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PROCEEDINGS OF THE CONFERENCE ON REWORK AND REPAIR OF PRINTED C--ETC(U)
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UNCLASSIFIED TR-0077(2902)-1 SAMSO-TR-77-117 NL

1 OF 4
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REPORT SAMSO-TR-77-117

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Proceedings of the Conference on Rework and Repair of Printed Circuit Boards

The Aerospace Corporation
El Segundo, California
22, 23 March 1977

AEROSPACE SYSTEMS SUPPORT GROUP
The Aerospace Corporation
El Segundo, Calif. 90245

1 August 1977

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Final Report

Prepared for
SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
Los Angeles Air Force Station
P.O. Box 92960, Worldway Postal Center
Los Angeles, Calif. 90009

AD No.
DDC FILE COPY

THE AEROSPACE CORPORATION

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This final report was submitted by The Aerospace Corporation, El Segundo, CA 90245, under contract F04701-76-C-0077 with the Space and Missile Systems Organization, Deputy for Space Communications Systems, P.O. Box 92960, Worldway Postal Center, Los Angeles, CA 90009. It was reviewed and approved for The Aerospace Corporation by E. Wade, Aerospace Systems Support Group, and L. Katzin, Engineering Science Operations. Colonel W. L. Bagwell, SAMSO/PPG, was the project officer.

This report has been reviewed by the Office of Information (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Approved

William L. Bagwell

W. L. Bagwell
Colonel, USAF
Director of Manufacturing
Deputy for Procurement
and Manufacturing

FOR THE COMMANDER

Eugene W. Grimm

Eugene W. Grimm
Colonel, USAF
Deputy for Procurement
and Manufacturing

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Soldering	Workmanship
Encapsulation	Repair
Foaming	Rework

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

On 22 and 23 March 1977, SAMSO and Aerospace sponsored a unique conference on the rework and repair of already assembled printed circuit boards. Although there have been many conferences relating to the design, fabrication, and testing of space and missile systems and components, little attention has been directed towards repair and rework problems. This conference was intended to provide a forum for the exchange of industry and government experiences, problems, and solutions in this specialized area.

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19. KEY WORDS (Continued)

20. ABSTRACT (Continued)

Printed circuit boards are used in space and missile systems to mount and interconnect the thousands of electronic parts in the various electronic components. Although it is everyone's intention to perfectly assemble the parts on each printed circuit board, and to never rework the boards after assembly, cost and schedule considerations require the repair or rework in many situations. Fundamentally, these situations develop as a result of poor workmanship, a part failure, or a design change.

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1. INTRODUCTION

On 22 and 23 March, SAMSO and Aerospace sponsored a unique conference on the rework and repair of already assembled printed circuit boards. Although there have been many conferences relating to the design, fabrication, and testing of space and missile systems and components, little attention has been directed towards repair and rework problems. This conference was intended to provide a forum for the exchange of industry and government experiences, problems, and solutions in this specialized area. Printed circuit boards are used in space and missile systems to mount and interconnect the thousands of electronic parts in the various electronic components. Although it is everyone's intention to perfectly assemble the parts on each printed circuit board, and to never rework the boards after assembly, cost and schedule considerations require the repair or rework in many situations. Fundamentally these situations develop as a result of poor workmanship, a part failure, or a design change.

For example, the final inspection on a completely assembled printed wiring board, worth hundreds of dollars, may uncover minor discrepancies such as scratches in conductors, voids in conformal coating, lack of bonding of a conductor, or an improperly soldered connection. In such cases, a repair procedure is appropriate if it can reduce the degree of nonconformance to an acceptable level. The high levels of reliability required by space systems result in setting levels of workmanship that are difficult to achieve. These high levels may then result in repeated rework on the same assembly in an attempt to achieve the desired perfection.

As another example, a $2 resistor might fail during ground tests of a space vehicle. The resistor may be mounted on a printed circuit board with 10 integrated circuits each costing $500. Should the entire board be scrapped or should the failed resistors be replaced by reworking the assembled board?

The answer in this example is not as simple as it might seem. Before the decision on whether to scrap or repair can be made, the reason for the failure should be found. This is necessary to ensure that the resistor failure was not caused by a failure of some other part or by the test equipment. In other words, one should determine that replacing the resistor will not simply result in the failure of the new resistor when the test is repeated. In addition, when the resistor failed, it may have overheated other parts or it may have caused an over-voltage or over-current condition in adjoining circuitry. Before the repair decision can be made, one must determine the total extent of the repair by identifying other parts that would also require replacing because of the overstress associated with the failure.

Having made a decision to repair an assembled printed circuit board, the contractor faces the problems addressed in the conference. How should the rework be done so that the resulting board is as reliable as a newly assembled one? How do you know that the rework was accomplished satisfactorily?

These proceedings of the conference contain the presentation material used. The conference was jointly arranged by Col. W. Bagwell, SAMSO Director of Manufacturing and Quality Control; Len Katzin of the Aerospace Reliability and Components Department; J. Egan, Associate Head of the Reliability and Components Department; and E. Wade, Director of the Aerospace Systems Support Group. Mr. Katzin organized the technical sessions and made a presentation on "Future Trends." The conference was attended by 150 industry representatives, 25 SAMSO representatives, 25 Aerospace personnel, and 40 individuals from other government agencies.

2. MEETING AGENDA

The agenda of the Conference on Rework and Repair of Printed Circuit Boards, held on March 22 and 23, 1977 at The Aerospace Corporation, consisted of the following items:

1.	Welcome	Col W. Bagwell, SAMSO, Dir. of Manufacturing and Quality Assurance Col F. McCartney, SAMSO, Deputy for Space Communications

First Session – 9:00 AM March 22, 1977

2.	Introduction	C. Holzbauer, TRW Systems
3.	Rework and Repair - The Definition (Appendix A)	V. J. Petrusis, TRW Defense and Space Systems
4.	Designing for Rework (Appendix B)	M. Brown, TRW Defense and Space Systems
5.	Validation of Repair Techniques (Appendix C)	J. T. Strohmer, National Security Agency
6.	Repair and Rework of New Printed Circuit Assemblies (Appendix D)	J. T. Strohner, National Security Agency
7.	Printed Wiring Board Problems, UHF Receiver Subsystem (Appendix E)	T. Long and H. Snyder, ECI Division, E-Systems, Inc.
8.	Measling - Causes and Effects (Appendix F)	R. Douglas, TRW Defense and Space Systems

Second Session – 1:00 PM March 22, 1977

9.	Introduction	W. Hurd, Lockheed Missiles and Space Company
10.	Hysol Coatings (Appendix G)	D. Van Farrell, Honeywell, Inc.

11.	Polyurethane Coatings (Appendix H)	W. Lang and K. Weeks, Lockheed Missiles and Space Company
12.	Parylene Coatings (Appendix I)	R. A. Dunaetz, Hughes Aircraft Company
13.	Foam Type Conformal Coatings (Appendix J)	R. Kiesell, Motorola, Inc.
14.	Conithane/Solithane (Appendix K)	M. Singleton and F. Hornbuckle, SCI Systems
15.	Summary (Appendix L)	W. Lang, Lockheed Missiles and Space Company
16.	General Discussion	W. Hurd, Lockheed Missiles and Space Company

Third Session – 9:00 AM March 23, 1977

17.	Introduction	G. Robinson, Hughes Aircraft Company
18.	Inspection for Board Damage (Appendix M)	W. Williams, General Dynamics Corporation
19.	Repairability of Epoxy vs Polyimide Circuit Boards (Appendix N)	J. J. Budna, Hughes Aircraft Company
20.	Repair of Printed Wiring Boards: Burs, Blisters and Cracks (Appendix O)	Y. Moriwaki, Hughes Aircraft Company
21.	General Repair of Printed Wiring Board Assemblies (Appendix P)	M. Perchick, RCA, Astro-Electronics Division
22.	Foamed Module Repair (Appendix Q)	M. Furney, General Dynamics Corporation
23.	Repair of Printed Wiring Board Assemblies (Appendix R)	R. C. Black, Hughes Aircraft Company

24.	Repairing Printed Circuit Card Assemblies (Appendix S)	J. P. McGrady, ITT

Fourth Session – 1:00 PM March 23, 1977

25.	Introduction - Special Problems and Panel Discussion	H. Anslow and J. Richardson, The Aerospace Corporation
26.	Special Problems: Trends (Appendix U)	L. Katzin, The Aerospace Corporation
	Multilayer Assembly Reliability Assurance (Appendix T)	General Electric Company, Utica
27.	Panel Discussion	W. Hurd, Lockheed M. Brown, TRW W. Kuster, Hughes R. M. Gerber, Aerospace
28.	Closing Remarks	E. Wade, The Aerospace Corporation

APPENDIX A

REWORK AND REPAIR - THE DEFINITION

V. J. Petrusis
TRW Defense and Space Systems

CONFERENCE ON REWORK AND REPAIR
OF PRINTED CIRCUIT ASSEMBLIES

SESSION 1

REWORK AND REPAIR

V. J. PETRUSIS
TRW DEFENSE AND SPACE SYSTEMS

MARCH 22, 1977

OUTLINE

- INTRODUCTION
- REWORK AND REPAIR - DEFINITIONS
- NONCONFORMING ITEM REPROCESSING
  - REWORK
  - REPAIR
- RECAP

REWORK AND REPAIR - DEFINITIONS

- REWORK

  A PROCESS THAT RESTORES ALL NONCONFORMING CHARACTERISTICS (OF A NONCONFORMING ITEM) TO THE SPECIFICATION REQUIREMENTS.

- REPAIR

  A PROCESS DESIGNED TO REDUCE BUT NOT COMPLETELY ELIMINATE THE NONCONFORMANCE.

REWORK AND REPAIR - DEFINITIONS (CONTINUED)

- IPC-T-50A

  REWORK

  THE ACT OF REPEATING ONE OR MORE MANUFACTURING OPERATIONS FOR THE PURPOSE OF IMPROVING THE YIELD OF ACCEPTABLE PARTS.

  REPAIR

  THE ACT OF RESTORING THE FUNCTIONAL CAPABILITY OF A DEFECTIVE PART WITHOUT NECESSARILY RESTORING APPEARANCE, INTERCHANGEABILITY, AND UNIFORMITY.

REWORK AND REPAIR - DEFINITIONS (CONTINUED)

- NHB 5300.4(1B)

  REWORK

  THE CONTINUATION OF PROCESSING ARTICLES AND MATERIALS THAT WILL MAKE THEM CONFORM TO DRAWINGS, SPECIFICATIONS, PROCEDURES, OR CONTRACT.

  REPAIR

  OPERATIONS PERFORMED ON NONCONFORMING ARTICLE TO PLACE IT IN USABLE AND ACCEPTABLE CONDITION.

REWORK AND REPAIR - DEFINITIONS

- MILITARY STANDARD 1520A

  REWORKED MATERIAL

  MATERIAL THAT WAS NONCONFORMING BUT HAS BEEN SUBJECTED TO A PROCESS THAT RESTORES ALL NONCONFORMING CHARACTERISTICS TO THE REQUIREMENTS IN THE CONTRACT, SPECIFICATION, DRAWING OR OTHER APPROVED PRODUCT DESCRIPTION.

  REPAIRED MATERIAL

  NONCONFORMING MATERIAL PRESENTED BY THE CONTRACTOR TO THE GOVERNMENT FOR ACCEPTANCE AFTER IT HAS BEEN SUBJECTED TO A PROCESS DESIGNED TO REDUCE BUT NOT COMPLETELY ELIMINATE THE NONCONFORMANCE.

NONCONFORMING ITEM REPROCESSING

- IDENTIFICATION AND SEGREGATION
  - MANUFACTURING SHOP ORDER
  - DISCREPANCY REPORT

- PRELIMINARY REVIEW
  - DEFECTIVE ITEM REVIEW AND DISPOSITION
  - CORRECTIVE ACTION

- REWORK
  - INSTRUCTIONS
    - MANUFACTURING SHOP ORDER/PLANNING CHANGE NOTICE - SPECIAL INSTRUCTIONS
    - FABRICATION INSPECTION PROCESS PROCEDURES
  - REWORK
  - INSPECTION

NONCONFORMING ITEM REPROCESSING - (CONTINUED)

- **REPAIR**

  MATERIAL REVIEW BOARD

  INSTRUCTIONS

    SPECIAL INSTRUCTIONS

    STANDARD REPAIR PROCEDURES

  REPAIR

  INSPECTION

  CORRECTIVE ACTION

MANUFACTURING SHOP ORDER

LABOR ACTIVITY CODE → 0 ON STDS SET UP | 1 ON STDS RUN | 2 NO. STDS | 3 R&D MFG | 4 R&D ENGR | 5 R&D OTHER

MSO NO.	QTY.	PART NO	REV	DESCRIPTION	DUE DATE
		256586-1		MODULE ASSY A14	

JOB NO.	S/N	S/N THRU	NEXT ASSEMBLY NO. (S)	NEXT ASSEMBLY DESCRIPTION	START DATE

P/L	PROJECT	CONFIGURED ITEM PART NO.	UNIT
25	777	256599	FREQ. GENERATOR

SPLIT FROM

SPLIT LOT RECORD

NO.	OPN	DATE	BY	QTY	BAL

DRAWING NO./V.A.	REV.	E.O.	COPY

CHANGE BLOCK

ISSUE	DATE	DESCRIPTION OF CHANGE	PLAN	S/N EFF.	REV	QUAL. ASS'Y STAMP	DATE
8	11/10	RESEQ OP 85, REVISE SPEC CALLOUTS	STAPLES	18UP	B4		

OPN NO.	P/L	WORK CTR	OPERATION DESCRIPTION	EMPL NO.	NCMR / DR	INSP STAMP	STD HRS SET UP RUN
			THE FOLLOWING PPV AFFECTS THIS MSO FIPP 4-34-01 PPV DR PR 4-34-02				
10		PC	KIT PER PAL				
15		QI	KIT INSPECTION PER QPII 2273-009 REV				
20		AA	INK STAMP I.D. AND DESIGNATORS PER VA SHT. 2 AND FIPP 12-6-0101 PIN 0110 REV				

BONDING AND ENCAPSULATION RECORD

MSO OPR	PR SPEC / FIPP	CLEANER / PRIMER	MATERIALS	MATERIAL TRACEABILITY	MIX RATIO	MAT'L WTS MIXED	CURE CYCLE	CURE TEMP	TIME IN / TIME OUT	EMPL / DATE	QI
20	FIPP 12-6-0101 PR12-1 TYP II CL 1A	ISOPROPYL ALCOHOL	WORNOWINK M		20		2 HRS	150°F +10°F			
			CATALYST A		1						

				TOTAL		SET UP / RUN	

COMPLETION RECORD		DATE	QTY	STORES
SCRAPPED BY	1			
CANCELLED BY	2			
RECEIVED BY	3			

PLANNER	EXT.
D. STAPLES	53181
REQUESTER	CCC

FINAL INSPECTION		STAMP
DATE		
QTY.		
REV.		

CUM. AVERAGE STANDARD HOURS PER UNIT	LEAD PRODUCT LINE		PERFORMING PRODUCT LINE		TOTAL	LINE INSPECTION
	FAB/ASSY	SET UP/TEST	FAB/ASSY	SET UP/TEST		

SYSTEMS 1754 REV. 9-68

PAGE 1 OF 6

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PLANNING CHANGE NOTICE

LABOR ACTIVITY CODE → 0 ON STOP SETUP | 1 ON STOP RUN | 2 NO. STOPS | 3 R&R MFG | 4 R&R ENGR | 5 R&R OTHER

MSO NO.	QTY.	PART NO	REV	DESCRIPTION	DUE DATE
[illegible]	1	[illegible]	[illegible]	[illegible]	

JOB NO.	S/N	S/N THRU	NEXT ASSEMBLY NO. ID	NEXT ASSEMBLY DESCRIPTION	START DATE
[illegible]	[illegible]				

P/L	PROJECT	CONFIGURED ITEM PART NO.	UNIT
[illegible]	[illegible]	[illegible]	

SPLIT FROM NO. | SPLIT LOT RECORD: OPN | DATE | BY | QTY | BAL

DRAWING NO./V.A. | REV. | E.O. | COPY

CHANGE BLOCK

ISSUE	DATE	DESCRIPTION OF CHANGE	PLAN	S/N EFF.	REV	QUAL. ASSUR. STAMP	DATE
[illegible]		[illegible]					

OPN NO.	P/L	WORK CTR	OPERATION DESCRIPTION	EMPL NO.	NCMR / DR	INSP STAMP	HRS SET UP	HRS RUN
			[illegible]					
A		AA	[illegible]					
			[illegible]					
			[illegible]					
			[illegible]					
B		BE	[illegible]					

BONDING AND ENCAPSULATION RECORD

MSO OPR	PR SPEC FIPP	CLEANER PRIMER	MATERIALS	MATERIAL TRACEABILITY	MIX RATIO	MAT'L WTS MIXED	CURE CYCLE	CURE TEMP	TIME IN / TIME OUT	EMPL / DATE	QI
B	FIPP 4-34-01 (PIN PR 4-34-1)	Isopro. Alcohol	Lefkoweld 46		100		3 hrs	150°F ±10°F			
			Lefkoweld 52		74						

			TOTAL			SET UP		
						RUN		

PLANNER: D. STAPLES

REQUESTER:

PCN No. [illegible]

SYSTEMS 3403 REV. 4-69

PAGE 1 OF

DISCREPANCY REPORT

PROJECT | SL SEC. NO. | DRAWING NO. | PAGE 1 OF ___ | NO D 3159

10 MFG. CODE | 14 WC | 18 JOB NO. | 22 DOCUMENT NO. | 30 PART NAME | 38 PART NO. | REV. | DATE MO DAY YR | SERIAL NO. | QTY. INSP.

SQK. NO.	QTY. PARTS AFFECTED	NO. OF DEFECTS	DEFECT CODE

REP. YOU DAT NO. | MANUFACTURER NAME | INSPECTOR

NONCONFORMANCE:

22 CAUSE CODE | 24 RESP. CODE | 26 C.A. CODE | 28 PRELIMINARY REVIEW DISPOSITION (1 2 3 4 6)

NFG. EMP. DATE | IN STA DA

REMARKS/INSTRUCTIONS

MANUFACTURING DATE | ENGINEERING DATE | INSP. SUPERVISOR DATE

MATERIAL REVIEW BOARD ACTION

SQK. NO.	QTY.	28 MRB DISPOSITION REWORK	REPAIR	SCRAP	USE
		7	8 9 0		A
		7	8 9 0		A
		7	8 9 0		A
		7	8 9 0		A
		7	8 9 0		A
		7	8 9 0		A

INSTRUCTIONS:

RECURRENCE QTY.

CORRECTIVE ACTION: By: | CAR PR SHEET

ENGINEERING DATE | MANUFACTURING DATE | QUALITY ASSURANCE DATE | CUSTOMER GAR DA

SYSTEMS 4961 REV. 10-75

(1) DATA SYSTEMS (P.A.)

D 3159

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RECAP

- REWORK VS. REPAIR
- CONTROL OF THE PROCESS
- CORRECTIVE ACTION

APPENDIX B

DESIGNING FOR REWORK

M. Brown
TRW Defense and Space Systems

Rejection criteria. Evidence of any defects, including but not limited to the following, shall be cause for rejection.

a. Charring, burning, or other damage to insulation.

b. Splattering of flux or solder on adjacent connections or components.

c. Solder points (peaks).

d. Pits, scars, or holes.

e. Excessive solder which obscures the connection configuration.

f. Excessive wicking.

g. Loose leads or wires.

h. Cold solder connections.

i. Rosin solder connection.

j. Fractured solder connection.

k. Cut, nicked, stretched, scraped leads, or wires.

l. Unclean connection (e.g., lint, residue, flux, solder, splash, dirt, etc.).

m. Dewetting, nonwetting.

n. Insufficient solder.

o. Visible bare primary conductor within the solder joint area.

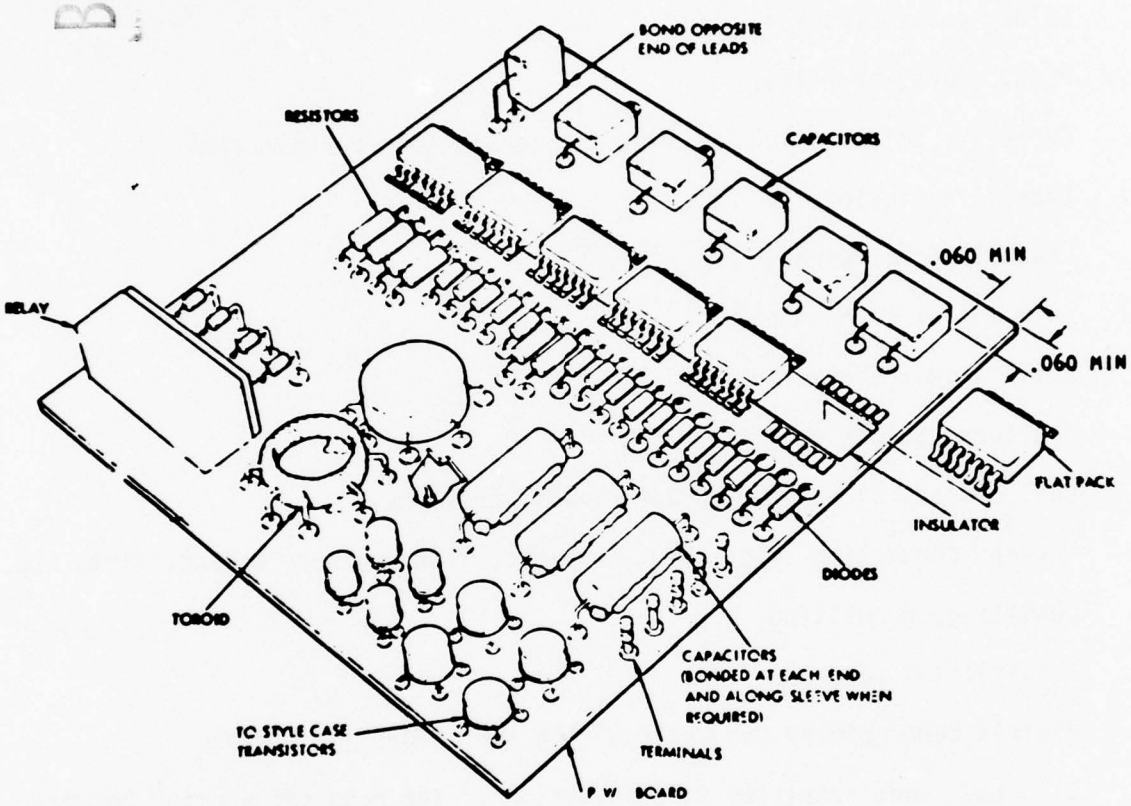
p. Clinched leads resulting in a reduction of the required spacing between conductors.

q. Splicing.

