MEMORY ASSEMBLY TO
HYBRID MICROCIRCUITS

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MEMORY ASSEMBLY TO HYBRID MICROCIRCUITS

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A process is described which will allow Bendix to do all the assembly work on memory modules rather than ship HMCs to the memory plane supplier for assembly. The process relies heavily on programmed soldering machine instructions. Memory planes are bonded to HMCs with epoxy sheet adhesive and a technique is discussed for applying a thin polyurethane coating to solder joints. A method of testing the memory plane on existing equipment and a cause-of-failure test matrix are also presented.

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CONTENTS

Section	Page
SUMMARY	4
DISCUSSION.	5
SCOPE AND PURPOSE	5
PRIOR WORK.	5
ACTIVITY.	6
<u>Bonding</u>	6
<u>Soldering</u>	6
<u>Manufacturing Process</u>	8
<u>Rework.</u>	9
<u>Memory Plane Problems</u>	11
ACCOMPLISHMENTS	13
FUTURE WORK	14
REFERENCES.	15
DISTRIBUTION.	16

ILLUSTRATIONS

Figure	Page
1 Bonded Memory Module.	7
2 Machine Soldering Technique	8
3 Cause of Failure Matrix	10

SUMMARY

A memory module consists of a wired array of ferrite cores bonded and soldered to a hybrid microcircuit (HMC). The Bendix-manufactured HMC is shipped to the memory plane supplier, where it is attached to the memory plane and returned to Bendix. By developing suitable manufacturing processes at Bendix, the need to ship the HMC to the memory supplier can be eliminated and material control problems can be simplified.

A process is described that will allow Bendix to do all memory assembly work except stringing the core array.

- A controlled process that relies more on programmed soldering machine instructions and less on operator variables was developed to produce repeatable solder joints. A key to this process was producing well-tinned magnet wires prior to making the solder joint.
- A process was developed to bond memory planes to HMCs with an epoxy sheet adhesive.
- A thin polyurethane coating can be selectively applied to solder joints with a very fine 5/0 artist's brush. The work must be done under a microscope.
- A method of testing the memory plane on existing equipment and a cause-of-failure test matrix for the completed module were developed.

Restringing defective memory planes at Bendix is feasible, but additional development will be required. The reliability of machine soldered joints should be determined by subjecting properly soldered memory modules to an extensive thermal cycling evaluation.

DISCUSSION

SCOPE AND PURPOSE

Memory Module XA201B is supplied by Electronic Memories, Hawthorne, California. The memory plane consists of an array of ferrite cores strung with 26 turns of magnet wire. Bendix supplies Electronic Memories (EM) with a hybrid microcircuit (HMC) to which EM bonds and solders the memory plane.

Both the stringing and the soldering operations require highly-trained, dextrous operators to perform the delicate hand operations. Frequent scheduling and logistics problems prompted EM to request Bendix to develop an in-house soldering capability. This project had a two-fold purpose:

- To develop an efficient, repeatable soldering method to connect the memory plane to the HMC, and
- To eliminate the need to ship an HMC to Electronic Memories.

A complete manufacturing process for attaching the memory plane to the HMC includes development and evaluation of these four things:

- An ability to test memory planes on an inspection tester,
- A method to bond memory planes to HMCs,
- An ability to analyze product failures, and
- A method to rework strung arrays as necessary.

PRIOR WORK

Experimental work done in March 1973 showed that adaptation of reflow soldering methods on flat-pack integrated circuits might be feasible on the memory module. Prior experience in handling magnet wire¹ was used to reduce the number of soldering options required to obtain a satisfactory memory soldering process. Prior experience with testing memories on the QA1001 was used to develop a cause-of-failure test matrix.

The QA1001 is adapted to test Memory Module XA201B when mounted in a special molded carrier. Electronic Memories mounts the memory plane on a printed circuit card which has a standard edge-mounted printed connector. The test board contains discrete resistors and diodes electrically similar to the thin-film resistors and beam-lead diodes on the XA201C HMC. A test adapter was built to allow the memory-plane-on-a-card to be tested on the QA1001.

