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The Notebook of Larry D. Bolton - Mail Stop 1701, Univac, Univac Park, St. Paul

Background: Just a few months after I started working as a component engineer at Univac in June of 1965, I was loaned to the 1824/MBRV/BGRV program that had its offices in the Shepard Road factory. This was the first program to use the new integrated microelectronic devices that could incorporate an entire logic gate on one piece of silicon in a single 14 or 16 pin ceramic flat package. The packages were made of gold plated kovar and glass frit or ceramic. The silicon die was attached to the open package with a solder eutectic. Gold wires, of approximately 1 to 1.5 mil in diameter, were attached to aluminum pads on the silicon die. The other end was attached to the gold plated lead pads on the inside of the package. A gold plated kovar lid was then attached to the package opening using a solder pre-form which was reflowed in a heated sealing furnace. The kovar and glass/ceramic combination made a hermetically sealed package. One of the first suppliers of this new technology was Westinghouse (W) in Baltimore, Maryland. Early semiconductor manufacturers were on the east coast. Silicon Valley in California had not yet become significant. Westinghouse was making custom silicon circuits designed in collaboration with Univac engineers. Up until this time, processes were being developed for making transistors. Processes for making microelectronic devices were new in this new industry and there were all sorts of problems in making them reliable. (Reference to the Procurement write-up by Mike Svendsen) Since the 1824 was an aerospace computer, it would be subject to a lot of shock and vibration so any loose particles would cause havoc with machine reliability. Univac Quality and Reliability was working closely with the suppliers and, in the case of Westinghouse, had persons in residence every week. I was working with Robert D. Nelson on the program and we worked with David A. Oines in the central component engineering group to diagnose and fix these reliability issues. Bob and I spent alternate weeks at Westinghouse in late 1965 to early 1966 monitoring their progress. The following is a transcript of a log book kept by Larry Bolton during this time.

Abbreviations you may see in this transcript:

AF - Air Force

Al - Aluminum

Anal. - Analyzed

Ckts - Circuits

Cps - Cycles per second (the term "Hertz" had not been adopted yet)

DTL - Diode-Transistor Logic: Logic inputs were via diodes as opposed to the logic inputs being via multiple emitters of transistors as was done in the next generation of logic elements (TTL Transistor-Transistor Logic).

ECN - Engineering Change Notice

Exp - Experiment

F.A. or FA - Failure Analysis

Insp - Inspection

Mfg - Manufacturing

P.O. - Purchase Order

Pcs - Pieces

Pkg or pkgs - package or packages

pn or P/N - Part number

Purch - Purchasing

Q&R - Quality and Reliability

QA - Quality Assurance

QC - Quality Control

RTI - Request To Inspect

RTV'd - Returned To Vendor

Vis. - Visual

W - Westinghouse

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Mission #1, 11/16/65

Talked to Bud Trapp about plague (Editors note: *purple plague is a brittle combination of gold and aluminum which forms when the two are in contact at high temperatures. It is not a good thing.*). He thinks that if bond won't push off then it is well connected to aluminum. But Bob (Nelson) feels that a plague ring may exist, causing intermittency. Bud says a week spot would let the Al peel off.

Pre Oct. 23 lidded procedure

- x-ray
- shock
- x-ray
- inspect
- mark package
- remove questionable items ← Q&R does
- prepare report
- ship

Get Mark's AF QC manual for MaCrahan

Saw capacitance test. Looks like there is a potential, still problems.

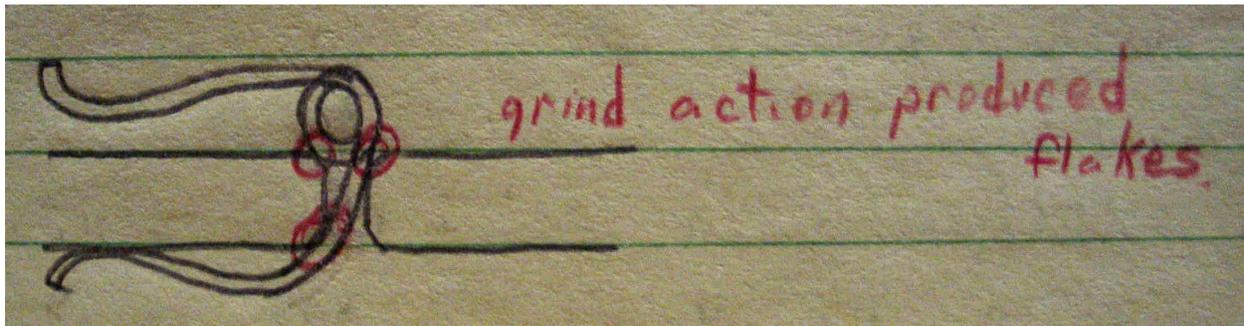
Left 8 units face up in lid box for 1 hr. One had a potential 113 failure (editor: *SB113 was our quality assurance document for semiconductor suppliers*). Particle unidentified.