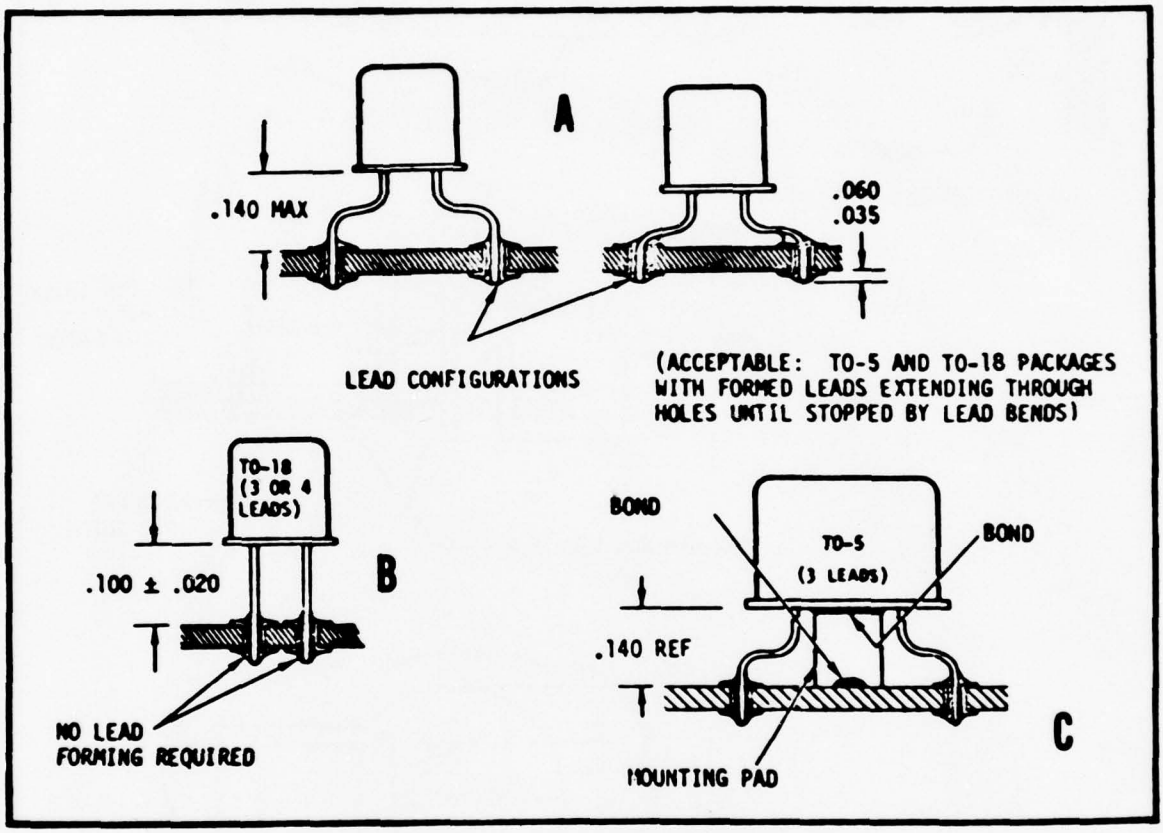
r. Plated through holes not filled with continuous solder plug.

Rework. Soldered joints reworked to correct deficiencies shall be one hundred percent reinspected for deficiencies in question and for any other features that may have been affected by the reworking operation.

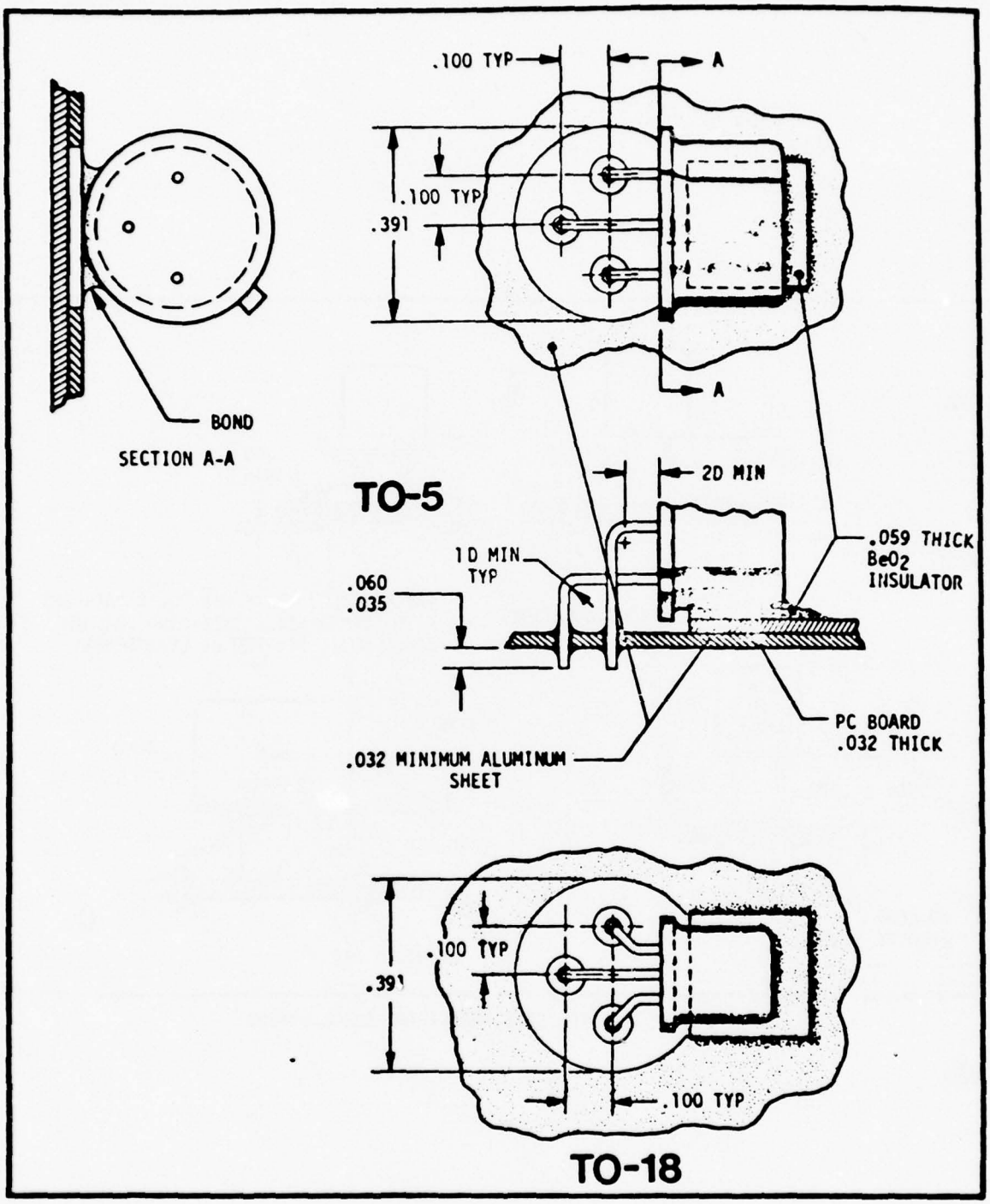
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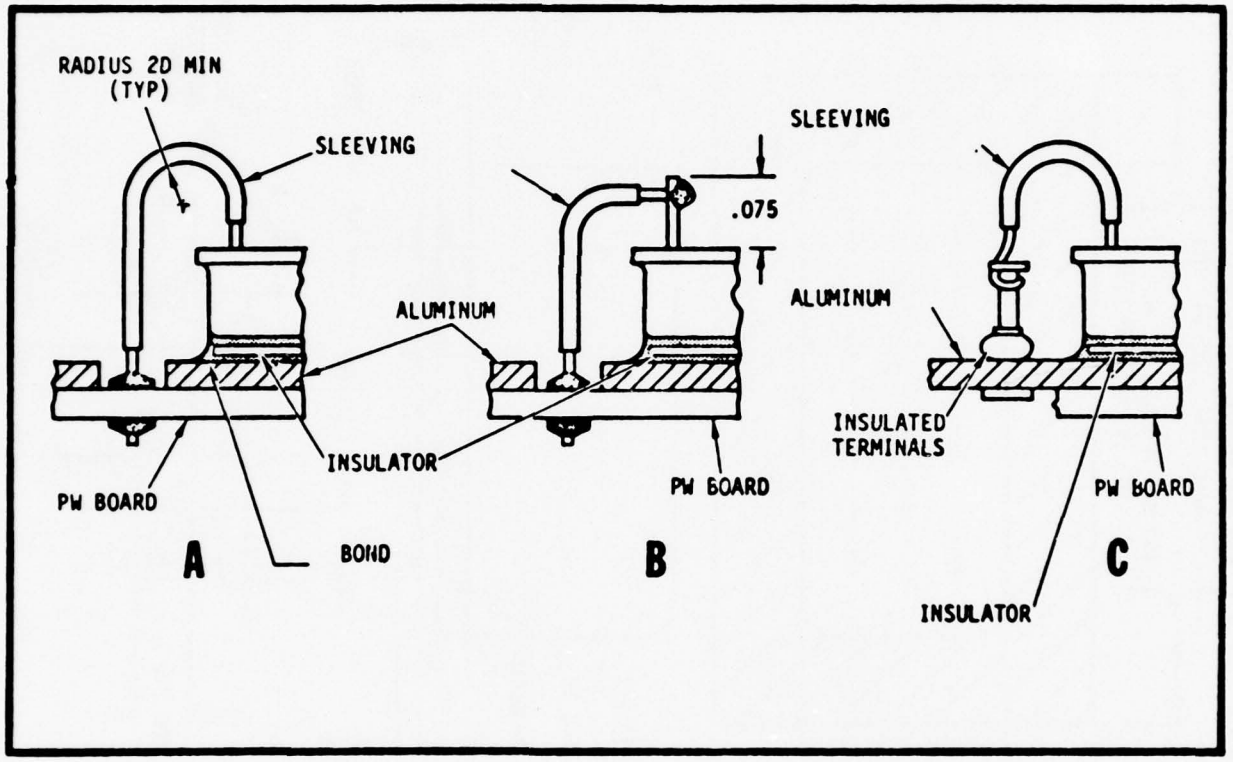
TYPICAL CIRCUIT CARD ASSEMBLY



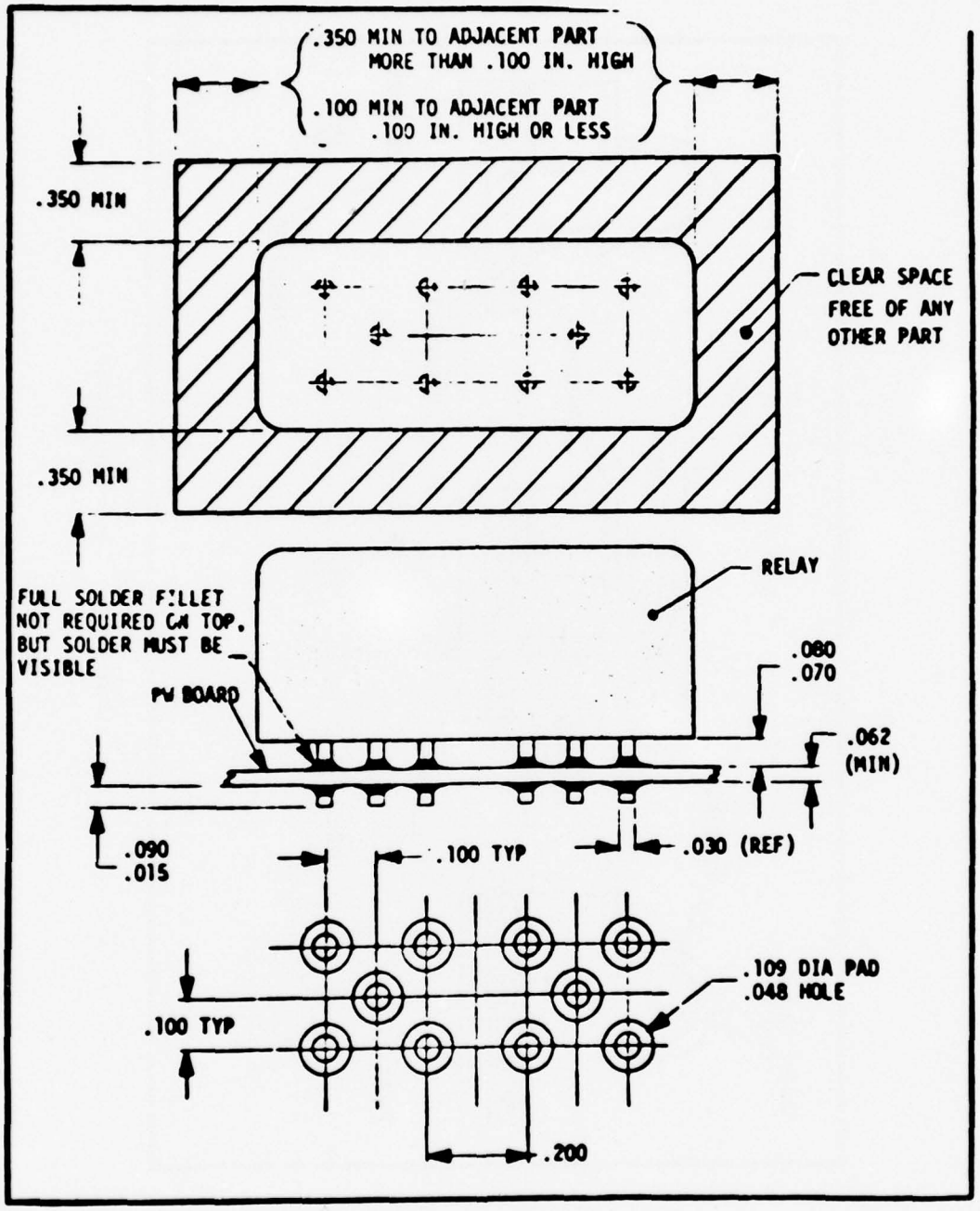
TO TYPE CASE TRANSISTOR INSTALLATION



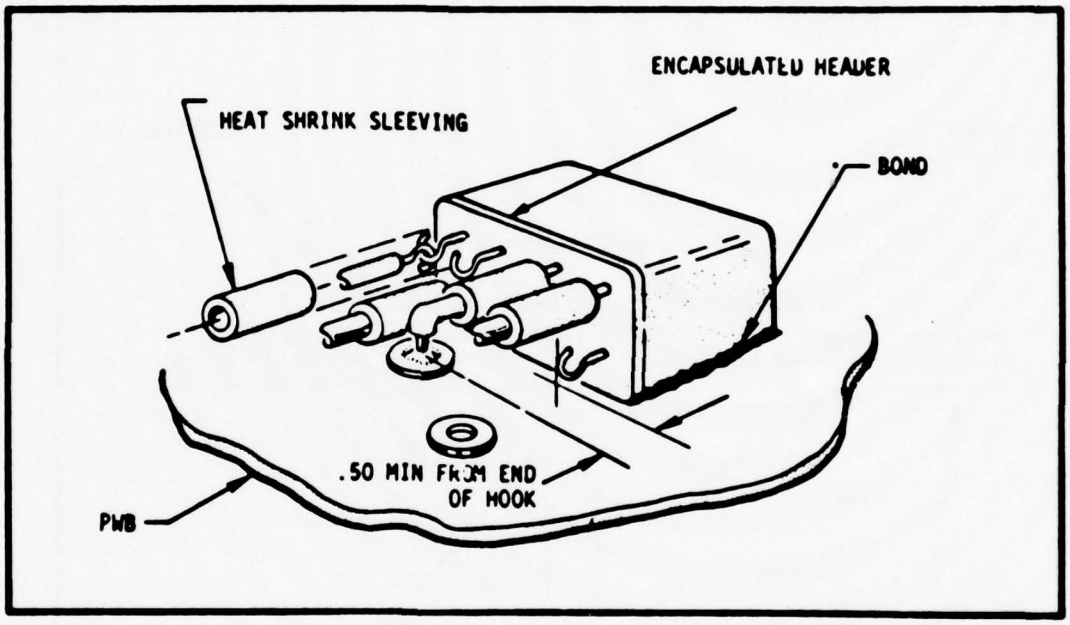
Side Mounting of 2 and 3 Lead TO-5 and TO-18 High Heat Dissipation Semiconductors for Laminated Heatsink-to-Board Assemblies Only



