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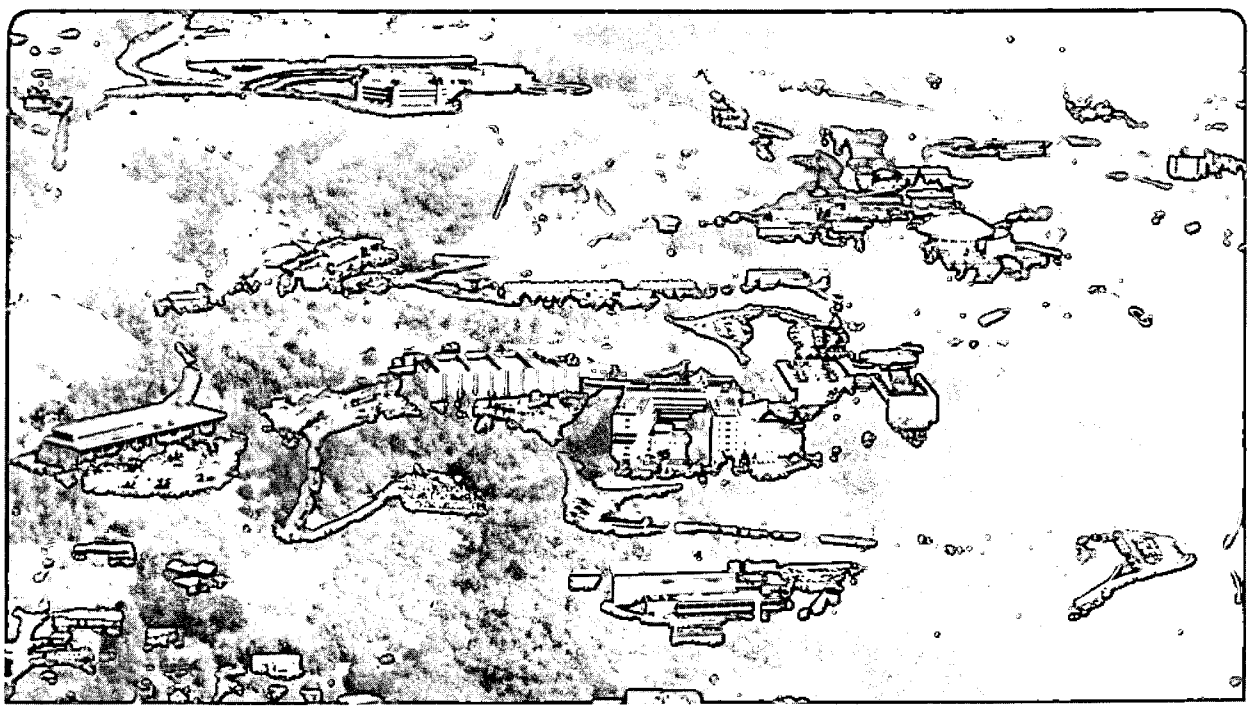

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ENGINEERING NOTE

CODE	SERIAL	PAGE
P40406	M5730	1 of 5

AUTHOR	DEPARTMENT	LOCATION	DATE
Dale Nesbitt	Mechanical Engineering	Berkeley	11 June 1981

PROGRAM — PROJECT — JOB

PEP-4

FIELD CAGES

TITLE

FABRICATION OF FINE FIELD CAGES

INTRODUCTION:

The purpose of this Engineering Note is to provide a short summary (time does not permit a detailed account) of the problems encountered and solution devised in the fabrication the P.C. boards used for the TPC Fine Field Cages. A number of people contributed significantly to the successful completion of this job. Hopefully they will all be mentioned.

APPLICABLE DRAWINGS:

20C0256	LRFFC PC Board
20C0246	LRFFC Removable PC Board
20C8396	LRFFC Assy. South End
20C8406	LRFFC Assy. North End
20C3496	LRFFC Resistor Panel North
20C3506	LRFFC Resistor Panel South
20C2896	Artwork SRFFC Resistor Panel
20C2906	Resistor PC Board SRFFC
20C2916	Short PC Board SRFFC
20C3796	Resistor/Spark Gap Location Assy. South
20C3806	Resistor/Spark Gap Location Assy. North
20C8416	SRFFC South End Assy.
20C8426	SRFFC North End Assy.
19Q7276	Final Mech. Assy. SRFFC South
19Q7286	Final Mech. Assy. SRFFC North

ARTWORK:

The decision had been made to put the artwork on glass because of the accuracies required (see drawings). Kodax was the only know source for photographic glass of the required size. Ivan Wood with Faye Witharm's assistance did all the programming and artwork imaging. Developing was done by LBL Technical Photograph Department. While the pattern appears simple (basically straight lines with pads around holes) the task of programming was not. The few lines that were on 7.5 mm centers instead of 5 mm complicated everything greatly. The plotting was done by Ivan Wood (at night after working all day) on the Gerber Plotter located at LLL. Each completed glass artwork was inspected (see inspection for the method). The first couple were good, then nothing was satisfactory. After carefully checking each step of the process it was determined that the 2nd lot of kodax plates had to be plotted at a speed no more than 50% of the plotters capacity. This doubled the run time to 10-12 hours per

artwork. It took almost a month to resolve this problem. Kodax finally admitted they had changed the emulsion. (The moral (a) Don't trust any vendor (b) Run a small test sample from each lot at different speeds.)

The trace location with respect to true position was better than ±.002 inches except on 20C0246-1 which was out by .0055 inches. This artwork should be replotted if any more boards need to be made. (See P.C. Processing for special procedures used to produce the boards to within ±.004 inches.) A record of the inspection results of both the artwork and boards is in a notebook which is to be stored in the printroom with this Engineering Note M5730 on the outside. In general the line widths were excellant but there were a few bulges, nicks and holes. All larger than 4-6 thousands were repaired by W. Quan.

The glass was cut to size and two holes drilled in the glass and plugged with plastic (see drawings) by Kevin Medlock in the glass shop. This part went well. Then holes were to be bored in the plastic plug precisely. This was done in Building 25 (Mechancial Technicians) but proved to be very difficult and expensive. Holding the desired tolerance was the trouble. In retrospect this entire step could probably be eliminated by aligning a fiducial on the artwork to a hole in the P.C. Boards and then (as was done anyway) make the board to board lineup by use of a transit (See assembly).

P.C. BOARD PROCESSING:

All of the machining to the outside dimensions and drilling of tooling holes was done at LBL on the G. & L. N.C.M. All of the rest of the holes were drilled by an outside firm that does nothing but drill P.C. Boards (Circuit Board Drilling - P.O. 7756302). They could not meet our tolerances on the O.S. dimensions or tooling holes but their charge on what they could do was only a small percentage of the cost on the G.& L. (This is due to their specialized; high speed, automatic equipment and NOT due to the people). All the people in the M.S. did an excellant job such as Sylvester Clark, Jack Smith, Bill Brown and Loren Wampler.

The real moral is to try harder to design everything so that a Co. like Circuit Board Drilling could do everything. In retrospect I think this would have been possible.

Originally a contract was given to General Circuits for $311 each for P.C. processing (20C0256-3). They did their very best but after 6 weeks it was mutually agreed to cancel the contract and do them at LBL. The size was too large for G.C's automatic processing equipment and they could not control it manually. They also did not have a clean room for their 'riston' applicator and could not keep dust out. They also had to have the imaging

done elsewhere. Our P.C. Shop succeeded but only because of the dedication of Walter Quan and Cheryl Williams. (Along with some relaxation on requirements near the end.) The final yield was roughly 50%. Again most of the processing had to be done manually in large specially made SST tanks. This makes it difficult to control of course. Typical problems included obtaining good plated thru holes versus loosing line definition. This was never fully resolved. In the end we made a minor modification at assembly which enabled us to not be dependent upon good plated thru holes. (This would have saved much pain, effort and money had we not specified plated thru holes.) Another problem was open across traces, holes and nicks. Each trace had to be inspected under magnification (D.T. Lim and group) and all breaks and holes or nicks over .005/.006 were repaired. We had a few boards repaired, for the above, by a 'brush plating technic' by Circuit Aids of Sunnyvale. Initially, the results looked good but later continuity checks revealed full opens or worse yet intermittents and or high resistance. Eventually all trace repairs were made by the Electronics Fabrication Shop. (L. Pracht, A. Kanzaki, Ed. Wong, et al.) by soldering a .008/.010 cu wire along the trace (very carefully). Many days were spent doing these repairs. Another problem was extraneous cooper between traces. This was <u>all</u> removed by hand by C. Williams or W. Quan.

In addition to the common problems above we had to try to make a board with traces to within ±.004 of true position with the one artwork which was out by .0055. We (primarily C. Williams) acheived this by first heating the unexposed P.C. Board up to 190°F (along with a 2nd board) placing both with glass artwork in the imager and exposing as fast as possible! The final error was less than .003. However, as mentioned before in case new boards are made I recommend new artwork!

