Thermometer Production

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DESCRIPTION

Provide the ability to map the temperature of the surface of an R.F. cavity undergoing testing while submerged in a liquid helium bath. Specially made thermometers are required for this type of testing.

These custom thermometers are made by encapsulating a 100Ω Allen Bradley carbon composition resistor in a low thermal conductivity body. The top (mating) surface is carefully sanded down to expose the carbon element. All surfaces are sealed with three layers of electrical insulating varnish. This varnish seals out moisture in addition to electrically insulating at the point of contact with the cell surface.

Electrical connections through the encapsulated thermometer are made of manganin wire soldered to the resistor and soldered to the motherboard. The encapsulated thermometer is mounted to a spring-loaded shaft (pogo-stick). The pogo-stick is inserted into a hole on the motherboard, sixteen thermometers per board. Then thirty-six motherboards are clamped to the cavity. All 576 thermometers are mated to the cavity surface with a small dab of Apiezon N grease to provide a good thermal contact.

MATERIALS

- G-10 sheets, 6” x 5.875” x 0.125”
- Allen Bradley 100 ohm, ⅛ watt carbon composition resistors
- Manganin wire, 30 AWG Heavy Formvar insulation
- GE 7031 varnish
- 50/50 mixture of toluene/ethyl alcohol
- Stycast 2850 FT epoxy, black
- Catalyst 9
- IDI Spring contact probes (pogo-sticks), type S-2-F-4-G (IDI PN: 100025-006-922)

EQUIPMENT

- Wheaton Dry-Seal Vacuum Desiccator, Glass (Cole-Parmer PN: P-08912-60)
- Roughing pump with associated hoses, traps and valves
- Digital scale
- Digital Multimeter
- Soldering Iron with very small tip

- Board Holders
- Glove box/Ventilation Hood

TOOLS

- Micrometer, 6 – inch
- Ruler, machinist 6 – inch
- Small diagonal cutters
- Tweezers
- X-acto knife
- Small table vise

MISCELLANEOUS

- Nitrile gloves
- Small hobby paint brush
- Tongue depressors (at least 6 – inches long)
- Emory Cloth (fine, medium, coarse)
- 63/37 rosin-core solder
- Flux
- Plastic syringe injectors
- Small plastic containers for mixing epoxy
- Alcohol
- Binder style paper clips
- Super glue
- Elmer's white or yellow glue (wood)

THERMOMETRY FABRICATION PROCEDURE

1. Machine G-10 boards according to specification sheet #1. Cut boards in half to form two 6” x 6” boards. This allows the boards to fit inside vacuum jar.
2. Place G-10 board on a flat surface with blind holes facing up. Super glue a “pogo-stick” into each blind hole. Ensure pogo-sticks are perpendicular to board (see specification sheet #2 for alignment tool).
3. Cut manganin wire into 2-inch long pieces. Cut enough pieces for all the resistors.
4. Using an x-acto knife with a sharp blade carefully scrape approximately ⅛- inch Formvar insulation from one end and ¼-inch on the other end of each 2 inch long manganin wire.
5. Tin both ends of manganin wires with solder.
6. Using an x-acto knife or tweezers gently scrape resistor leads ⅛-inch from each side of resistor body until shiny (Fig. 1).
7. Tin both resistor leads with solder.
8. Place a resistor lead into a small table-top vise and gently clamp. Using tweezers bend one end of the manganin wire into a little hook or “J” shape and then hang it on the tinned resistor lead (Fig. 2) and (Photos 8, 9, 10). Using a small solder tip lightly solder (reflow) into place (use minimal solder to keep the joint as small as possible). Flip the resistor around in the table-top vice and repeat this step for the other resistor lead. Cut resistor leads to length (fig. 2).
9. Attach machined G-10 board to board holders (Fig. 3) (Photos 2 & 3), placing slots face up (pogo-sticks will be pointing down).

10. Insert manganin wire leads of soldered resistor/wire lead assembly (Fig.4)(Photo 2 & 3) into #60 thru-holes on G-10 board (spec. sheet #1: wire to be inserted from slotted side of G-10 board and centered between wire holes. Non-slotted side of board has blind holes for pogo-stick placement).
11. Using fingers and wood tongue depressor carefully push resistor body completely into bottom of slot. Seeding the entire board with resistor/wire assemblies until board is full (Fig. 5). Dropping a small amount of thin super glue on top of each resistor body will ensure resistor/wire assembly will remain in proper position (Photo 2 & 3).
12. Mix 2850FT epoxy with catalyst #9 on a digital scale. Ratio by weight is 95% epoxy to 5% catalyst. Note: Epoxy working time is about 30 minutes.
13. Mix enough in a small container to fill a plastic syringe to about ⅔-full. Mix well but do not whip as air will become incorporated into the mixture.
14. Place the small container with epoxy into vacuum chamber and rough down to approximately 1 torr for 3 minutes. Mixture will expand to about twice its size and then collapse (CAUTION: apply vacuum slowly, as epoxy sometimes reacts violently when de-airing).
15. Slowly vent chamber to atmospheric pressure and remove container of epoxy.
16. Pour de-aired epoxy mixture into a syringe injector.
17. Place epoxy filled syringe, w/o plunger, into the vacuum chamber and de-air once again for 1-2 minutes (Do not let epoxy expand so much that is overflows the syringe).

18. Place plunger into syringe and fill seeded G-10 slots, ensuring that resistor bodies are covered with the epoxy. Fill all six slots on the board (Photo 13).
19. Place board with epoxy-filled slots into vacuum chamber and de-air to approximately 1 torr for 2 - 3 minutes.
20. Vent vacuum chamber to atmospheric pressure and remove board. If necessary fill any voids with epoxy.
21. Let board cure for at least 24 hours.
22. Remove board holders from board.
23. Mix another batch of epoxy in a small container (enough to fill a plastic syringe about 2/3 full).
24. De-air using steps 12 thru 17.
25. Place board slot-side down on a flat surface. Pogo-sticks and manganin wires should be facing up in preparation for step 26 (Photo 6 & 7).
26. Place plunger into syringe and apply epoxy to the lead/pogo-stick side of board. Lay a bead of epoxy from one edge of the G-10 board to the other side similar to that done in step 18. These beads run parallel and adjacent to the slots and will enclose the lead holes and pogo-stick attachment area (Fig 5) (Photo 12 & 13).
27. Allow epoxy to cure for at least 24 hours.
28. To prepare G-10 board for cutting on band saw temporary wood shields will be constructed and installed over pogo-sticks and manganin wires. Place a wood tongue depressor on flat surface and glue (Elmer's glue) three pieces of flat balsawood stock (1/4" wide x 1/16" thick x ¾" long) onto one surface of tongue

depressor (Fig. 6) (Photo 11). Ensure balsawood strips are located and glued in between the pogo-sticks/manganin wires. Place the tongue depressor with balsawood strips on one side of a row of pogo-sticks/manganin wires and one without balsawood strips on the opposite side of that same row and glue them together to sandwich the pogo stick/manganin wires (Photo 14, 15). Perform this for the remaining rows. Six "sandwich" assemblies are needed per board. These "sandwiches" will be removed after the G-10 board is cut into six strips of 8-sensors each (Photo 16 thru 19). These may be reused, if desired, for additional G-10 boards. (Binder style paper clips make excellent clamps for holding sandwiches together while the glue dries).

29. Using a band saw cut prepared G-10 board on each side of tongue depressor sandwiches. Let the blade ride down the wood tongue depressor as your guide and make sure manganin wires are leaning away from cutting blade. Note: The use of a chicken stick is helpful when pushing these through the band saw.
30. *Carefully* pry wood sandwiches off with a flat tip screw driver (Photo 18, 19).
31. Return cut G-10 strips to band saw and cut into individual sensors. Ensure manganin wires are not cut by saw blade during this process. (Operate a wet/dry vac with a HEPA filter installed and a crevice attachment duct taped close enough to cutting area/blade to capture G-10 dust while cutting boards).
32. Using stationary disc sander carefully sand down sensor face until surface of G-10 is just exposed.

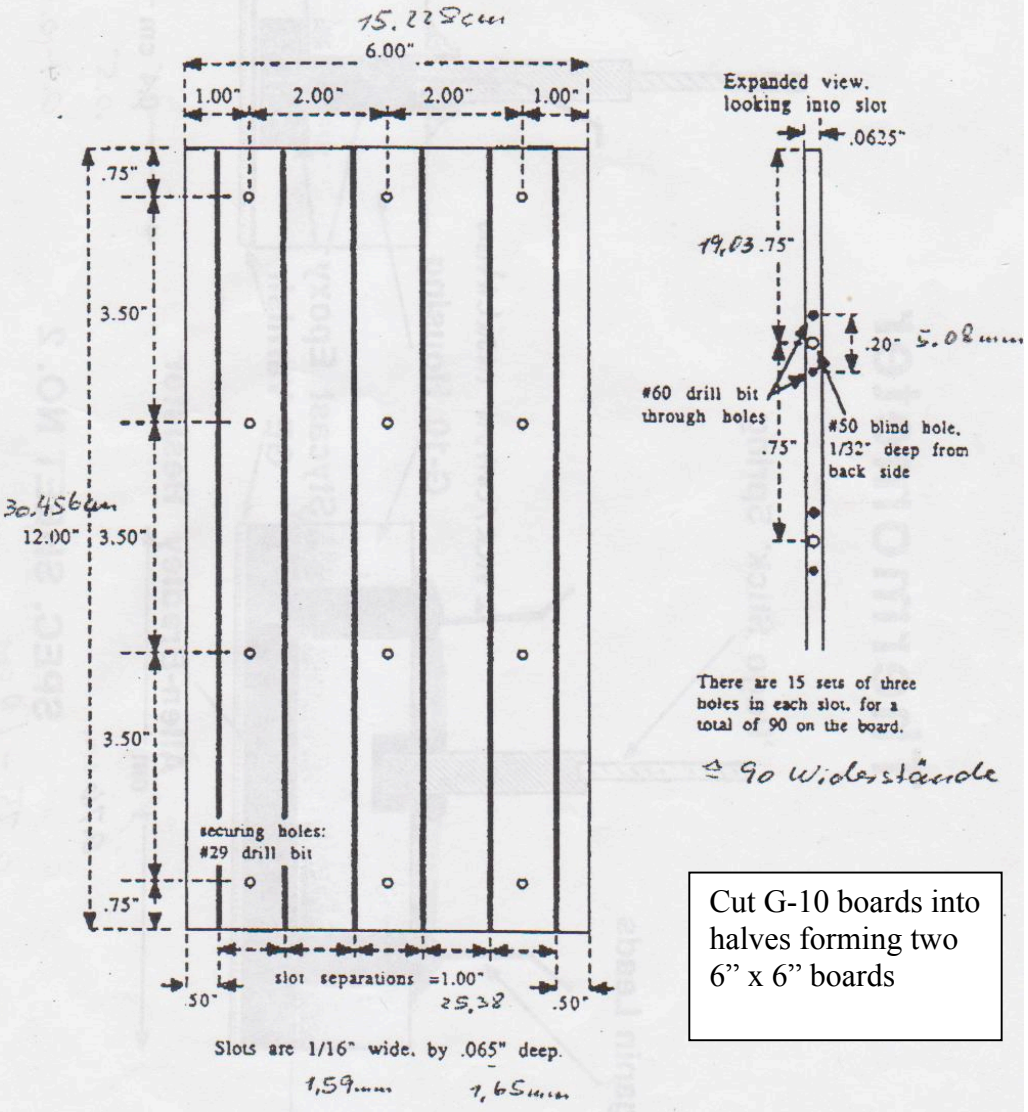
33. Using coarse, medium, and fine grades of emery cloth, hand hone carbon surface area open to about 0.020" width without exposing soldered lead areas (Photo 22). Ensure surface area remains perpendicular to pogo stick during this process.
34. Apply GE varnish to all sides of sensor (varnish should be thinned to about a 50/50 solution, by volume, with thinner. The thinner is a 50/50 solution, by volume, of toluene and ethyl alcohol). Apply three coats in all allowing sufficient drying time, 10 minutes, in between each coat (Photo 20, 21).
35. Verify resistance of each completed sensor is between 100 – 130Ω. This completes thermometry sensor fabrication.

POPULATING MOTHERBOARDS WITH THERMOMETRY SENSORS PROCEDURE

1. Insert pogo stick end of completed thermometry sensor into mother board receptacle hole (Fig. 7) (Photo 1 & 23).
2. Shape manganin wire into a large “J-shape” and solder to solder pad. Solder wire on opposite side of board (Photo 1 & 23).
3. Upon completion of soldering all sensors to board verify resistance is between 100 - 130Ω.