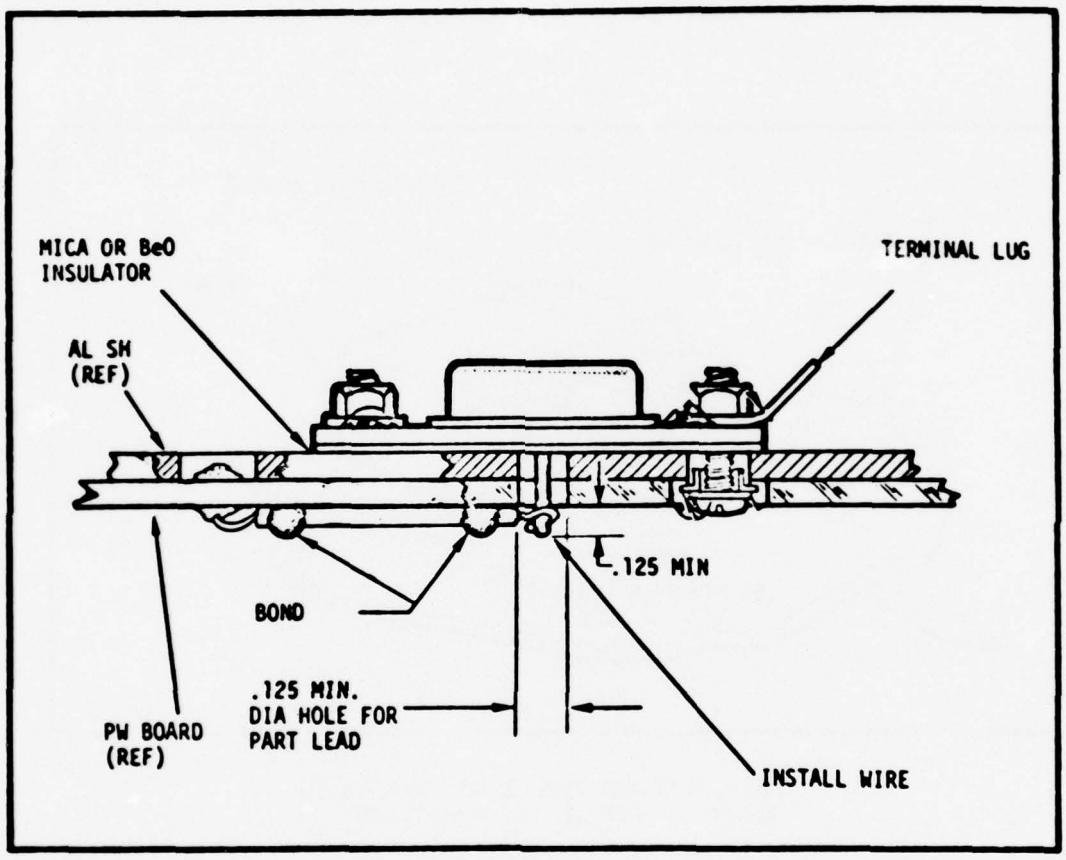
Inverted Mounting of Transistor



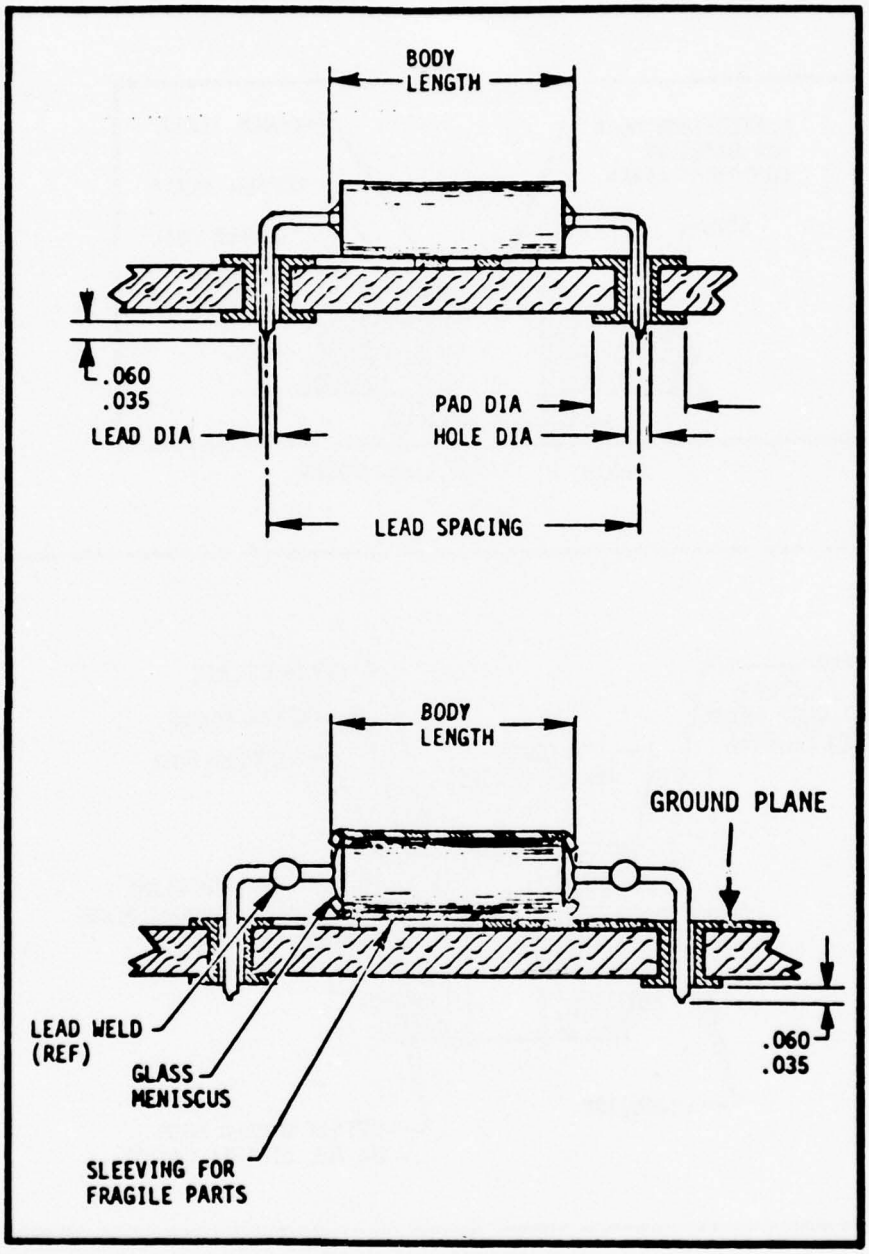
VERTICAL RELAY MOUNTING



RELAY SIDE MOUNTING (2DOXX) APPLIES TO BOARDS WITH OR WITHOUT A HEAT SINK



TO-3 and TO-66 Transistors



CYLINDRICAL PARTS WITH AXIAL LEADS

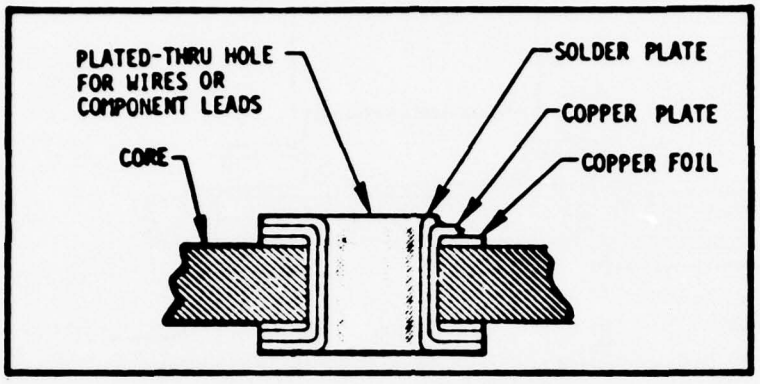
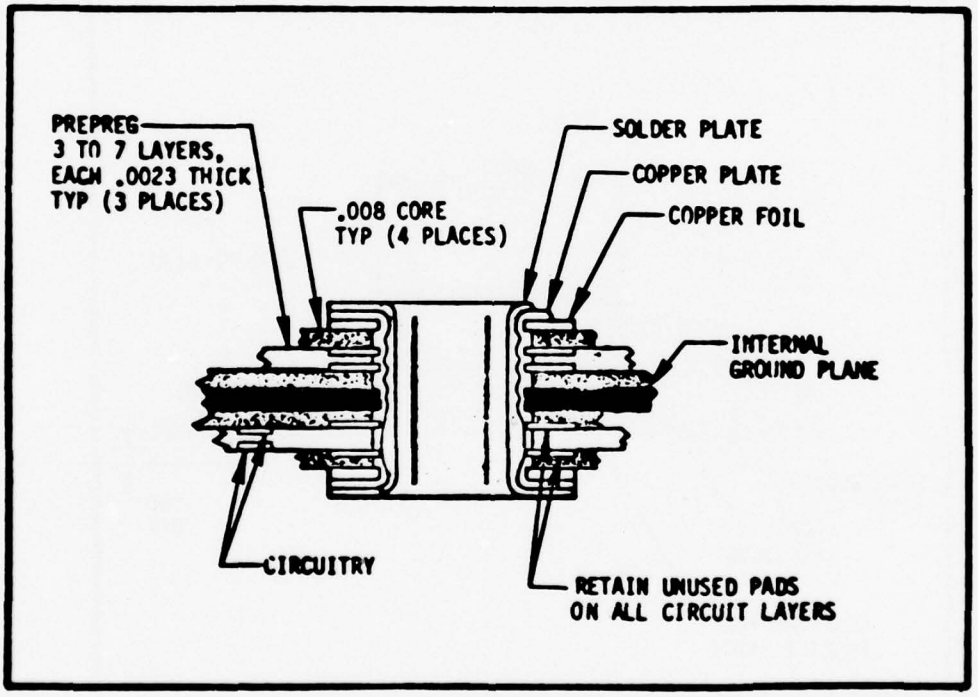
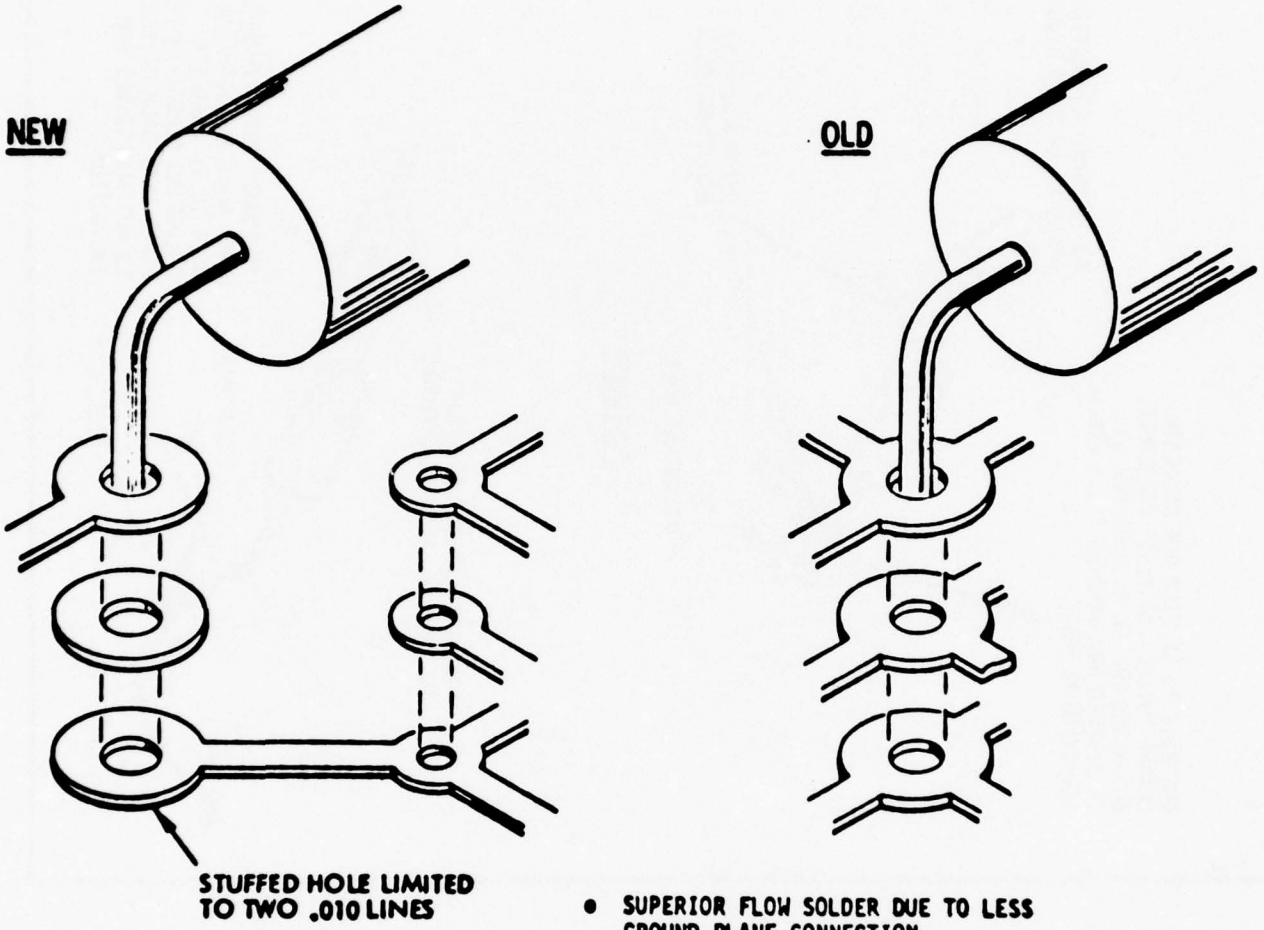


FIGURE 1 Two Sided Board

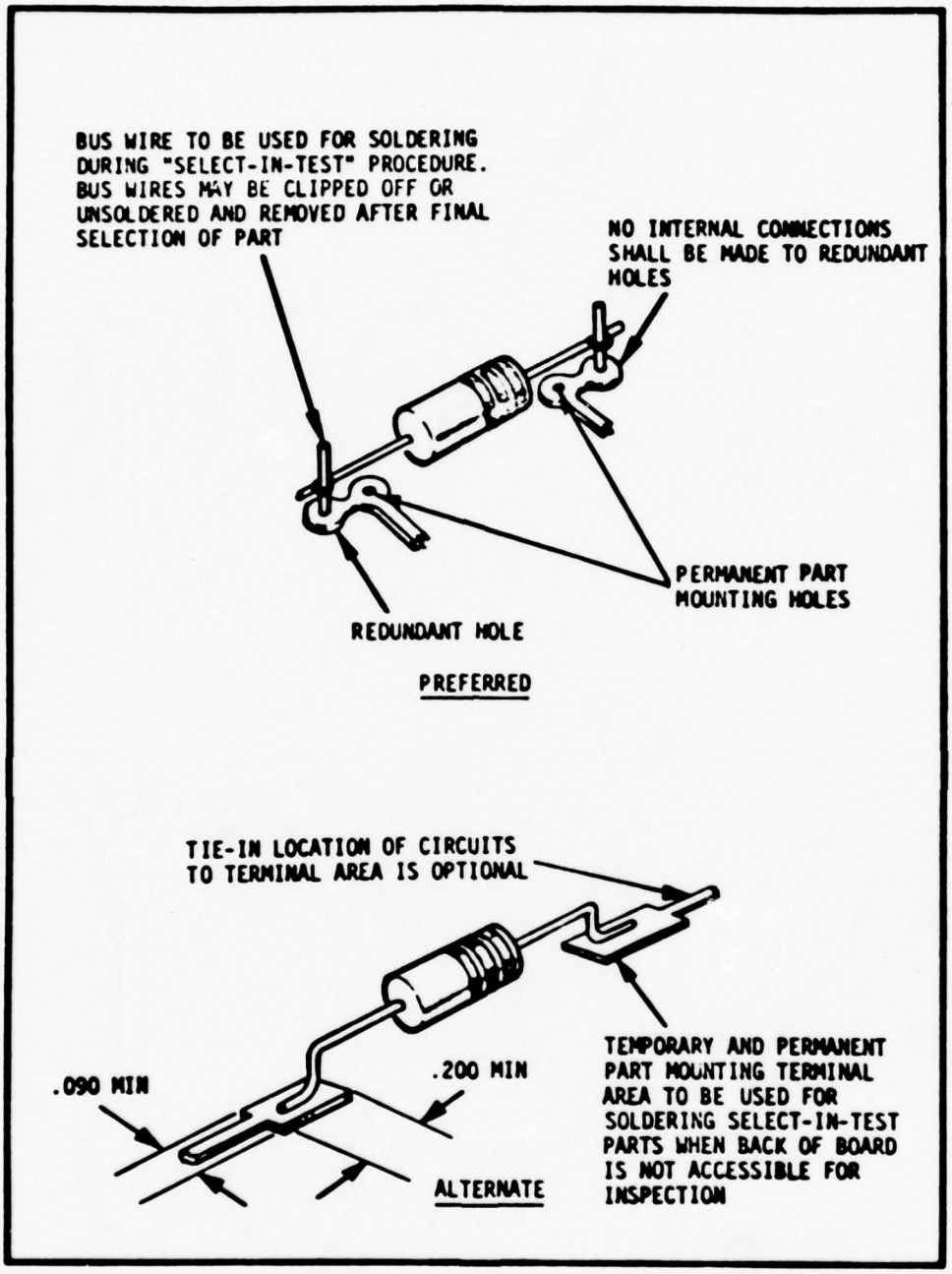


Multilayer Board

PLATED THRU-HOLE INTERCEPTS – M/L BOARDS

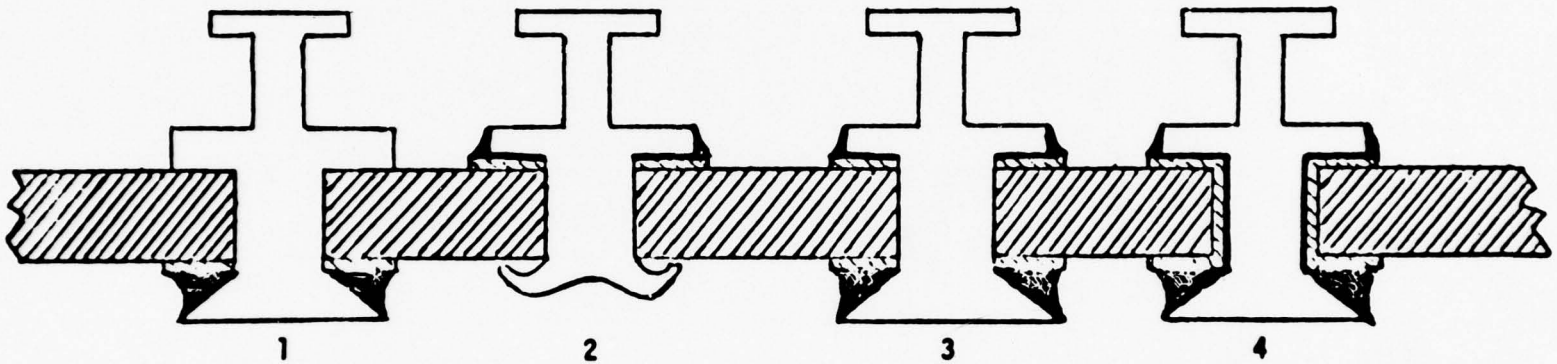


- SUPERIOR FLOW SOLDER DUE TO LESS GROUND PLANE CONNECTION
- EASIER REMOVAL OF COMPONENTS RESULTS IN FEWER LIFTED PADS



TYPICAL USE OF DOUBLE PAD AND CONTACT WIRE FOR SELECT-IN-TEST PROCEDURE

TERMINAL SWAGING ON PRINTED WIRING BOARDS



1) Undesirable
2) Desirable
3) Undesirable
4) Acceptable - Conditionally

APPENDIX C

VALIDATION OF REPAIR TECHNIQUES

J. T. Strohmer
National Security Agency

VALIDATION OF REPAIR TECHNIQUES

(Briefing Notes)

JOHN T. STROHMER
Department of Defense
Ft. G. G. Meade, MD 20755

This brief paper is to share with you the results of the first Institute of Printed Circuits (IPC) Round Robin Repair Test Program. I intend to only highlight the study, the complete study has been reported by Ralph Hersey, Lawrence Livermore Laboratories, the Chairman of the IPC Task Group for this project. My Agency and Collins Radio Group were the testing elements. It is my understanding the IPC will validate all repair techniques that appear in IPC-R-700 Modification and Repair Procedures for Printed Wiring.

The stated objectives of this study were:

PROVIDE VALIDATION:	To provide test data on the relative ability of selected repair methods to withstand specified environmental testing.
COMPARE METHODS:	To provide comparative test data on similar repair methods subjected to the same test environments.
COMPARE SKILL LEVELS	To provide data on repairs performed by two groups of average capability personnel, with each repair group performing at different levels of repair skill.
ORIGINATE METHODS	To provide examples of how to originate a repair method based upon individual repair requirements.
ENVIRONMENTAL SURVIVAL	To provide a guideline on how one can environmentally test repair techniques.

The repair methods selected for this, the first study program, were damaged conductors, solder bridging; damaged conductors, solid jumper wire on surfaces; damaged conductors, metal foil jumper on surface; damaged conductors, jumper wire through boards; and pad/conductor pattern delaminated and missing.

In order to learn more about the degree of difficulty and effectiveness of the repair techniques, two levels of personnel skill were selected. One group had no previous modification or repair experience, only the ability to use basic tools and to perform simple soldering operations. The other group had considerable specialized training and experience.

The test specimens were identical boards having three networks, each of which had specific design parameters. The circuits were designed to permit initial and final electrical interconnection resistance testing. The specific defects outlined above were intentionally created in an identical manner on each test specimen board. Repairs were made by both levels of personnel and the specimens were coded and shipped to our Agency and Collins Radio Group for testing.

After the electrical tests were performed the following environmental and subsequent electrical tests were also performed:

MECHANICAL SHOCK

MIL-STD-202, Method 213, Test Condition J, 30g's, 11 ms, half-sine. Three shocks along each of the three mutually perpendicular axis (total 18 shocks). Electrical continuity was monitored by one tester during mechanical shock testing.

VIBRATION (Non-Resonant)

IPC-TMM-650, Method 2.6.9

One sweep from 20 to 2000 to 20 Hz performed in 16 minutes

The input acceleration (g's) over the 20 to 2000 to 20 Hz frequency range shall be 15 g's. Electrical continuity was monitored by one tester during mechanical vibration testing.

THERMAL CYCLING

IPC-TMM-650, Method 2.6.6, Class A Modified

The thermal cycle had the following profile:

STEP	TEMPERATURE	TIME (Min)
1	100 $^{+5}_{-0}$	45
2	+25 $\pm$ 5	15 max.
3	-60 $^{+0}_{-5}$	45
4	+25 $\pm$ 5	15 max.

RESULTS:

The quality of the repairs was directly related to the skilled and unskilled personnel. In fact, numerous failures were detected on the initial electrical resistance test of specimens prepared by unskilled personnel. After these failures were corrected by skilled personnel, no further failures occurred. It is also interesting to note the specimens that failed initially were obviously not electrically tested prior to shipment.

I have attempted to briefly describe this test program and I strongly suggest the reader obtain a copy of the formal IPC report on this subject.

THANK YOU

PROVIDE VALIDATION

COMPARE METHODS

COMPARE SKILL LEVELS

ENVIRONMENTAL SURVIVAL

DAMAGED CONDUCTOR: SOLDER BRIDGE

DAMAGED CONDUCTOR: JUMPER WIRE ON SURFACE

DAMAGED CONDUCTOR: METAL-FOIL JUMPER ON SURFACE

DAMAGED CONDUCTOR: JUMPER WIRE THROUGH BOARD

LAND/CONDUCTOR DELAMINATED AND MISSING

VALIDATION TESTERS:

Collins Radio Group
National Security Agency

MECHANICAL SHOCK: 30 g's 11 ms, half-sine

VIBRATION NON-RESONANT: 20 to 2000 to 20 Hz 16 minutes

THERMAL CYCLING:

Step	Temperature	Time (min)
1	100	45
2	+ 25	15
3	- 60	45
4	+ 25	15

APPENDIX D

REPAIR AND REWORK OF NEW PRINTED CIRCUIT ASSEMBLIES

J. T. Strohmer
National Security Agency

REPAIR AND REWORK OF NEW PRINTED WIRING ASSEMBLIES

(Briefing Notes)

John T. Strohmer
JOHN T. STROHMER
DEPARTMENT OF DEFENSE
FT. G. G. MEADE, MD 20755

This is a brief presentation to discuss some of the Department of Defense (DoD) experiences related to repairing new printed wiring assemblies at the manufacturing plant. Because of the expense involved in scrapping and replacement, it is obvious that one must allow sensible (and proven) repair procedures in order to meet delivery requirements and to avoid wasting money. My experience stems from the engineering department which oversees the production programs for modern sophisticated electronic equipments. We establish the requests for printed circuits at the R/D level, monitor production, and service equipment programs through their entire life cycle.

In order to set the tone for other speakers at this seminar, I have selected the following topics to speak briefly and entertain any questions:

BLISTERED MULTILAYER BOARDS
LIFTED CONDUCTOR PATH
MISSING OR DAMAGED CONDUCTOR
MEASLES ON PRINTED WIRING ASSEMBLIES
PAD SPIN-OUT
MEALING

Regardless of the type of repair being made, it is of the utmost importance to have qualified personnel for the repair, rework, or touch-up. Acceptable repairs rework or solder touch-up depends on the training, competence, skill, and experience of the person performing the operation.

The basic criteria for all repairs is that the assembly meets the original design requirements.

BLISTERS ON MULTILAYER PWBs:

One vendor had a problem of air entrapment in 15 layer boards. Investigation revealed a rapid heat build-up in the laminated press caused gelation of resin prior to full flow-out of air. Blisters of 1/4-inch in diameter or less, and in an unpopulated area of the boards were accepted. Blisters 1/4 to 3/4-inch were drilled at each end of the blister, baked for 2-hours at 250°F and injected with epoxy using a hyperdermic needle, placed in a vacuum system to drain out air. They were then cured at ambient conditions. Cost of these boards was approximately $1000.00 each. There were over 150 boards involved.

LIFTED CONDUCTOR PATH:

To repair lifted conductor patterns, we removed conformal coating with fiberglass eraser cleaned area with solvent (chlorothene NU) using soft brushes and low pressure air. We pressed the lifted conductor patterns down on the board with a smooth wooden probe. Pre-heating the assembly in an oven for 1-hour at 110°C, is important. It was necessary to mix the epoxy adhesive (FYLAC 501H-A, PN50-700015-4, and 501 H-B, PN50 700017-2) remove pre-heated assembly and apply adhesive within 3-minutes after removal from oven. Using a hypodermic syringe one can apply a fillet of adhesive along one edge of the repair area and tilt to allow adhesive to flow under the repair area. Place the board horizontal and apply a thin coating over the area, then apply a fillet of adhesive along each edge of the conductor. Curing in oven at 110°C for 16-hours is also necessary.

MISSING OR DAMAGED CONDUCTOR: (In solder joint area)

Complete breaks, scratches, nicks, or pin holes which reduce the cross-sectional area of the conductor may be considered for repair. No more than two repairs should be allowed on each assembly. And, only one per individual conductor

pattern. Conductor patterns stripped from scrap boards may be salvaged and soldered to the damaged board. Circuit should be a lap joint and be bonded to the board with an adhesive. The same preparation and procedures as described in lifted conductor may be employed.

MEASLES ON PRINTED WIRING ASSEMBLIES:

Where small fractures have occured between the epoxy resin and the fiberglass filler, repairs may be allowed but only on the outer layer of the board and not closer than 1/4-inch from the edge. Remove measled area with a scalpel or xacto-knife and brush away all loose resin or fiberglass. Heat board 220°F - 240°F (104-116°C) for 1-hour. Immediately upon removal from oven fill area, to be repaired with epoxy resin. Cure at 212°F for one hour (100-105°C). EPON 815 resin and DTA curing agent (dielhytenetriammine) is excellent for this type of repair.

PAD SPIN-OUT:

Thin line conductor, small hole to pad diameter ratio, and close spacing are taxing the state of the arts. The problem of pads breaking adhesion and spinning out during drilling is appearing more frequently. Although there are no repairs for this problem, redesign by so forming octogonal, square, or rectangular pads can eliminate the problem on future production. Pads with corners (as opposed to circular offer a tremendous resistance to spin-out.)

MEALING:

Mealing is the separation of the conformal coating from the surface of the board. When viewed at high magnification, white spots appear as a result of light reflection of the lifted portion of the coating. This occurs as a result of contami-

nant on the board surface and is pronounced when exposed to temperature, humidity environments.

The paractical way to eliminate mealing is to optimize the cleaning procedure to assure effective removal of foreign residue from the board surface. A suggested guideline is enclosed as Appendix I.

I would like to summarize by adding there are many other useful documents to be used as sources for either specific repair procedures, or acceptance limits after a repair.

