KØFF Homebrew Tips

Geiger Counters in the Ham Shack

Many hams are also interested in nuclear radiation detection for a number of reasons. A few of those reasons might be:
A) Collecting radioactive radio tubes
B) Testing high power equipment for X-Ray emissions
C) Testing and cleaning up surplus radio gear (radium paint abounds!)
D) ARRL has approved GAMMA RADIATION as a ham band for contests!!

For many years I never saw any decent radiation detection gear at hamfests. Since the late 1990's
the US Gov't has been surplussing out those Civil Defense units that were stored in basements and
attics all over our country, many of which now wind up for sale cheap.

There are several versions of these yellow, CD placarded hand held detectors. Ones marked
CD V-715, CD V 710, CD V-720 and a few others WITHOUT external sensors or cords are high range
ion-chamber detectors and have little use except near an atomic detonation.
One model is a true Geiger Counter, the CD V-700. This one has a silver handheld probe attached to the
unit by a cord. Sensitivity of this Geiger Counter is very good and has many everyday uses around any
home or ham shack.
http://www.qsl.net/k0ff/What%20*IS*%20and%20What%20*IS%20NOT*%20A%20Geiger%20Counter/

Unfortunately the electronics in these 50 year old units is deteriorating, causing intermittents and
down right failures.

Even though all the true Geiger Counters bear the ID CDV-700, there were several different manufacturers,
each with their own circuit preferences. Between makers, even the battery count (all use D Cells) varies
from 2 to 5 cells!
Also there were different versions within the same maker, such as model 6, 6A and 6B. All versions use
an earphone (no speaker) and have a meter with 3 ranges.

Many regard the Lionel units to have the best circuit design, however the mechanical details are lacking.
Units made by Anton and some others are pretty much collected as display items due to wretched unreliability. One manufacturer,
Electro Neutronics Inc, abbreviated ENi has some really good components and mechanical design, but
their circuit is the worst and most unreliable of all.

In my opinion the physical layout of the ENi is better than that of
the Lionel, so the merger of the Lionel circuit concept into the ENi
mechanical layout really does give the best of both worlds.
What follows is a drastic modification to an ENi, updating it with some modern components, while
changing the circuit to better follow that used by the Lionel. This melding of the two technologies I
dubbed the LENi.
Below each picture is the link to the high resolution version, should you care to download it for details.

Once the basic LENi conversion is finished, additional improvements may be added to further upgrade the usefulness of the device. The Speak2Me speaker module has been the most popular add on. From there it is easy to add, volume control, Sonalert, power LED, Fast/Slow Response switch, reset zero button, pulse LED, variable high voltage, digital readout, internal sensors, etc.

Fig. 1 ORIGINAL SCHEMATIC OF ENi CD V 700:

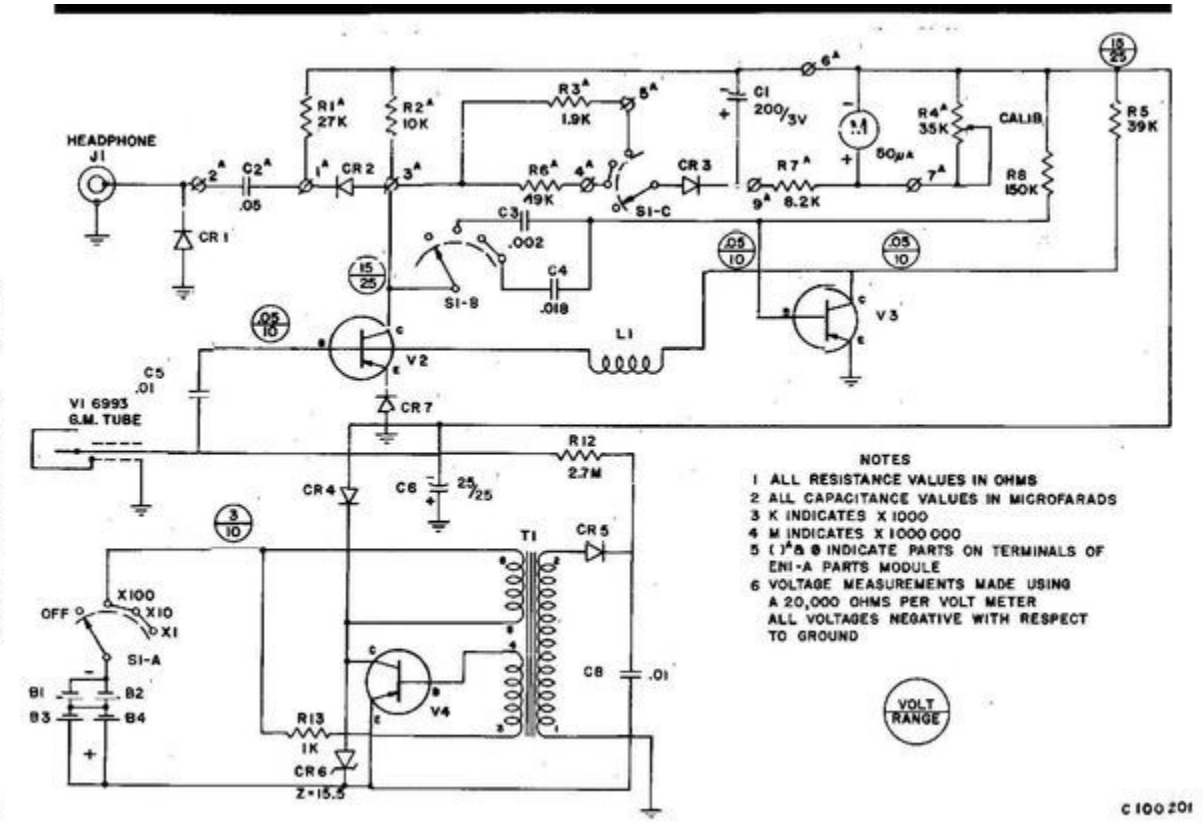

Fig. 5 — Schematic for V-700

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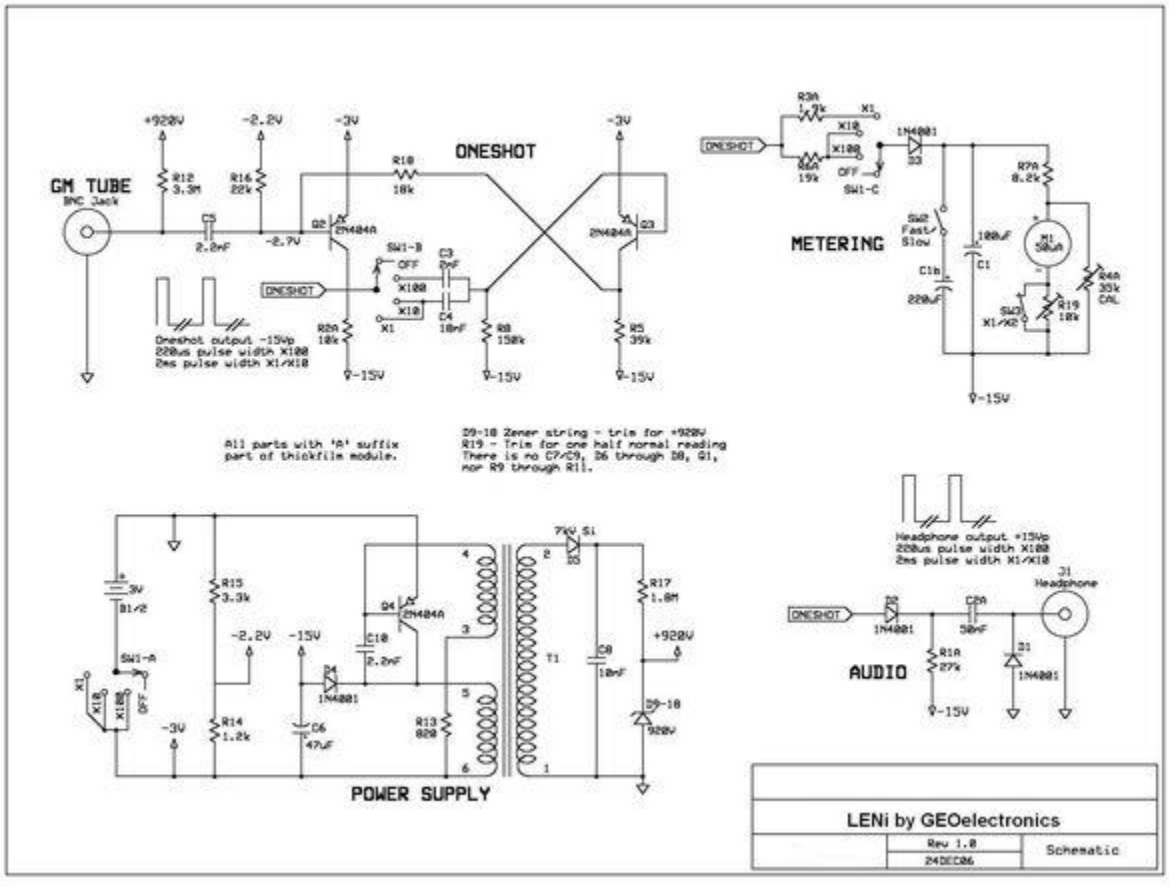
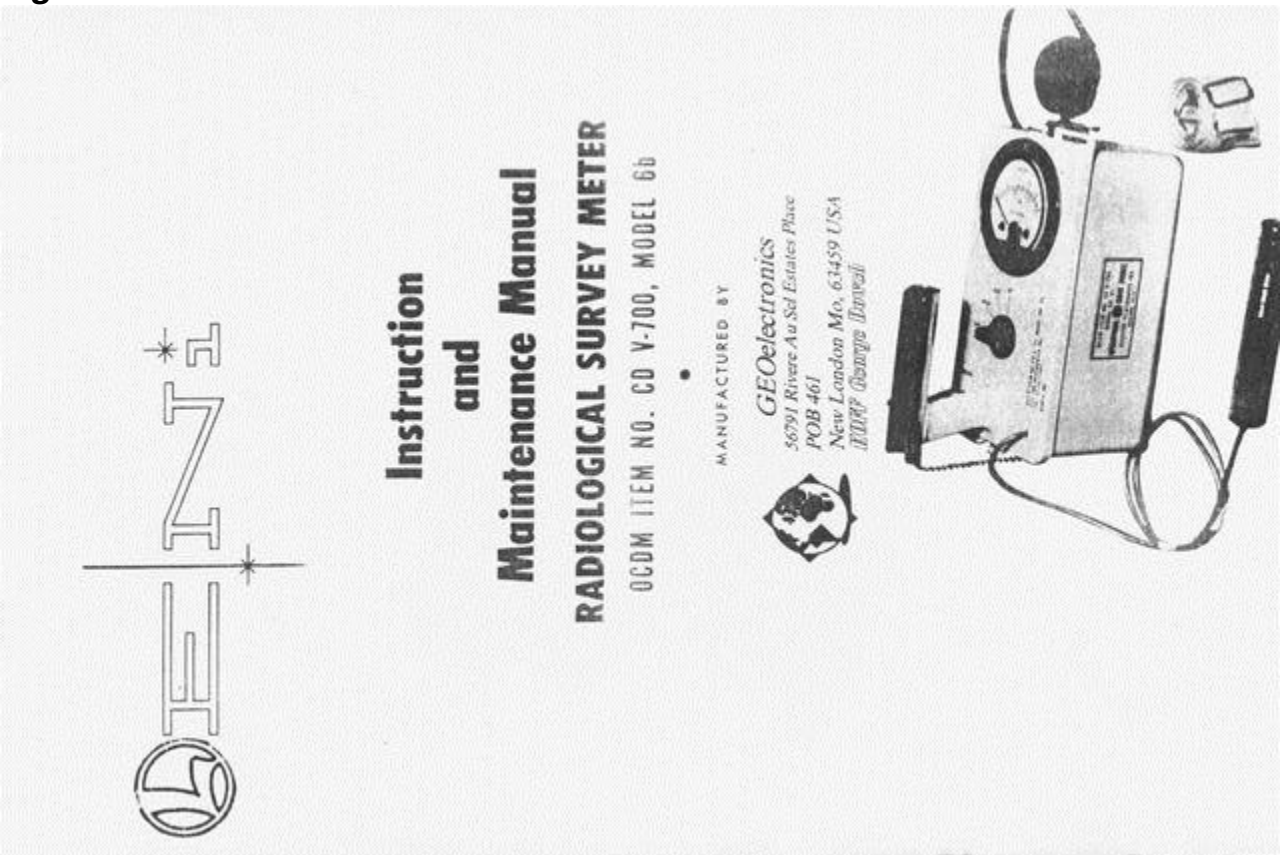
Fig. 2 FINAL SCHEMATIC OF LENi:



http://www.qsl.net/k0ff/LENi%20Geiger%20Counter/LENi%20Schematic.jpg

scan it and stick it in the case bottom over the old schematic.

Fig.3 New cover for instruction manual too:



http://www.qsl.net/k0ff/LENi%20Geiger%20Counter/New%20Manual%20CoverB+W.jpg

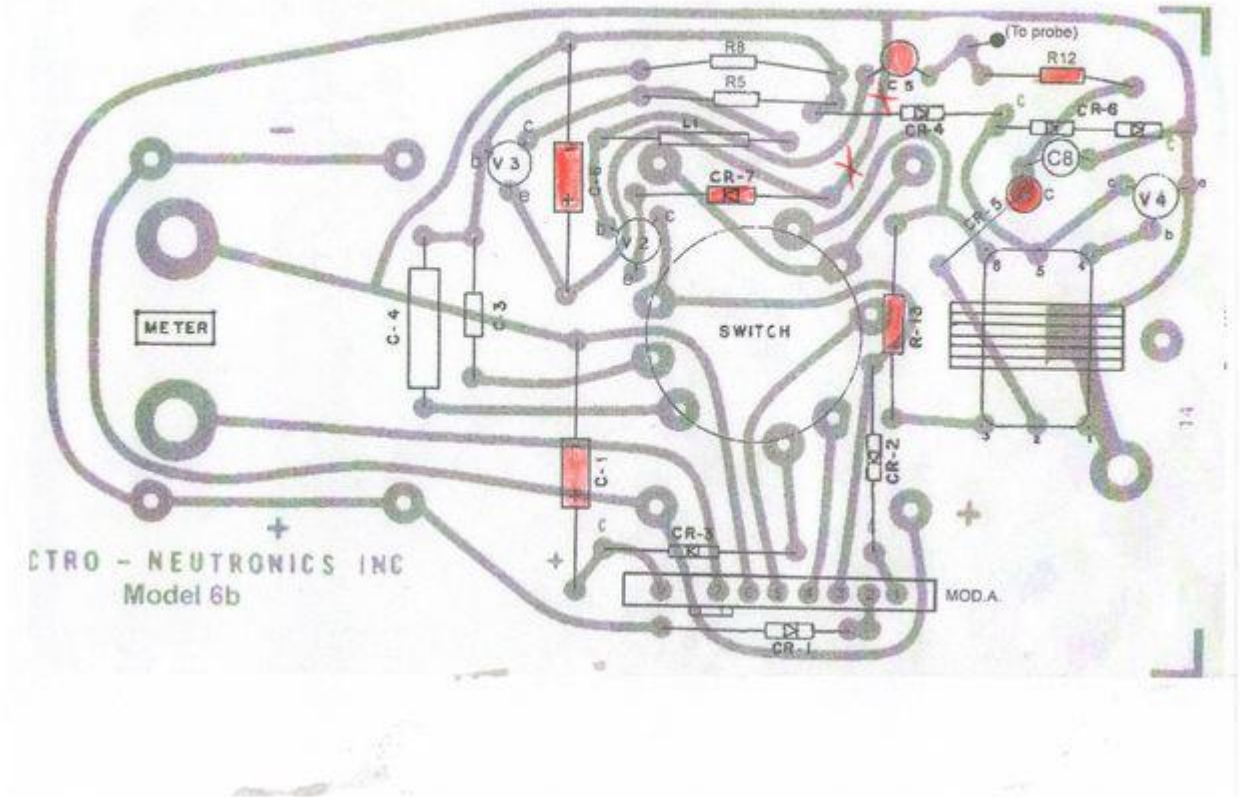
Except for this schematic, and ENi board layout, all the other pages in the manual are from the ENi CD V 700 6B.

Look at the schematics of both the ENi and the Lionel to observe the "before" and "after" circuits.

By performing the simple and inexpensive K0FF LENi mod, you can create a Lionel clone from an ENi.

The LENi modification procedure:

Fig. 4 - Parts marked in red will be removed for replacement. Cut one trace on the PCB between the red X's:



http://www.qsl.net/k0ff/LENi%20Geiger%20Counter/Remove%20Red%20Marked%20Parts%20and%20Cut%20Trace.jpg

1) On the component side of the board, replace Selenium HV diode CR-5 with a new silicon diode, 7 kV @ 100 mA.
Two 1N4007's in series will work fine.

2) Remove R13 and replace it with an 820 Ohm resistor.

3) Add a .0022 uF 50 V capacitor between Base (B) and Collector (C) of transistor V4. This can be tacked on the solder side of the board.

4) Remove R12

5) Prepare a 900V Zener diode regulator sub board as follows:

Nine 100 Volt Zener never yield 900 Volts, but a bit below, usually 20 Volts or so. You can make up this shortfall by adding a 10th Zener, I use a 51 V unit for a total of 10 Zeners in series, and 915 Volts:

Fig. 5- Prepare Zener Regulator Sub Board:

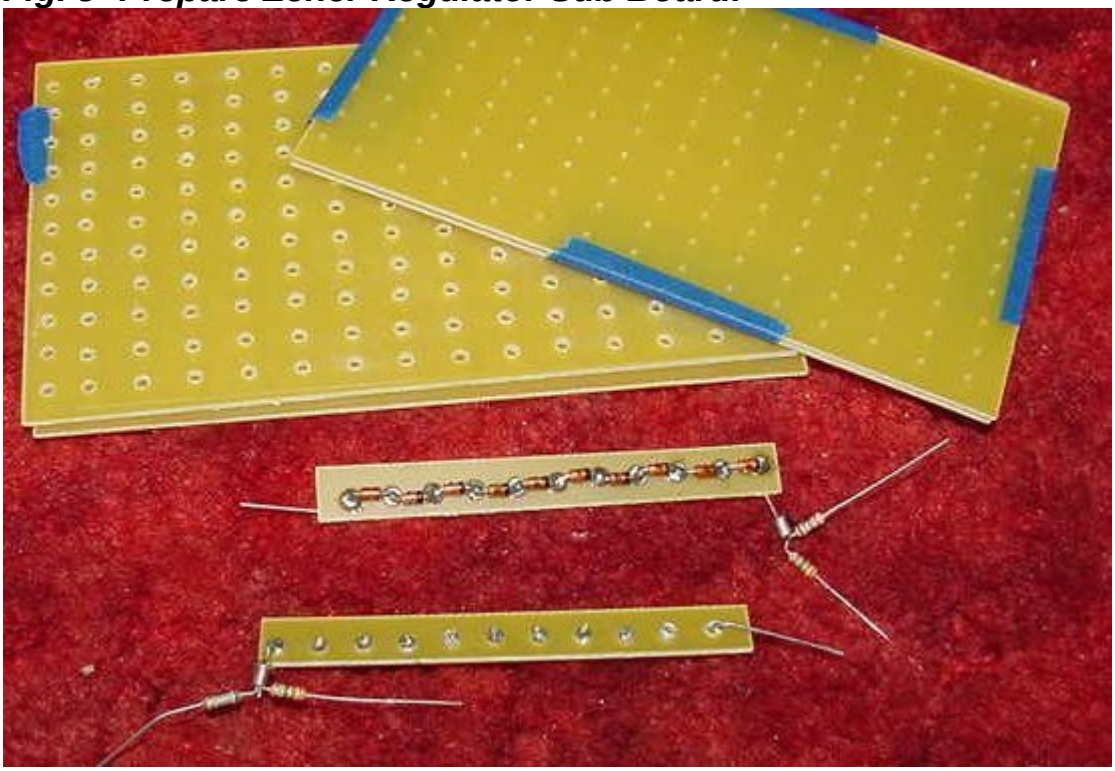
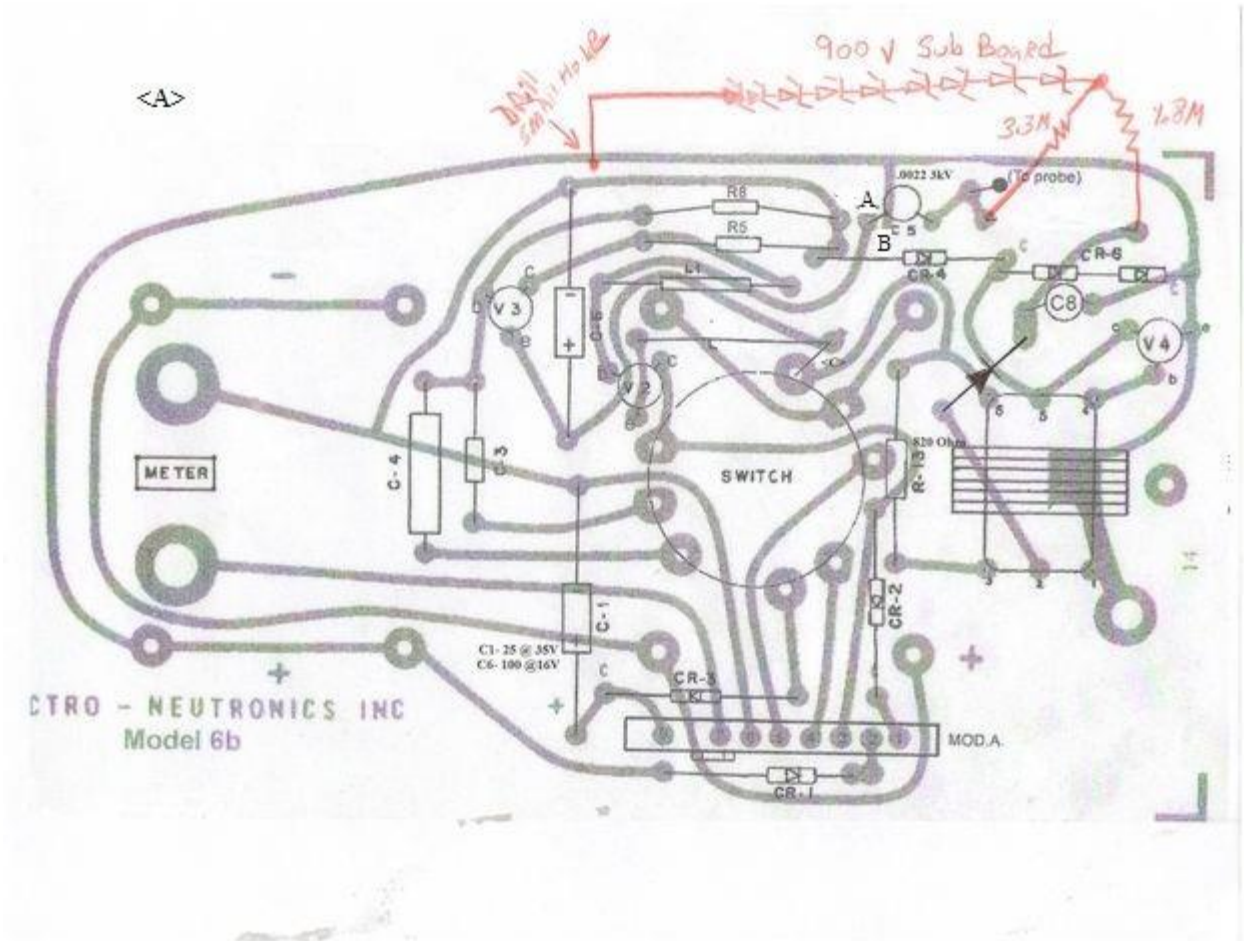
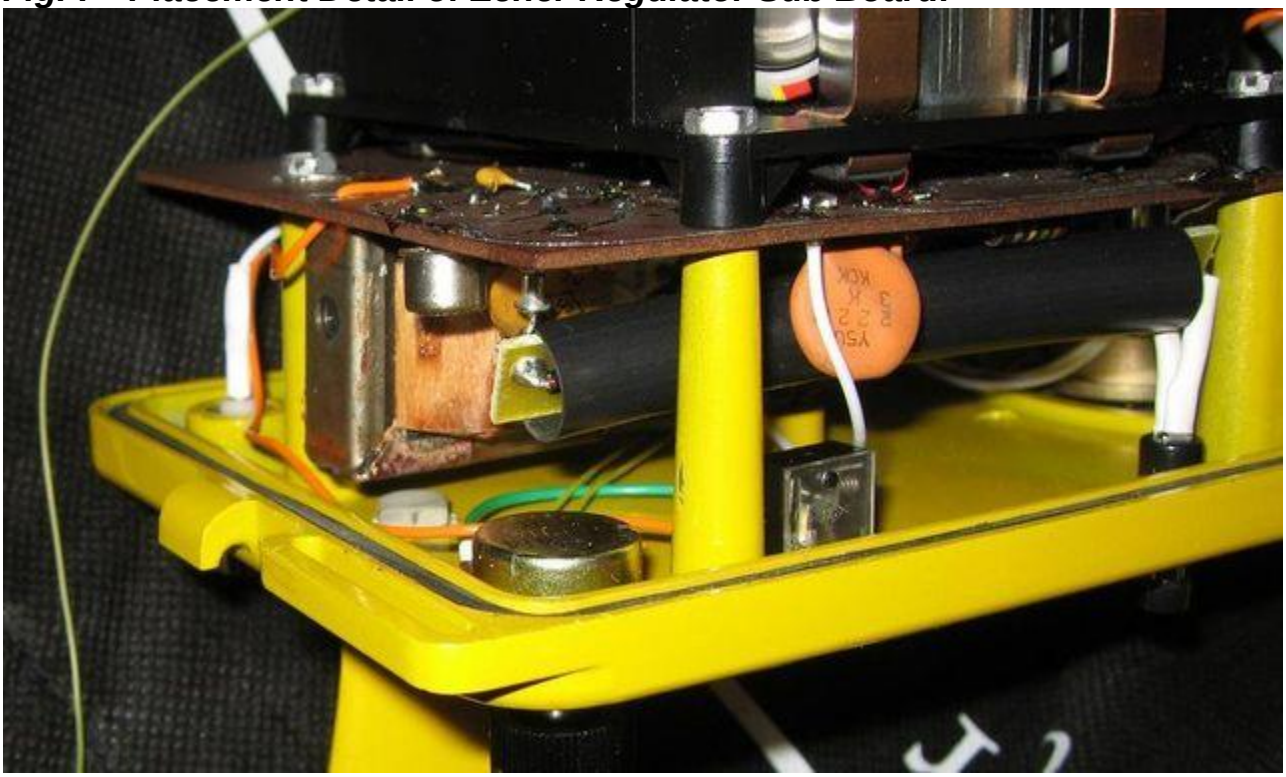


Fig. 6 - Wiring the Zener Regulator Sub Board:
Resistors R-17 and R-12 (on the LENi Schematic) are attached to the Regulator sub-board as flying components. The finished assembly wires to the main board at 3 points. Note the ground leg needs a small hole drilled in the main board:



http://www.qsl.net/k0ff/LENi%20Geiger%20Counter/Wire%20Reg%20Sub%20Board.jpg

Fig. 7 - Placement Detail of Zener Regulator Sub Board:



6) Replace the input capacitor, C5 (a .01) with a .0025 @ 3kV. The reduced coupling helps prevent overload and destruction of the input transistor.

7) Cut a portion of the circuit trace between the hole where CR-7 anode was (lead opposite the bar end) and the ground (+) buss. This connection is now severed for ever. CR-7 is removed and replaced with a jumper wire, which also proceeds to bridge the gap from the former anode hole to the switch contact pad immediately adjacent(this is the trace that goes to transformer Pin 6. Doing so effectively ungrounds the emitters of V2 and V3 and reroutes them to the negative battery terminal, via the on-off switch as shown in schematic to correspond exactly to the Lionel circuit.