G-10 Board for Temperature Mapping Resistors
Thickness= 1/8"

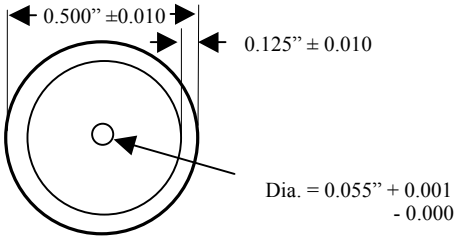
J Graber/SRF
11 MAY 90

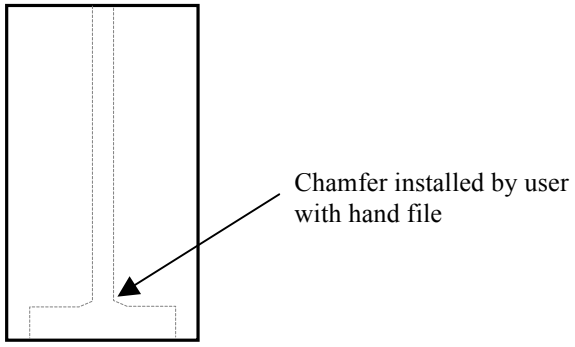


Cut G-10 boards into halves forming two 6" x 6" boards

SPEC. SHEET NO. 1

Material: Teflon





ALIGNMENT TOOL

SPEC SHEET #2

100 ohm, ⅛ - watt Resistor

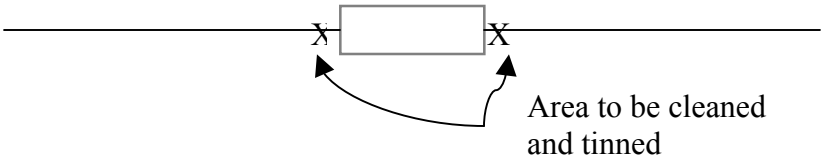
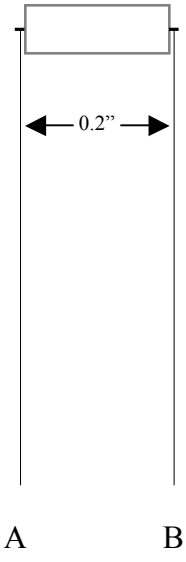


Fig. 1

Soldered Resistor / Manganin Wire Assembly

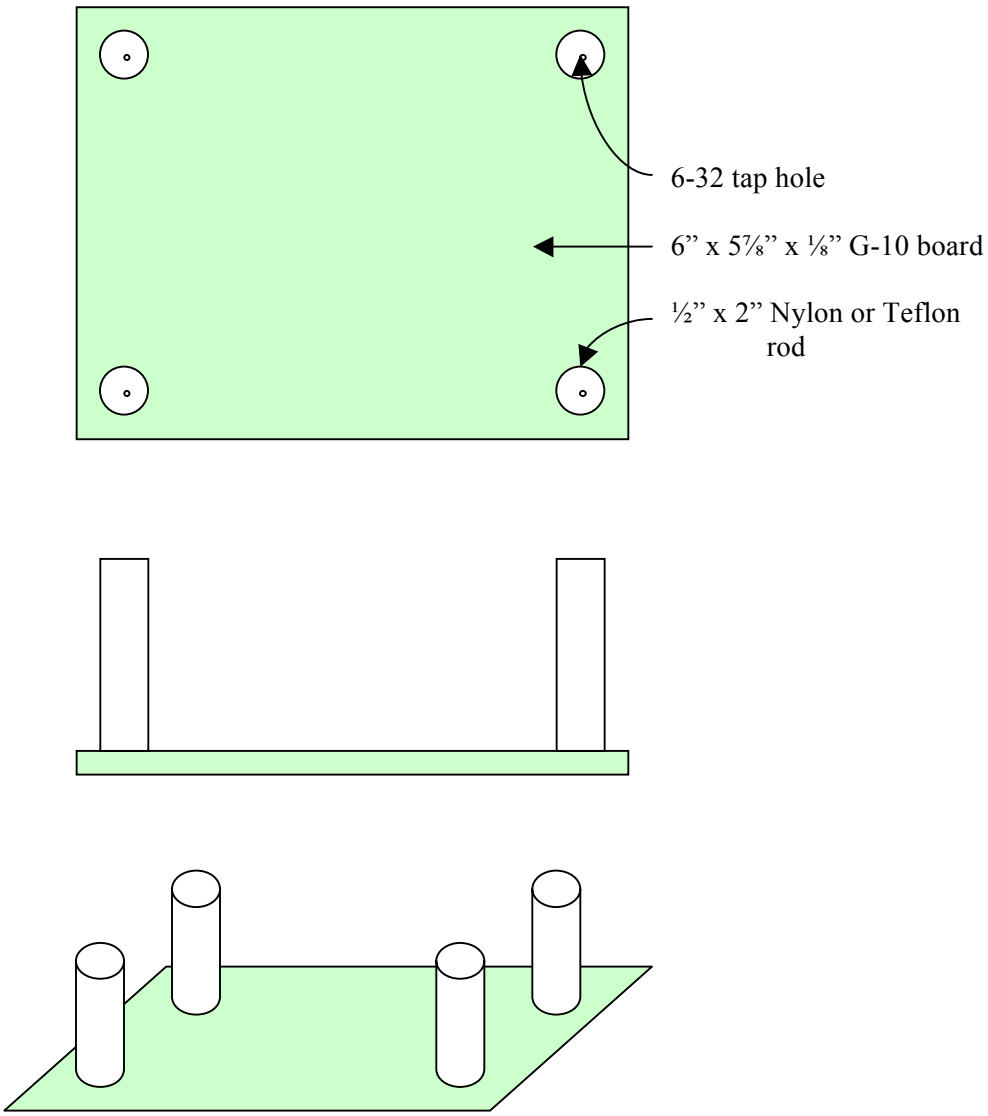


Trim *resistor leads* as close as possible after soldering on manganin wires.

Trim *manganin wire leads* as close as possible to soldered area.

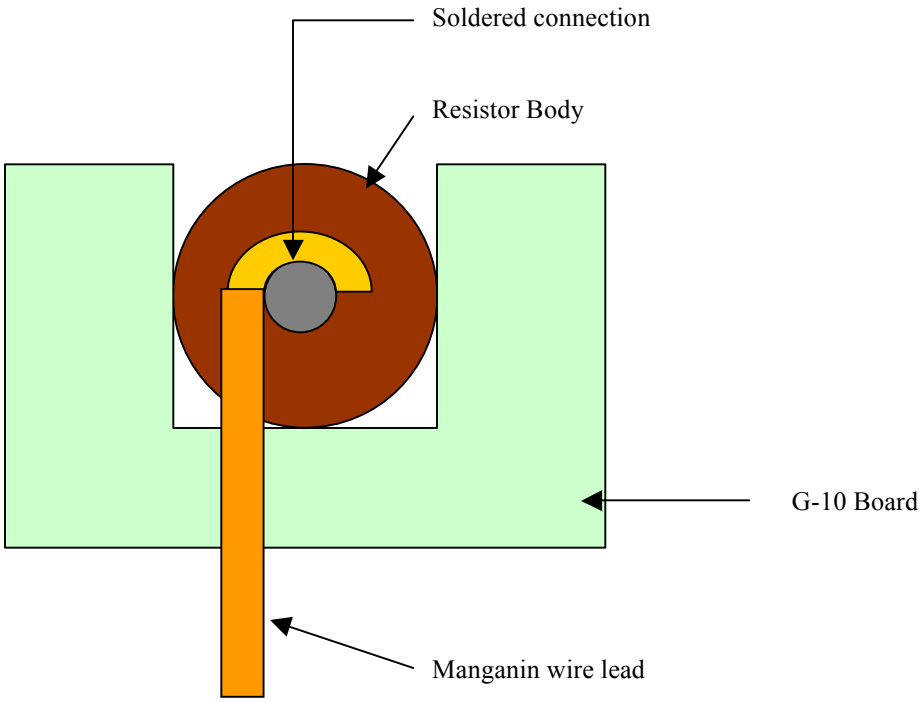
Maximum resistance is 130 ohms point A to point B.

Fig. 2



Board Holder

Fig. 3



Resistor/Wire Assembly
(Single Cross-Sectional View)

Fig. 4

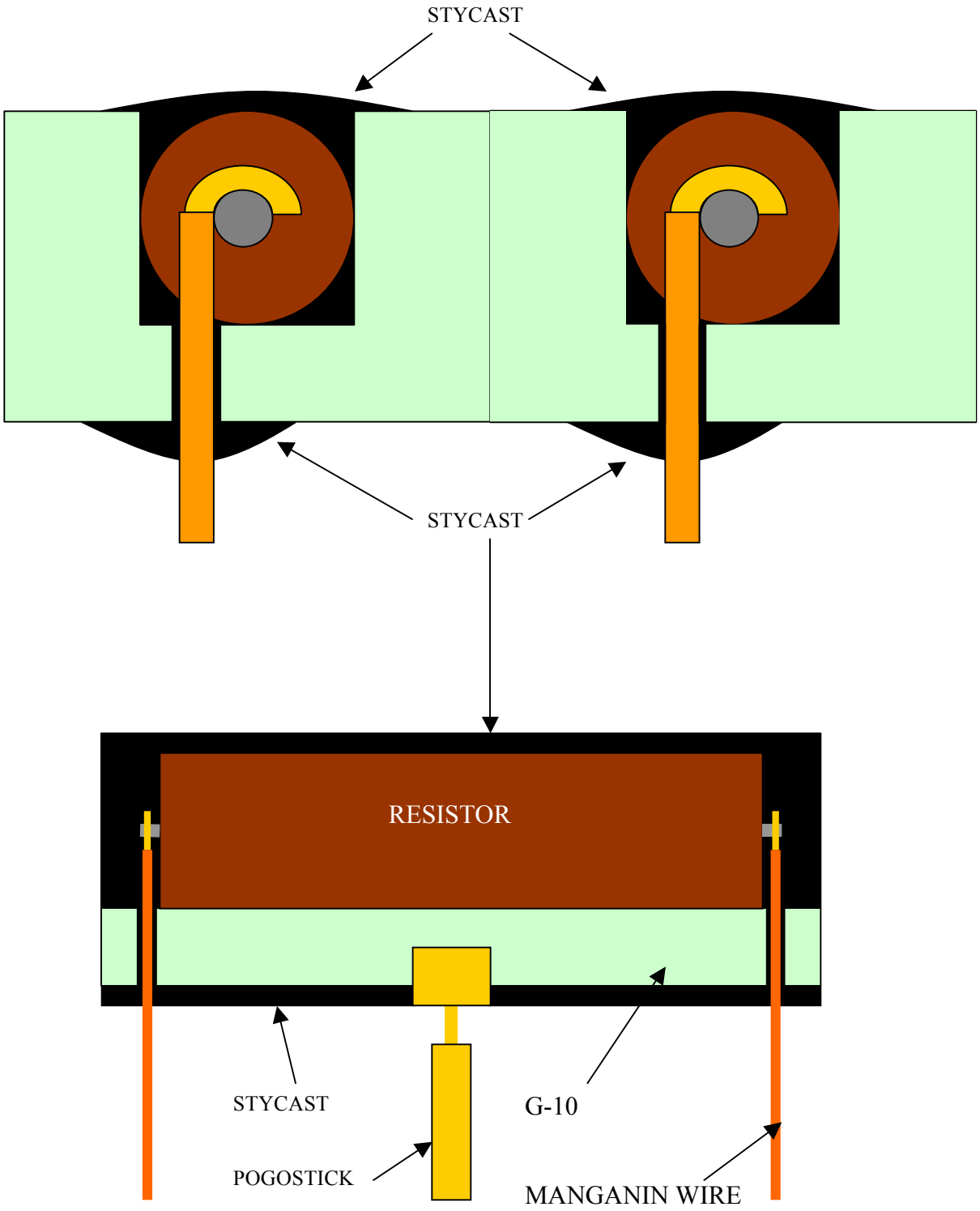


Fig. 5
(Top fig. is end view of two rows)
(Bottom fig. is side view of single resistor)