Watched a cleaning step. Had dirty cloth. Clean all in morning. Bottom only at noon. Just put on new gloves this morning. May be graphite on sleeves.

Spangenberg thinks graphite boats are used on late shifts. Will check on this.

Checked 7 units 617's BLT-85 chip good (one epi-spike), package good. Almost put back in BLT-87 lot. Were exposed for 1.5 min after blow off.

Checked boats for source of metal particles. Found several large flakes which were loosened by forceps. I moved the springs on the fashion used to mount chips on boats. This caused a few pieces of metal to fall on a piece of paper below. Size ranged from 1 very large piece to infinitesimal pieces. Microscopic examination of the boats showed several large flakes ready to fall off.



Boat construction was rather haphazard.

11/17/65

Lidders were turning over circuits one at a time as Bob wished. It is slower. Springs are rotated a minimal distance.

- 9:10 Lid BLT-87 617's
- Die mount BLT-89 617's
- Bonding BLT-85 617's
- Furnaces at 540°C & 475°C

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Inspected two rejects. One had an SB113 particle, other must have been minor as I found no flaw in either chip or package.

They began pulling bad x-ray units this morning. It is being done right and removing F (editor: *fixed*) & M (editor: *moveable*) marked boxes. Trapp still has to re-x-ray those that had been negatives.

Examined plague samples. No plague. Package OK.

Status of exp #5? X-rays yet

Lot 24 of 312's, 25 of 324's, & 27 of 315's are ready to ship. 324's must be vibrated first.

Audit of x-ray

x-rays 0056, 0063, 0055 of above lots

x-ray 0056 box 2 row 1 no. 14 circuit not anal.

Looked over the hard-coated boats w/microscope. These are better than regular Al. Little flaking. Time in usage may have some effect, however, as hard-coated boats have not been used as long.

Looked at cloth used to clean lid box. Cloth blackened by a film. Also found several particles. Many appeared to be metallic flakes similar to those on old Al boats. Also a couple shiny slivers like come from solder pre-forms. Also dark unidentified particles.

Found a lidding fixture which is used in A mod that is used in B mod at night. A mod uses graphite boats & it's possible the fixture contaminates things.

Brief time study of two bonders on 617's one about 45 sec/cycle, other 42 sec/cycle.

Analyzed x-rays. Sure is hard to spot the failures as well as why some are good. I think it will be hard for us to check on these. Girl had missed analyzing one part.

Did not get chance to audit today.

In furnace H₂ is lidding gas. N₂ is curtain gas to keep H₂ from escaping.

Parts are at temp from 2 1/4 to 2 1/2 min. Jerry thought spec said 2 min & he started an ECN but this had been changed to 3 min since August.

11/18/65

Lidders are using wide forceps to align lids.

WS-280 lot BLT-89 are in die mount, bond, & vis insp

Checked plague samples from 11am & 3:30pm 11/17/65, All OK

Corrective action is being taken on missing x-ray part.

Exp. #2 & 5 are both awaiting the second x-ray.

Time study on 617 bonding time - 40 sec/cycle

Laid a piece of paper in open for 1 hr. There were about 5 particles, size of bond wire diameter.

1:30 one unit emerged with lid & spring popped off. Spring probably had side tension & moved either when boat hit belt or when solder melted. 1 corner of lid had solder on it. Girl said this happens every once in a while.

They clean lid box first in morning, before lunch, & after work in afternoon.

Lot BLT-85 to environmental.

Line will be on maybe Fri, Sat, & Sun after T.G. (editor: *Thanksgiving*)

8 units BLT-89 rejects 617's for 1 hr exposed in lid box. No particles.

Sampled 7 units BLT-89 617s. Chip OK, case OK.

Plague test 10am & 1:30pm 11/18 OK

Larry Pollock submitted a test plan for 317 & 324 ckts in vibration to Bob Nelson over phone. They would like to know quickly so they can build experiment.

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Hood over die mount has 1/2" thick wooly mat for filter.