Fig. 8 - Detail of step (7):

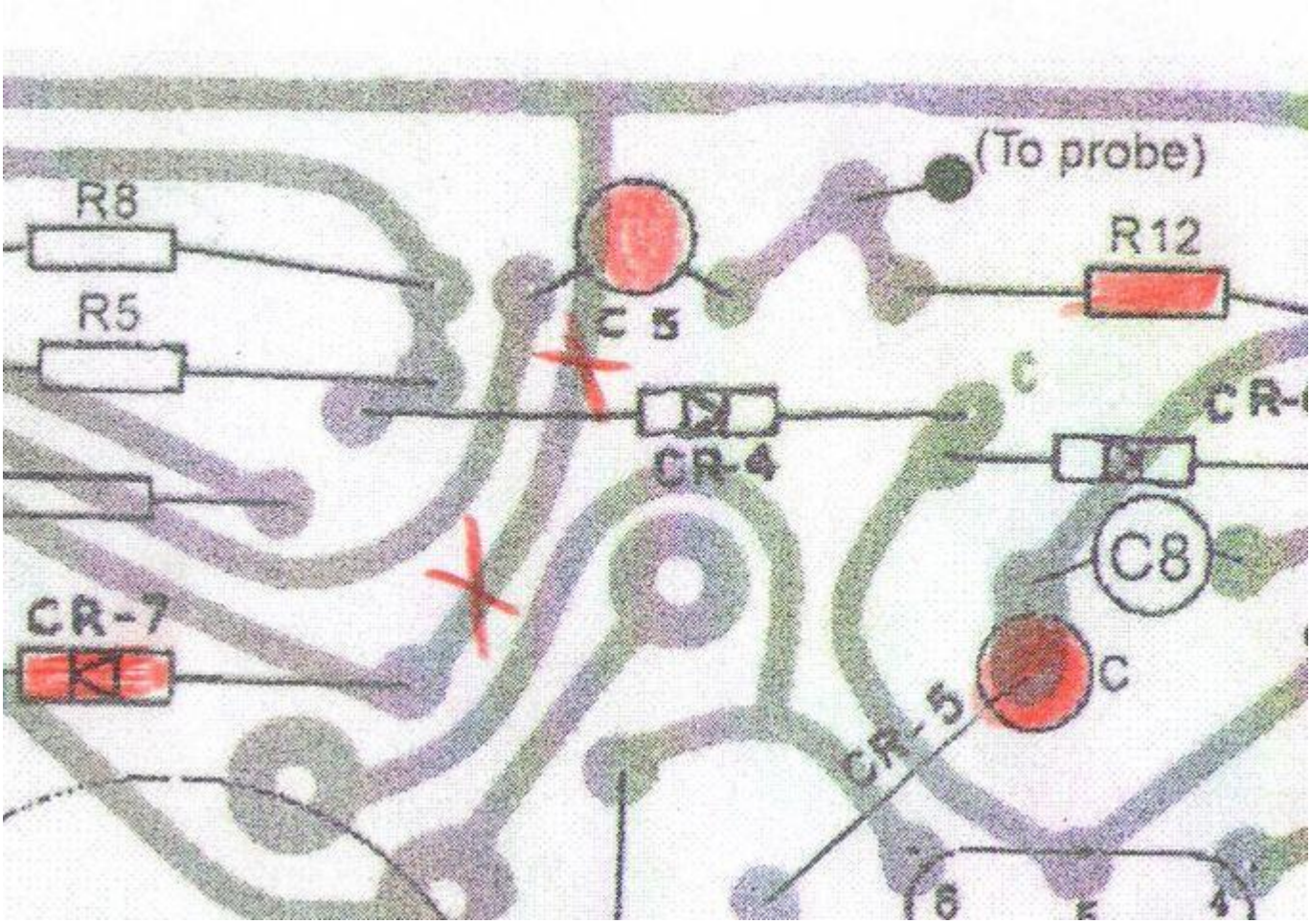
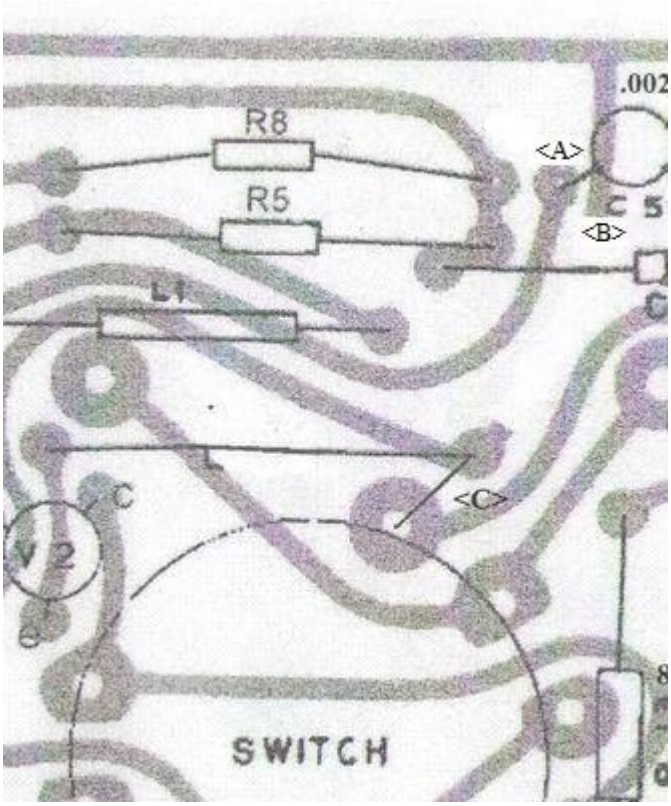
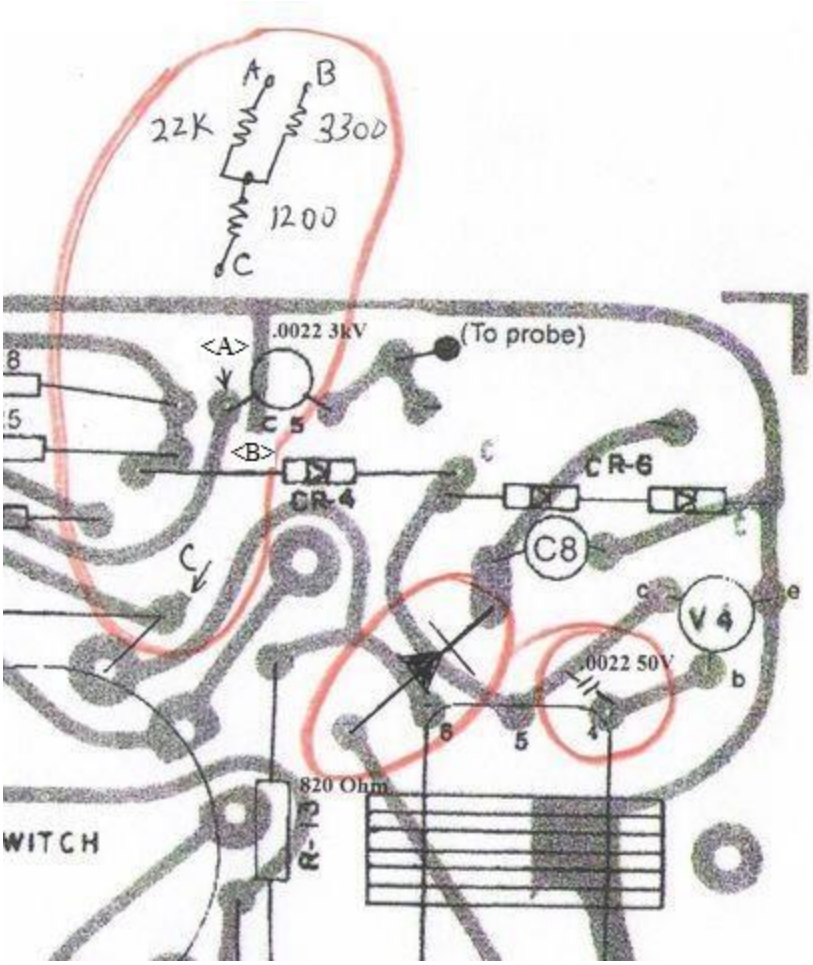


Fig. 9 - Replace CR-7 with jumper (zero Ohm resistor)



8) Next step will be to change the metering circuit, to improve operation, hang time, and eliminate premature failures. Add the resistors R-14, R-15 and R-16 to the solder side of the board, across the gap created in the foil in step (7), to points labeled <A>, <B>, <C> in the detail. I make "Y" out of the 3 resistors and tack solder them on the foil side of the board.