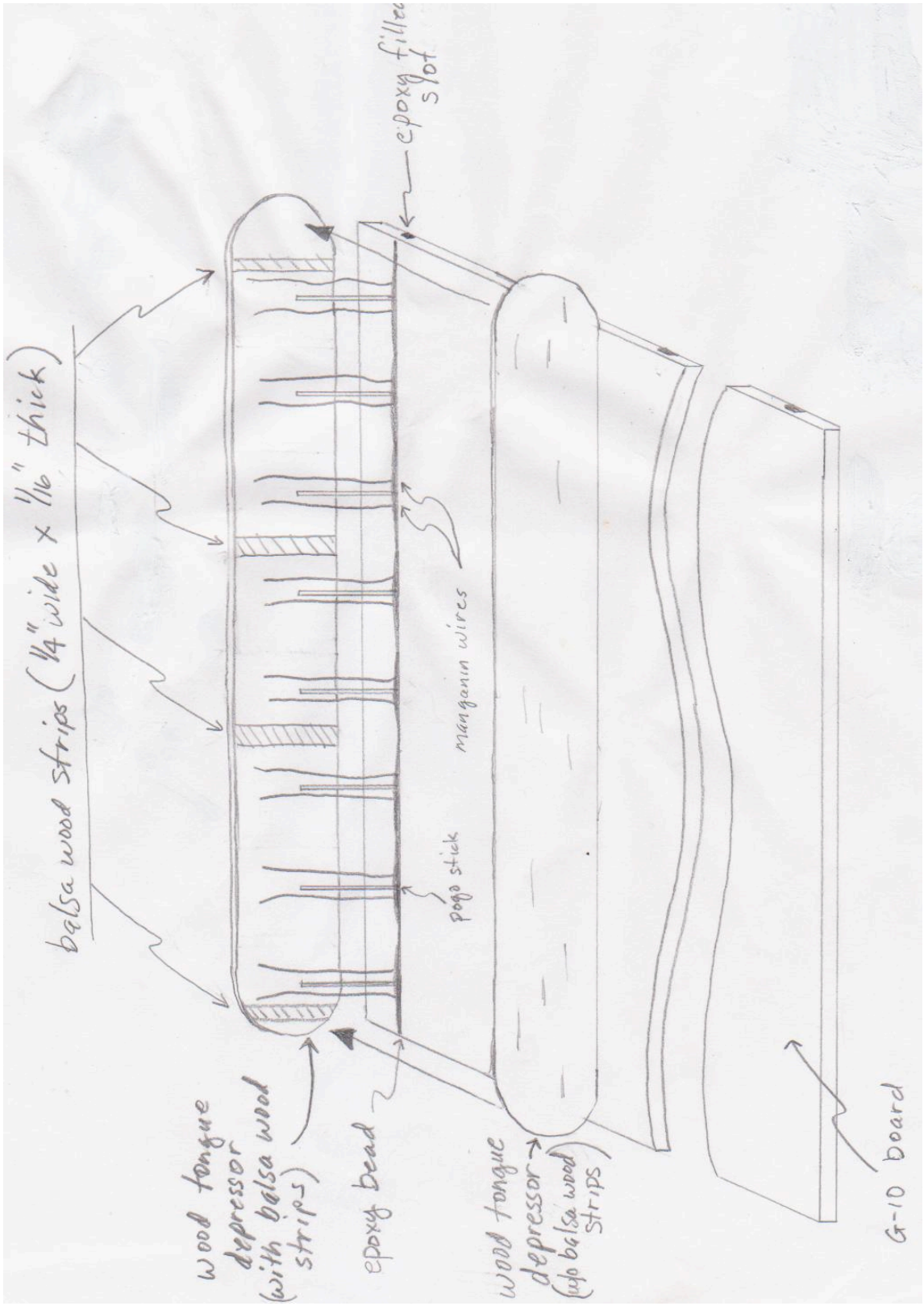

balsa wood strips (1/4" wide x 1/16" thick)
epoxy filled slot
manganin wires
pogo stick
wood tongue depressor (with balsa wood strips)
epoxy bead
wood tongue depressor (w/o balsa wood strips)
G-10 board

FIG. 6

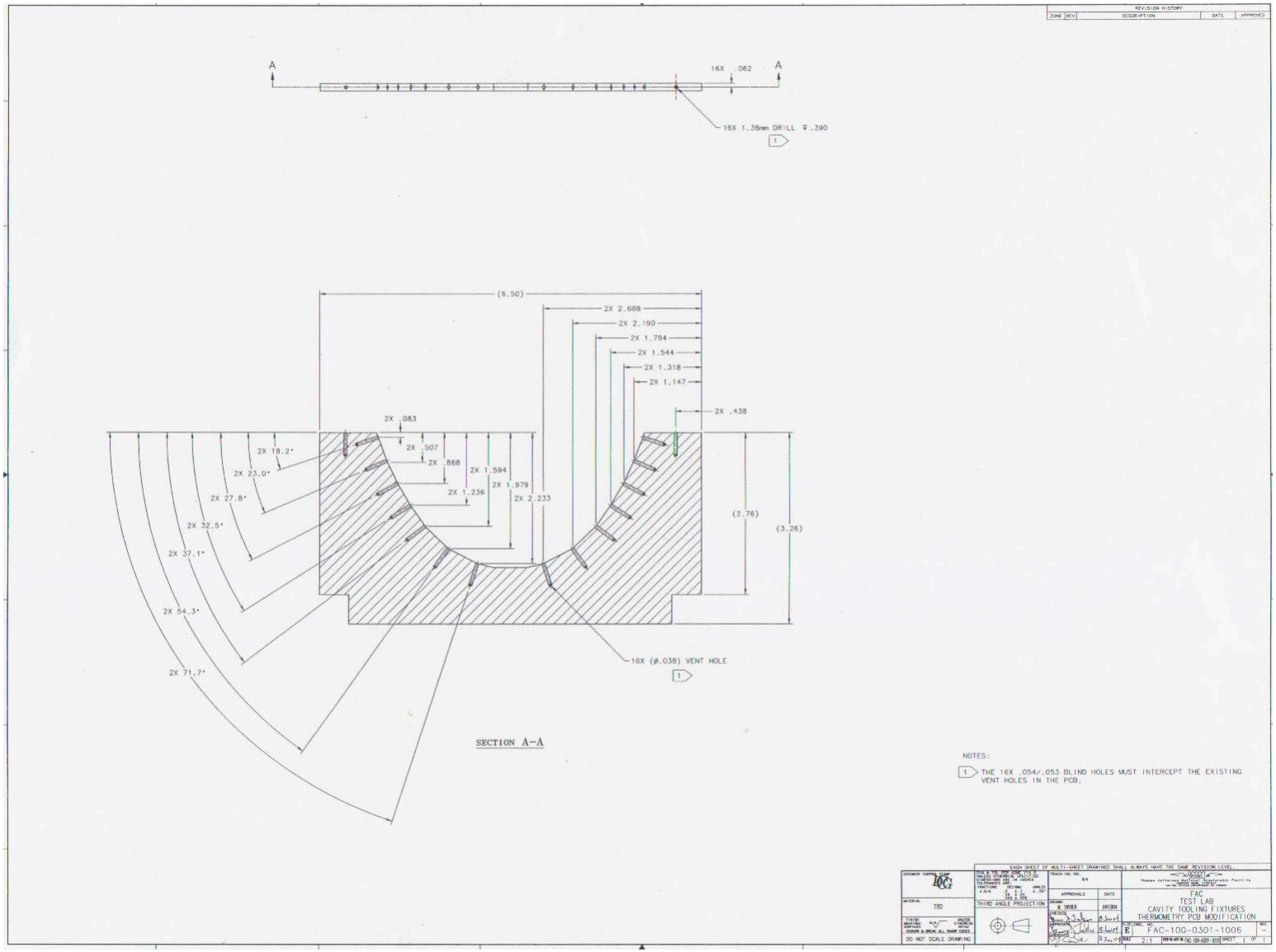
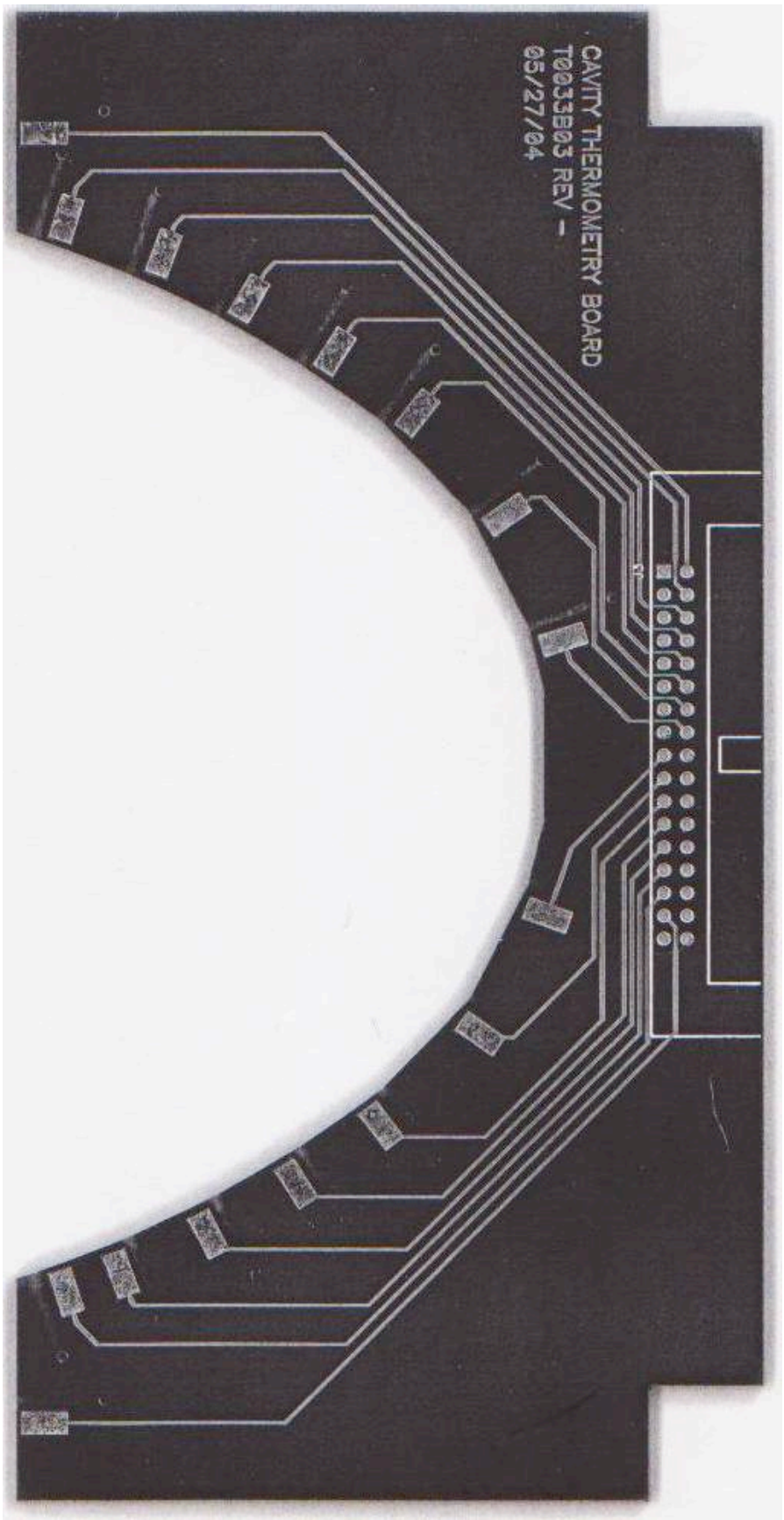

A
16X .062
A
16X 1.38mm DRILL ∓.390
1
(6.50)
2X 2.688
2X 2.190
2X 1.794
2X 1.544
2X 1.318
2X 1.147
2X .438
2X .083
2X .507
2X .868
2X 1.256
2X 1.594
2X 1.979
2X 2.233
2X 18.2°
2X 23.0°
2X 27.8°
2X 32.5°
2X 37.1°
2X 54.3°
2X 71.7°
(2.76)
(3.26)
16X (ø.038) VENT HOLE
1
SECTION A-A
NOTES:
1 THE 16X .054/.053 BLIND HOLES MUST INTERCEPT THE EXISTING VENT HOLES IN THE PCB.
REVISION HISTORY
ZONE REV DESCRIPTION DATE APPROVED
THIRD ANGLE PROJECTION
FAC
TEST LAB
CAVITY TOOLING FIXTURES
THERMOMETRY PCB MODIFICATION
FAC-100-0301-1006
E
2:1