11/19/65

9:00 am BLT-87 617's lidded

BLT-89 617's at die mount, bonding, & lidding, vis insp & lead pull

Watched girls re-examining an x-ray lot (0056). She still has a difficult job as she was not correlating too well. (I looked at these & couldn't correlate too well either). It would be well for us to review these.

Talk w/ Shapiro

Ceramic boats 2 \$5 each

Mfg has ordered hard-coat boats. Custom has 50 on the way.

Mfg looses 5% due to 9018 particles (shorts)

Don't plan to do much more UNIVAC because they can't ship it out.

Are looking into new lidded where there is a heat column where heat is pulsed to eutectic point.

Lid is placed in form first, then solder, then circuit upside down all time. Chip never exposed face up.

Narrower solder pre-forms - first quote \$1,500 for die.

Furnace at 538 & 479°C

Lidders turning over two at a time again.

Girls get T'd off a lot.

Meeting w/ Hamill, Husher, & March

Asked for copies of RTIs but they are not in good enough form to be copied

RTIs are not formal and no direct effect may be measurable

Hamill did not get x-ray status as I had requested. Claimed he did not have time. (I asked for it Wed.)

Follow up

On RTIs, W will want to discontinue use of these someday. We want to know how they can show to us & themselves the effectiveness or ineffectiveness of a particular step.

(editor: *The following is a list, as listed in the notebook, of Westinghouse persons involved with these issues*)

Bill (W. A.) Mac Crehan

Al (A. T.) Hamill

Bob (R. J.) March

Harry (H. S. Jr) Bridges

Gerry (G. B.) Shapiro

Vic (V. K.) Mitrison

Jim (J. O.) Moore

John (J. D.) Husher

Pat (P. T.) Clay

Bud (O. D.) Trapp (editor: *Dr. O. D. "Bud"*)

Trapp became well known in the IEEE and industry for reliability analysis methods. He

also was involved in starting other reliability analysis and consulting

companies such as Technology Associates after his stint with Westinghouse)

Ed (E. A.) Spangenberg

Larry (L. J.) Pollock

Mission #2 Action Items

1) Photo w/ short in glass (bond to base) 250Ω - Occurred after being in operation. Rhode (editor: *Bob Rhode of Univac Failure Analysis Lab*) overlapped & got portions this missing the short point.

2) Part & photo showing large particle.

3) Deleted (not work related)

4) Old particle count was 161 part, 4 mil size down. Now is 21 part, all less than 5 microns. Where did old figure come from & if they knew it was this bad why didn't they do something about it.

5) Plots of Glenn's down to -55°C to LP. Also Glenn's limits, 320s will be redone. We have in house problem.

6) Get lot QA reports (get copy) of 617's shipped through 11/30/65. Life test. Account for 2500 pcs slipped and lots they came from (Can't be any BLT 85, 87, 89). We see 2000. Where are parts now?

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- 7) Get He rejects that have been x-rayed & analyzed.
- 8) Completely audit x-rays.
- 9) Inspect samples.
- 10) X-ray lot status
- 11) Vic Matricino (w/ Shapiro, Pollock, etc) about Q&R lots & shipments
- 12) Investigate particle count method.
- 13) He rejects

Mission #2 11/30/65

Using only hard-coat boats to lid units.
No Univac on line.

Husher & Shapiro say particle count on 11/27 was 21 part. 5-10 microns.

Quote on bonder covers is \$5000 each. Claim if B mod gets covers then all bonders will need covers or total investment of \$30,000. They do not feel this is justified.

Cleaning lid boxes twice a day.

Still pieces of pre-form on bottom of lid box.

Problems with x-rays

Shifting of package may make F (editor: *fixed*) look like M (editor: *moveable*)

Some spots are gold embedded in lid.

Have lidded 617's, 324's, 326's

Sampled 60 of each of 4 lots, no moveable, a few fixed (not ident.)

Vibration 1 failure in 1 lot (324's)

Will have shipped 3,557 617's (hopefully by the end of today)

They pulled sample and rushed through QA.

<u>Old Lot</u>		<u>New Lot</u>		
23	266	29	1100	547 date code
			<u>1300</u>	548
25	~110?		Combined into one	
			QC lot	
26	125			
27	<u>766</u>			
		3667		

Don Cannon working w/ Trapp on FA of x-rays

Spangenberg took count (secretly) during week Bob was here.

Our x-ray resolves 2 millimeter, W resolves 4 millimeter. Because of this problem, W has a new x-ray machine coming which will resolve 0.2 millimeter.

Particle count:

Paper sits for 4 hours. Place under microscope. Has marked and measured grid to show size of particle. If so many particles in a square then know how many on sheet.