All lead lengths were kept short to minimize inductance and resistance in critical circuits. The critical noise voltages were even less than those observed during normal testing on the QA1001. All test memories performed properly on the QA1001. Since a feasible test approach was now available, development of the proposed manufacturing process was continued.

ACTIVITY

Bonding

Memory planes obtained from Electronic Memories were bonded to HMC XA201C. Ablefilm 517 0.009 inch (0.23 mm) thick and Ablefilm 532 0.003 inch (0.08 mm) thick were evaluated. The 0.009 inch (0.23 mm) thickness was excessive. The adhesive flow was uncontrolled and covered the thin film resistors. The 0.003 inch (0.08 mm) thickness was much better and easily produced a controlled bond.

Care in placing the adhesive on the substrate was required to prevent covering the thin film resistors. Preheating the substrate with the adhesive in place caused the adhesive to become tacky and retain its position while the memory plane was positioned and clamped in place for the adhesive cure. A pressure of 20 psi (137.9 kPa) was applied and the adhesive was cured for 5 hours at 100°C. A sketch of the assembled memory is shown in Figure 1.

Soldering

Hand soldering methods have traditionally been used to solder small magnet wires. Soldering AWG 42 wire to a thin gold film on ceramic has proven to be difficult and to require extensive operator training. The operator must have exceptional dexterity in handling small parts. At best, the hand process is slow.

An effort was made to minimize operator variables as much as practical. A Browne SR-3 soldering station was selected because of the heat and timing controls available. In addition, a sonic scrubbing action advertised to eliminate the need for removal of heat-strippable insulation was used.

Soldering action on the Browne SR-3 is obtained by using a probe made from 0.020- or 0.030-inch-diameter (0.51 or 0.76 mm) resistance wire to lightly press the wire to be soldered against the solder pad on the substrate (Figure 2). At the appropriate time, the operator applies a controlled current pulse through the probe, causing solder to melt around the wire and solder pad. A variable amplitude sonic vibration can be applied to the probe to cause molten solder to "scrub" heat meltable insulation from the magnet wire.

Moderate success was obtained with the sonic action when using Ag 1.5 solder. Poor results were obtained with 50/50 Pb/In,

Figure 1. Bonded Memory Module

Sn62, and Sn63 solders. Joint consistency and visual appearance of the Ag 1.5 joints were not as good as desired and the process time was considered excessive. The sonic method was abandoned and a more controllable, more efficient process was pursued.

The next process attempted was a re-flow method similar to that used for flatpack soldering. Complete tinning of the magnet wire was a prerequisite to satisfactory joints. All wires on a side of the memory plane were tinned together in a solder pot. The magnet wire was coated with nylon over polyurethane, which required a solder pot set at 370°C. Ag 1.5 solder was used to minimize copper dissolution. Two problems occurred.

Although most wires were tinned satisfactorily, heat propagated along some wires, penetrated into the memory plane, and caused excessive melting of insulation. A reduction of the time in the molten solder sufficient to prevent excessive melting resulted in some wires not being properly stripped and tinned.

Absolute control of tinning length was not obtained. Heat-stripping the magnet wire with a controlled-temperature soldering iron was also inconsistent and inefficient.

The next process was successful. The magnet wire insulation was stripped with Iso-Verre, a chemical stripper (Material Standard 4700282). All wires on a given side were stripped simultaneously. Adequate control of strip length was obtained. After the stripper was removed, the wires were tinned in a solder pot.

Figure 2. Machine Soldering Technique

Preforms of Sn63 solder were melted onto the gold solder pads on the HMC. A mixture of rosin flux and alcohol was used to aid in controlling the amount of flux used.

The memory was then bonded to the HMC. After bonding, the tinned magnet wires were reflow-soldered to the solder pads. Satisfactory joints of production quality were consistently obtained on HMCs containing high-quality gold film. Care in positioning the probe was required to prevent damage to the memory. The probe was left in place while the solder cooled to prevent wire movement and a possible cold solder joint. The solder surface was generally frosty rather than shiny. The degree of frostiness was affected by time and temperature settings on the SR-3 and was indicative of the amount of gold dissolution in the solder.