NASA HANDBOOK NHB 5300.4 SOLDERING REQUIREMENTS

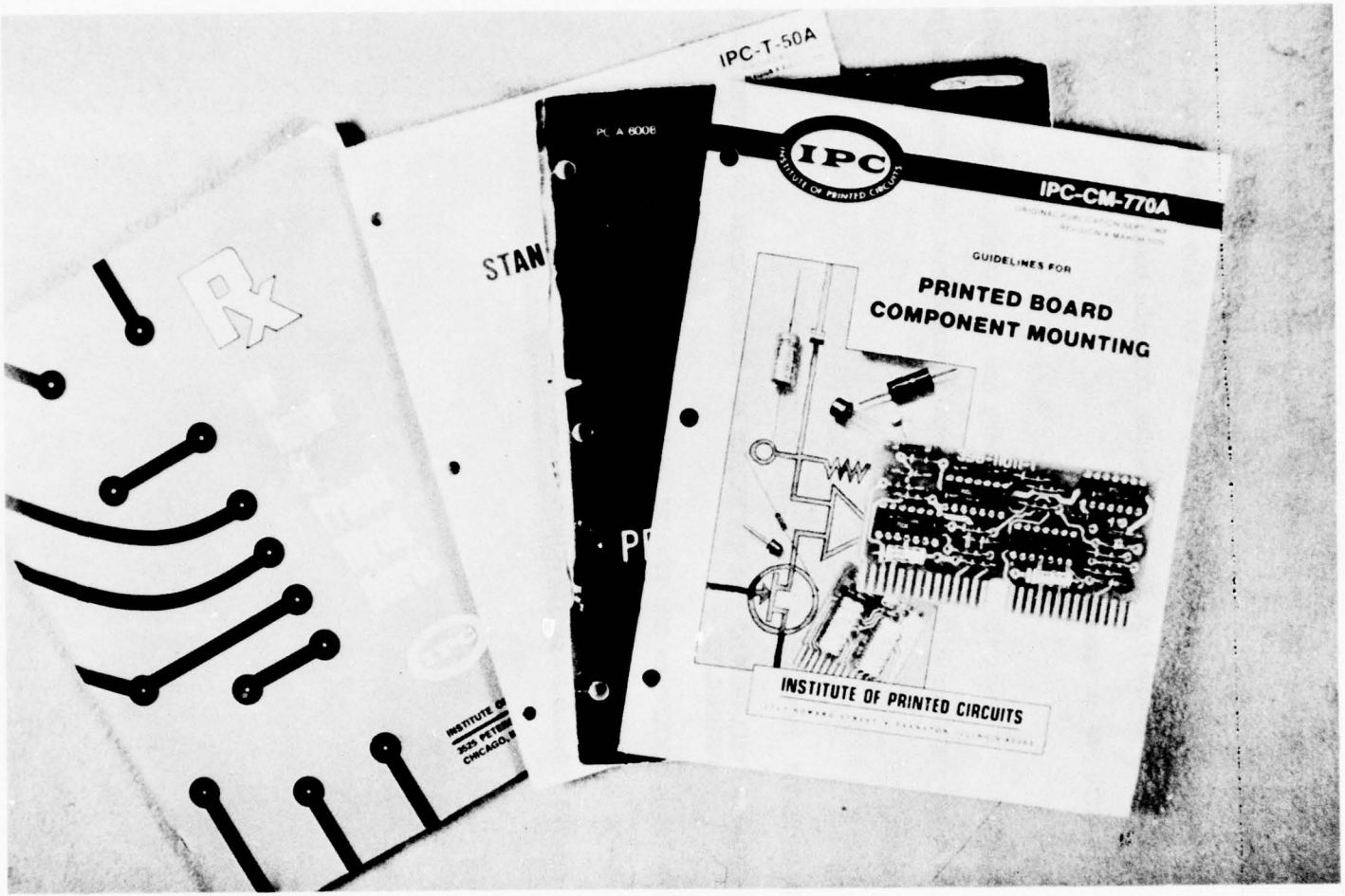
MIL-STD-1569 REQUIREMENT FOR THE REPAIR AND MODIFICATION OF PRINTED WIRING ASSEMBLIES

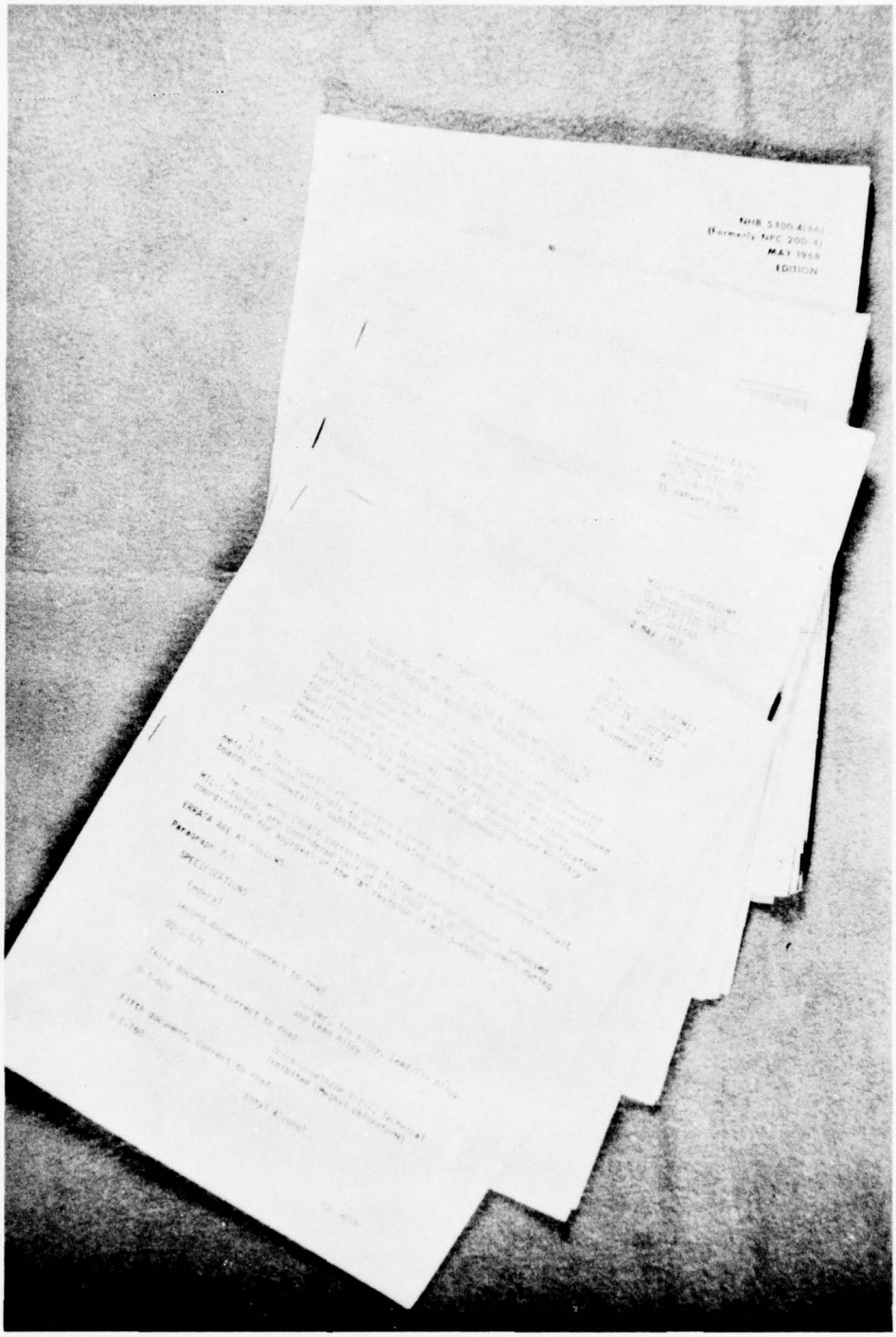
IPC-R-700 MODIFICATION AND REPAIRS ON PRINTED WIRING

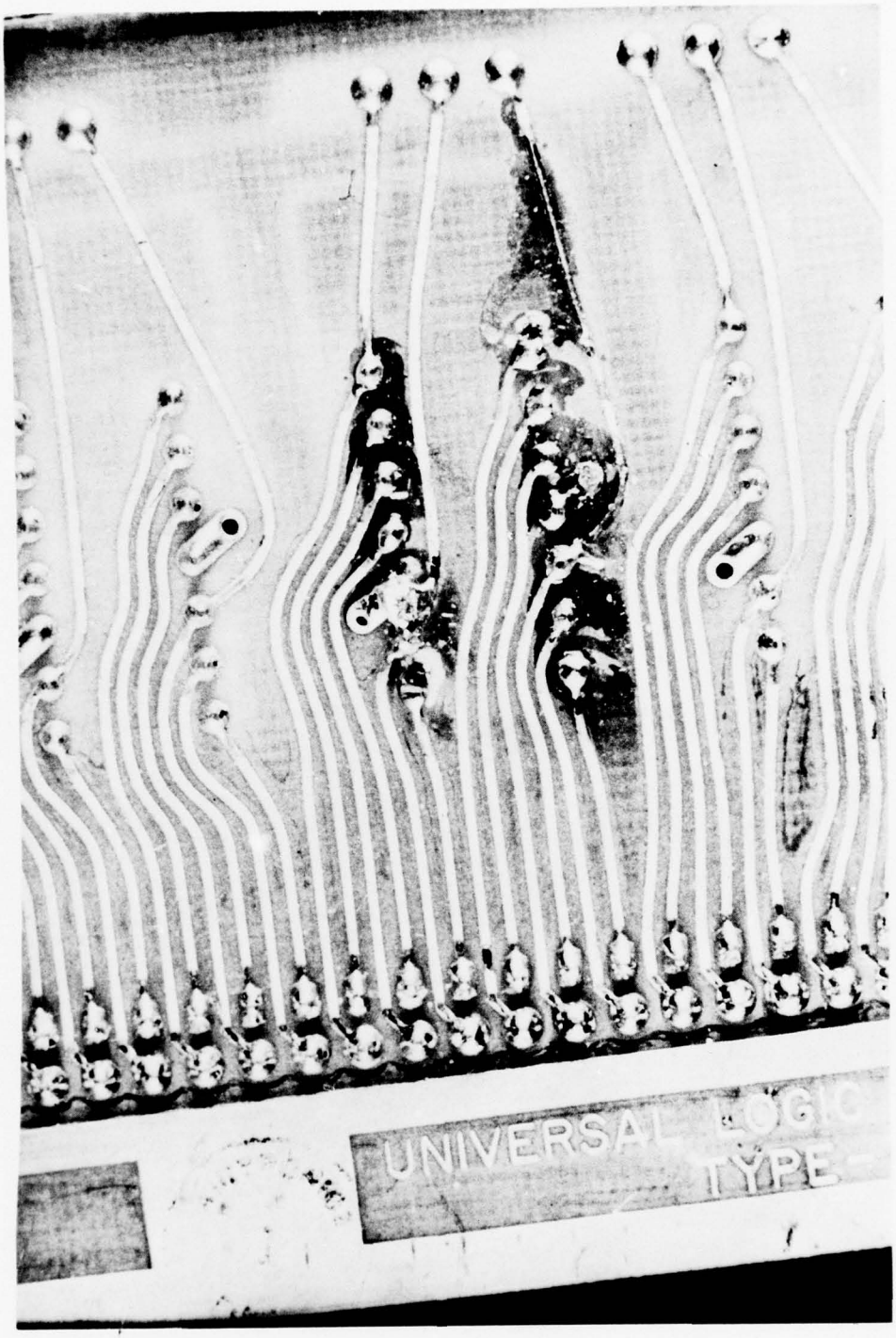
IPC-A-600 ACCEPTABILIZY OF PRINTED WIRING BOARDS

IPC-CM-770 PRINTED BOARD COMPONENT MOUNTING

THANK YOU.


IPC-T-50A
IPC
IPC-CM-770A
GUIDELINES FOR
PRINTED BOARD
COMPONENT MOUNTING
INSTITUTE OF PRINTED CIRCUITS

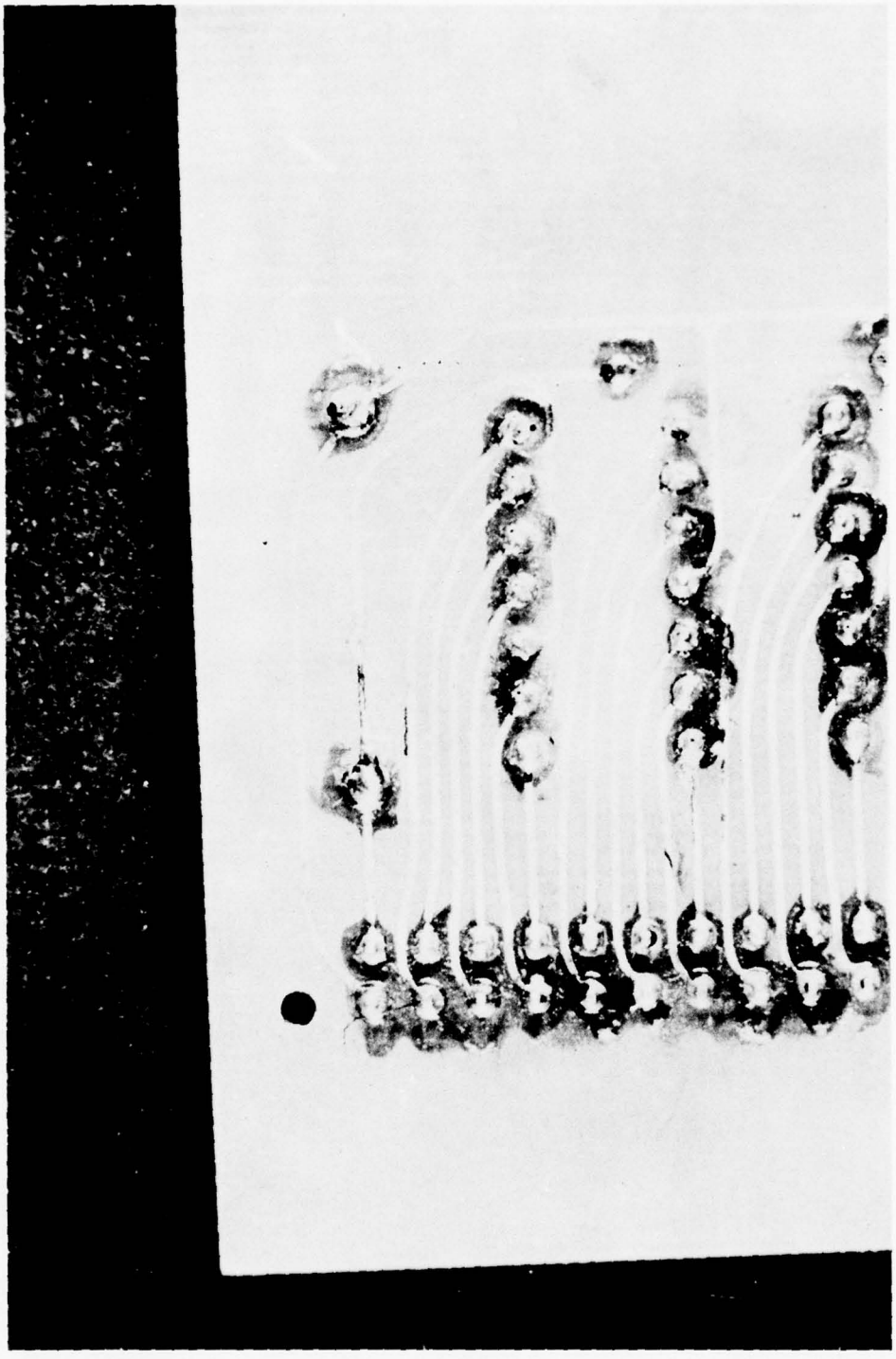

NHB 5300.4(3A)
(Formerly NPC 200-1)
MAY 1968
EDITION

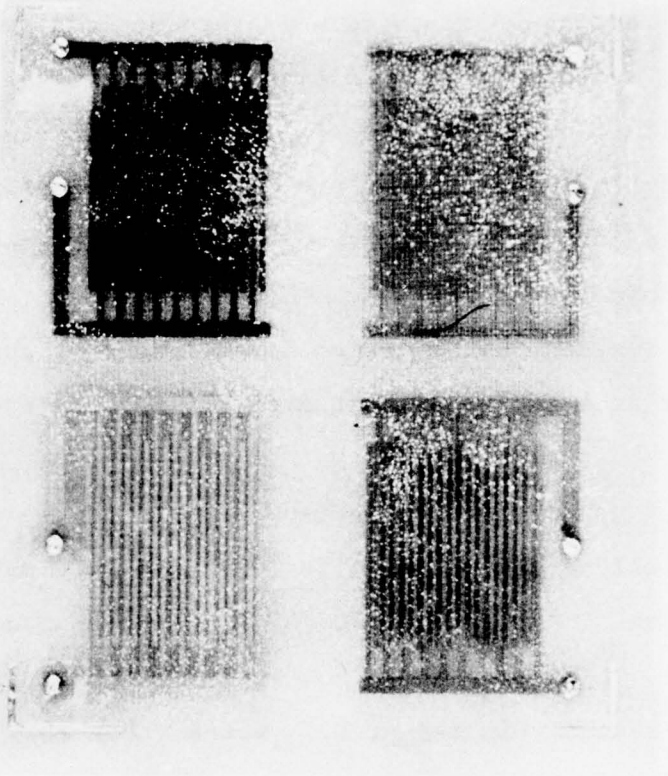

UNIVERSAL LOGIC
TYPE











GUIDELINE
PRINTED CIRCUIT BOARD ASSEMBLY
CLEANING PROCEDURE

This procedure was established in mid 1972 by consolidating procedures from many contractor sources; by creating a composite procedure; and by testing; by using it on production programs and modifying as necessary to refine the procedure. It is offered as an excellent starting point to set-up a production line and almost certainly will require slight modification to suit the product conditions. The usual precautions such as not cleaning aluminum parts with trichloroethanes, not scrubbing components so as not to remove the date codes; proper masking; proper racking etc, are not discussed in this procedure:

* Vapor degrease by immersion in boiling sump for 1½ minutes, raise to vapor area and spray both sides 15 seconds each, immerse in cool sump.

* After touch-up, repeat above.

* Mix alkaline detergent (5 to 10%) with D.I. water, starting with 5% solution. Heat to 115° to 130°F, immerse assembly and soak one minute.

* Rinse assembly in tap or D.I. water, then soak in D.I. water for one minute.

* Immerse assembly in Isopropyl alcohol at room temperature and soak for three minutes. During this time, period scrub both sides in all directions, except for I.C. devices.

* Place assembly in a new bath of Isopropyl alcohol, also at room temperature; immerse rinse for 30 seconds.

* Rinse, then soak assembly in D.I. water (200,000 ohms minimum) for one minute.

* Rack-mount assembly in drying chamber at 185°F ± 10 for two hours.

* Remove assembly mask and conformal coat both sides within two hours after removal from drying chamber. If two hours is exceeded, re-dry.

* Air-dry assembly (room ambient) for 30 minutes, then place in drying chamber at 185°F ± 10 for 30 minutes to post cure conformal coating. Caution - do not use the same drying chamber as used prior to conformal coating.

* Remove masking materials, cool to room temperature and place assembly in protective plastic package until further processing.

GEORGE A. SMITH
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APPENDIX E

PRINTED WIRING BOARD PROBLEMS
UHF RECEIVER SUBSYSTEM

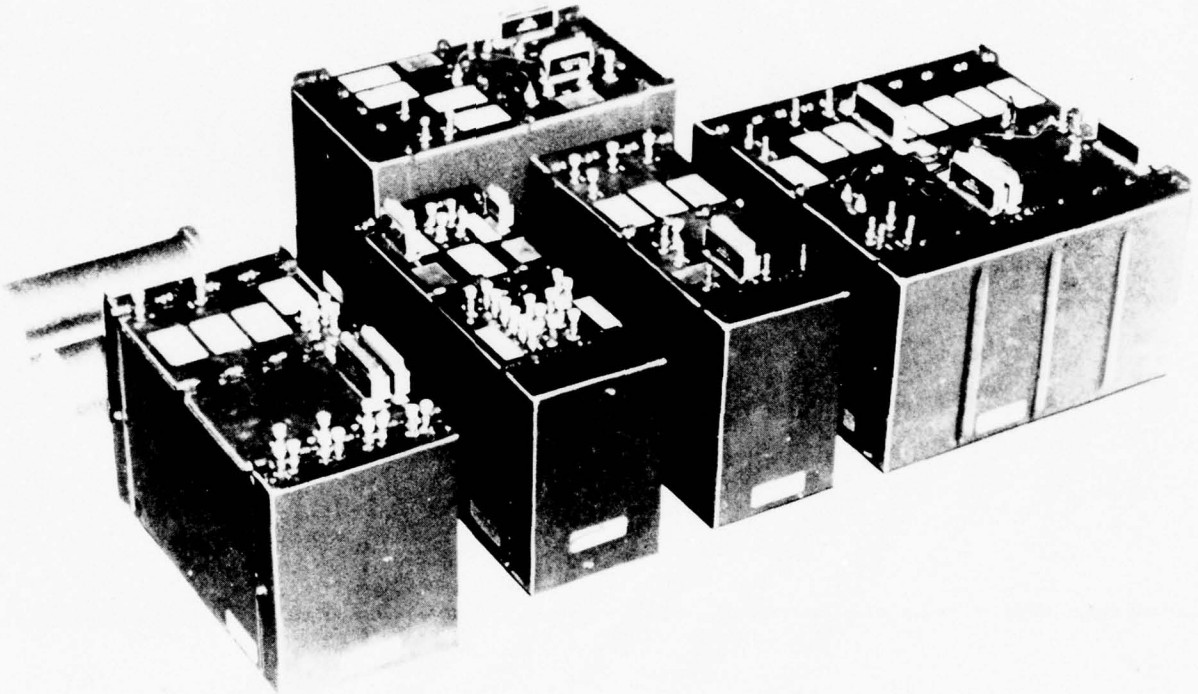
T. Long and H. Snyder
ECI Division, E-Systems, Inc.