Fig. 10 - Detail "add resistors":

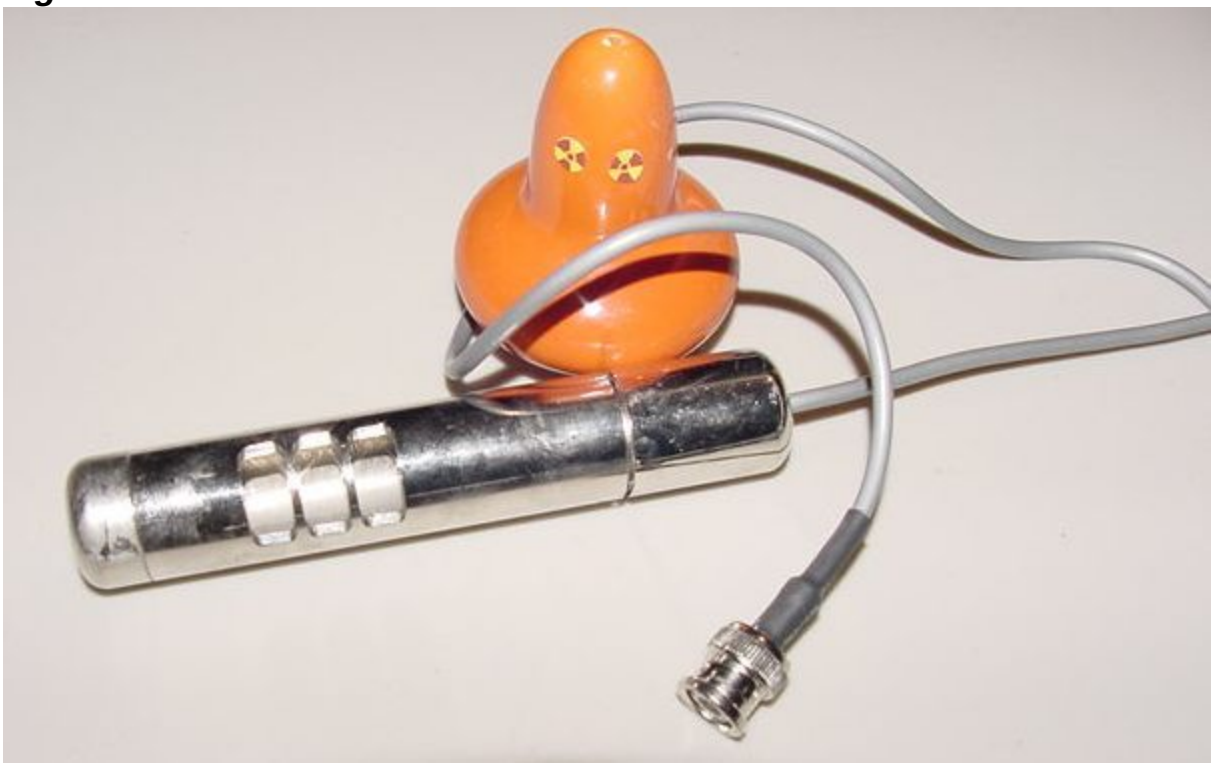


Optional: Add a BNC connector to the panel in the place where the cable originally entered. Adding a
mating connector to the probe cord allows for interchanging additional probes for special applications.

7) Resolder all the pads for the Large Scale IC Module, the part
where the CAL pot is located.
These are often loose or bad from vibration, and this is a good time to address this problem. Look closely at all the other pads, especially the transformer connections, and touch up the solder as needed. LENi's use a single point ground, a screw located near the transformer. This *MUST* be tight and have the star washer in place for a good ground. A loose screw here is the number one cause of intermittent operation, and even component failure.

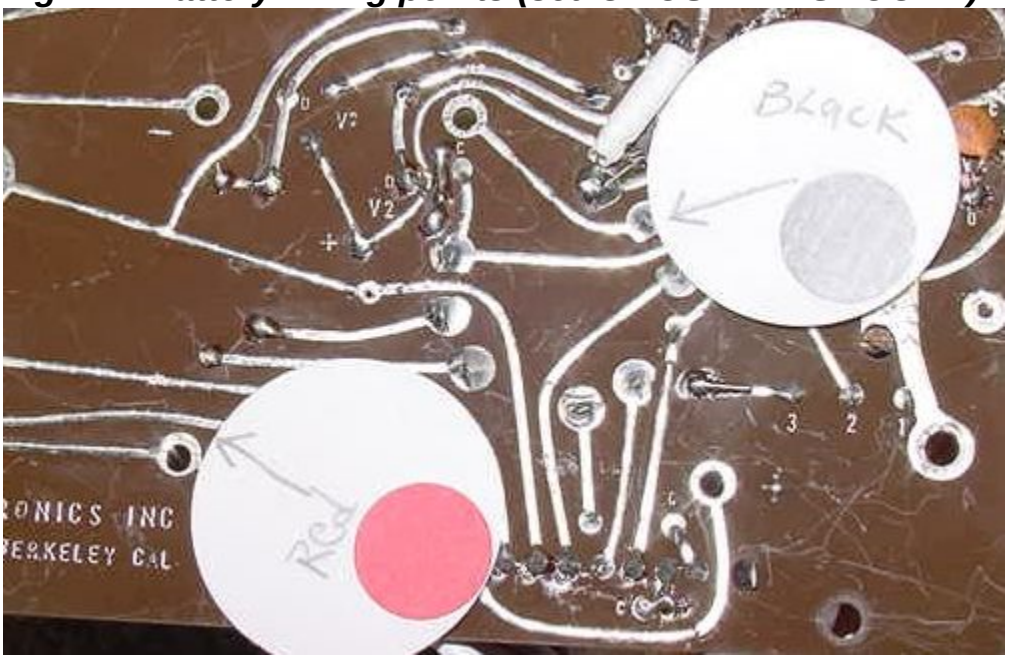
That's all the basic electronic changes. Of course I always encourage a BNC be added for probe changing. Please turn off the unit when changing
probes.

Fig. 11 - Probe with BNC added:



Lastly, the unit will now work fine from only 2 batteries instead of the original 4, so you can remove part of the battery box with a hacksaw, leaving about 1/2" of the cut battery chamber for housing the soundcard option. Save the cut of piece for housing future mods, like the AC power supply .
I always do away with the spring contacts that are supposed to make electrical connection to the board pads, and replace with hard-wired Teflon wires. The intermittents disappear like magic.

Fig. 12 - Battery wiring points (set is POSITIVE GROUND):



OTHER MODS:

Reset Switch = a pushbutton wired across the meter. Manually shorts out
meter when driven way off scale by a high countrate.

X2 scale extension = a 10K pot in series with either meter lead, shorted out
with a panel switch for X1. Adjust pot with a steady source for 1/2 reading.

Fast-Slow = Meter averaging capacitor, 100 uF for FAST, with a panel switch, add 330 for 430 total for SLOW.

Soundcard = (Speake2Me Module) see Part II, below:

Volume Control = 1K pot in series with the 4 Ohm speaker. Usually placed in the vacated single button earphone jack hole. Alternative location is on battery case, rear apron, below snap catch.

PULSE LED = LED wired across speaker terminals on SOUNDCARD. No series resistor but you can use up to 820 Ohms for effect.

POWER LED = LED wired across 3V battery terminals, after on-off switch. Use 820 Ohm resistor.

Battery Condition = a DPDT momentary pushbutton that turns the meter

into a voltmeter using a suitable series resistor(68kOhm). Both sides of the meter need to be switched.

Headlights = White LED lamps or one White and one UV. Only used on LONi variant.

DRILLING PANEL for SWITCHES = all switch and pushbutton locations are spotted on the bottom of the panel by 1/4" circular mold marks. Center punch the desired location and drill from the bottom (to preserve paint on surface side).

Drill pattern as seen from TOP SIDE:
http://www.qsl.net/k0ff/LENi%20Geiger%20Counter/Drill%20Template

Nomenclature: I use laser printed clear address type labels, sealed with "decal set".

On certain model ENi's the original panel lettering is painted on instead of raised like later versions. The paint is flush, so once the panel is drilled and nomenclature is added, a single sheet of adhesive backed clear laminating plastic can be overlaid for a really nice looking and permanent panel.

If the unit fails to calibrate, or some scales are off compared to others, always replace V2 and V3 first. Replace them both at once. In many instances, these parts will test OK but replacing them cures the problem.

Never replace the precision capacitors C-3 and C-4 unless broken or damaged, they are part of the calibration circuit and should be replaced with exact parts only.

Fully modified LENi with all add-ons:

Fig. 12A - LENi right side:

Fig. 14 - LENi left side:

Fig. 15 - LENi back side:

Fig. 16 - LENi bottom, shield open:

Fig. 16 - LENi bottom, shield closed:

Fig. 18 - X-Ray view:

This webapge exists to encourage the hobby of nuclear rad detection:

http://tech.groups.yahoo.com/group/GeigerCounterEnthusiasts/

If you have doubts that an amateur could find radioactive stuff in the ordinary environment, take a peek at some of the "finds" that I have done with my LENi: http://www.qsl.net/k0ff/Road%20Rad%20Finds/

Happy Homebrewing, Geo>KØFF

PART II The Speak2Me Module

KØFF Homebrew Tips

Assembly and Installation Instructions for the

SPEAK2ME
CDV-705 Clone Kit
For LENi and ENi Geiger Counters
Or as a stand-alone speaker for any Geiger system.
By GEOelectronics

The CDV-705 was a speaker option made contemporaneously with the CDV-700's, back in the early 1960's. Only a few hundred were ever made, and are much sought after today. This kit is a faithful reproduction of the circuitry of the CDV-705 and has been "updated" only in the sense that we use all new, modern components. A brief glance at the circuit might indicate an amplifier, but it is actually much more than that. A discrete component multivibrator is the actual description, and the subtle difference is that an amplifier alone would draw excessive battery current,. And more importantly would amplify background whine from the power supply in the CDV-705. This design eliminates both of those problems, and reduces battery drain to an inconsequential factor.