Manufacturing Process

The recommended process to obtain satisfactory solder joints in the least amount of time is given below. Refinements to this process in areas such as tooling and training should produce significant time savings.

Memories should be received in a test fixture with leads fixed in position. Apply a small coat of RTV3140 (Material Standard 2070102) to the exit areas of the leads with a 3/0 artist's brush. This will prevent the leads from becoming mislocated during lead forming. Cure the RTV in an oven with 50 percent humidity for 2 hours at 120°F (49°C).

Remove the memories from the test fixtures and cut leads to length. Most leads should be trimmed 0.300 inch (7.62 mm) from the memory. Three leads are left 0.400 inch (10.16 mm) in length.

Strip the insulation 0.05 inch (1.27 mm) from the end of the magnet wire by applying chemical stripper (Material Standard 4700282). Remove the stripper with a paper tissue after the insulation has loosened.

Tin the stripped portion of the leads in a 260°C solder pot with Sn60 solder.

Cut a 0.50 inch (12.7 mm) square of Ablefilm 532 (Material Standard 2181039). Wipe the substrate and memory bonding areas with a paper tissue soaked in alcohol. Place the adhesive in position and install a spring loaded clamp for constant pressure. Cure in an oven for 5 hours at 212°F (100°C).

Form and solder leads by trimming leads to exact length, melting a preform of Sn63 solder to the substrate soldering area, forming a loop in the wire and laying the tinned area of the lead over the melted preform, and reflow soldering.

Clean the assembly by washing it in alcohol.

Apply a polyurethane coating (Material Standard 5080556) to soldered areas using a 5/0 artist's brush. Magnet wires near the beam-lead diodes must be spaced away from the HMC and diodes to prevent wicking of the urethane under the diode body.

Rework

Some errors and failures will occur during the soldering or bonding process. Problems that are not obvious to the production operator will be detected on the QA1001. Because of the large number of failure possibilities, a cause-of-failure matrix was developed to assist in the trouble-shooting analysis (Figure 3). The following technique should be followed when looking for the location of a cause-of-failure.

Verify The Reject Reason.

Using Figure 3, PDXA201B, and AF-BXQA1001 for guidance, locate the broken wire, defective diode, defective core, short between

wires, interchanged wires, or wrong coil polarity. A multimeter set on 1X or 10X scale will be helpful. Use care not to damage leads when probing. When checking continuity between WS and MRead or MWrite, apply (-) to WS leads.

<u>Coil Ends</u>	<u>Normal Resistances</u>
BWO--BW10 to BW Common	195 ohms
MRead (+) to WSO--WS14(-)	8* ohms (0.6 ohm)
MWrite (+) to WSO--WS14(-)	8* ohms (0.6 ohm)
BSO--BS10 to Common	2 ohms

*Measured with Triplet Model 630-APL; includes forward diode junction resistance.

If MRead or MWrite lines are open, determine whether diode leads or wires are broken.

Put a tag with unit marked with rework instructions.

If magnet wires must be replaced, send the unit to the assembly area.

Memory Module Repair

Defective Diode. Remove diode from HMC. Solder pad of defective diode to solder pad of spare diode. If solder joints have already been covered with urethane coating, carefully remove enough coating to obtain a new solder joint. If spare diode has already been used, scrap unit.

Shorts At Solder Joints. Determine if solder is bridged between solder pads or if magnet wire is shorted to an incorrect solder pad. If not, disconnect both ends of the offending magnet wire and determine if the magnet wire is shorted to another winding.

Open Winding Or Shorts Between Windings. Send unit to assembly area for magnet wire replacement.

Memory Plane Problems

Soldering defects can be corrected rapidly by the SR-3 operator. Broken magnet wires and other problems with the memory plane are more serious. The memory plane can be returned to the memory supplier or it can be reworked at Bendix. Careful selection of a Bendix trained operator will be required if the repair is to be done successfully. Limited development work with winding repair indicated that Bendix can do this work. A recommended process is detailed below, but additional development will be required before Bendix will be qualified to do stringing rework.