FIG. 7



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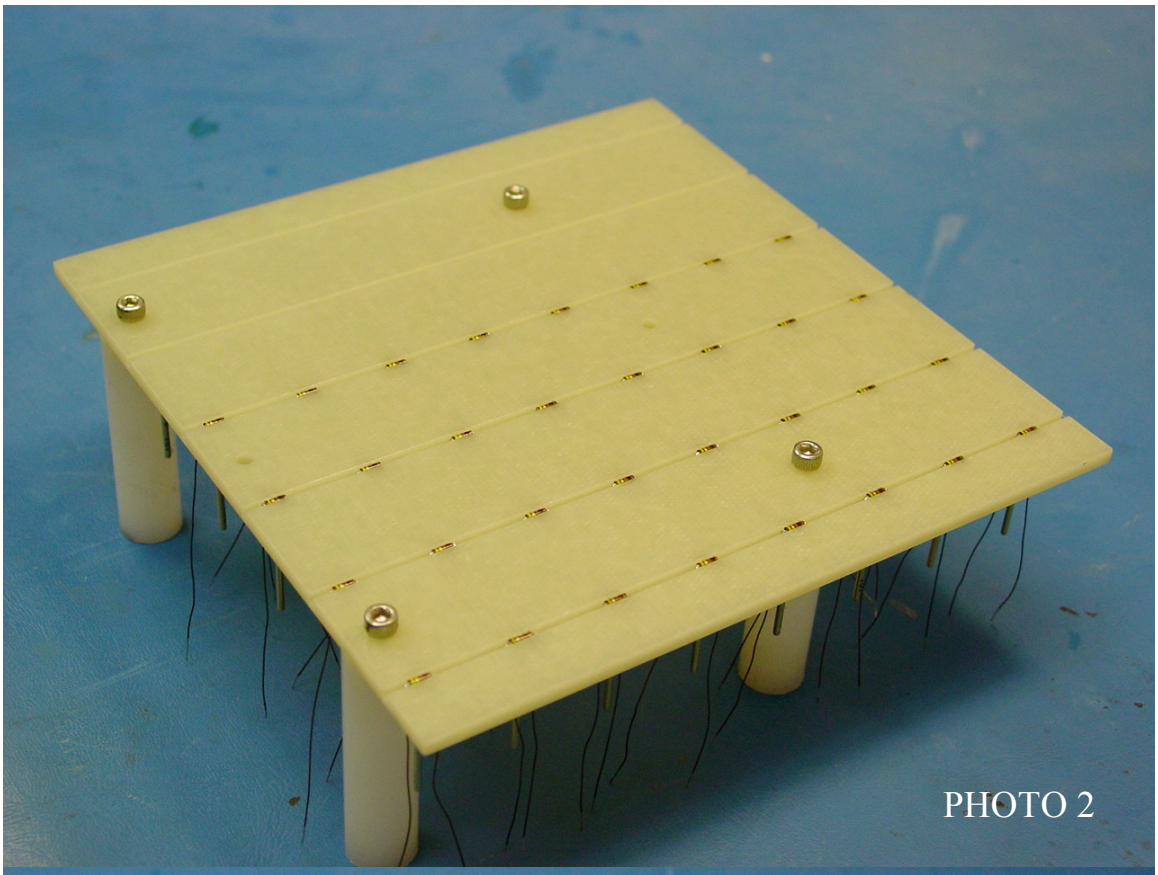

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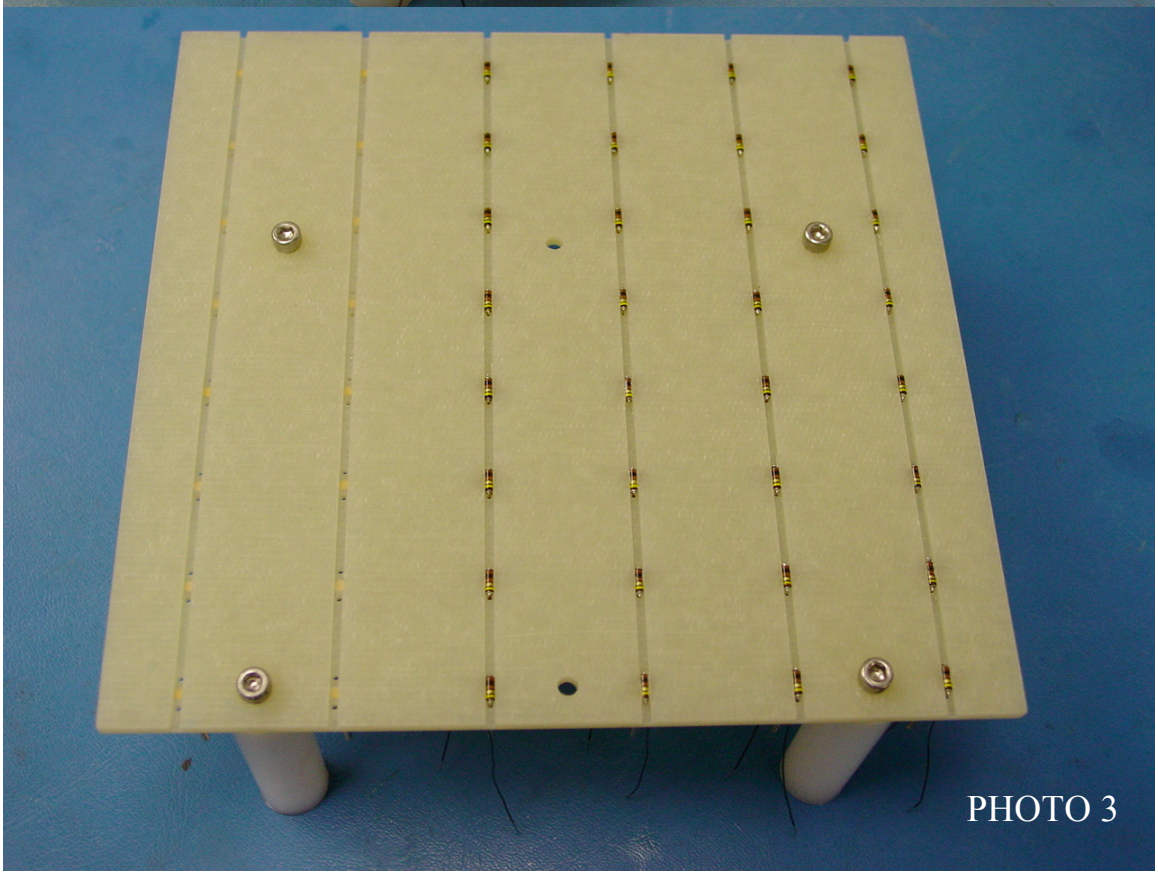

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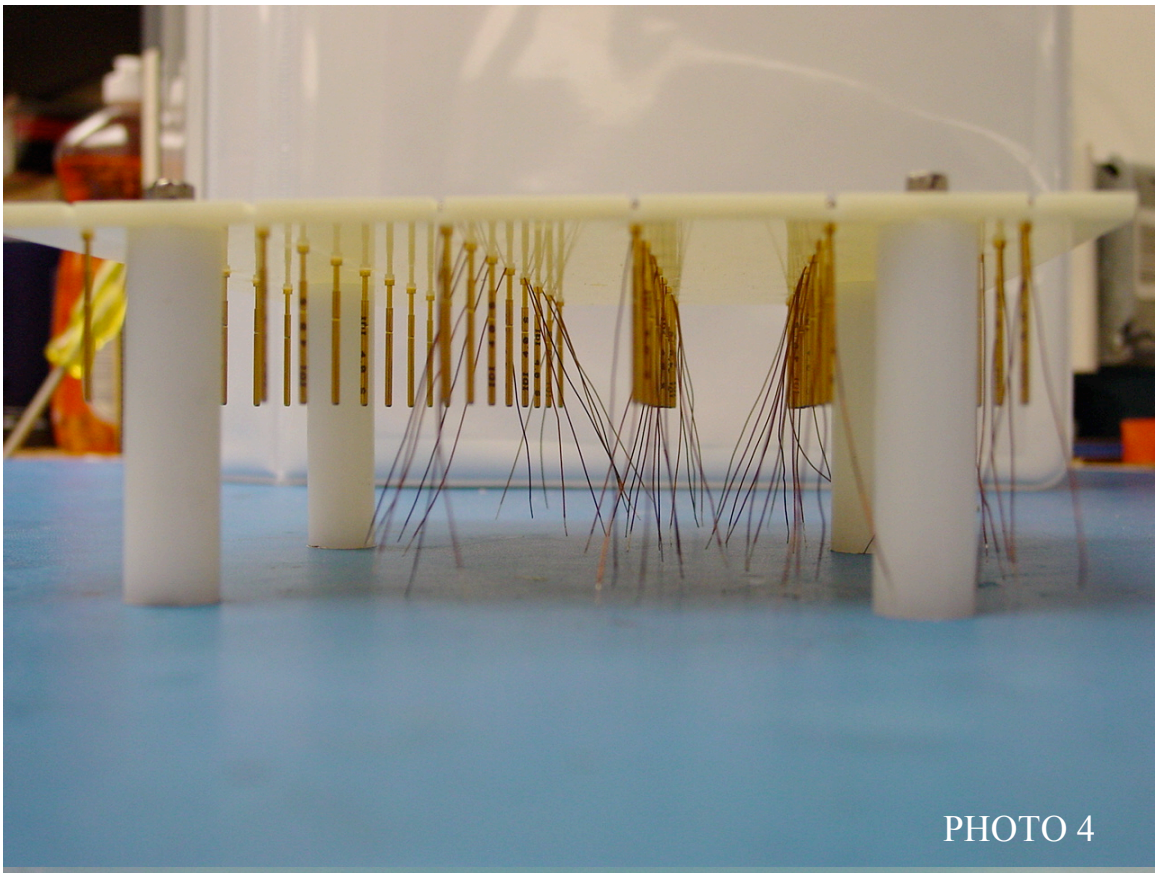
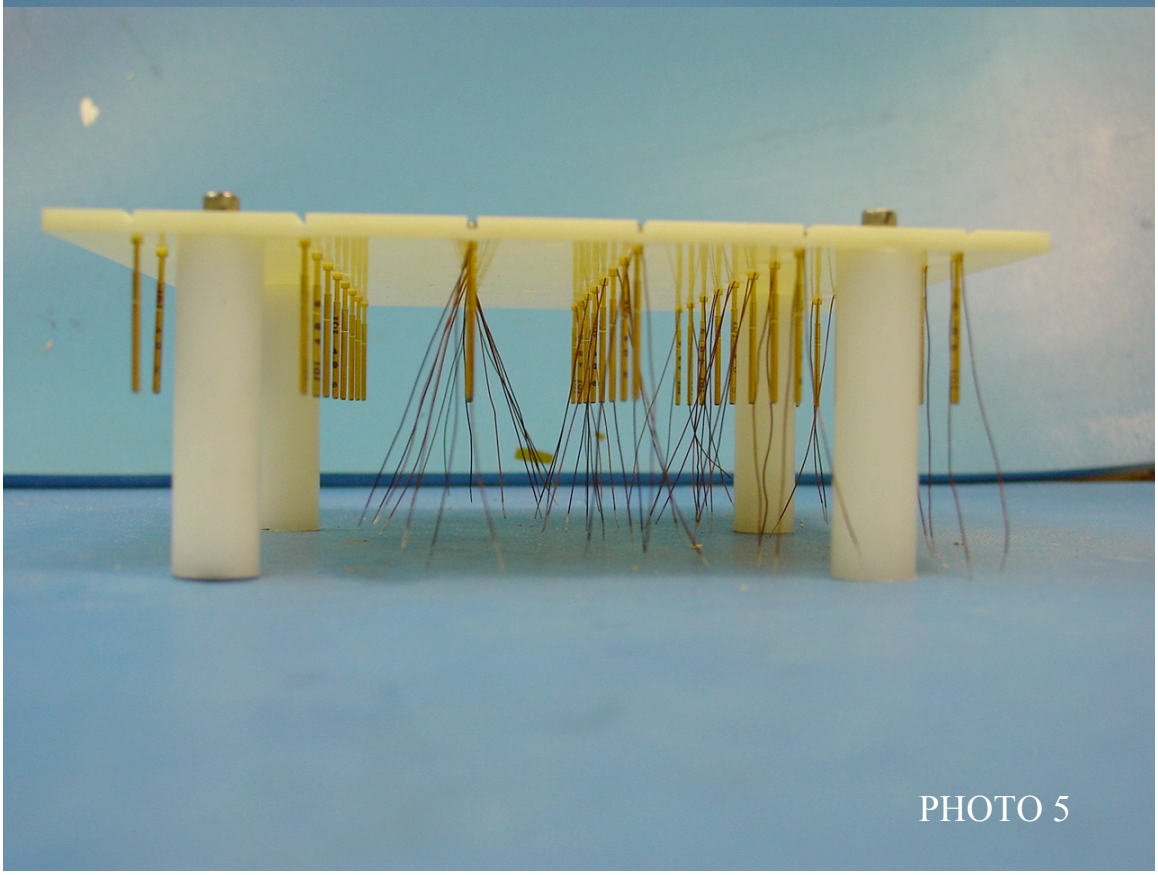