A mod wouldn't sign ECN to use hard-coat aluminum boats but I guess now they will.

Problems in x-ray analysis mostly from stuff on outside of package (1 gold string look like pigtail & changing angle of photo made it look like it was moveable). Different angle may be due to radial emission of x-rays or shift of package due to shock. Have found ball bonds, pigtails, and gold flakes.

Phone call

O & R 27 480 before x-ray 315's pulled 40 11 M 29 F

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Shipments on 4 P.O.s
8 pcs 601734 36-05188 no x-rays
box 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13 ← 315 pcs 543 cannot identify
24320 1 pc 36-05187 no ident. 542 dc
box 15 row 3 pos 2 0063 this one missing last order pulled was for 1
did not pull every unit data said bad
box 11 2 in row 3 & 2 in row 4 should have been pulled.
3 were pulled, other had a funny mark like 7
Conditional lot lot fail in life test sep package of 3 failures & all data but did not receive
Parts did move

Give same as in last lot, sep package & data & formally ask through purch.

MaCrehan thinks \$30,000 is not too much for bonder covers if they do the job.

12/1/65

Status of Exp 2 & 5
Circuits moving in boxes problem
Conditional lot problem on lot sent.

Furnace 500°C & 480°C
Begin die mount lot 3C24-41A 311's

Got three new covers for die mount stations.

Al Hamill not in today

There is in typing a food sized summary of tests, results, observations, & shipments of things pertaining to the pre & post Oct. 23 operations.

The crews were up very late last night. Husher is still here from yesterday.

For shipping against P.O.s they were going to pull but label which box, row, and number they were. For speed they decided not to separate orders & just said here are the boxes & here are the P.O.s to be filled by them.

B Mod.	Particle count	part/ft ³		Assembly	From 8/13
10/29	OA 97	Evapo 123	260	82	← previous low
11/12	166	230	157	136	
11/26	122	46	113	21	← new low

A mod

Also mounted 104 313's lot 2D22-13

Shipped out lots of stuff last night

Phone call

309	lot 11	
616	5	
617	26, 23	
314	19	all erased numbers

If you get letter that can assure us that these were x-rayed and analyzed then maybe we can accept the lots.

Would like lot, box, row, numbers

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March Joe Savage
Find out & list of ckts shipped
June 1 '64 → Sept '64
Ckt type, lot, qty, date shipped

Particle count method

Drop box: Disc on bottom for 4 hrs., count particles in designated squares thus resulting in X particles on paper
Area: Vacuum air through filter for 28 min at 3-4 feet above floor. Count particles above 5 microns size on filter.

Shapiro: In lid box they have designated no goal. They would like zero. They plan to read 1 a week. After they find where the values sit, then they will write a spec.

At 3:30 311's in bonding & die mount.

Began installation of die mount dust covers.

12/2/65

Informed Hamill of erased boxes & reminded him of lot failure mentioned in two previous phone calls.

9:30 Die mounting lot 3C24-41A 311's and bonding

Die mount hoods sit over cracks in table which will be covered with tape

Lot 27 of 315's is not a conditional lot as I saw data summaries.

The problem lots have been: (lots unknown)

- 310 - mech shock
- 317 - Herm fail
- 617 - oper life 3 pcs
- 617 - oper life 2 pcs (1 good @ 168 & 96)
- 617 - oper life (discovered late Tues night)

Still looking for shipments between 6/1/64 → 9/30/64

RTI questions to Husher.

Shapiro: Decision whether or not to use a step will be determined by the % yield of the device. If step produces no change in yield, then it probably is not necessary. Our spec determines inspection quality.

Lot audit 10 pcs 2D22-13 WS-271

- #1 OK
- 2 OK
- 3 OK
- 4 OK
- 5 OK
- 6 OK

Reject 7 no evidence of double stitch

8 passivation flaw?

9 irregular discolored shape in passivation, smeared stitch

Reject 10 looks like redid stitch bond, particle, ball on xtra input short interconnect

Going to hire another inspector & 3 other new girls

Al is writing letter confirming x-ray & pulling of confused lots. Letter does not explicitly mention the boxes of 8 & 1 but covers the lots they came from. To D. A. Oines, cc to Bergman.

Talked to Husher and am having the lot I inspected held till tomorrow

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Talked to Mr. Bob Bain who is a W rep to Autonetics. He reported corrosion problems related to leakage when ckt boards were cleaned with alcohol. Residue inside caused corrosion when unit was in operation for about 100 hours. Units were from mid & end '64. Liquid crept in along package lead.