Remove defect.

Open Winding. Locate fracture visually and carefully remove defective magnet wire. Use care not to damage good magnet wire. Refer to PDXA201B for wire identification.

Defective Core. Verify that all windings through the defective core have the correct number of turns. If an error is found, remove the incorrect winding and replace. If windings are correct, remove all wires that pass through the core and replace the core and windings. Destroy the defective core by breaking it. There is no core at intersection of BS10 and WS11.

Short Between Windings. Remove both windings.

Replace magnet wire.

Weld Stringing Needle To Magnet Wire. Use proper color of magnet wire insulation (red or blue).

Re-String Winding Using Proper Number Of Turns

Coil	Wire Color	Number Turns Through Core	Required Magnet Wire Length (Inches)(mm)
BW	Blue (Item 5)	8	11 (279.4)
MRead	Red (Item 4)	3	6 (152.4)
MWrite	Blue (Item 5)	3	6 (152.4)
BS	Red (Item 4)	12	16 (406.4)

1. Fasten end opposite needle to carrier with adhesive tape.
2. Feed needle through lower square hole in winding frame so it lies on top of existing wire through the core. Keeping needle on top allows better vision and reduces chance of damaging other wires in the matrix.
3. Guide needle through remaining cores. Cores and other wires may be gently moved with blunt tool (such as a sharpened toothpick). DO NOT FORCE the needle as this will damage the other wires. If necessary to use tweezers on the needle near the winding frame to move it through the cores, place a mask of 0.005 inch (0.127 mm) Mylar over the HMC to keep the tweezers from damaging the HMC, diodes, magnet wire, solder joints, or metallization.

4. After the needle has been gently coaxed through the array and out the other side of the winding frame, pull the wire through. Use care to keep the wire from kinking as it is pulled through.
5. Examine the needle for kinks and bends. Straighten the needle. DO NOT CUT IT; the point is specially formed and a cut end will damage wire insulation during the next pass through the matrix.
6. Repeat steps 2 through 5 until the proper number of turns have been applied.
7. If a wire is broken or kinked, replace it. Do not splice.
8. Cut the finished end of the winding from the excess stringing wire, allowing 1-inch (25.4 mm) minimum lead length for lead dress and solder joint.

After all indicated windings have been replaced, apply silicone rubber sealer (RTV 3140) to hold wires in proper slot in the winding frame.

ACCOMPLISHMENTS

A manufacturing process was developed to allow assembly at Bendix of a memory plane manufactured by Electronic Memories to a XA201C hybrid microcircuit manufactured by Bendix.

- Memory planes attached to printed circuit cards were successfully tested on the QA1001 tester.
- Memory planes were bonded to HMCs using 0.003-inch-thick (0.08 mm) Ablefilm 532 sheet epoxy adhesive.
- Good magnet wire tinning was obtained by using chemical stripper followed by tin-dipping in a conventional Sn60 solder pot (260°C).
- Good re-flow solder joints were obtained by using a Browne SR-3 soldering machine.
- A polyurethane protective coating was applied to the exposed solder joints and bare magnet wire to prevent fine-wire corrosion. Adequate control of the coating location was obtained by using a 5/0 artist's brush to apply a properly thinned polymer.
- A rework process and cause-of-failure matrix were developed.

- Experimental restringing of defective memory planes was done, although a refined process was not developed.

FUTURE WORK

- The restringing process should be developed. Until it is, memory planes requiring rework can be returned to Electronic Memories.
- Ten additional memory planes should be purchased and attached to the HMCs in accordance with the process developed on this project. After completion, the memory modules should be subjected to normal D-tests plus 500 temperature cycles. After thermal cycling, the solder joints should be critically examined to determine if solder joint degradation is a problem with machine-soldered joints. A previous investigation by R. L. Nagel of the Sandia Corporation showed that hand-soldered joints do not degrade after 500 thermal cycles.

REFERENCES

¹W. J. Kirk, Jr., *Magnet-Wire Stripping* (Final Report). UNCLASSIFIED.
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