PHOTO 4



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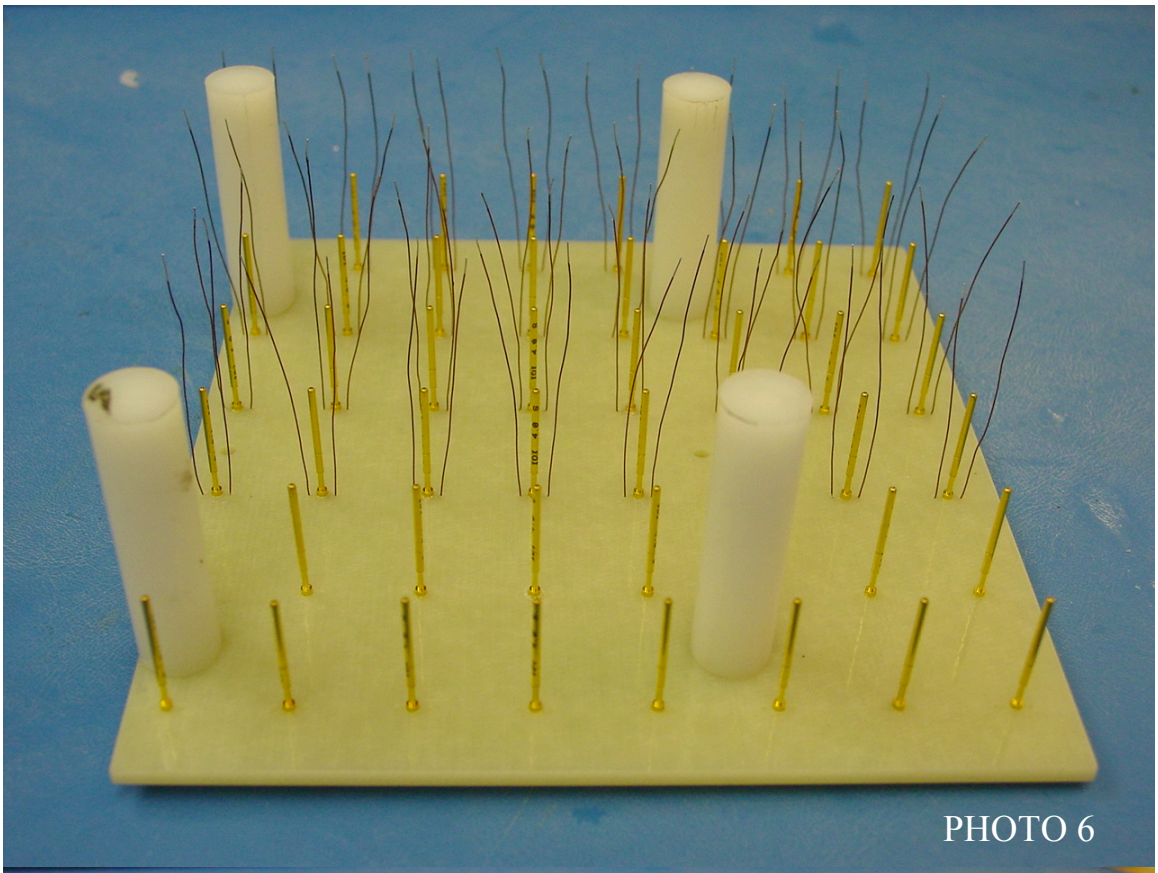

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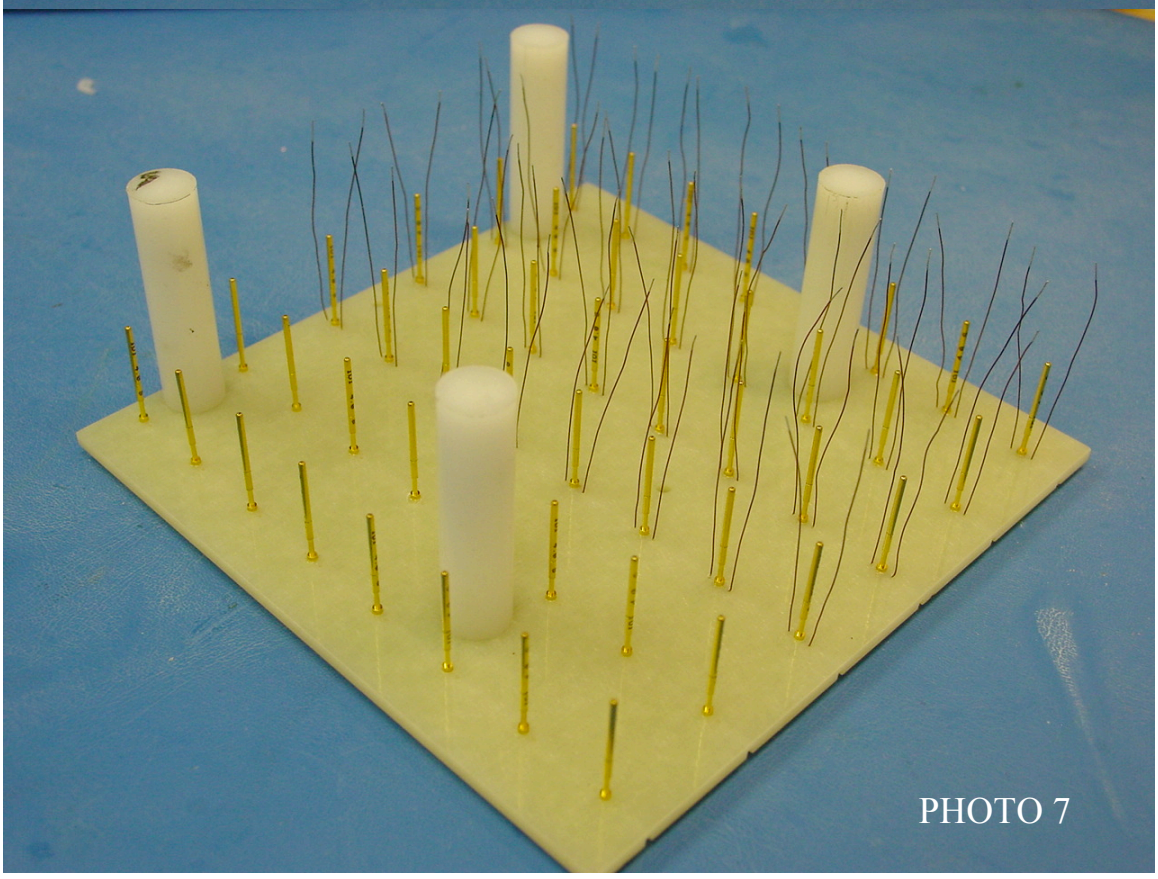
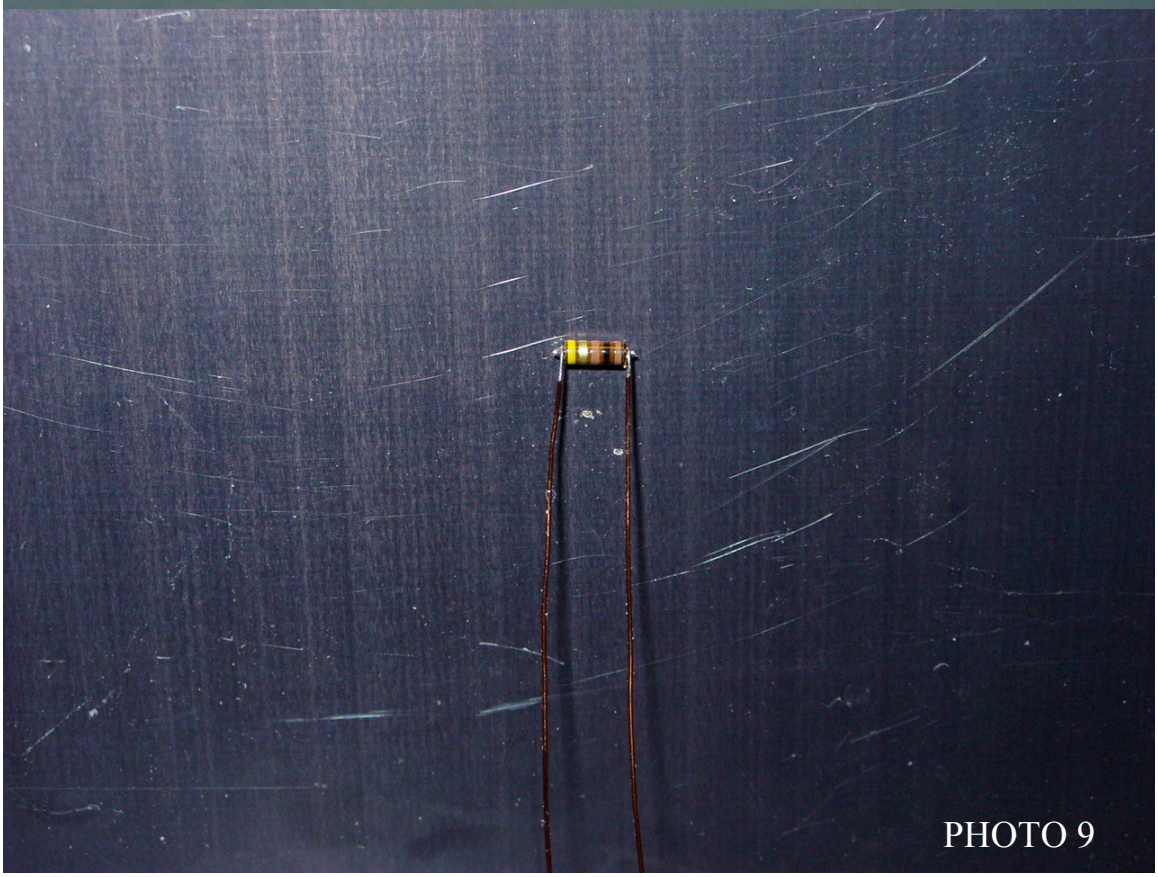


PHOTO 7

PHOTO 8



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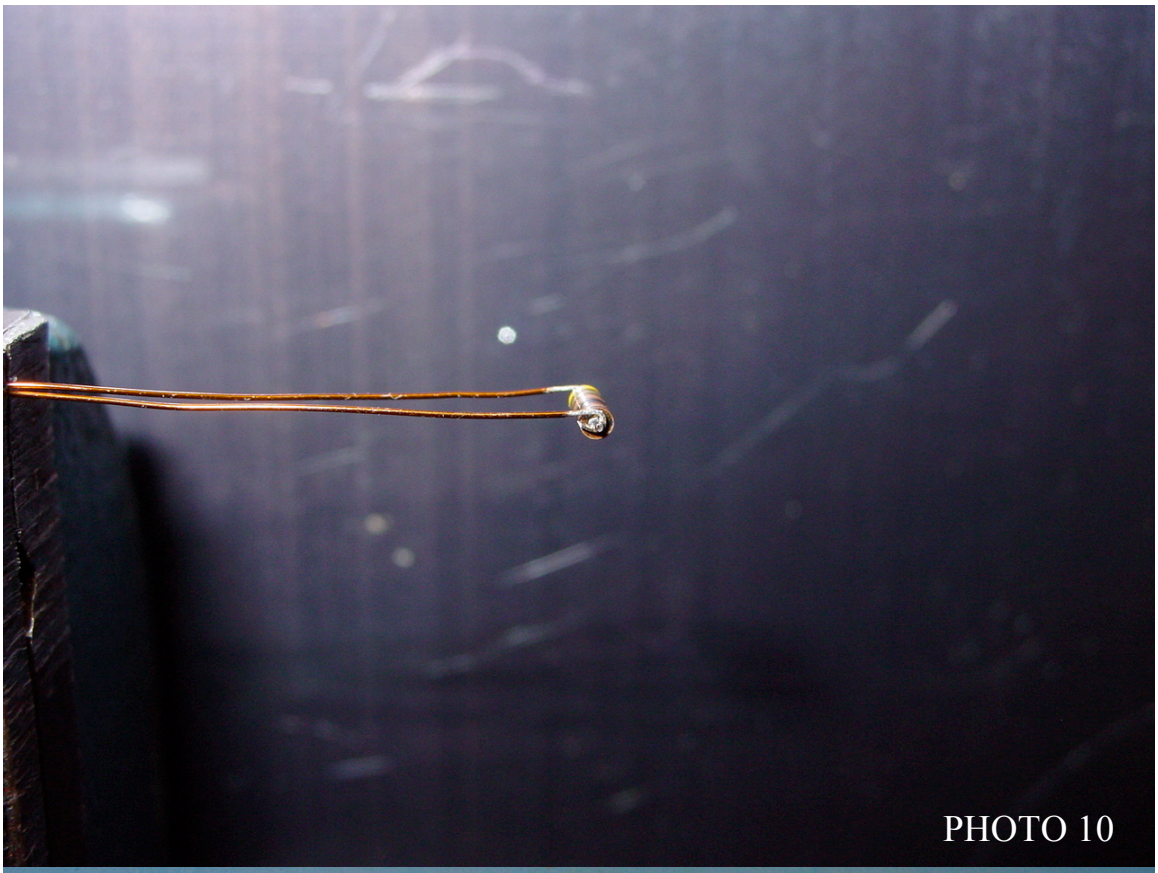