A circuit board is part of the kit, and we speak of the "top side" as the side with color-coded dots around certain of the eyeleted component holes. These dots also indicate the position and color of wire that connects the circuit board circuitry to the LENi, ENi or other Geiger Counter, as well as to the speaker and volume control. Place the circuit board on a flat surface in front of you, and position it with the yellow dots to the right.

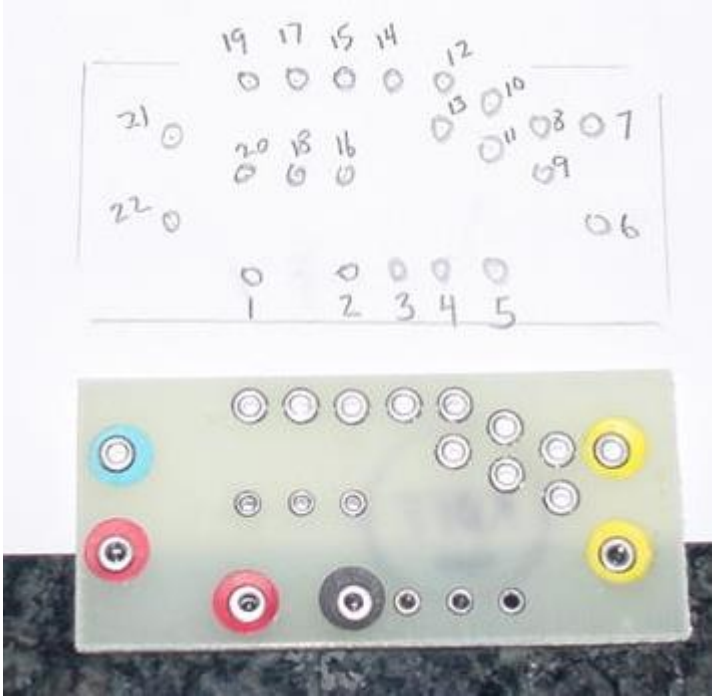
With this orientation, familiarize yourself with the layout and hole numbering sequence as shown in Photo #1. Starting with the bottom row of holes, the holes are numbered in a clockwise manner in a logical sequence. We will refer to these numbers when explaining parts placement.

(NS) means place the part but do not solder it yet. Usually more than one component lead will share an eyeleted hole. (S) means solder the connection. "Bend dim. =" is the pre-form distance between wires in case you have a bending fixture or just want to measure and pre-bend the components manually.

Note: if you are following the circuit without benefit of the kit, use perf-board or any other suitable substrate to hold the parts, and follow the general layout and instructions.

All LENi's were made with a compartment at the meter-end of the battery holder to accept this circuit board.

Please remember that LENi's, Eni's and some others are POSITIVE GROUND circuits.

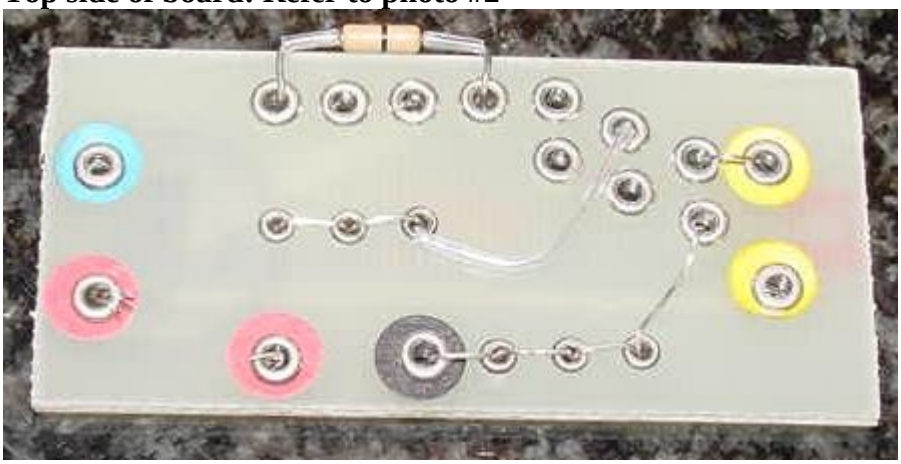


Circuit Board Assembly

JUMPERS:

First put all the jumper wires in into the correct holes, joining the various buss lines together electrically. Photo #2 and #3 shows this step, for top and bottom sides. All jumpers except one are made of bare wire, as supplied in the kit. It is strung between the holes and bent over on the bottom side. Trim excess, leave just enough to hold it in place until it gets soldered along with other leads that share that eyelet.

Top side of board: Refer to photo #2

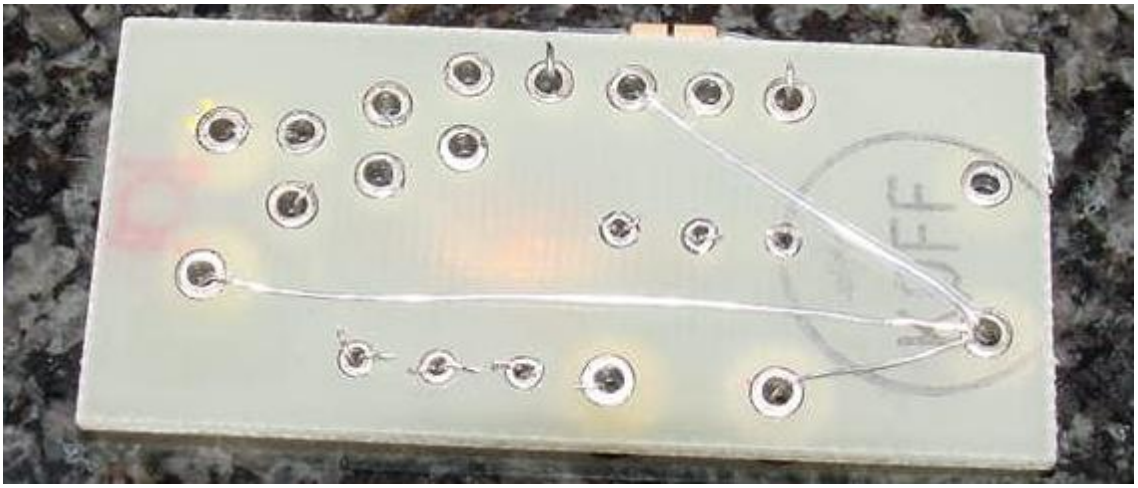


Put a zero-ohm resistor between #19 and #14. Approx ¼" of Teflon tubing should be placed on each lead before bending. Bend dimension for this part is .6 in. (NS)

Bare wire between #7 and #8 (NS)
Bare wire between #20-18-16 –10 ¾" of Teflon tubing on the part between 16 –10. (NS). All holes connected together in a "daisy chain".

Bare wire between 2-3-4-5-9 (NS). All holes are connected together in a "daisy chain"

Bottom side of board:
Refer to photo #3

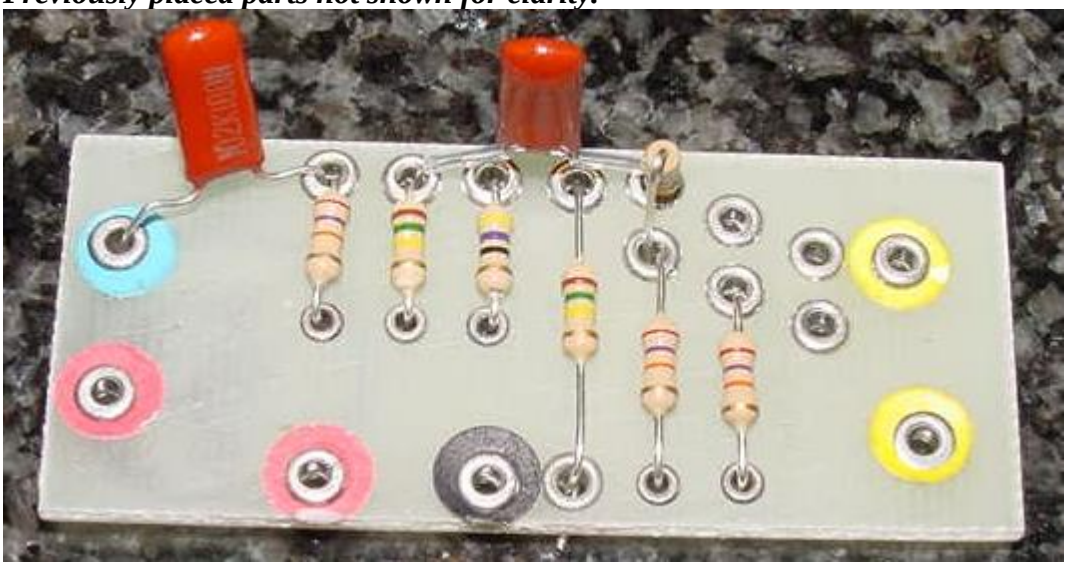


There are three jumpers on the bottom, all emanate from hole #22 and go to a single hole each going to a single destination. This style of jumper is called a "wagon wheel".