FLTSATCOM
UHF RECEIVER

DEFINITION OF THE PROBLEM

- TYPICAL HARDWARE
- DEFECT DEFINITION
- DEFECT MICROSECTIONS

UHF RECEIVER SUBSYSTEM



PRINTED WIRING BOARD PROBLEMS

- PROBLEM DEFINITION
- PROBLEM OCCURRENCE
- MIL-P-55110 REQUIREMENTS
- IMPACT OF PROBLEM
- PROPOSED SOLUTION
- ANALYSIS
- PROOF TEST
- CONCLUSIONS
- PROCUREMENT SPECIFICATION UPDATE

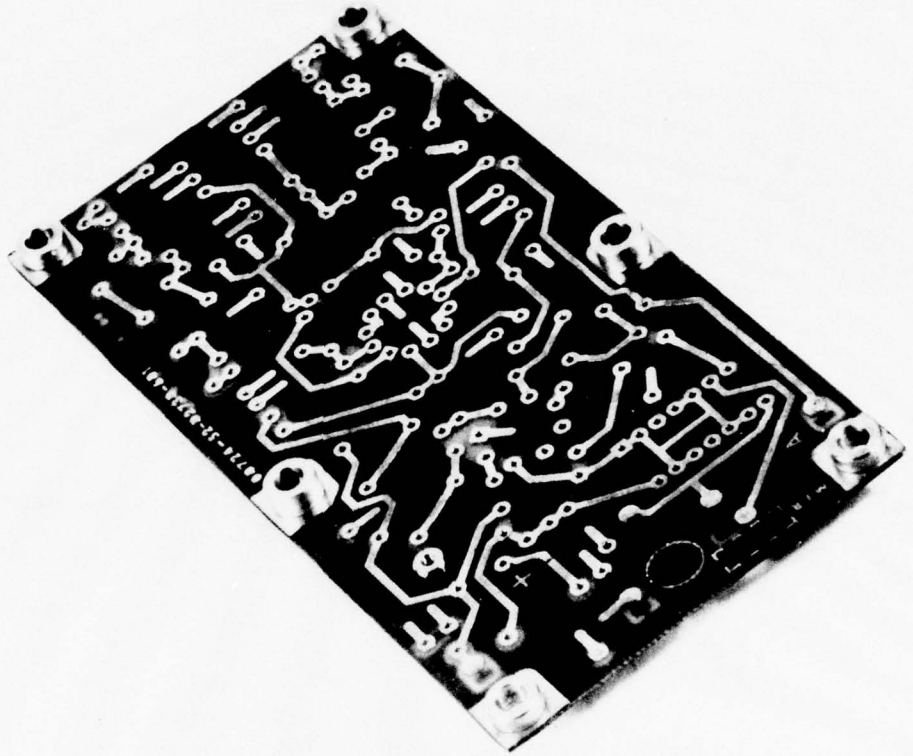
PRINTED WIRING BOARD PROBLEM

- BRAND "X" 2-SIDED PRINTED WIRING BOARDS
  - ALL BOARD THICKNESSES EXHIBIT
    - CRACKED BARRELS
      FRACTURED P-T-H
      CRACKED ANNULAR RING
  - DEFECT CAUSE
    - BARREL THICKNESS (COUPON MEET SPEC, ONE LOT < 0.0004)
    - EPOXY SMEAR (INADEQUATE CLEANING)
    - BRITTLE PLATING (POOR DUCTILITY)

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DEFECTIVE PRINTED WIRING BOARD

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UHF RECEIVER

DEFECTIVE PRINTED WIRING BOARD

- DELIVERY FROM MANUFACTURER [redacted]

52-02700 400X



#3 Left bottom

52-02700 400X



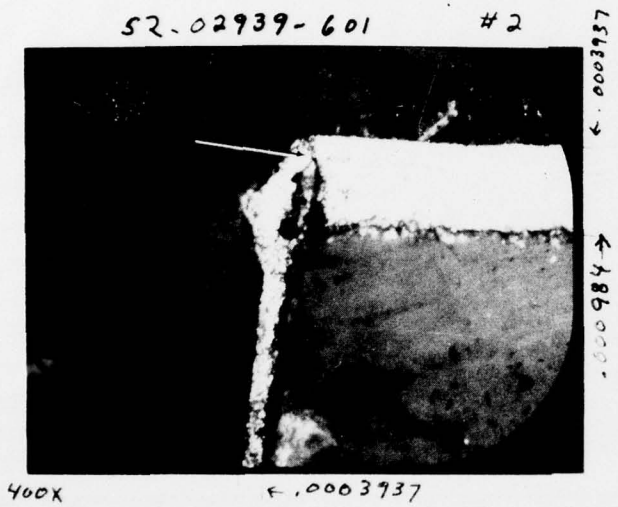
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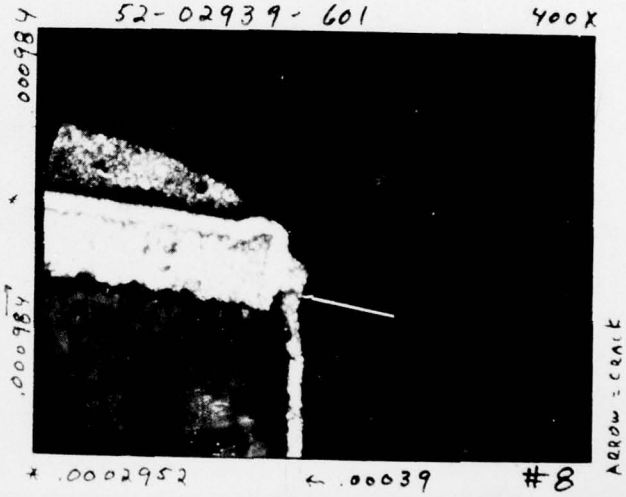
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ECI Division

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UHF RECEIVER

DEFECTIVE PRINTED WIRING BOARD

- CRACKED PLATED-THROUGH-HOLE

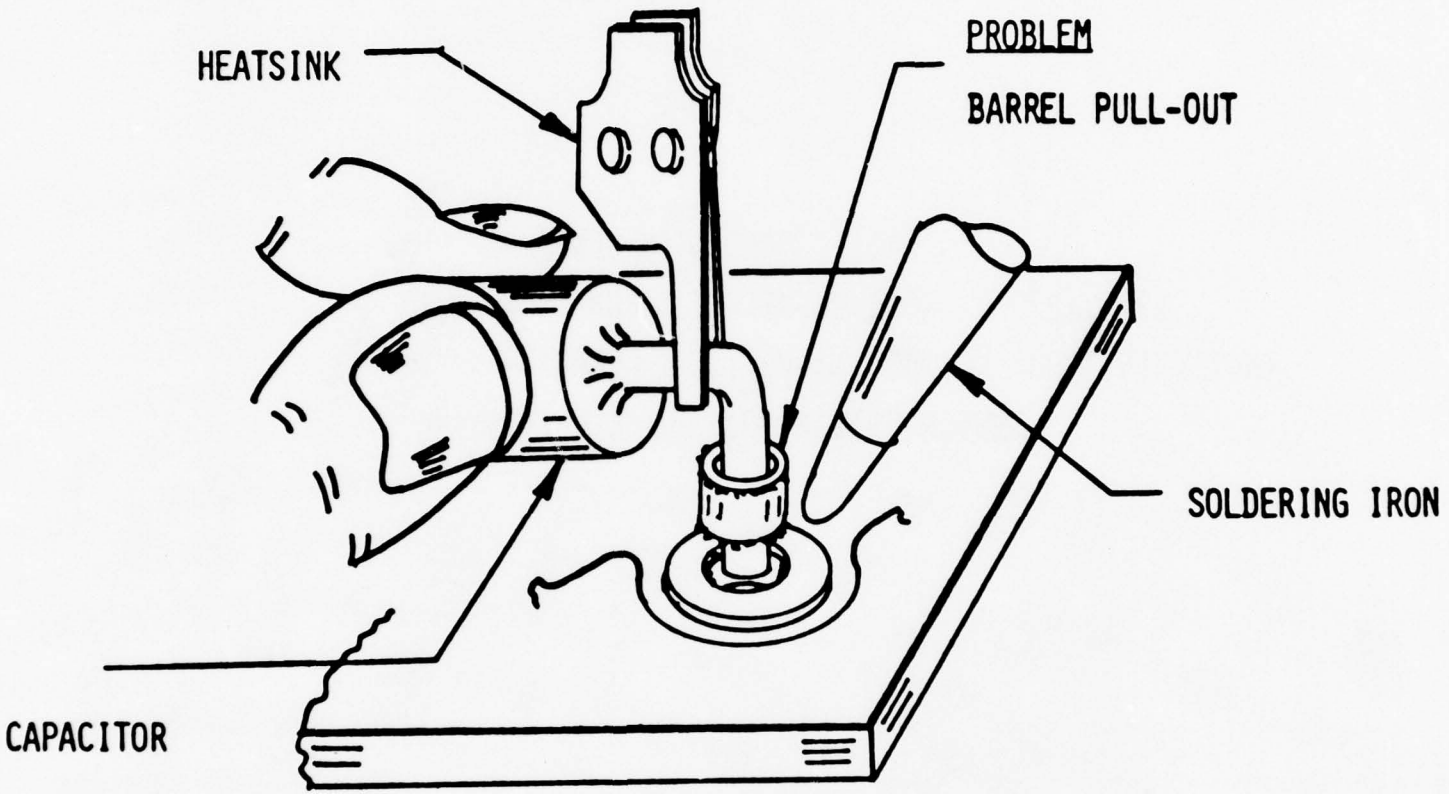




PROBLEM HISTORY

- PROBLEM OCCURRENCE
- SPECIFICATION COMPLIANCE
- POTENTIAL IMPACT

PLATED THROUGH HOLE PROBLEM OCCURRENCE



COMPONENT REMOVAL

- DEFECTIVE PRINTED WIRING BOARDS
  - PREPRODUCTION INSPECTION (QUALIFICATION)
  - PRODUCTION INSPECTION (ACCEPTANCE)
  - COUPON MICROSECTION*

*NOT A MIL-P-55110 REQUIREMENT

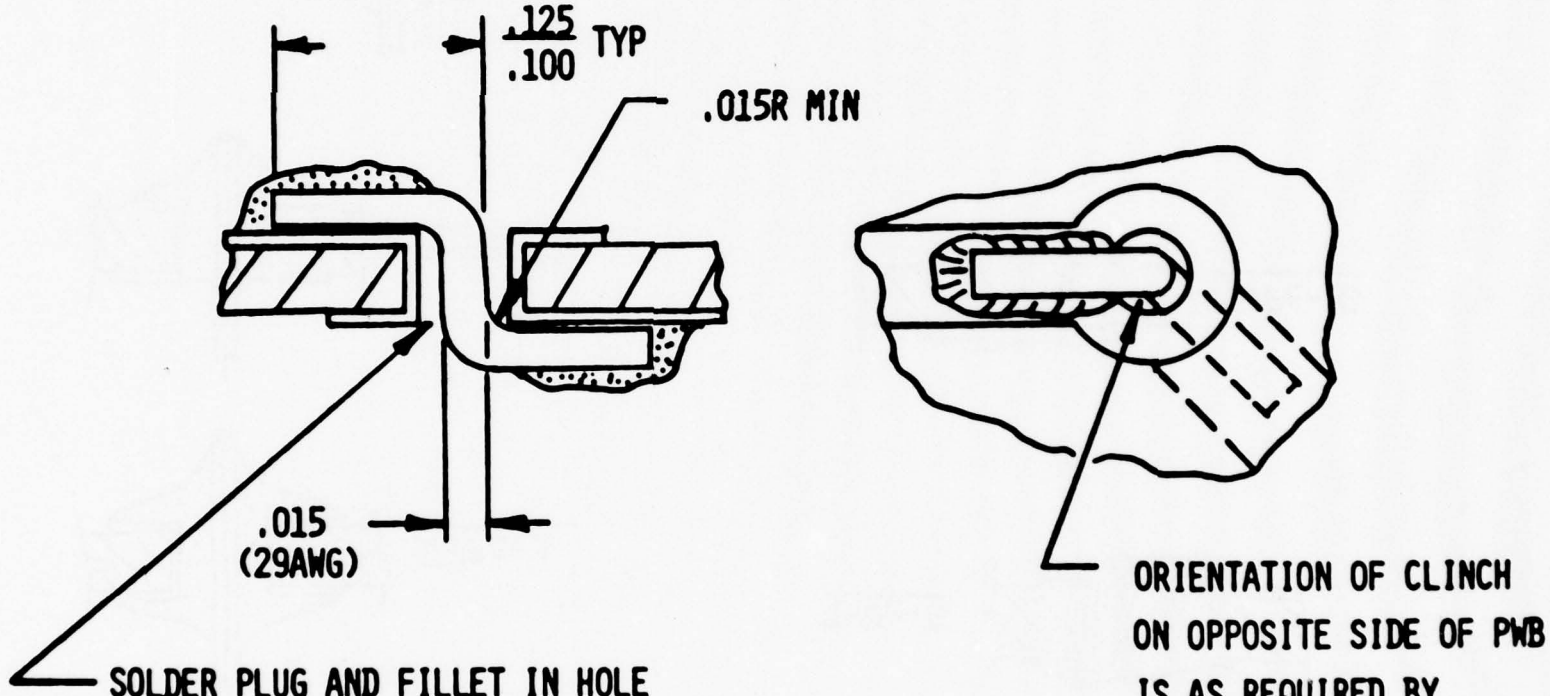
DEFECTIVE PRINTED WIRING BOARD IMPACT

- SUBSYSTEM DELIVERY
  - FLIGHT 1 — 4 TO 6 MONTHS DELAY
  - FLIGHT 2 — 3 TO 5 MONTHS DELAY
  - FLIGHT 3 — 1 TO 3 MONTHS DELAY
- PROGRAM COST

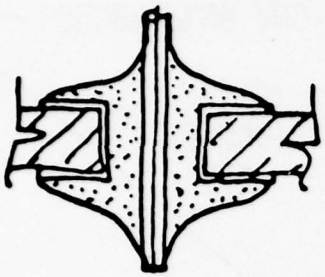
PROPOSED SOLUTION TO DEFECTIVE PRINTED WIRING BOARD P-T-H

- SOLDER JOINT CONFIGURATIONS
- DESIGN ANALYSIS
- PROOF TEST
- RESULTS
- PWB (2-SIDED) PROCUREMENT SPEC

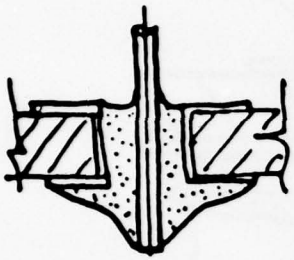
PROPOSED INTERFACIAL CONDUCTOR CONFIGURATION



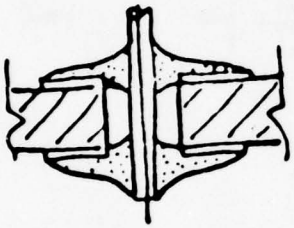
SOLDER JOINT/PLATED THROUGH HOLE CONFIGURATIONS CONSIDERED



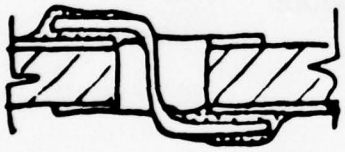
TYPE-1



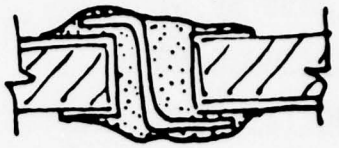
TYPE-2



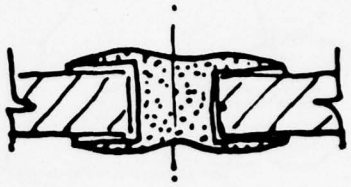
TYPE-3



TYPE-4



TYPE-5



TYPE-6

PROPOSED SOLDER JOINT/LEAD ANALYSIS

- ENVIRONMENTAL REQUIREMENTS
- STRESS LIMIT CRITERIA
- STRESS ANALYSIS

RECEIVER ENVIRONMENTAL REQUIREMENTS

TEMPERATURE & VIBRATION

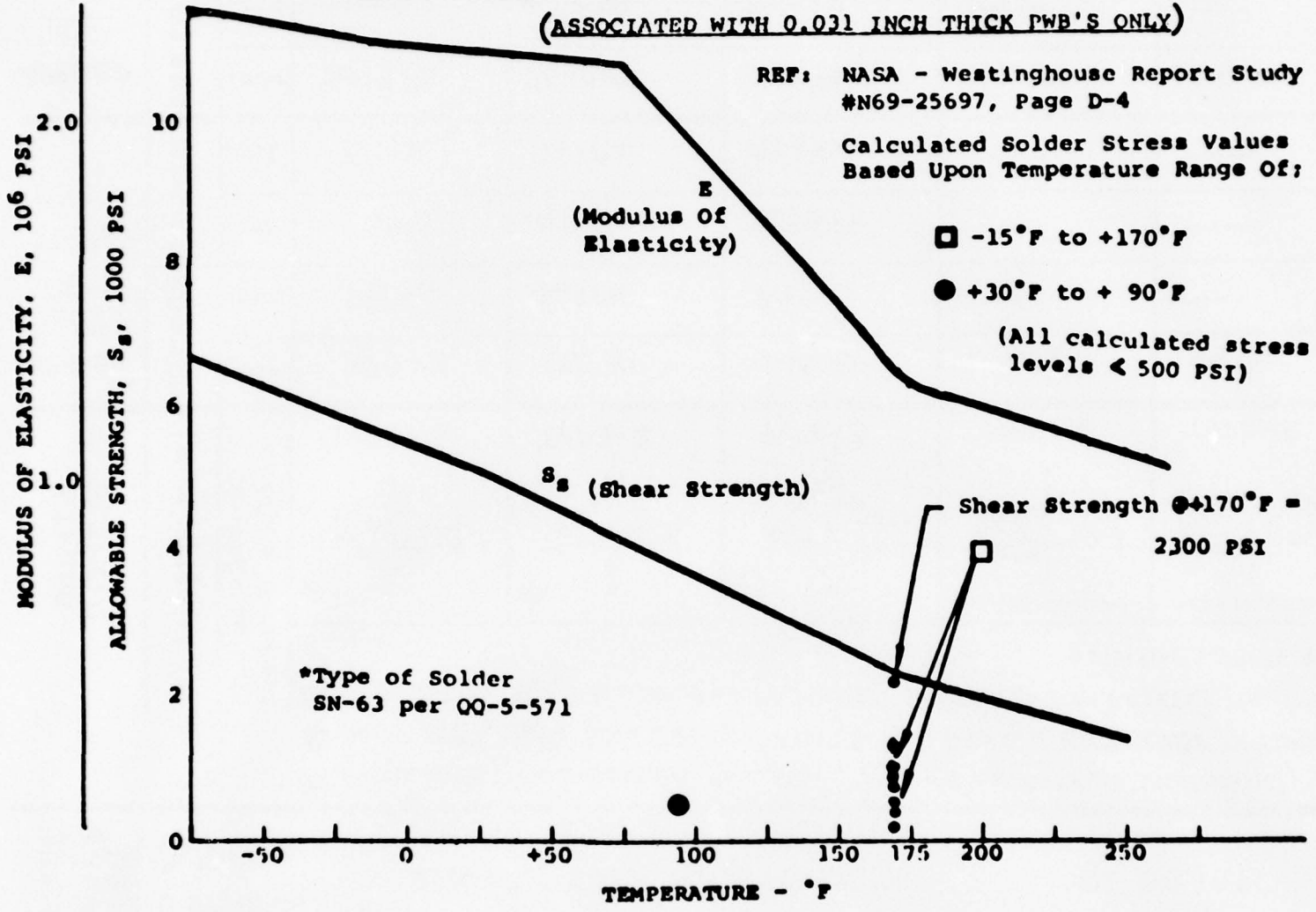
TEMP	QUAL	ACCEP
OP	0 - 130°F	10 - 120°F
NOP	0 - 150°F	0 - 150°F
STOR	0 - 150°F	0 - 150°F

VIB		
RANDOM	21 G'S RMS	10.5 G'S RMS
(3 AXES)	3 MIN/AXIS	1 MIN/AXIS

SOLDER JOINT STRESS LIMIT

VARIATIONS IN SOLDER* MECHANICAL PROPERTIES DUE TO TEMPERATURE VARIATIONS

(ASSOCIATED WITH 0.031 INCH THICK PWB'S ONLY)

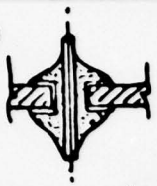
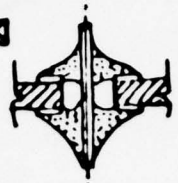


E-SYSTEMS
ECI Division

FLTSATCOM
UHF RECEIVER

SUMMARY OF STRESS VALUES FOR VARIOUS TYPES OF SOLDER JOINT CONFIGURATIONS

* INDICATES 100% SOLDER-FILL "PTH", FILLET ON CIRCUIT SIDE ONLY.
● INDICATES 100% SOLDER-FILL "PTH"; & FILLETS ON BOTHSIDES OF PWB.
⊠ INDICATES NO SOLDER-FILL (ASSUMES FRACTURED "PTH" BARREL), FILLETS BOTHSIDES OF PWB.