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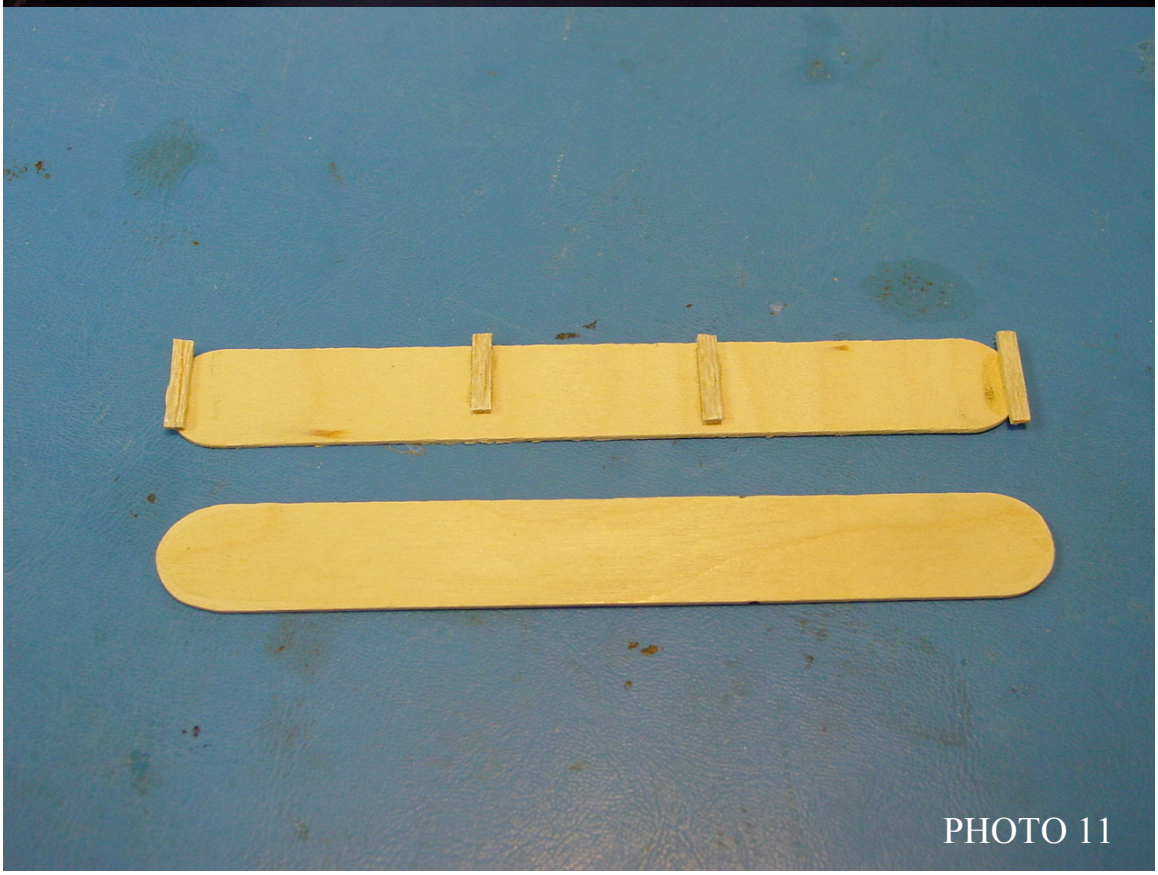

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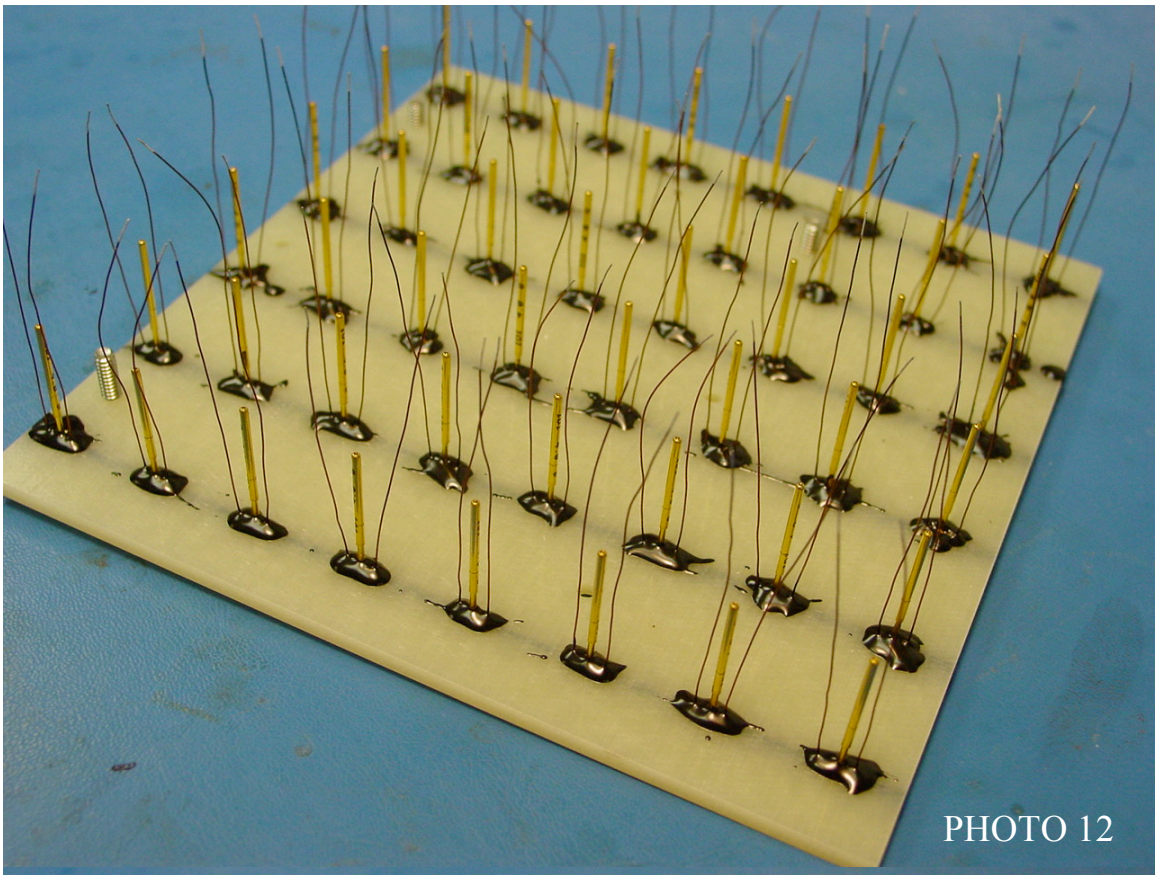

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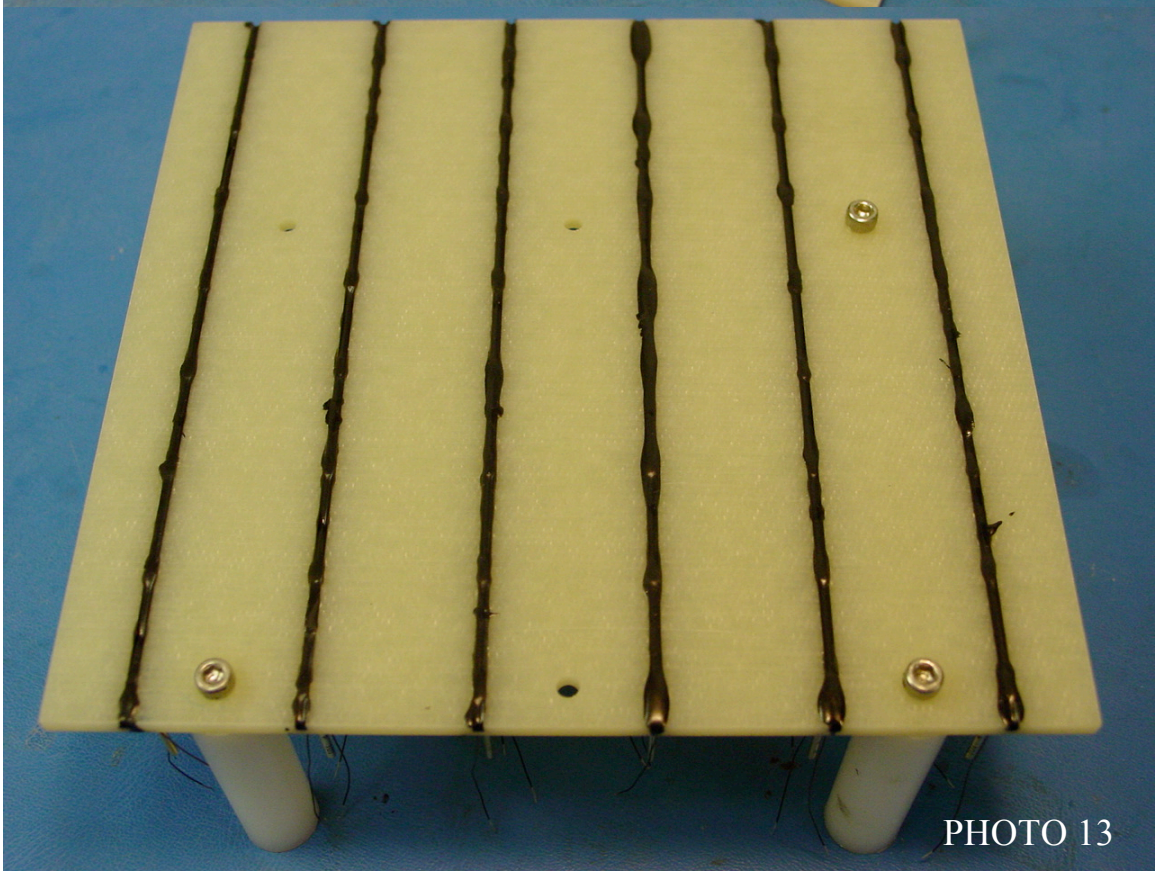

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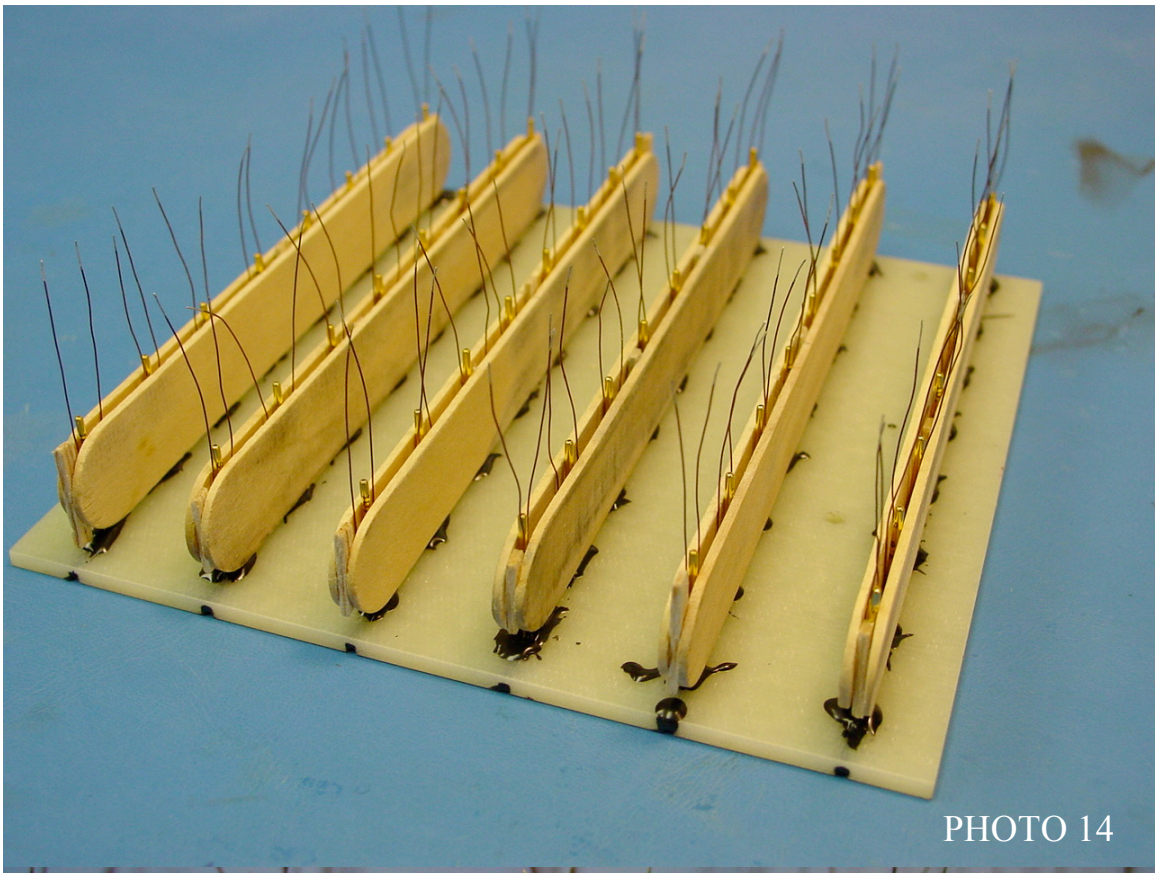