There was a very substaintial problem with the slotted small radius boards. Refer to Drawings 20C2906 and 20C2916. First, the slots were difficult to machine (read expensive). Second, it was not originally realized (by Physics or Engineering) that there would have to be anti-tracking protection in the slot. After considerable debate it was decided to add a plated thru hole near each edge of the slots every 20 mm apart and via a secondary process plate a trace in the bottom of the slot. The problems were that (a) the plating of the trace varied from poor to bad and (b) the plating in the holes varied from fair to non-existant. In addition experience showed that the traces on the ungrooved side (5 mm spacing) were easily broken (sometimes intermittently) at the edge of the groove by flexing. In the end a short wire was soldered from the 5 mm spaced side thru the hole onto the trace in the slot. Many of the traces in the slots had to have wires soldered along them. A number of approaches were tried and found wanting. Ed Wong and Al Kanzaki developed the final method. While there were other problems the above were the major ones that I recall after 9 to 12 months.

INSPECTIONS:

As previously referred to all artwork (and all P.C. Boards) were inspected to insure conformance to the desired tolerance. (The 'Final Spec' was for all voltage planes to be co-planner to with in ±.004, therefore the traces on any given P.C. Board should be better than that - in fact as good as practical.) The only instrument we found at LBL capable of measuring to the required accuracy was Jim Hodges Universal 10 x 20 inch measuring microscope. This is located in Building 25 and is described well in Engineering Note M5567, Code AA0501. We in fact were one of the first users. Donna Jones played a key roll in these measurements. Jim Hodges and Steve Klingler were always very accommodating. (Even when we kept them from completing their machine.)

ASSEMBLY - L.R. FIXED BOARDS - DWGS 20C8396 & 20C8406:

For once something went better than expected! This was the line up and bonding together of the 9 20C0256 boards to produce the above assemblies. I had Jack Borde use his best optical mike to line up the boards. First one was placed on the longest flat table in Building 77 and one of the center rings (R#100) lined up in line with the transit. Then the 2nd board was spaced the correct distance from the first and aligned in the same way. (5 mm spaced side is up-at this point.)

The two boards were then epoxied together temporarily using a .030 x 1 strip and quick set. After this had cured the alignment was rechecked. Then the boards were carefully turned over and the permanent strip (See Assy. Drawings) was epoxied in place and then the 9th board epoxied in the middle. (This middle board had to be machined narrower due to the out of tolerance CFC.) This is (or will be hopefully) noted on the drawing. Roy Oki, Bill Baldock and Otto Draeger all helped develope the successful technics which are admittedly not adequately described here.

One other item of note is that most of the jumpers (item 1) had to be replaced because the leads were cut flush initially (done to reduce chance of sharp points) which did not provide sufficient mechanical strength. Ed Wong demonstrated the proper technique of bending the lead along the trace a short distance and then covering with ball of solder. Again there were other problems and resolutions but time and memory (mine) are both short.

ASSEMBLY - SMALL RADIUS BOARDS:

These assemblies (20C8416 & 20C8426) turned into a real nightmare. The major problem, that associated with the slots has been mentioned (inadequately). Another major problem involved the supports and their effects

on corona. Correcting was primarily a cut and try job - done mostly by Bill Baldock. (With Allan Bross deciding when it was good enough.)

SUMMARY:

These assemblies could not have been made without the dedicated efforts all those mentioned and others unmentioned such as Gerald Wilson who always provided the best people available upon request. While the charges were not separated so that the cost of these assemblies can be determined its obvious that they were expensive. The following is offered in terms of hind sight for anyone who might be able to make use of it. Some possible ways to reduce the expense (and in some cases help acheive a more reliable product) are:

1) Tolerances should be carefully evaluated before starting to see how they will affect the costs. This includes both the basic function (those that affect the physics) and those that involve intermediate assembly methods (i.e. in this case line up of traces).

2) Uniform spacing etc. - In this cases if all traces had been say 7.5 mm (or better yet .300 inches) between it would have helped (would also have simplified the resistor packages, cabling etc.).

3) Avoid the absolute need for plated thru holes.

4) Keep the board size within the capabilities of automatic processing equipment. Its better to have more joints.

5) Eliminate grooving as a method to bend the boards into a hex if at all possible. I'd prefer lining up 6 physically separate (but electrically joined with jumpers) boards at assembly.

6) Prototype everything to full size before making final decisions.

SPECAL NOTE:

The glass artwork is stored in the LBL warehouse; Tag No. 27052, Bldg. 901, bay/row 504.

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