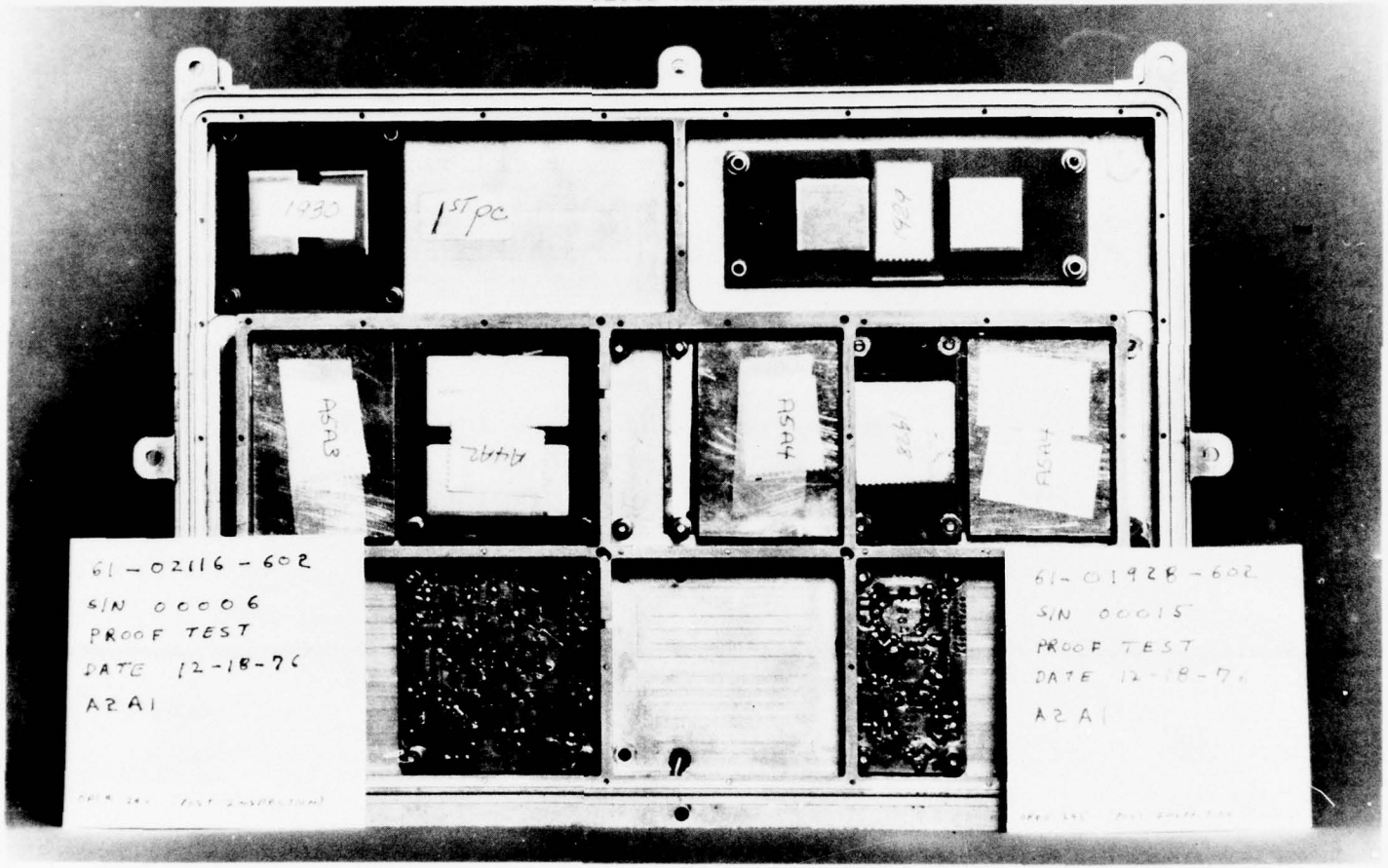
STRESS ELEMENT	LEAD MATERIAL	CONFORMAL COATING THICKNESS	●  TYPE-1	*  TYPE-2	⊠  TYPE-3	INTERFACIAL  TYPE-4	INTERFACIAL  TYPE-5
APPLIED SOLDER SHEAR STRESS (PSI)	COPPER	.000	273 PSI	657 PSI	616 PSI	476 PSI	199 PSI
		.002	147 PSI	465 PSI	249 PSI	—	—
	KOVAR	.000	878 PSI	1411 PSI	2264 PSI	—	—
		.002	510 PSI	743 PSI	974 PSI	—	—
APPLIED LEAD WIRE STRESS (PSI)	COPPER	.000	3019 PSI	5680 PSI	3920 PSI	3046 PSI	3490 PSI
		.002	—	4018 PSI	1584 PSI	—	—
	KOVAR	.000	10064 PSI	12147 PSI	12805 PSI	—	—
		.002	—	6650 PSI	5506 PSI	—	—

SOLDER JOINT/P-T-H PROOF TEST

- CANDIDATE PRINTED WIRING BOARDS
- JOINT CONFIGURATIONS
- TESTS
- ACCEPTANCE CRITERIA
- RESULTS

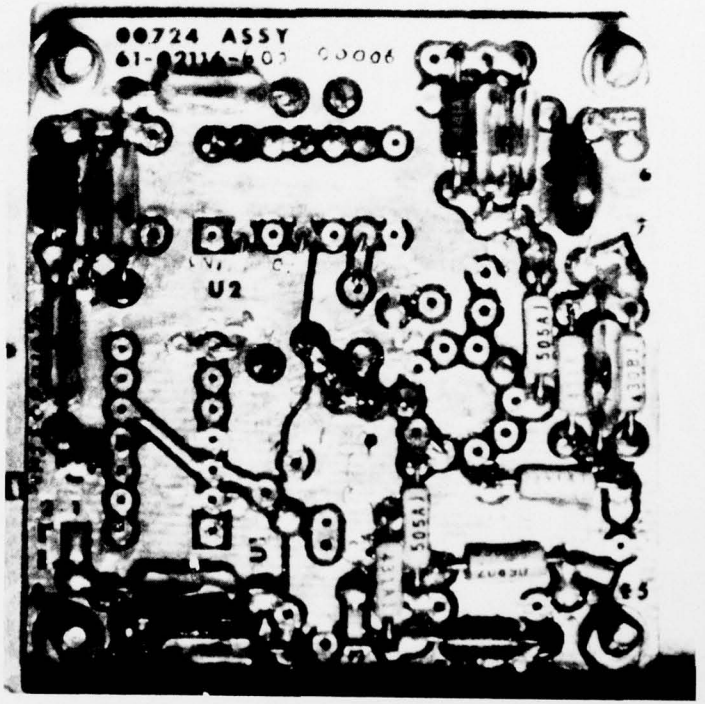
PRINTED WIRING BOARD PROBLEM

SLICE ASSEMBLY



PROOF TEST PRINTED WIRING BOARDS

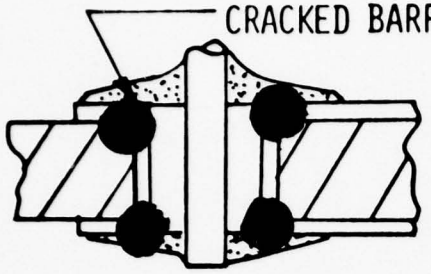
- MANUFACTURERS
  - BRAND "X" (6)
  - BRAND "Y" (2)

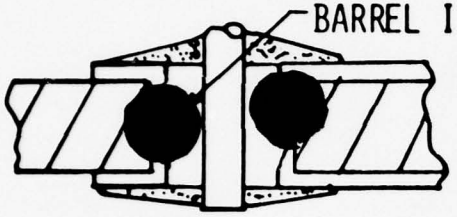


TEST BOARD

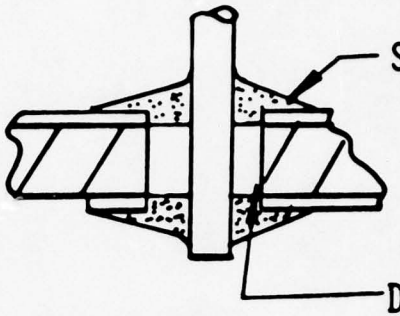
PROOF TEST JOINT CONFIGURATIONS

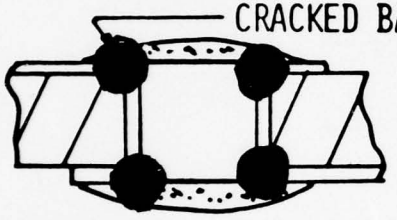
PROBLEMS

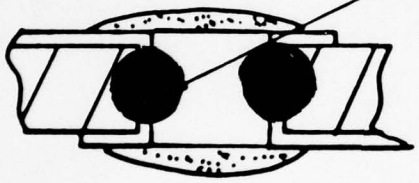


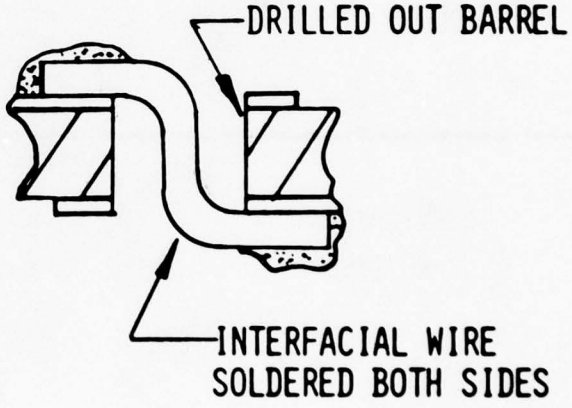


REWORK AND PROBLEM SIMULATIONS:









PROOF TESTS

- 10 (STANDARD) THERMOCYCLES FROM -21°C TO +71°C (-6° F TO 160° F)
- SIMULATE COATING CURE AT 140±5°F FOR 4 HOURS TIME
- QUALIFICATION LEVEL RANDOM VIBRATION FOR 3 MIN, 3 AXES, 21 G'RMS OVERALL
- 40 THERMOCYCLES FROM -15 TO 170°F (7 TO 9°F/MIN)
- 100 THERMOCYCLES FROM +30°F TO 90°F (7 TO 9°F/MIN)
- 100 TO 200 THERMOCYCLES FROM +30°F TO 90°F (7 TO 9°F/MIN)
- 200 TO 400 THERMOCYCLES FROM +30°F TO 90°F (7 TO 9°F/MIN)
- 400 TO 600 THERMOCYCLES FROM +30°F TO 90°F (7 TO 9°F/MIN)

PROOF TEST ACCEPTANCE CRITERIA

- NO SOLDER JOINTS EXHIBIT CRACKS AFTER 400 THERMOCYCLES
- SOLDER JOINT CRACKS $<360^{\circ}$ AROUND LEADS
- 360° CRACKS PROVIDED CONTINUITY IS ASCERTAINED OVER TEMPERATURE RANGE

PROOF TEST RESULTS

- NO SOLDER JOINT CRACKS EXHIBITED THROUGHOUT COMPLETE 600 THERMOCYCLE TESTING.

NEW PWB PROCUREMENT SPECIFICATION 88-00107

- SOLDER FLOAT AND MICROSECTION (ACTUAL HARDWARE)
- PLATED THROUGH HOLE REWORK STRENGTH (MICROSECTION-ACTUAL HARDWARE)
- DRILL USEAGE (LIMITATION)
- SAMPLE TESTING OF ACTUAL HARDWARE
- FIRST AND LAST DRILLS IN COUPON
- DEFECT DEFINITION

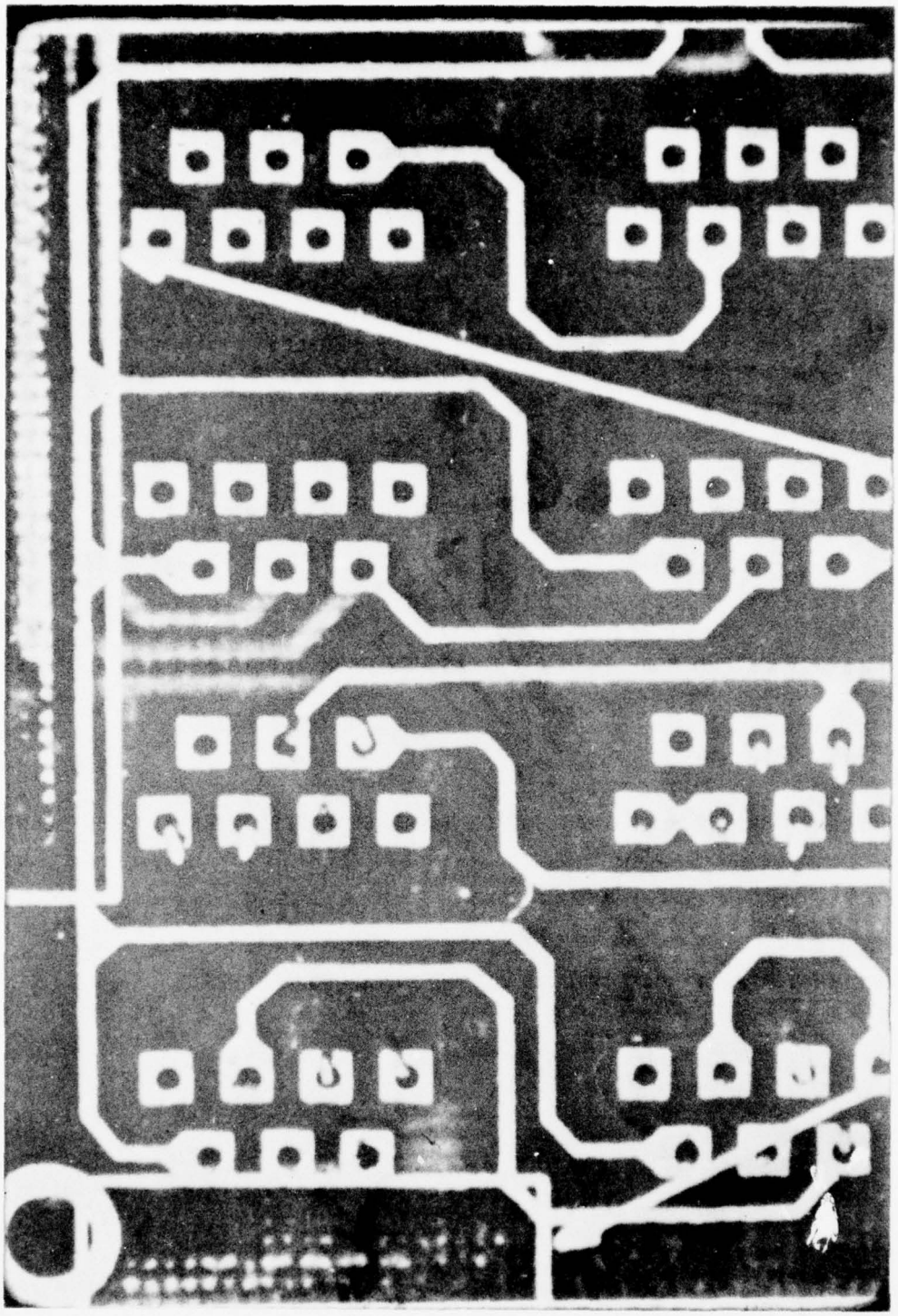
APPENDIX F

MEASLING - CAUSES AND EFFECTS

R. Douglas
TRW Defense and Space Systems

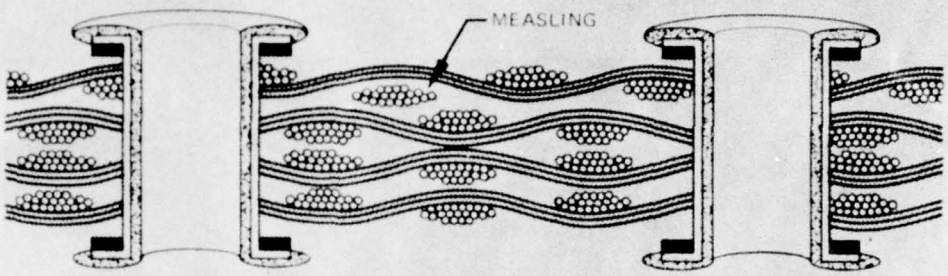
ACCEPTANCE CRITERIA FOR MEASLES

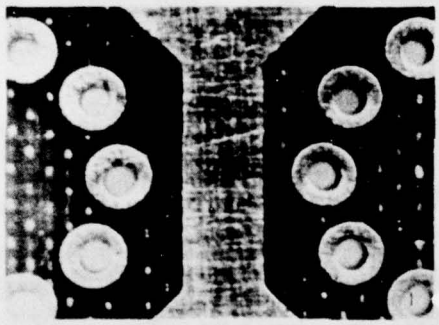
- SHALL NOT BE CONTINUOUS BETWEEN CONDUCTIVE AREAS.
- SHALL NOT EXTEND MORE THAN 0.031 INCHES FROM INITIAL POINT OF STRESS.
- SHALL NOT BRIDGE MORE THAN 50% OF THE DISTANCE BETWEEN ADJACENT CONDUCTORS.
- SHALL NOT AFFECT MORE THAN 3% OF THE TOTAL BOARD AREA.

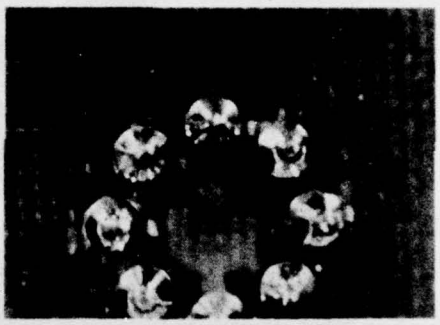


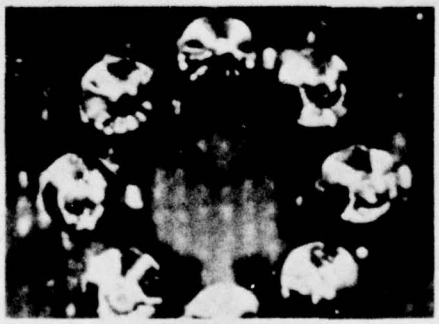
Identification of
MEASLES

MEASLING — A condition existing in the base laminate in the form of *discrete* white spots or "crosses" *below* the surface of the base laminate, reflecting a separation of fibres in the glass cloth *at* the weave intersection.







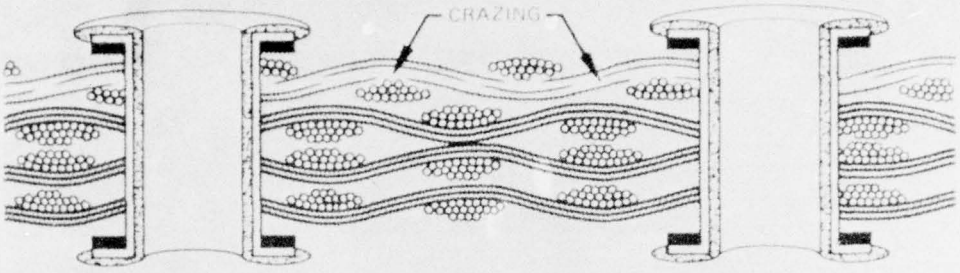


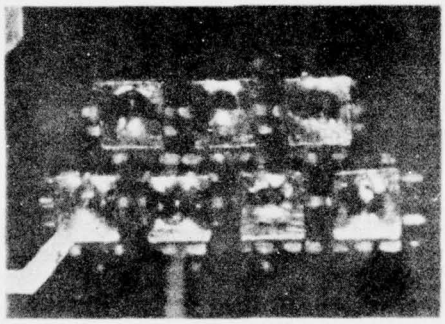


Identification of

CRAZING

CRAZING – A condition existing in the base laminate in the form of *connected* white spots or "crosses" *on or below* the surface of the base laminate, reflecting the separation of fibres in the glass cloth and *connecting* weave intersections.







APPENDIX G

HYSOL COATINGS

D. Van Farrell
Honeywell, Inc.

Honeywell

AVIONICS DIVISION

ST. PETERSBURG, FLORIDA

ITEMS TO BE PRESENTED:

- INSPECTION PRIOR TO, DURING AND AFTER REWORK
- SEQUENTIAL REMOVAL
- COATING REMOVAL/RE-APPLICATION
- REMOVAL AND REPLACEMENT OF COMPONENTS
- ADDING TO THE CIRCUIT

INSPECTION PRIOR TO, DURING AND AFTER REWORK

- INSPECTION PRIOR TO REWORK:

  VISUAL INSPECTION IS PERFORMED ON DISCREPANT PART OR SUBASSEMBLY PRIOR TO REMOVAL OR DISTURBING OF THE DISCREPANT HARDWARE. THE REPORTED NONCONFORMANCE WILL DICTATE THE DEGREE AND TYPE OF INSPECTION NECESSARY.

- INSPECTION DURING REWORK

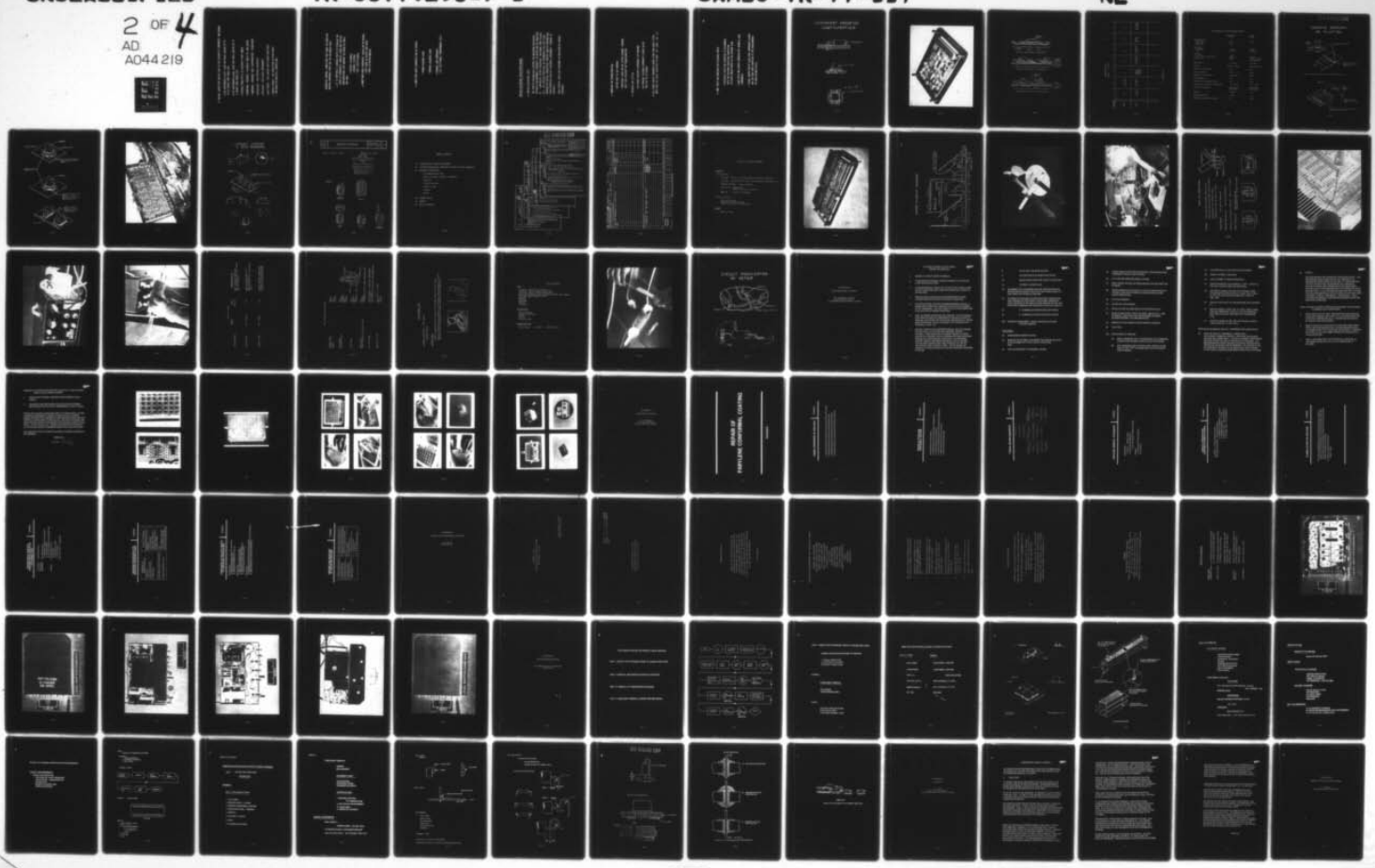
  - DUE TO THE COMPLEXITY OF THE HARDWARE BEING REWORKED, IN-PROCESS INSPECTIONS WILL BE REQUIRED FOR ANY ITEM THAT MAY BE COVERED UP AND WILL NOT BE VISIBLE AT FINAL INSPECTION. THIS IN-PROCESS INSPECTION MAY INCLUDE DCAS/CUSTOMER.

- INSPECTION AFTER REWORK

  - INSPECTION OF REWORK MUST MEET THE CRITERIA ESTABLISHED PER FIRST PASS BUILD. ANY DEVIATION FROM PRINT AS A RESULT OF REWORK MUST HAVE PRIOR MATERIAL REVIEW BOARD APPROVAL.