Die mount 3C29-15 of WS-270
Bond 3C29-15 & 3C24-41A 311's
Insp. 2D22-13 WS-271

12/3/65

Jerry Shapiro concerned that he has to re-inspect that part of lot inspected before I found particle. He reports that girl washed the particle off. She must have done this later as she couldn't get it off while I was there. Jerry wants to lid today because if he can't lid our stuff then he doesn't lid anything today. He is supposed to lid 30,000 units this month.

Jerry will inspect 50 or 60 samples. If he finds no particles he will lid. If finds one reject he will re-inspect.

Re-inspected 16 of 60 that Jerry inspected. All OK. He found all OK. I give permission to lid lot.

10:00am die mount (2 stations) 3C29-15 270's
bond 3 stations 3C29-15 270's
vis insp 3C24-41A 208's
lid 2D22-13 271's

3C29-15 1332 dies
3C24-41A 1314 dies
2D22-13 924 dies

Jerry is to order a vacuum cleaning system for B mod. A mod has just installed one. Cost \$1500.

10 samples 2D22-13 WS.271's
1 OK pits in interconnects, some → 50% W (ed: width)
2 OK small multicolor spots on passivation
3 OK
4 OK 1 bond single stitch
5 OK
6 OK
7 OK
8 OK
9 OK
10 OK

Lidding box seems to be quite a bit cleaner than when I first came. Very few bits of pre-form, etc. lying around. Sometimes she lids one at a time (when I watch)

Phone call

Got lots w/ good parts missing
Getting test samples not x-ray 310 lot 324 lot
316's shipped date code & Q&R lot
Want everything w/ date code 435
What is fallout in 260 width

Answers

310 lot - samples originally messed up in shock and did over. Parts gone w/ number circled are parts in the second QA sample & therefore were not re-xrayed. The 324 samples were not x-rayed & should not have been shipped if they were shipped.

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A cutting of over 260 mil package would cause a loss in 60% per Univac rejection rates. It used to be 35%. To meet spec would require entirely new package at time of 12 mos & 8000 dollars therefore please to change spec.

No further work has been done on experiments 2 & 5.

Mission #3 Actions

1. Forms for questions?
2. List of manufacturing change effective by date code
3. 326 part fail pictures or others
4. Data on verif testing (who has data) Pat Clay
5. For any failure they need approval by Univac.
6. Look at data. Should be orderly & in control. Tell if things not neat then need extend period.
7. X-ray lot nos, procedures (who pulls & how) etc.
8. Failure should have been analyzed, good conclusions. Report should explain itself.
9. Should be able to get (report by part and week for lot and qty). Samples and what did they show.
10. 40G 60 cps or 20G sweep down to 20 can't do 40
11. Shipments of 430→435

Mission #3 12/9/65

Hamill: Pat Clay has all data on verification testing. March pulls samples. All data here is same as was sent with shipment. Any conclusions or summaries are either with data or are contained in Hamill's letter of 12/1/65. Hamill will supply list of all product lidded after 10/23. The agreement specifies 40G at 60 cps. Now a sweep is used & cannot achieve 40G at 20 cps therefore 20G is used. Hamill will try to extend list.

Lot 2D22-14 waiting for Q&R samples

In process

	<u>W</u>	<u>U</u>	lot	quant
	WS-136	328's	328-37	
	208 & 269	311, 310	3C24-40	1088 die
	132	317	DD-69	385
	272	314	2D22-16	
Wafer test	272	314	2D21-5	900 waf
Wafer test	269	310	3C24-43	
Await QA	208	311 DC 550	3C24-41A	954

All wafer test area is gone to allow expansion of assembly.

Teflon tape is being used on holders for vis insp and also to cover a lidding fixture base for 1/4 x 1/8 packages.

Data examination

324 lot 26 DC547 666 lidded 551 shipped
436 ckts 24 x-ray rejects

*324 lot 26 2C72-4 DC 547 666 lidded 551 lidded
60 ckts 1 vibration reject failed therefore 100%
x-ray 0095
must use Hammill's letter to explain reject
lot never was rejected

*326 lot 21 2C74-4 DC 547 595 lidded
60 ckts 2 x-ray rejects (type not identified) How can have rejects when not shocked yet?
x-ray 0096 after vibration units were re-x-rayed and 3 (2+1) rejects were found (type not identified)

617 lot 29 BLT 85, 89 DC 547 1778 lidded
no failures of any kind
x-ray 0097

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*617 lot 29 BLT 87 DC 548 1539 lidded

2 units opened - no mention on data sheet that these were inspected moveables. Must use Hamill's letter to see this.
x-ray 0101

*None of these lots were given group A test after vibration as far as I can tell

QC release to Univac Qual Lot Locker

Vibration test:

Now: constant 20G 22 cps to 2000 cps

Can be: constant 40G 40 cps to 2000 cps or constant 1" displacement 5 cps to 40 cps

Vibration testing is done one at a time at a rate of about 45/hr.