From 22 to 15, Use 1 " of Teflon tubing (NS)
From 22 to 6 use bare wire (NS)

From 22 to 1 use bare wire (NS)

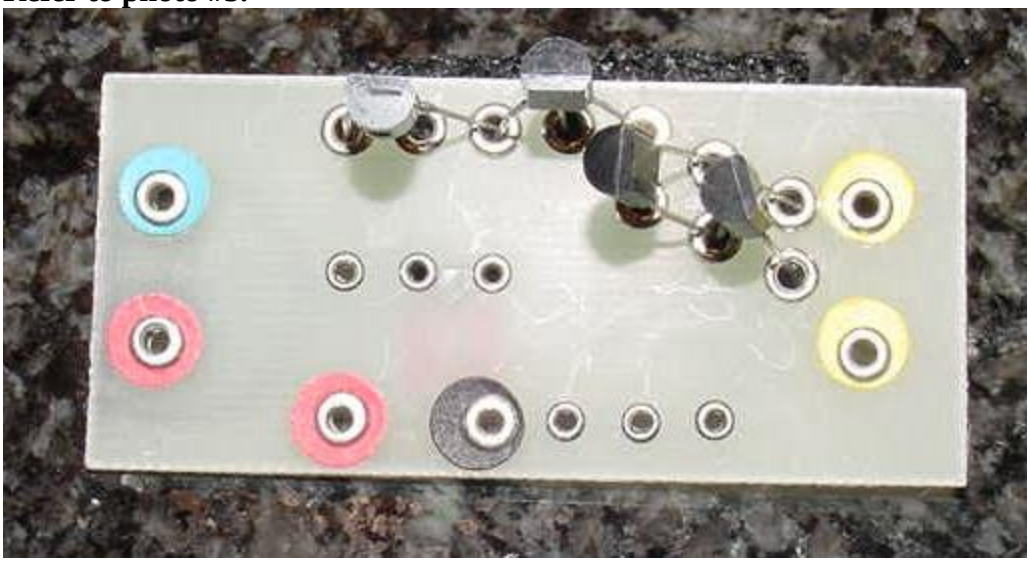
RESISTORS and CAPACITORS:
REFER TO PHOTO # 4.
Previously placed parts not shown for clarity.



From left to right:

C1-.001 @50V cap between 21 and 19. No polarity issues. Bend dim. = .5". (NS)
C2-.001 cap @50V between 17-12, use 3/8" Teflon tubing on each lead No polarity issues. Bend dim. =. 5"(NS)
R3-27K ¼ W resistor (red-violet-orange) Between 19 (NS) and 20 (S). Bend dim. = .3"
R2-150K ¼ W resistor (brown-green-yellow) Between 17 (NS) and 18 (S) Bend dim. = .3"
R6-47 Ohm 1/4W resistor (yellow-violet-black) Between 15 (NS) and 16 (S) Bend dim=. 3"
R1-150K (brown-green-yellow). Between 14 (NS) – 3 (S). Bend dim. =. 75"
R4-820 Ohm (gray-red-brown). Between 12-13 (NS). This component stands on end.
R5-27K (red-violet-orange). Between 13 (NS)-4 (S). Bend dim. = .6"
R7-27K (red-violet-orange). Between 11 (NS)-5 (S). Bend dim. = .5"

TRANSISTORS
Refer to photo #5.



Previously placed parts not shown for clarity.

Q1 and Q2 are placed along the top edge. These are both PNP transistors, p/n 2N3906.

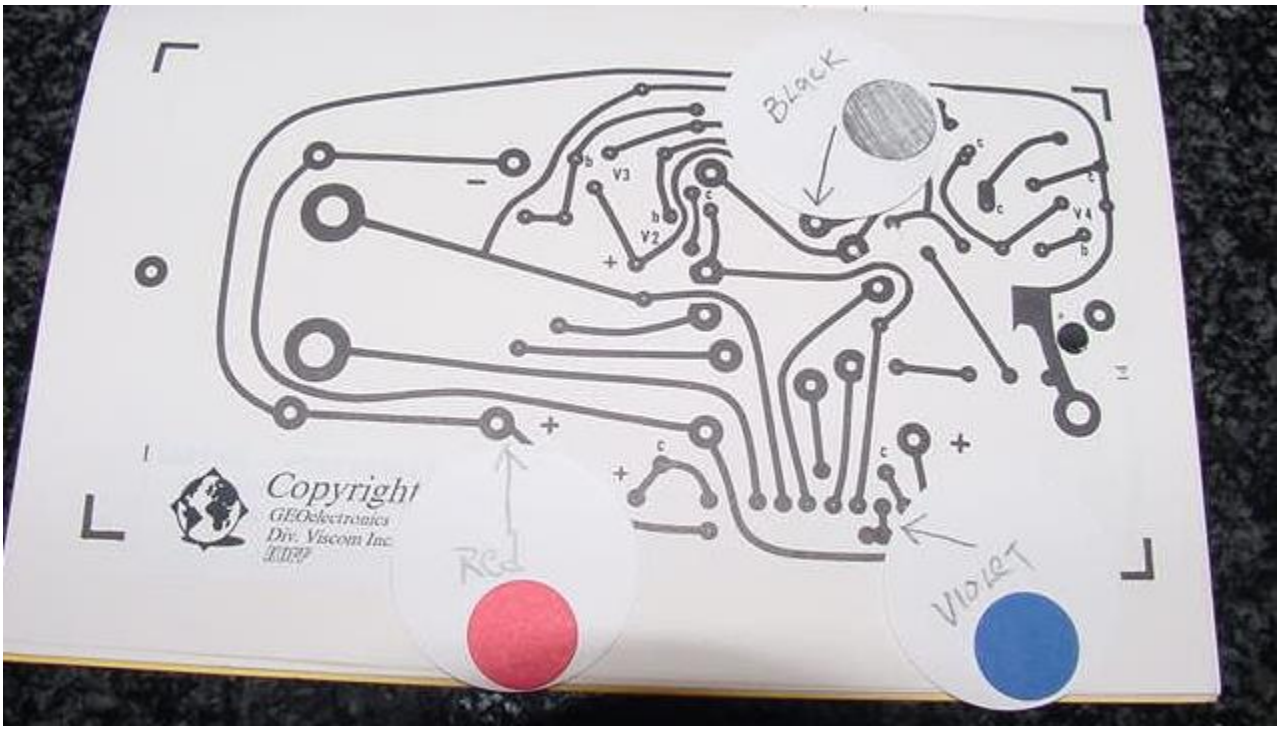
There are 5 eyeleted holes across the top edge.
Q1 (2N3906) is to the left and is placed with the flat side facing away from the board center.
Q1
E-15 (NS)
B-17 (S)
C-19 (S)

Q2 (2N3906) share one hole (#15)with Q1, the center in the row of 5. The flat side of Q2 faces board center.
Q2
E-15 (S)
B-14 (S)
C-12 (S)

Q3 and Q4 are NPN transistors, p/n 2N3904. Both flat sides face away from board center.
Q3
E-11 (NS)
B-13 (S)
C-10 (S)

Q4
E-9 (S)
B-11 (S)
C-8 (S)

Now inspect the whole board. There should be 4 transistors, 6 resistors lying down, one resistor standing up and two capacitors. All holes should be soldered by this time except the ones with colored dots. We will now install the wires into those holes and solder.



Red dot- hole # 1- Insert and solder one end of a 6" piece of red Teflon insulated wire (S). This is the POSITIVE 3V lead that goes to the Geiger Counter board RED tap-off point, see picture of CDV700. CAUTION CAUTION CAUTION: LENi's and Eni's ARE POSITIVE GROUND

Red dot- hole #22. No external wires hooked up to this if the board is used in a LENi. Just solder it closed (S). The extra terminal is used on stand-alone speaker boxes that have their own battery supply.

Black dot- hole #2- insert and solder a 6" piece of black Teflon insulated wire. This is the NEGATIVE power lead that goes to the Geiger Counter board BLACK tap-off point.

Violet dot- hole #21.
Insert and solder one end of a 6" piece of violet Teflon insulated wire (S). This lead is the PULSE input and connects the Geiger Circuit board VIOLET tap-off point.
If a volume control is to be used, remove the existing violet wire and "PHONE" jack from the LENi. This panel hole will be used for the volume control.

Volume Control Installation as provided in the kit*: *If no volume control is used, skip this step.

Remove the "PHONE" jack and its violet wire. Keep the rubber washer for reuse. Mount the volume control potentiometer into the hole thus vacated. Place the rubber washer on the threaded shaft so that it is on the inside of the chassis. On the outside, secure the threaded shaft collar with a lock washer and nut. Secure the knob on the shaft.
Looking at the back of the volume pot, the left and center terminals are used. Electrically this is a simple variable resistor placed in series with the yellow lead from the circuit board hole #7 going to the speaker.

Yellow dots- Speaker output leads. Holes #6 and #7 Insert one end of an 18" piece of Kynar insulated wire into each eyelet and solder (S) (S).

***FOR NON-VOLUME CONTROL USE*: Run each of the two yellow wires to a speaker terminal and solder. No polarity issues. Run the wire through a solder-lug strain relief at both ends to protect the speaker and circuitry should someone remove the battery box and pull on the wires.**

***FOR VOLUME CONTROL USE, AS SUPPLIED IN KIT*:**
Run the yellow wire from hole # 6 to a speaker terminal. No polarity issues but do secure the ends mechanically with provided clips. Run the yellow wire from hole #7 to the center terminal of the volume control (S). Run another piece of yellow wire from the left side terminal (S) (as viewed from the rear) to the unused speaker terminal (S).