AD-A044 219 AEROSPACE CORP EL SEGUNDO CALIF F/G 9/5
PROCEEDINGS OF THE CONFERENCE ON REWORK AND REPAIR OF PRINTED C--ETC(U)
AUG 77 F04701-76-C-0077
UNCLASSIFIED TR-0077(2902)-1 SAMSO-TR-77-117 NL

2 OF 4
AD
A044 219



- SPECIAL INSPECTION TOOLING USED IN THE SALVAGE OF COMPONENTS AND REWORK

  - 0.3X SUPPLEMENTAL SCOPE LENSE FOR FOCAL LENGTHS UP TO 14-15 INCHES (MAX POWER 10X)
  - 0.5X SUPPLEMENTAL SCOPE LENSE FOR FOCAL LENGTHS UP TO 9 INCHES (MAX POWER 15X)
  - FLEXIBLE FIBER OPTIC 7X EYELOUPE 2 FEET LENGTH
  - DERMOTRON - MEASURES THICKNESS FROM 0 TO .004 INCHES
  - IONOGRAPH - MEASURES IONIC CONTAMINATION - CLEANLINESS
  - BLACKLIGHT - FOR COATING CONTINUITY
  - RETICULES - FOR VISUAL MEASUREMENT
  - HOLE SCOPES - FOR LOOKING INTO PLATED THRU HOLES
  - COAXIAL SCOPES - FOR INSPECTION OF BLIND HOLES
  - SEM-EDAX-FOR ANALYSIS; COMPOSITION

SEQUENTIAL REMOVAL (CONDITIONS THAT CAUSE THE NEED FOR REUSING COMPONENT PARTS AND THE RATIONALE USED).

- IT IS HONEYWELL'S GENERAL POLICY TO DISALLOW THE REUSE OF COMPONENTS, HOWEVER, THERE ARE CERTAIN CONSIDERATIONS THAT WARRANT THE REUSE OF PARTS. THEY ARE:
  - CONTRACT ALLOWABLE
  - SCHEDULE SLIPPAGE
  - COST EFFECTIVENESS
- CONDITIONS WHERE COMPONENTS SHOULD NOT BE REUSED:
  - PART LEADS IN PLATED THRU HOLES
  - PARTS IN POTTED MODULES

- CONDITIONS WHERE COMPONENTS MAY BE REUSED:

  - PLANAR SOLDERED LEADS

  - TERMINAL SOLDERED LEADS

  - FLEXABLE LEAD COMPONENTS
    (I.E. SLIP RINGS, TRANSFORMERS, ETC.)

SPECIAL ELECTRICAL TESTS AFTER REWORK

- SPECIAL ELECTRICAL TEST -

  THE TYPE OF FAILURE WILL DICTATE THE NECESSARY ELECTRICAL TESTING A SUB-ASSEMBLY, ASSEMBLY, OR DEVICE MAY BE SUBJECTED TO - CONTINUITY, HI-POT ISOLATION, FUNCTIONAL TEMP CYCLING, ETC. ALL SPECIAL TESTS WILL BE DOCUMENTED IN A TEST PLAN APPROVED BY DESIGN, PRODUCTION, PROCESS QUALITY ENGINEERING, OTHER APPROVALS SUCH AS (CUSTOMER, GOVERNMENT - DEPENDS ON CONTRACT).

  THESE SPECIAL TESTS ARE PERFORMED OR MONITORED BY PRODUCT ASSURANCE.

- REMOVING FOR TROUBLESHOOTING
  - ENTIRE PART IS NOT REMOVED
  - INDIVIDUAL LEADS MAY BE LIFTED (PLANAR TERMINAL ONLY) AND ISOLATED FOR TROUBLESHOOTING
- CRITERIA FOR LIFTING
  - ON PLANAR SOLDERED COMPONENTS 15° MAXIMUM
  - ON TERMINAL SOLDERED COMPONENTS STRESS RELIEF MUST NOT BE DISTURBED
- ALL GLASS SEALED COMPONENTS WHERE LEADS HAVE BEEN LIFTED MUST HAVE THE SEALS INSPECTED TO NASA - SR - QUAL - 66 - 21.

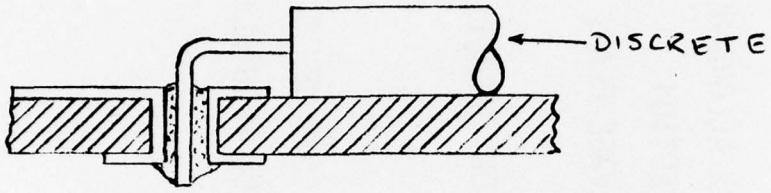
- WHAT TESTS ARE REQUIRED FOR SALVAGED PARTS?

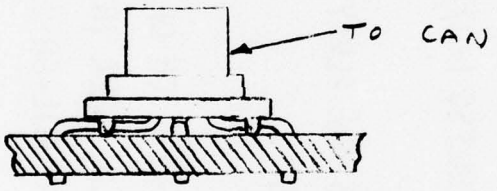
  - ELECTRICAL TESTS ARE CONDUCTED IN ACCORDANCE WITH THE ORIGINAL RECEIVING INSPECTION CRITERIA UNLESS NOTED IN THE SALVAGE PLAN.

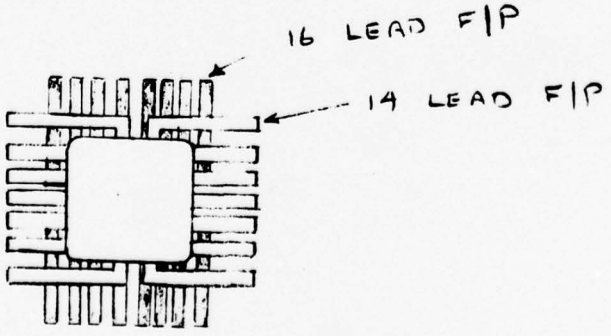
  - LEAK TESTS ARE ALWAYS CONDUCTED ON HERMETIC SEAL COMPONENTS.

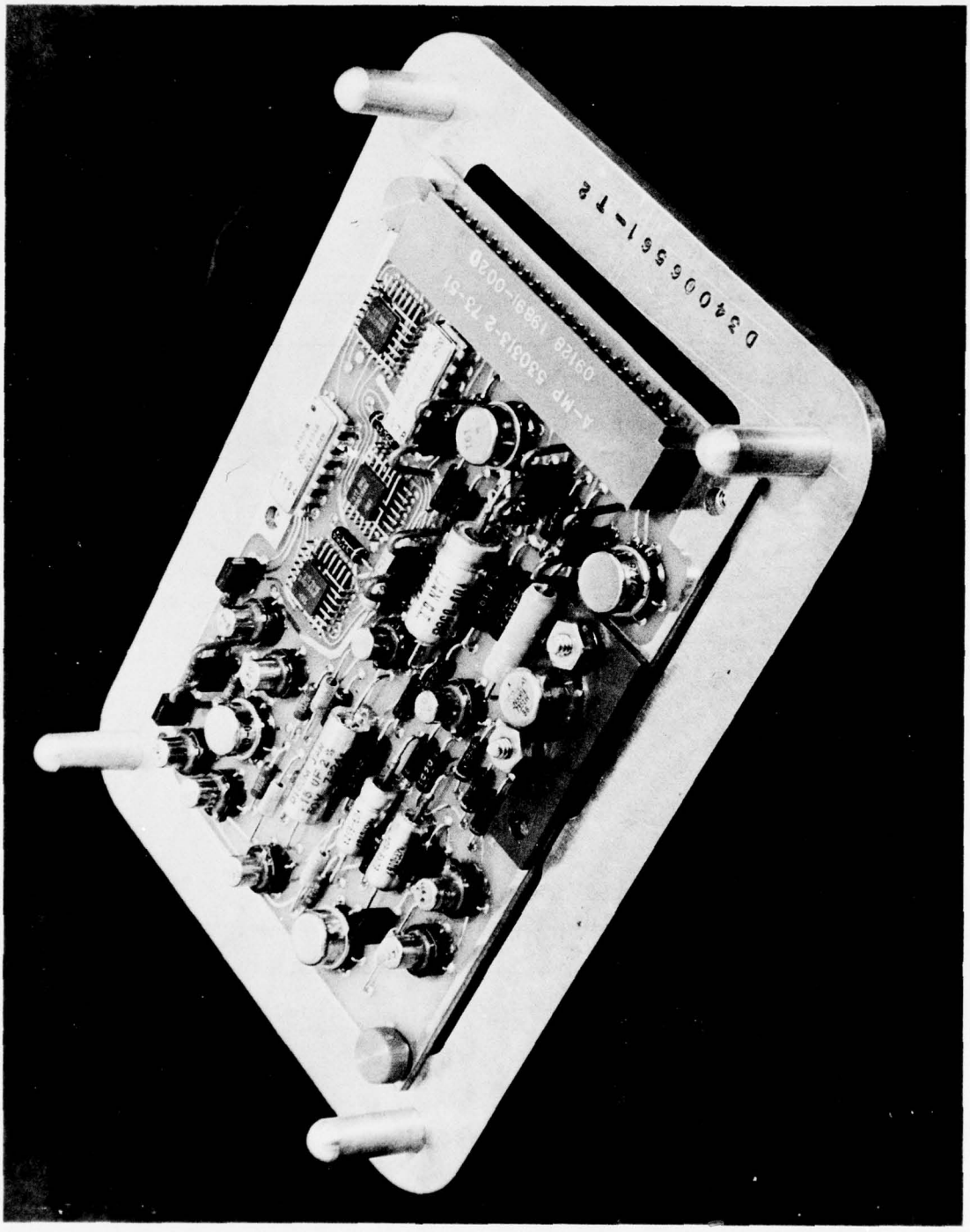
  - VISUAL INSPECTION OF GLASS SEAL COMPONENTS ALWAYS HAS THE SEAL AREA INSPECTED TO THE REQUIREMENTS OF NASA-SR-QUAL-66-21.

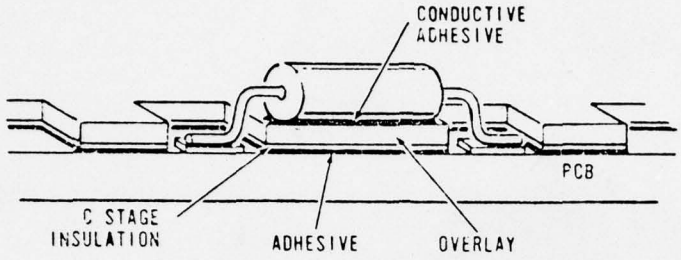
COMPONENT MOUNTING CONFIGURATION



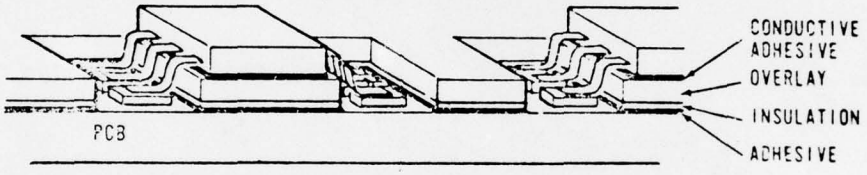




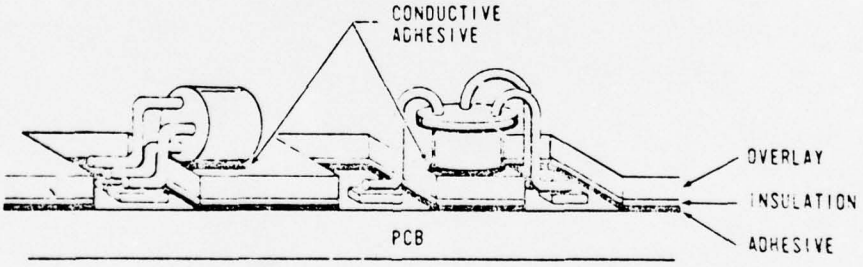

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A-MP 530313-2 73-51
09128 19891-0020



Discrete Mounting Configuration



Flatpack Mounting Configuration



Transistor Mounting Configuration

PROGRAM USAGE

(BOND & COAT)

PROGRAM	A	B	C	D	E	F	G
BOND	C7	C7 & EPON 828	C7	C7	C7	C7	C7
COAT	HYSOL PC 18	SOLITHANE 113	DEXTOR HYSOL LAMINAR X500	SOLITHANE 113	SOLITHANE 113	HYSOL PC 18	DC 3140 SILICONE

C7 = ARMSTRONG C7

CONFORMAL COATING PROPERTIES

	SOLITHANE 113	HYSOL PC 18
Formulation		
Resin (113)	56.6	PC 18
Catalyst	40.5	
Cab-o-Sil	2.9	
Pot Life		
Room Temp	6 Hrs.	8 Hrs.
-35 °F	14 Days	6 Months
Curing		
Room	2 Hrs.	
Plus 170°F (Tack Free)	3 Hrs.	1½ Hrs.
Full Cure	Room	8 Hrs @ 150°F (Hi-Humidity)
Application	2-6 Mils	1-3 Mils
Finish	Clear to Satin	Clear Hi Gloss
Viscosity (CPS Max)	200	450
Spec. Gravity	1.073	1.06
Adhesion (Grams Min.)	Excellent	3000
Elongation (%)	100	90
Dielectric Strength (V/mm)	350	1200
Insulation Resistance (Ohms Min)	2.5×10^{14}	2.5×10^{12}
Solvent Resistance	Good After Tack Free	Good After Full Cure
Harness	55-68A	—
Outgassing (RT)	.136%	—
Moisture Absorption (Water)	.2%	.46%

BEST AVAILABLE COPY

ADHESIVE BONDING OR FILLETING

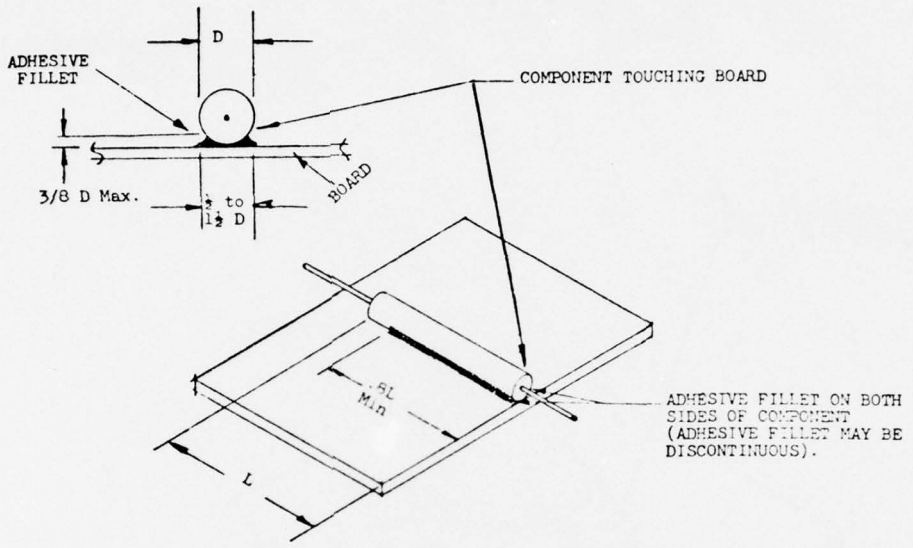
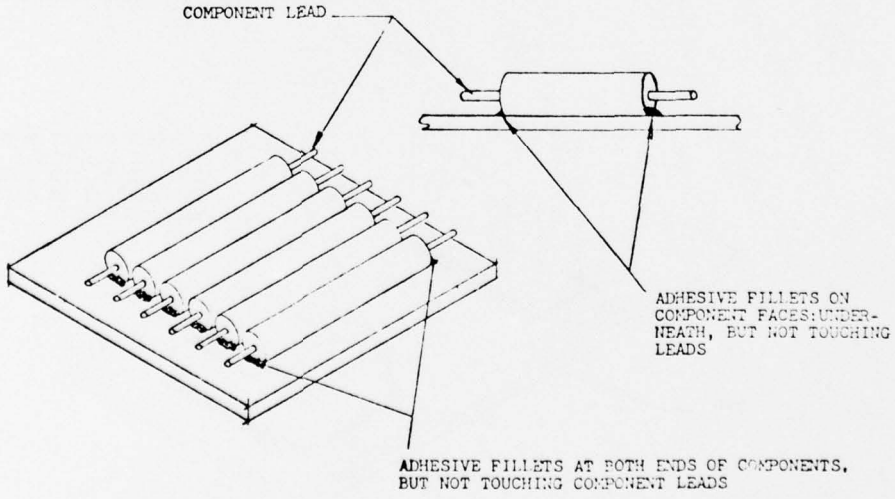
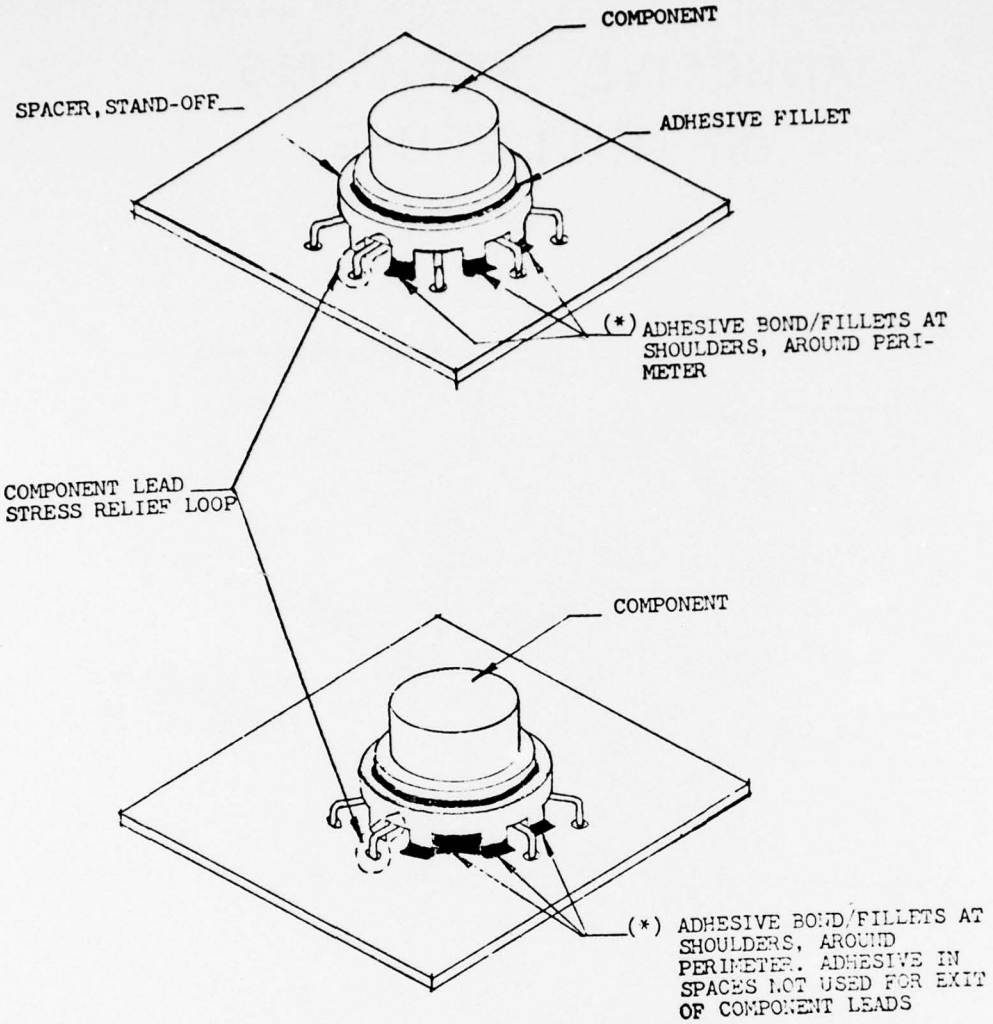
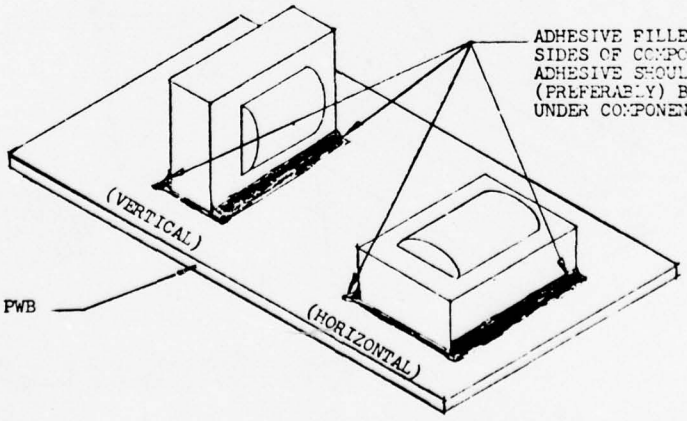
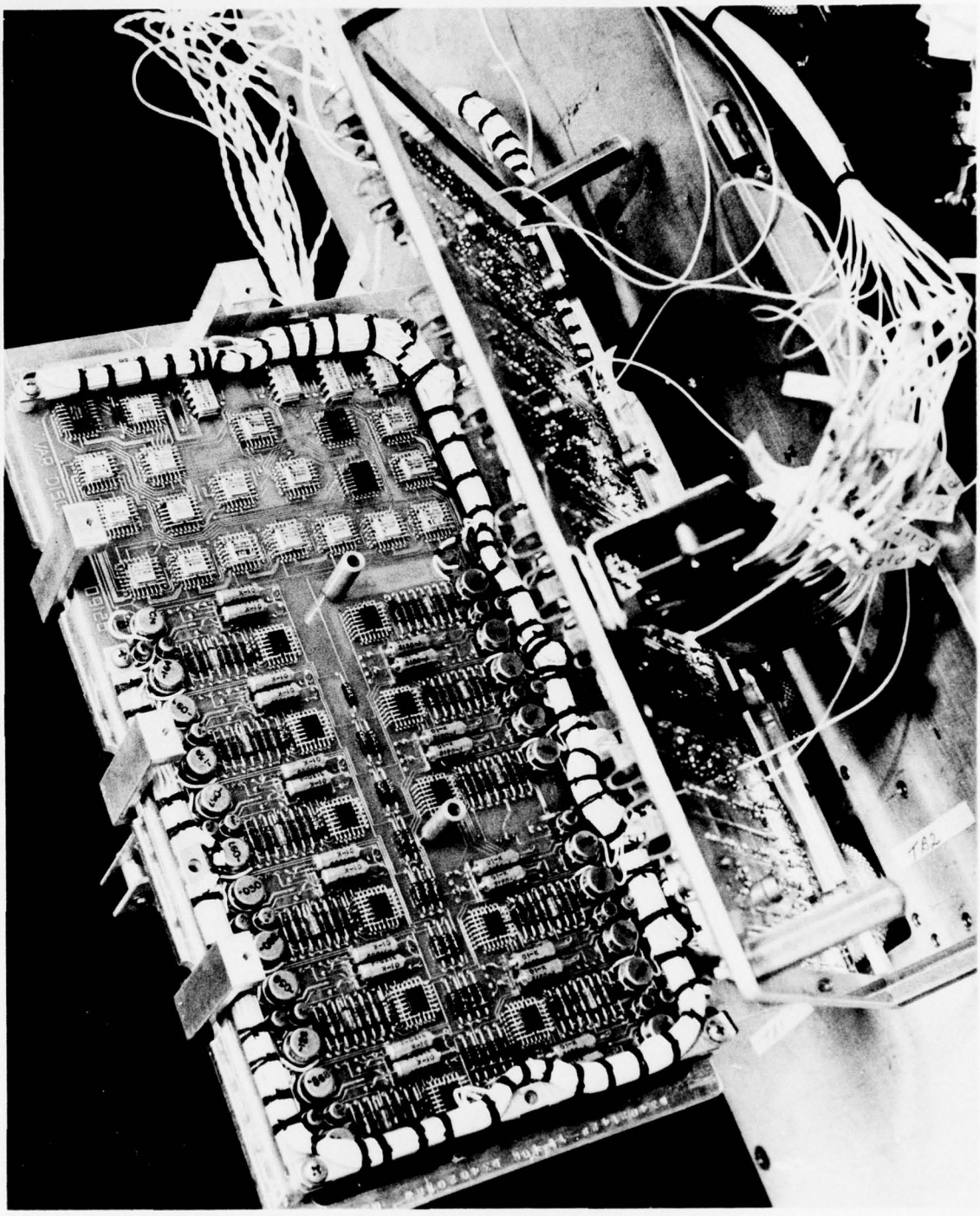