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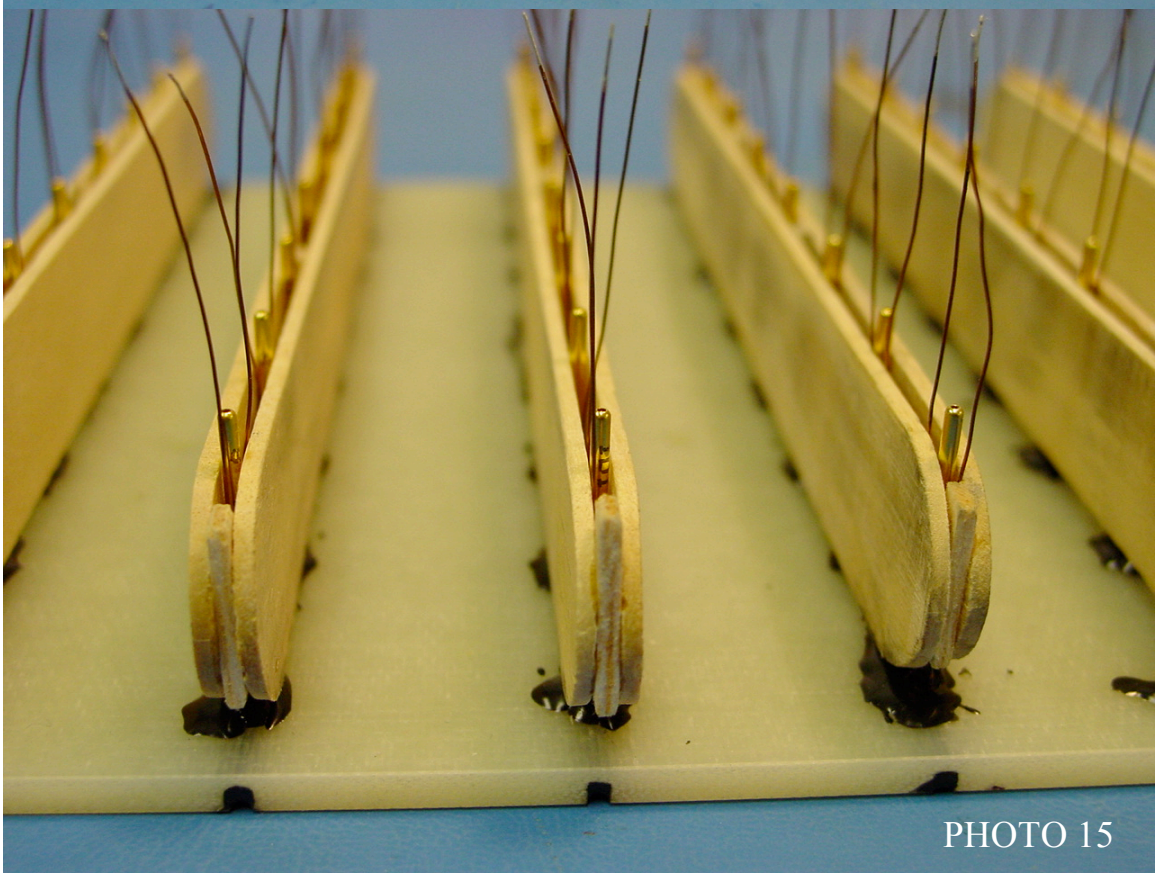

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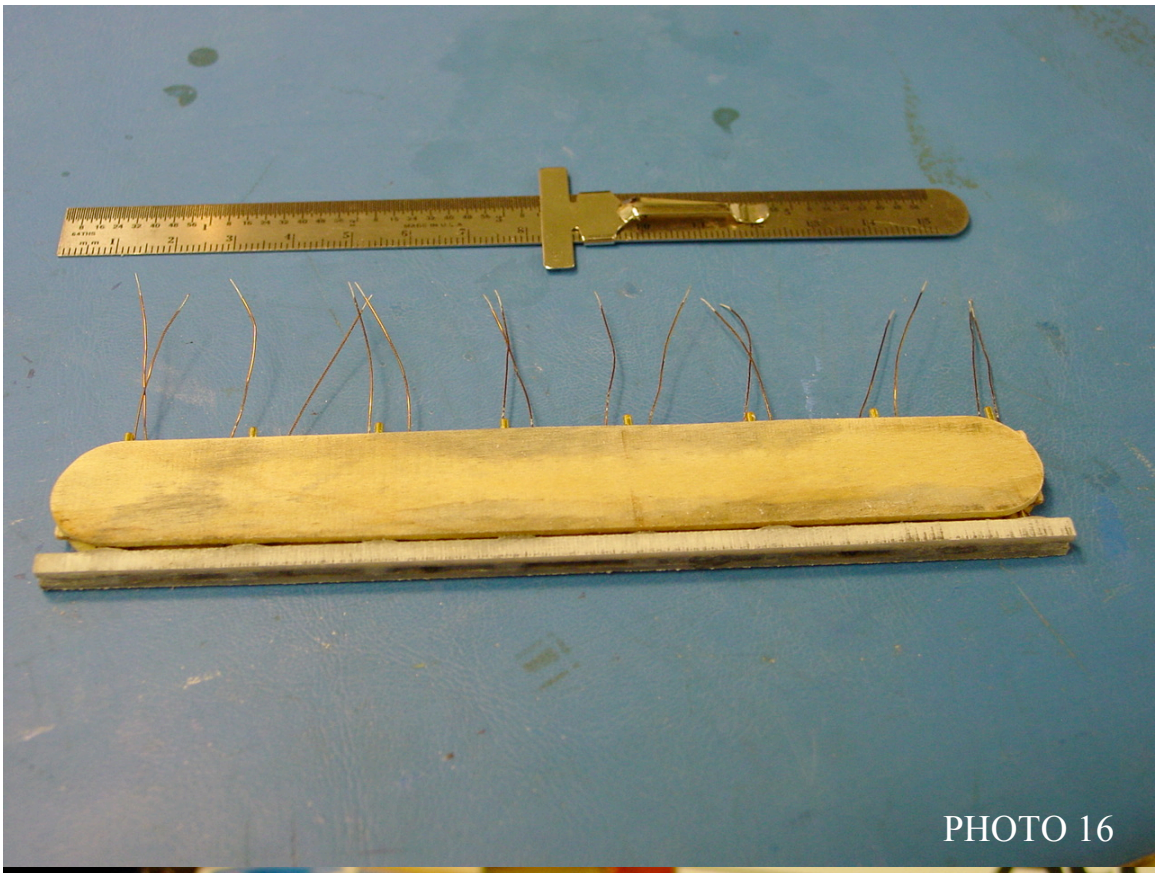

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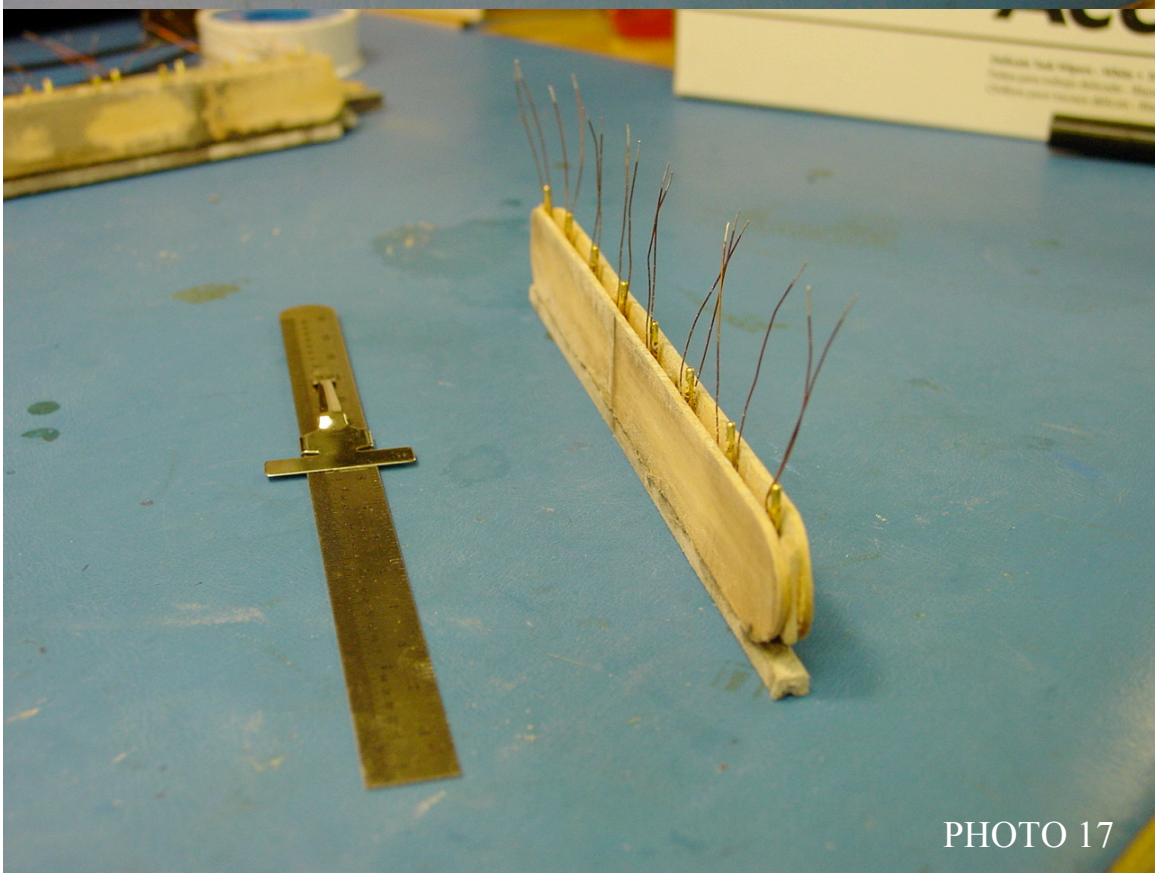

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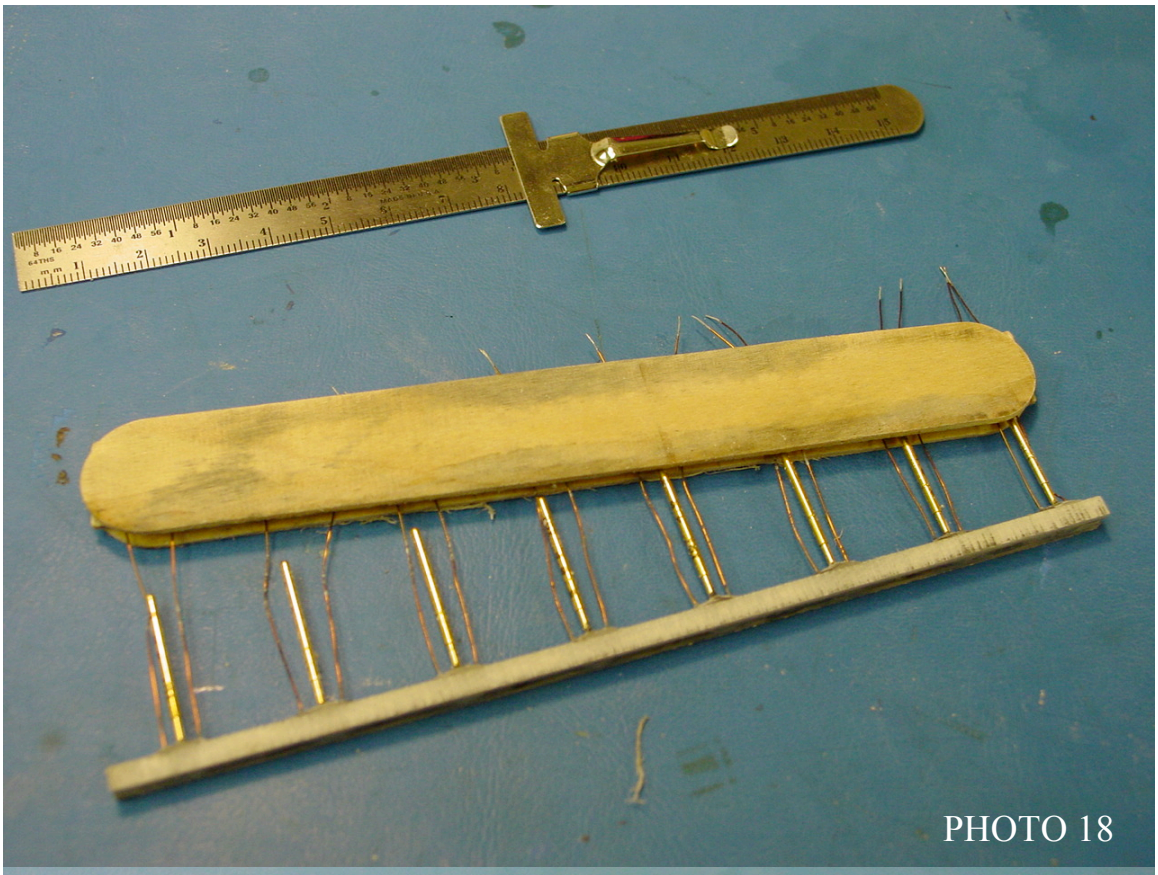