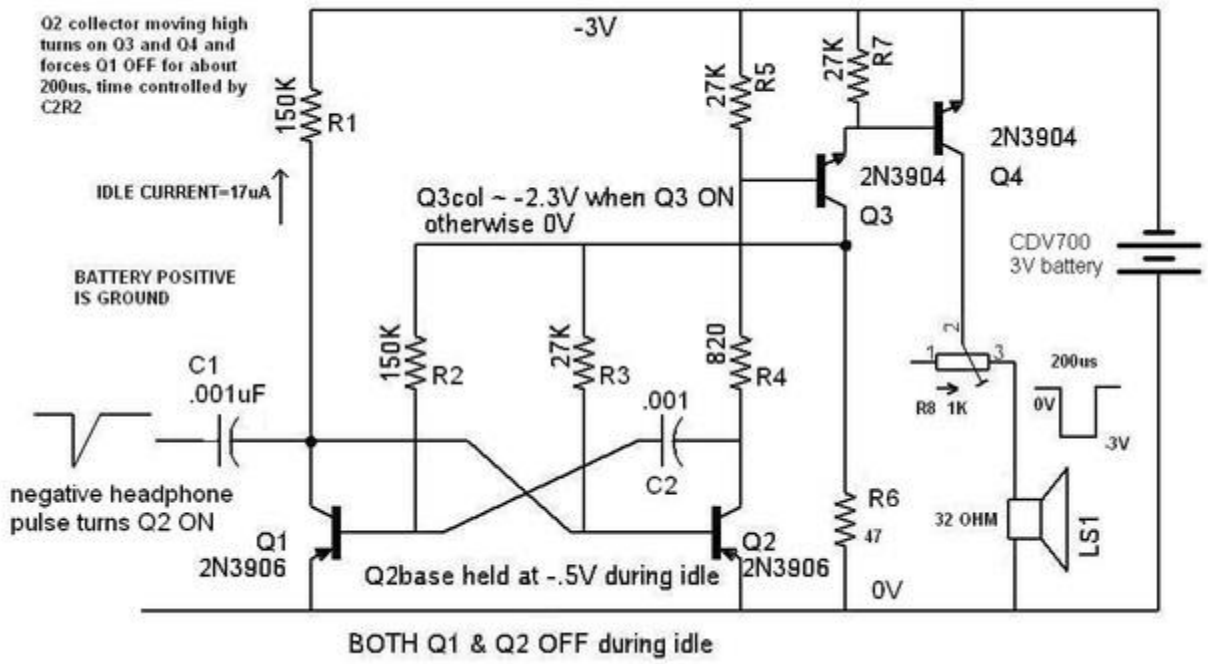
This completes the assembly and installation. Slow pulses from the Geiger should be audible as loud natural sounding clicks in the speaker, one click per event. Faster pulses are perceived as an audio tone, still one cycle per event, and will track up to very high rates. SPEAK2ME power is automatically switched along with the LENi, and its use will not appreciably affect the battery life.

The supplied 32-Ohm, thin profile speaker is best installed in the battery case, left side front as viewed by the operator. A hole just smaller than the speaker should be cut or punched in the battery box wall. Three screw holes (top, +/- 120 degrees) allow mounting via metal brackets, also supplied. A yellow plastic speaker grill waterproofs the set while letting out most of the sound. Cut to fit, and then glue the supplied yellow plastic speaker cover in place before mounting the speaker. Secure the yellow speaker wires mechanically by wrapping them around the cutouts in the speaker frame. The other end is secured with the supplied metal clip, which should be attached to the battery holder with one of the existing mounting screws.
If you are not comfortable around metalworking machinery, I can make the hole for you, and even assemble and install the whole project in your LENi or ENi. Your free first annual tune-up would be a good time to add the SPEAKE2ME to your LENi.

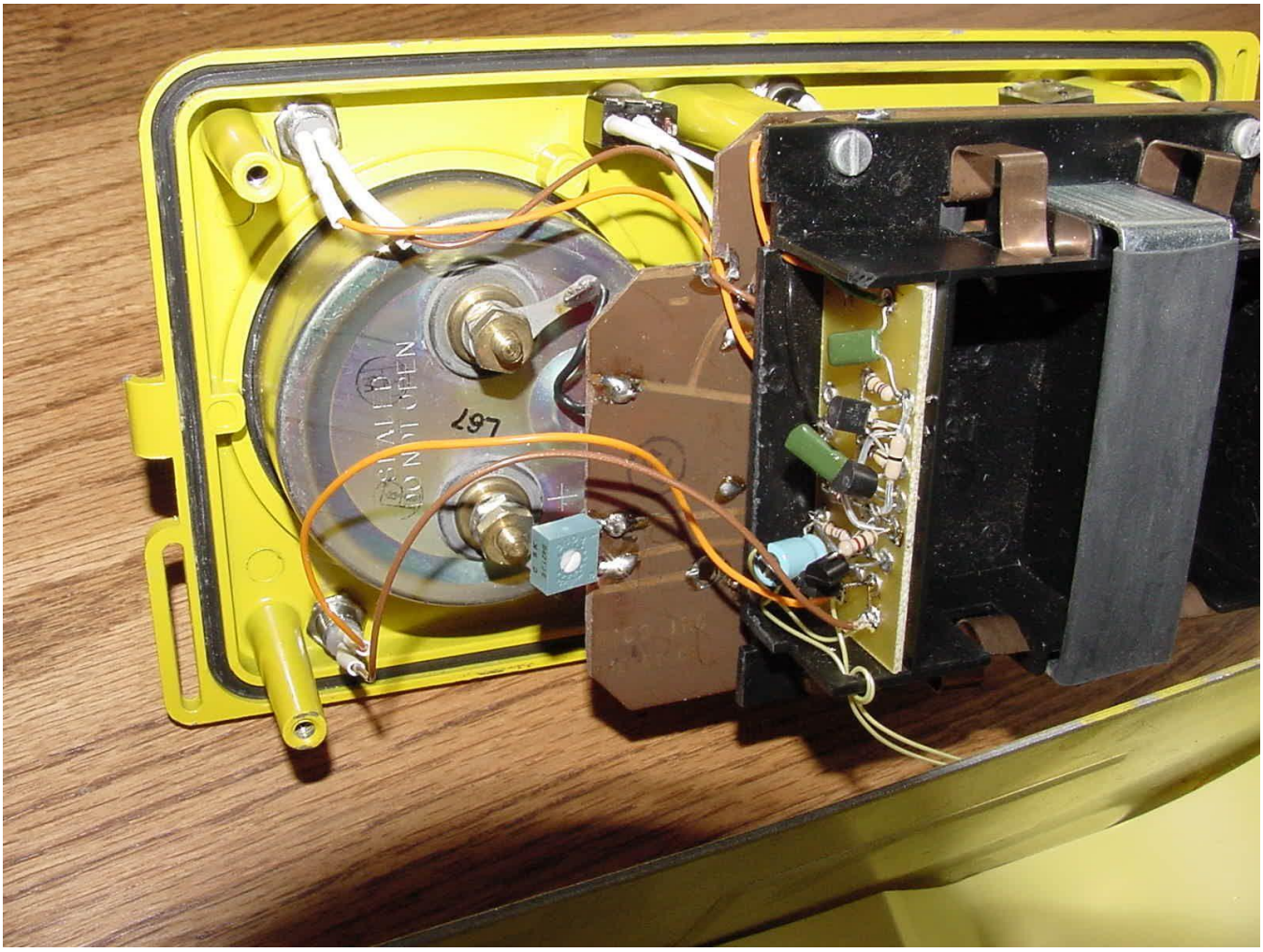
In order to have enough clearance between the main Geiger Counter circuit board and the speaker, it may be necessary to notch out a small area near the board's edge to provide a clear channel. There are no circuit traces in that area to worry about.

Useful modifications for the advanced experimenter.
Try placing an LED (supplied in kit) across the speaker wires for a flashing pulse indicator. The long wire lead from the LED goes to hole# 6, the shorter lead to hole#7. In this way the LED is unaffected by the volume control.

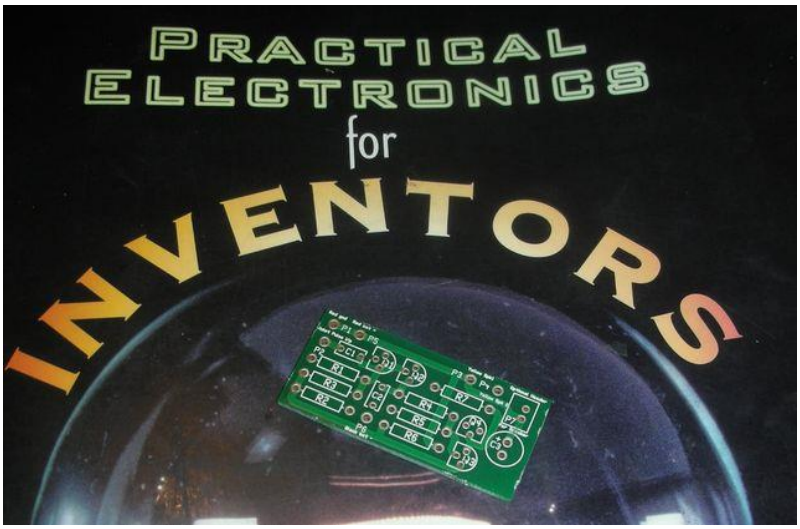
Reach inside the volume pot with a needle or other small tool to scrape away the conductive layer attached to the unused terminal. This effectively provides an OFF function for the audible clicks, and at the same time, allows the pulses to be routed to another circuit for further processing, as in a scaler, LED etc via that unused terminal Now you know why the instructions have you wiring the volume control in a manner opposite conventional practice!



BOTH Q1 & Q2 OFF during idle



UPDATE: Images Inc has produced a PCB for this project:



Have Fun

George Dowell