Lot DD-69 WS-132 U-317s

Chip very good 8 samples

Package 1 very bad gold thread rising from bottom to within 1/2 mil of pin.

Almost short. Reinspect the lot.

Larry Pollock:

1.) Doesn't want to go below 20 cps. He would rather spend the extra time in the 20→100 cps range.

2.) Wants letter from DAO or RDN giving and supporting reasons why they believe particles follow field theory. I told him Hamill has pictures. He still wants "proof".

12/10/65

Meet with Bridges, Mitrison, Pat Clay, Bud Trapp, Mac Crehan, March. Phone to Hamill. We hashed through the clarification of material sent to Univac with shipments. Namely, Q&R report summary, x-ray trip ticket, x-rays, x-ray summary sheet, F. A. reports, etc. We would like these a little more clear. Bridges, Mitrison, and Hamill will write summary explaining a little better what happened to 617 lot 29, 326 lot 21, and 324 lot 26.

Also Husher would like our interpretation of attachment VI. On page VI-1 they pull 30 He rejects and x-ray. 15 of these are put through sequence on bottom of VI-1. Sequence on page VI-2 is separate and is done on 60 good samples. No group A tests are done. Say Oines said not necessary & if anything end of group C should be done. For bottom page VI-1, they pull 30 x-ray, shock, x-ray. Pull 15 which look like might have particles and vibrate, x-ray, electrical test, delid.

Phone call

- 1.) Field theory note
- 2.) Inspection yesterday
- 3.) Vib one at a time
- 4.) Interp of VI

5. Do need P.O. slip
6. Can't see Hamill on vibration
7. Meeting
8. Jim Moore

326 21 - X

Bring back 10 more fixtures & packages

Duplicates machine motion, occurring at high freq operation. Prove that D. C. results give same results at pulse. Hamill's letter not enough (worthless). Prove that high freq pulse is now better.

We expect a report & review on RTIs or status.

Mission #4

12/27

Hamill thought he wrote letter explaining the life test rejects & the extra 96 hrs in test.

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Master Spec MS-S003

Daily moisture readings in dry box 35 ppm max post readings near box
Vacuum clean dry box once a week
Plague test 2 times a day - pull bonds

WS 562 - Parts in development for Univac Blue Bell

Moisture meter is broken, therefore no readings are taken. Cannot use regular vacuum cleaner to clean as it raises too much dust. This may have to be deleted from the spec.

Letter about lot 25 617's should include

1. Data w/ brief summary
2. F. A. report of failed unit
3. Reasons why bake is as good as burn-in
4. Relation between failure & other measurement changes

No Univac material in production today - No units lidded at all today.

12/30

Saw x-ray of vibration failure. Particle is stuck on one of the chips as suspected. It is noted that there is a lot of chip area to make contact on the 4 chips.

Several times this week I have heard W people talking about flaking gold problems in 1/4 x 1/4 packages. Lacked time to ask about the effect on Univac product & what action is being taken. Inspected new report on re-inspected units which are to be shipped. Units were previous rejects. Al, Harry, & I only made a couple minor changes. Read to Bob over phone.

Read Al's letter on the three lots which the reports were mixed up on. The results are much clearer. Results agree with those I found almost exactly. Differences were errors I got in oral information. Only difficulty is that W people cannot add & there are a couple differences in the total number of units affected at various steps.

No product lidded today. No Univac stuff moving.

W has installed new x-ray machine, could be 2 weeks before operable. Has higher resolution.

Failure analysis of vibration failure.

The unit with leads clipped is glued to a metal core which can be placed inside a thick metal sleeve to keep the grinding plane parallel to the package plane. Grinding is done till the lid becomes thin enough to tell where the lid is fastened to the package. An Xacto knife is used to cut the lid along the inner rim, then the lid is lifted free. This method seemed to produce several small particles of lit metal in the package. We found a clump of gold about the size of a ball bond shorting tow interconnects. One relatively flatter side seemed to be silvery colored indicating it may have been attached to the base or solder at one time. Three colored pictures were taken. The particle was then dislodged and visually examined again. We found a spot in the base where the gold had been scraped rather deeply to help make a better bond to the base. It is possible the gold clumped up when scraped & broke loose when shaken. No further photos were taken during the time I was observing. The new design of the 328 circuit which I was told was about to be completed in the next few months would eliminate multiple chips, gold-kovar plated ceramic bases, and eliminate need to scrape off a base bond.

