 30ma in operation. Before connecting, test that the output of the charger stays regulated at 5.0 Volts down to no load. You may have to experiment with different PS's to find one that doesn't introduce electrical noise.
- I used alligator clips for connecting the power supply to the spring clip in the battery compartment (-5V) and the ground post on the back (0V). You *could* install a pin-type power plug and socket connector, but that risks damage from a slipping drill bit and makes the mod non-reversible.
- Adjust the hex screw on the trip arm for 90-degree tracking during play.
- Set up your VTF, VTA, RA (recliner angle), then sit back and enjoy!