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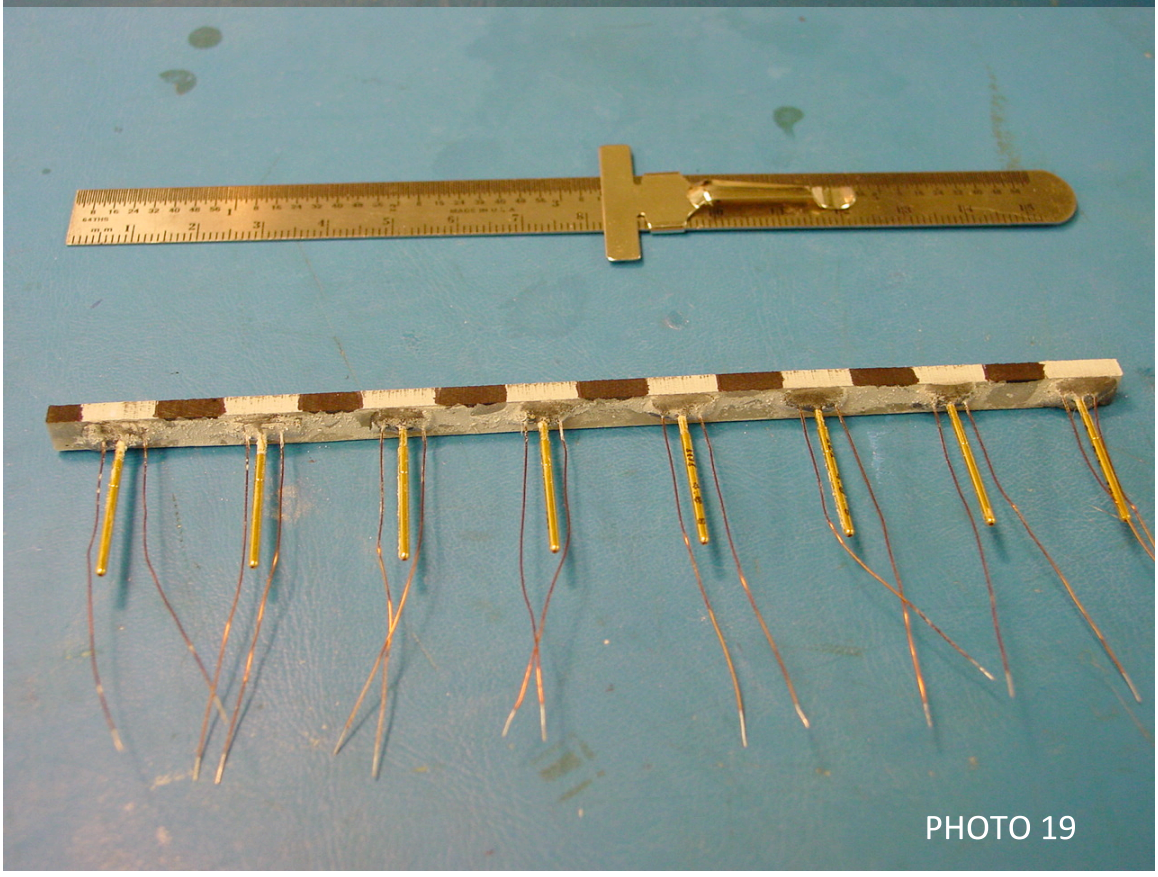

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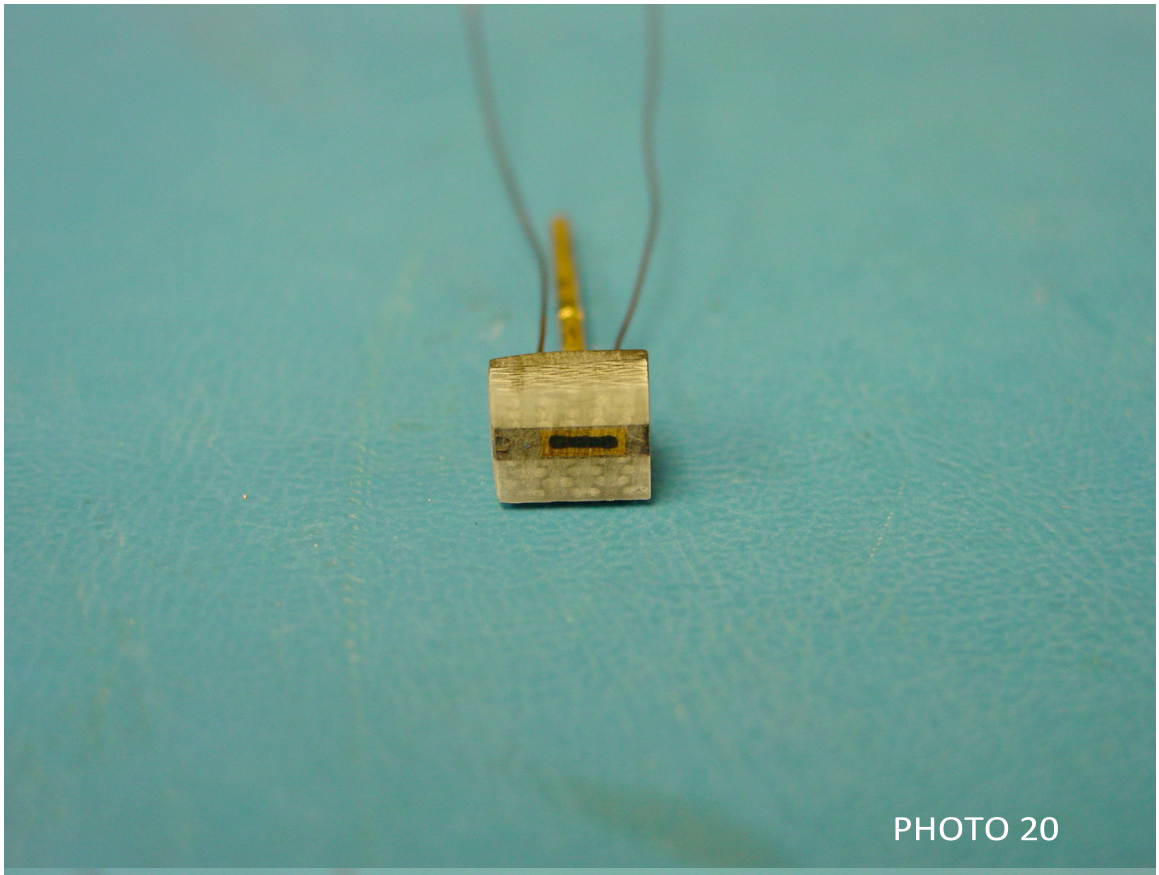

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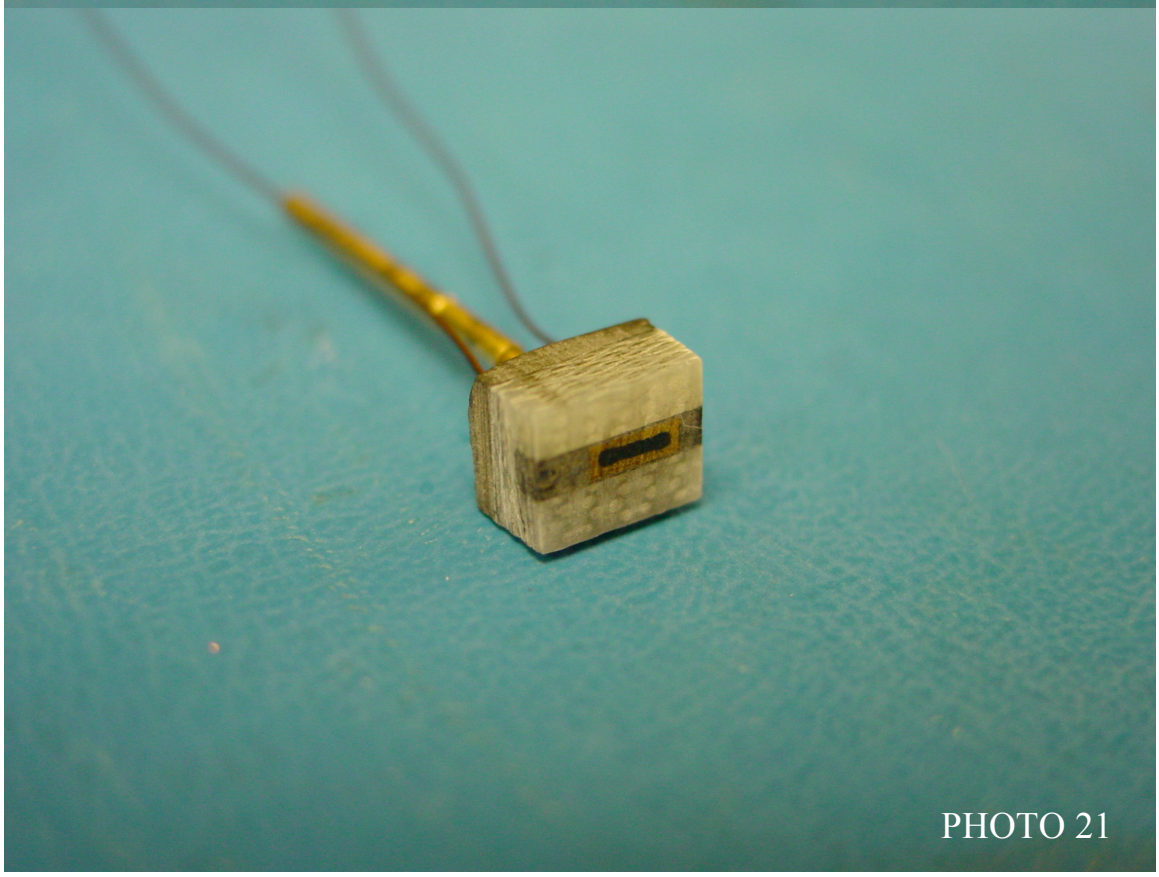

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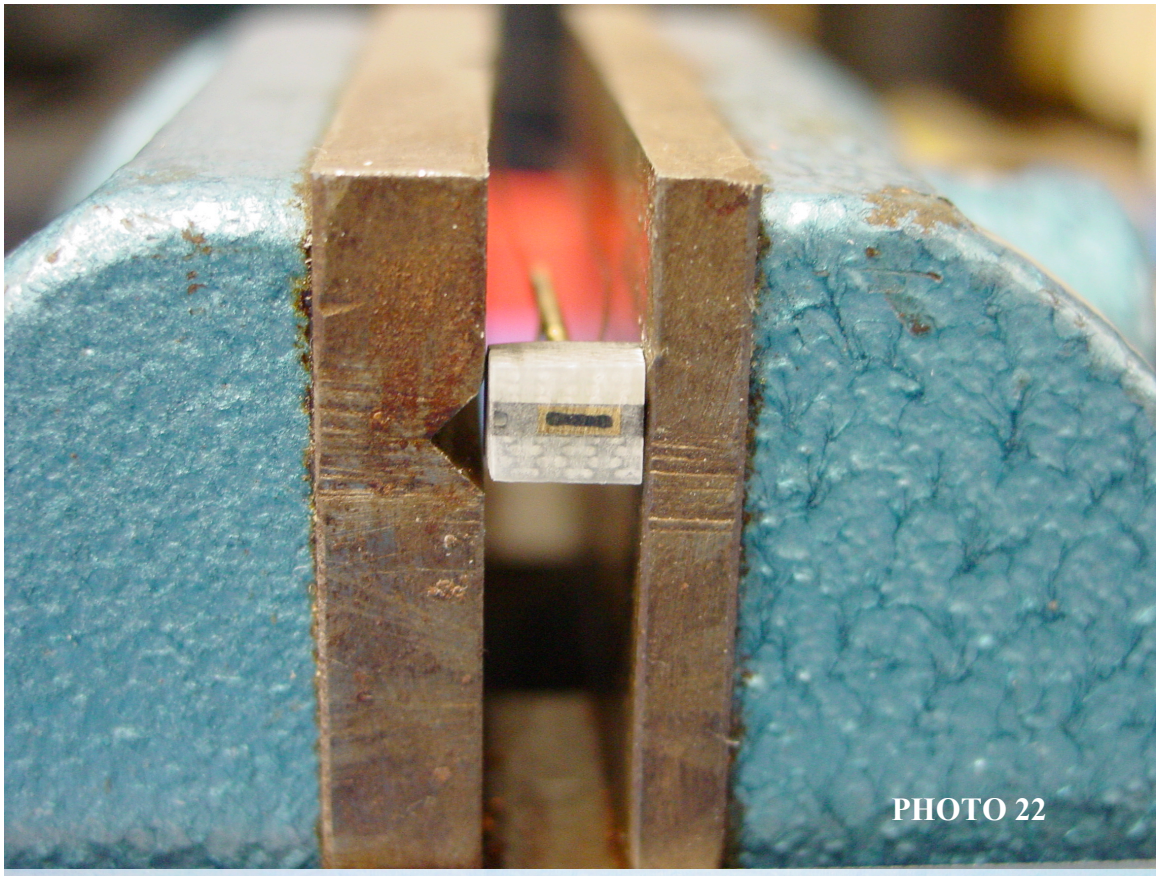

PHOTO 22

PHOTO 23