This failure should show that the sprays & blow off used after bonding or even visual inspection is still not 100% positive.

Mission #5 Actions

1. Can remove p/n & change and can paint edge or surface (preferably) short lead edge) to identify burned-in parts
2. 500 1/4 x 1/4 14 lead pkgs
3. Q&R audit copies since 1/21
4. Q&R summary report of audit since 1/30
5. Answer to RDN letter
6. # Packages into B mod

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7. ckt types lidded daily
8. What other studies by W to insure clean product.
9. What doing to resolve R&D problems.
10. Dice availability form submitted to Univac purch. on Wed.
11. Check dice inventory
12. Audit
13. Get 5 lidded/day elect. Rejects

Mission #5 2/15/66

Asked HB for #16, #2, #4 & info on color coded pkgs
Reported from unknown person (w/beard) that Univac 1000 & 1001 have top priority

#4 HB also stated that letter in re to RDN letter of 1/31 was completed & probably had been sent. Claimed Bert had copy.

Particle counts

	<u>12/23</u>	<u>1/7</u>	<u>1/21</u>	<u>2/4</u>
OA	195	530	100	235
Evap.	105	175	125	982
Assy.	133	135	92	200

No corrective action taken, only warning

600 Max limit

Day they replaced tube in diffusion furnace. Only action was not to do this while other product in process.

Lead trim moved from assembly area

Item #11 Larry Pollock says he showed rough draft to RDN. Actual letter should have been sent last week through Howard Bridges in St. Paul (He seemed reluctant to talk to me any further on the steps presented or status)

#1 See Bridges for copies. ES said Bert (another Univac component engineer on the project) went over what he had. Bridges in rush to leave tonight & won't have time for my problems till Thursday. He recommended going through marketing on most questions.

#2 Can't get packages today. Should have by end of the week.

#3 Will get on Thurs.

#4 (back 1 page)

#5 -----

#6 ----- Can't find cap to get me on line to look

#9 -----

#11 (back 1 page)

#13 -----

#14 -----

#16 asked HB. Hope to have by end of week. Wondered why we don't have info.

#17 "Will try" Opened 15 the other day & had no problems opening these the other day.

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(editor: *the following is a brief outline of the process flow Westinghouse used*)

Wafer

Elect. Test & marked

Scribe

Dice Breakup & separate Package

Vis. Insp

Cabinet 1

Ckt packed in plastic bag (beaker TCE & alcohol boil & spray

Heat column

Die mount

TCE spray & clean

Cabinet 2

Heat column

Wire Bond

Cabinet 3

Tail pull tails - on to table & floor

Cabinet 4

Low pow. Insp. ↓→ Rejects

Cabinet 5

High pow. Insp. ↓→ Rejects

Cabinet 5

Audit

8 hr. bake

lid box ← lid & preform clean

lidding & furnace

storage cabinet & beaker

Package environmental

Numbering & lettering

Trim leads

Electrical test

Open units rejected

Sample at Univac QA

HB & Rudisel stated that P/N can be removed & can be color coded. Details would have to be worked out later.

2/14/66 425

#2 Have 400+ pkgs to deliver

Lidded 28 pcs 313 today

They had problems on 2/14 in that 50% of material on a 2 chip package was being rejected. Production was halted.

3 of 5 bonders are certified for Univac ckts

For packing shipping boxes girls are called from anywhere, evaporation & assembly areas.

Bonders also called to die mount.

Very much Univac on line today

2/16/66

G. S. came to me & reported can't get any Univac stuff through pre cap. Is due to fixed particles thought to be from plastic bag used to hold pkgs before boil. Boil doesn't remove them & heat column adheres them. Now will put pkgs into a pyrex beaker & cover with Al foil.

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Die sort	134	3C01-1	2349
	WS270	3C29-24	609
	272	2D21-8	456
	272	2D22-4	222
	271	2D21-16	221
	208 & 269	3C24-40	1088
Wafer test	271	2D21-13	860
	282G & 282Q	4C38-2	350
	271	2D22-22	713
Vis. Insp	280	BLT-113	874
	285	3C24-46	75
	280	BLT-114	1046
	135	2C74-5	370
	272	2D21-10	274
	272	2D22-18	709
Wafer test	271	2D21-2	293
	279Q	BLT-110	250→300

Are identifying individual trays
 Audit every tray
 2 rejects on tray rejects (the) lot
 Sample is pulled from a wafer, assembled & tested for lot qualification

51 328's 12/31 RTV'd by Univac
 Watch for results
 Rejects - 1 appeared to be glass run out on header. This is not rejectable.

~~Univac stuff is audited 100% tray 100% parts. A reject above AQL rejects whole lot. Then is 100% reinspected. Ho!
 Ho! (This would make 300% inspection. 200% is wild enough)~~
 No lidded today. Only a few package test samples.

No audit today.

WS 311		WS 280		WS 208	
G.	B.	G.	B.	G.	B.
43	7	30	11	8	1
36	13	29	12	35	12
42	7	30	13	44	5
15	8	36	7	47	0
29	23	29	11		
40	11	37	8		
45	7	40	5	WS 134	
48	2	42	3	16	14
46	5	44	1	30	2
48	3	42	3		
48	3	44	0		
49	3	42	0		
49	1	41	2	WS 132	
48	1	40	3	30	0
23	0	29	11		
51	0				
52	0				
42	12				
16	8				

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Epilog: Thus ended my trips to Westinghouse. As I recall, Westinghouse was becoming more difficult to work with and it required persons of higher rank to intervene. The comments in this notebook reflect the state of the art in integrated circuit manufacturing in the mid 1960's. Univac/Sperry/Unisys continued to work similar issues with almost all major semiconductor manufacturers into the 1980s. I believe we made a major contribution in getting manufacturers to understand the importance of quality and reliability in their products. These efforts lead to better yields and lower costs for all. As we know today, you cannot make the latest technology circuits with dirty fabrication and assembly areas and without attention to detail. The sizes of particles we were concerned with in the 1960s were mountains compared to the size of particles that can cause problems today.

The following table summarizes the Univac part number, Westinghouse part number, function, and package that were being processed at this time.

Univac P/N	Westinghouse P/N	Function	Package
7900309	WS 268	DTL And-Or Gate	10-pin flat pack
" 310	" 269	DTL 3-3 Gate	10-pin flat pack
" 311	" 208	DTL 3-3 Gate (high fanout)	10-pin flat pack
" 312	" 270	DTL And-Or Gate	10-pin flat pack
" 313	" 271	DTL 2-2 Gate w/Inverter	10-pin flat pack
" 314	" 272	DTL And-Or Gate	10-pin flat pack
" 315	" 130	Dual Matching Circuit	10-pin flat pack
" 316	" 131	D-A Switch	10-pin flat pack
" 317	" 132	DTL Dual Diverter Driver	10-pin flat pack
" 319	" 804	Sense Amplifier (Matched set of four)	10-pin flat pack
" 320	" 803	Sense Amplifier Gate	10-pin flat pack
" 324	" 133	Destructive ReadOut Memory Bit Driver	10-pin flat pack
" 325	" 134	Diverter Gate	10-pin flat pack
" 326	" 135	Dual High Current Darlington	10-pin flat pack
" 328	" 136	Four transistor hybrid	10-pin flat pack
" 570	" 281	DTL 3-3 Gate	10-pin flat pack
" 616	" 279	DTL 2-4 Gate	10-pin flat pack
" 617	" 280	DTL 3-3 Gate	10-pin flat pack
7901000	In process	DTL 4-4 Gate	14-pin flat pack
7901001	In process	DTL 2-2-2-2 Gate	14-pin flat pack

The 10 and 14 pin flat packs had 1/4 inch by 1/4 inch by 0.100 inch thick bodies. They were hermetically sealed kovar and glass with a hollow interior. Flat kovar leads (pins) extended through the glass walls on opposite edges of the package. All kovar was gold plated.

Because of the problems we had with Westinghouse, I don't think our relationship with them continued for very long. The Univac 7901000 and 7901001 circuits were not significantly supplied by them. Suppliers such as Texas Instruments, Motorola, Signetics, and National became our major suppliers.

Notes: The Westinghouse plant was just off the main highway near Laurel, MD, midway between Baltimore and Washington, DC. We flew in to Baltimore via Chicago. We stayed at either the Colony Seven motel in Laurel, MD or Holiday Inn West or South in Baltimore. Motel rates were about \$9 per night. Travel expenses, excluding labor hours, were about \$200 for the week, including motel, car, and meals. We had a desk in the plant at the end of a dead end hallway but there was a window overlooking the highway.