FIGURE 1: ADHESIVE BONDING CYLINDRICAL COMPONENTS (PREFERRED METHOD)

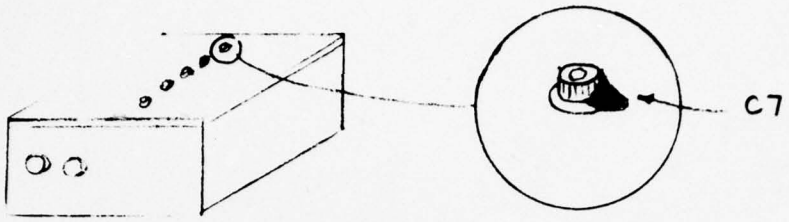


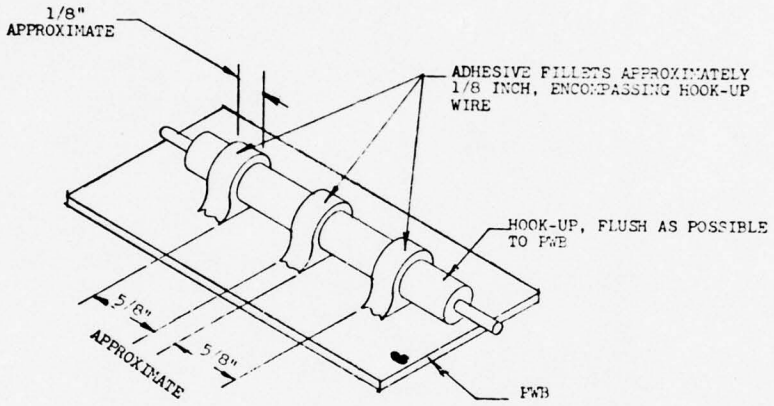

COMPONENT
SPACER, STAND-OFF
ADHESIVE FILLET
(*) ADHESIVE BOND/FILLETS AT SHOULDERS, AROUND PERIMETER
COMPONENT LEAD STRESS RELIEF LOOP
COMPONENT
(*) ADHESIVE BOND/FILLETS AT SHOULDERS, AROUND PERIMETER. ADHESIVE IN SPACES NOT USED FOR EXIT OF COMPONENT LEADS

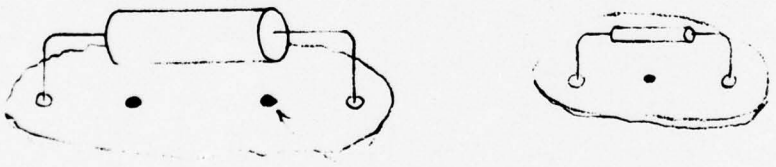

ADHESIVE FILLET BOTH SIDES OF COMPONENT. ADHESIVE SHOULD ALSO (PREFERABLY) BE USED UNDER COMPONENT
(VERTICAL)
PWB
(HORIZONTAL)



CEMENT STAKING & SPOT BONDING



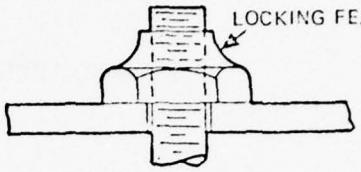








SELF LOCKING NUTS

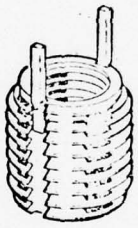


No drilled hole in screw, bolt or stud

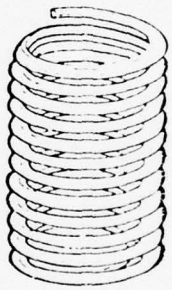
Screw, stud or bolt shall always extend past locking feature a minimum of:

- 1-1/2 full threads, for screws 48 or more threads per inch
- 0.03 inch minimum for screws less than 48 threads per inch

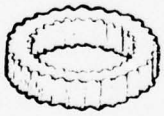
INSERTS



NEWTON (KEENSERT)



HELI-COIL

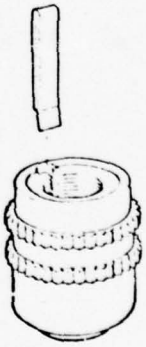




ROSAN



NYLOK

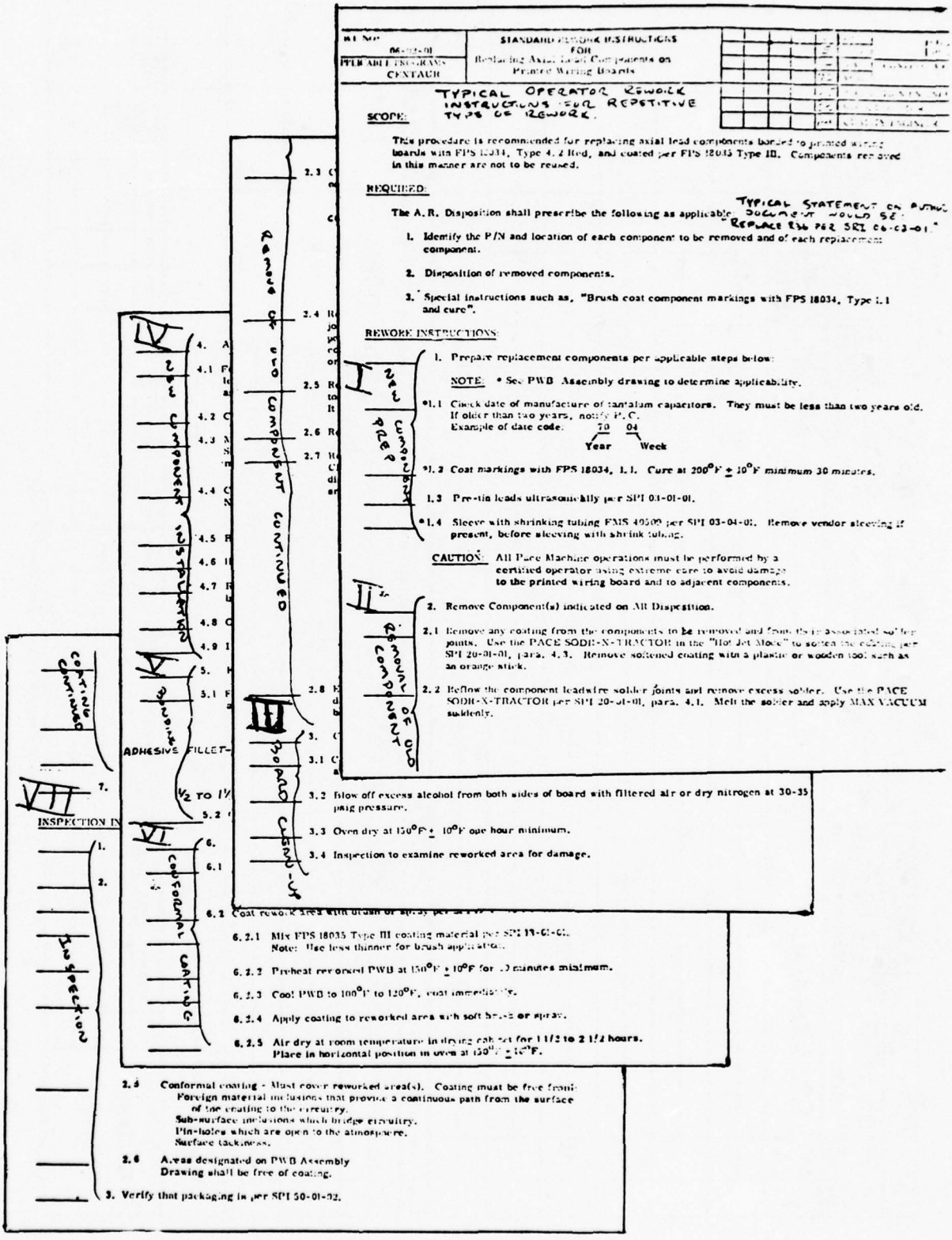


NEWTON (NICO-LOK)

REWORK APPROACH

- FURTHER FAULT ISOLATION REQUIRED
- FAILURE MECHANISM OF PART/PART FAILURE ANALYSIS REQUIRED
- OPERATOR INSTRUCTION
    - Prep Replacement Part
    - Remove Coating & Cement & Component
    - Clean-Up
    - Install New Part
    - Fillet & Coat
    - Inspect
    - Retest
- AUTHORIZATION
- REWORK
- RETEST SEQUENCE

BEST AVAILABLE COPY



M.I. No. 66-03-01	STANDARD REWORK INSTRUCTIONS FOR Replacing Axial Lead Components on Printed Wiring Boards
PTEB ABLE PROGRAMS CENTAUR	

TYPICAL OPERATOR REWORK INSTRUCTIONS FOR REPETITIVE TYPE OF REWORK.

SCOPE:

This procedure is recommended for replacing axial lead components bonded to printed wiring boards with FPS 18034, Type 4.2 Red, and coated per FPS 18035 Type III. Components removed in this manner are not to be reused.

REQUIRED:

The A.R. Disposition shall prescribe the following as applicable. TYPICAL STATEMENT ON PURCH. DOCUMENT WOULD BE: "REPLACE R36 PER SPI 66-03-01"

1. Identify the P/N and location of each component to be removed and of each replacement component.
2. Disposition of removed components.
3. Special instructions such as, "Brush coat component markings with FPS 18034, Type I.1 and cure".

REWORK INSTRUCTIONS:

I. NEW COMPONENT PREP

1. Prepare replacement components per applicable steps below:

NOTE: * See PWB Assembly drawing to determine applicability.

*1.1 Check date of manufacture of tantalum capacitors. They must be less than two years old. If older than two years, notify P.C.
Example of date code: 70 (Year) 04 (Week)

*1.2 Coat markings with FPS 18034, I.1. Cure at 200°F ± 10°F minimum 30 minutes.

1.3 Pre-tin leads ultrasonically per SPI 03-01-01.

*1.4 Sleeve with shrinking tubing FMS 40500 per SPI 03-04-01. Remove vendor sleeving if present, before sleeving with shrink tubing.

CAUTION: All Pace Machine operations must be performed by a certified operator using extreme care to avoid damage to the printed wiring board and to adjacent components.

II. REMOVAL OF OLD COMPONENT

2. Remove Component(s) indicated on Alt Disposition.

2.1 Remove any coating from the components to be removed and from their associated solder joints. Use the PACE SODR-X-TRACTOR in the "Hot Jet Mode" to soften the coating per SPI 20-01-01, para. 4.3. Remove softened coating with a plastic or wooden tool such as an orange stick.

2.2 Reflow the component leadwire solder joints and remove excess solder. Use the PACE SODR-X-TRACTOR per SPI 20-01-01, para. 4.1. Melt the solder and apply MAX VACUUM suddenly.

III. BOARD CLEAN-UP

3.1 Clean with alcohol per SPI 02-01-01.

3.2 Blow off excess alcohol from both sides of board with filtered air or dry nitrogen at 30-35 psig pressure.

3.3 Oven dry at 150°F ± 10°F one hour minimum.

3.4 Inspection to examine reworked area for damage.

IV. NEW COMPONENT INSTALLATION

4. Apply adhesive fillet ½ to 1½ [illegible]

4.1 Place component on adhesive fillet.

4.2 Cure adhesive per [illegible]

4.3 Solder component leads per SPI 20-01-01.

4.4 Clean with alcohol per SPI 02-01-01.

4.5 Remove excess solder.

4.6 Inspect solder joints per SPI 20-01-01.

4.7 Remove excess flux per SPI 02-01-01.

4.8 Clean with alcohol per SPI 02-01-01.

4.9 Inspect per SPI 20-01-01.

V. CONFORMAL COATING

5. Apply conformal coating per SPI 19-01-01.

5.1 Prepare coating per SPI 19-01-01.

5.2 [illegible]

VI. CONFORMAL COATING

6. Coat reworked area with brush or spray per SPI 19-01-01.

6.1 Mix FPS 18035 Type III coating material per SPI 19-01-01.
Note: Use less thinner for brush application.

6.2 Preheat reworked PWB at 150°F ± 10°F for 30 minutes minimum.

6.3 Cool PWB to 100°F to 120°F, coat immediately.

6.4 Apply coating to reworked area with soft brush or spray.

6.5 Air dry at room temperature in drying cabinet for 1 1/2 to 2 1/2 hours. Place in horizontal position in oven at 150°F ± 10°F.

VII. INSPECTION

1. [illegible]

2. Inspection

2.5 Conformal coating - Must cover reworked area(s). Coating must be free from:
Foreign material inclusions that provide a continuous path from the surface of the coating to the circuitry.
Sub-surface inclusions which bridge circuitry.
Pin-holes which are open to the atmosphere.
Surface tackiness.

2.6 Areas designated on PWB Assembly Drawing shall be free of coating.

3. Verify that packaging is per SPI 50-01-02.

H AVIONICS DIVISION ST. PETERSBURG, FLORIDA

AR ACTION REGISTER

1. PART NUMBER	2. REV.	3. S/N - L/N	5. INITIAL AR	6. AR NO.
34013967 -001	C	3P	—	071561

7. PART NAME	8. PGM	9.	33. AR CLOSED - STAMP DATE
OSCIL. COMP. BD. ASSY	CENT	SHEET 1 OF 1	

10. ITEM	11. WC OP	12. DESCRIPTION OF NONCONFORMANCE	13. INITIATOR	14. DEF. QTY.	15. CAUSE DEFECT	16. RTD	17. MR	18. OPERATOR NO.	19. M.I. INSP.	20. CUST/ GOV'T.
1	091	C4 CRACKED AT LEAD EXIT	J. Smith	1	00006		X			
	220				06070					

21. ITEM	22. MR INSTRUCTIONS	23. PROD. / PROD. ASSUR.	24. CORRECTIVE ACTION	25. OPERATOR NO.	26. M.I. INSP.	27. CUST/ GOV'T.
1	1.1 REPLACE C4 PER SRI 06-02-01	2-24-77 [illegible] 3-24-77 M. Yeager	T/A			

REFERENCE DOCUMENTS:

28. ITEM	29. RPSO NO.	30. SCRAP TICKET	31. SRP USE	32. MRB	ITEM	RPSO NO.	SCRAP TICKET	SRP USE	MRB	ITEM	RPSO NO.	SCRAP TICKET	SRP USE	MRB	ITEM	RPSO NO.	SCRAP TICKET	SRP USE	MRB

FZ. P.T.-033C (177)

Initiate - Disposition Action - Final Close Out - CADC

COATING AND CEMENT REMOVAL

COATING -

Possibilities -

Solvent - Xylene, Trichloroethane, Methylene Chloride

Peeling - Acceptable for RTV's (Pre-Soaking with Freon TF)

Thermal Parting - Thick Coatings.

Abraision - Rubberized
Portion of thick coatings

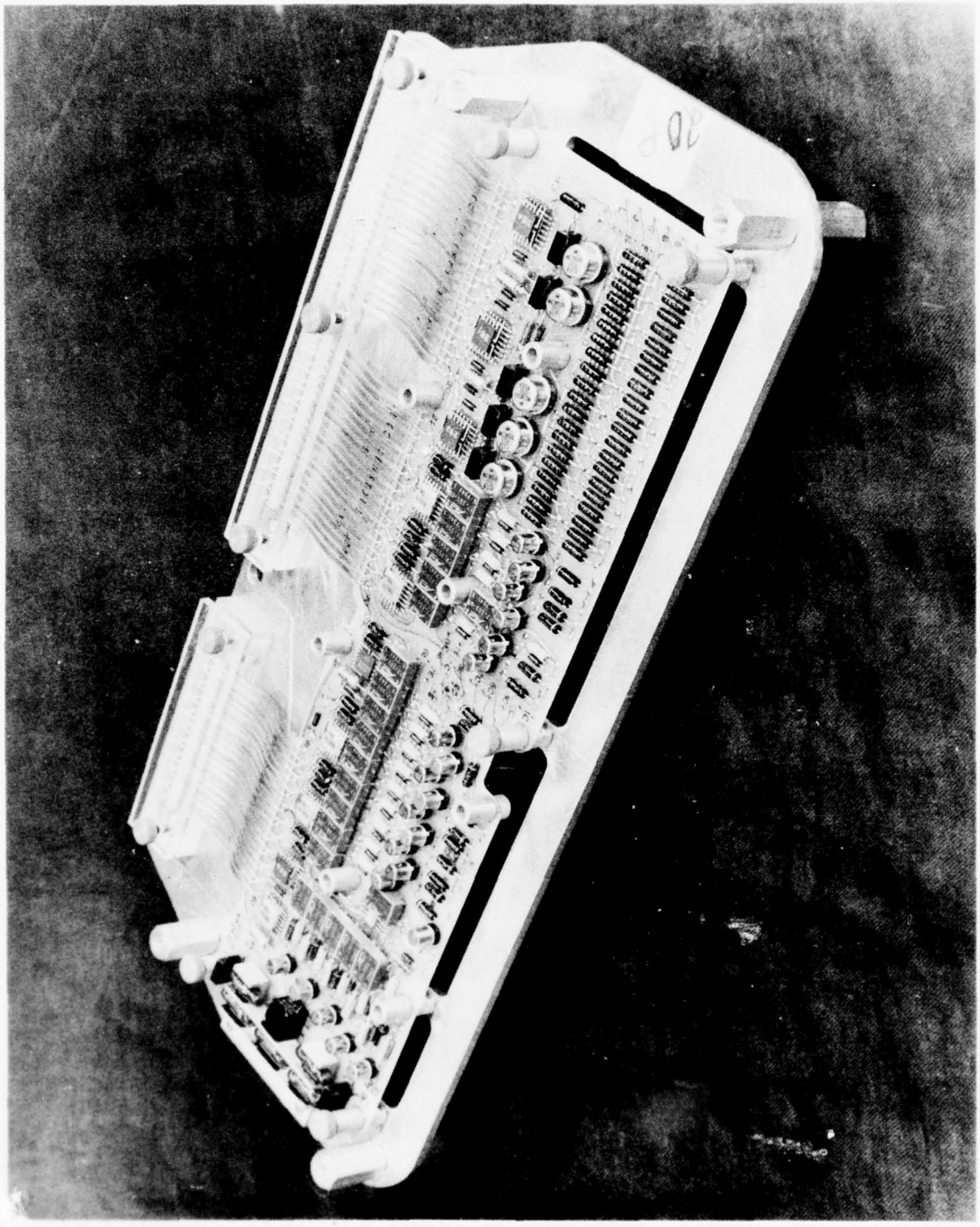
Hot Jet - Soften & Decompose

Desion Criteria

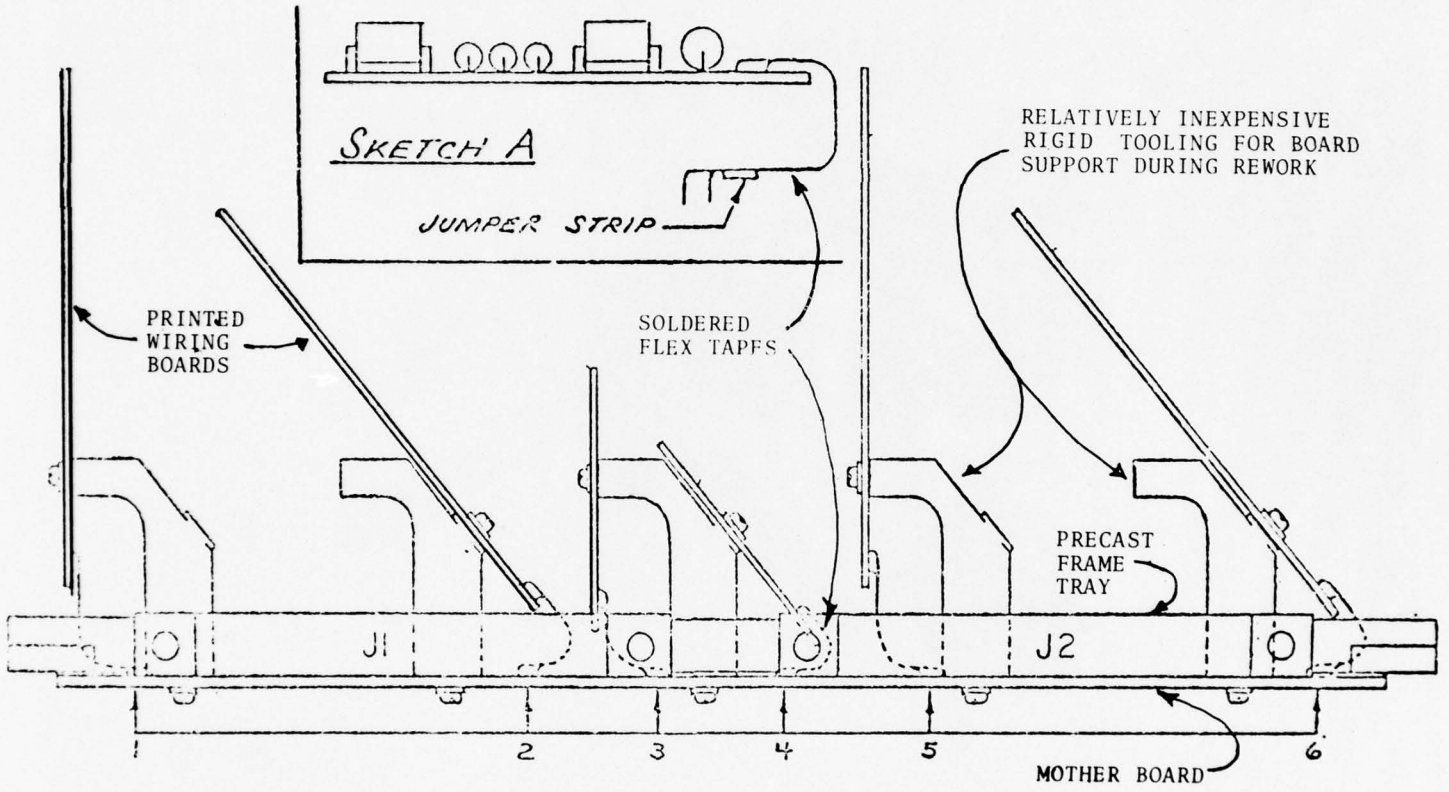
Type of Coating
Condition of the Coating
Nature of the P.C. Board parts.

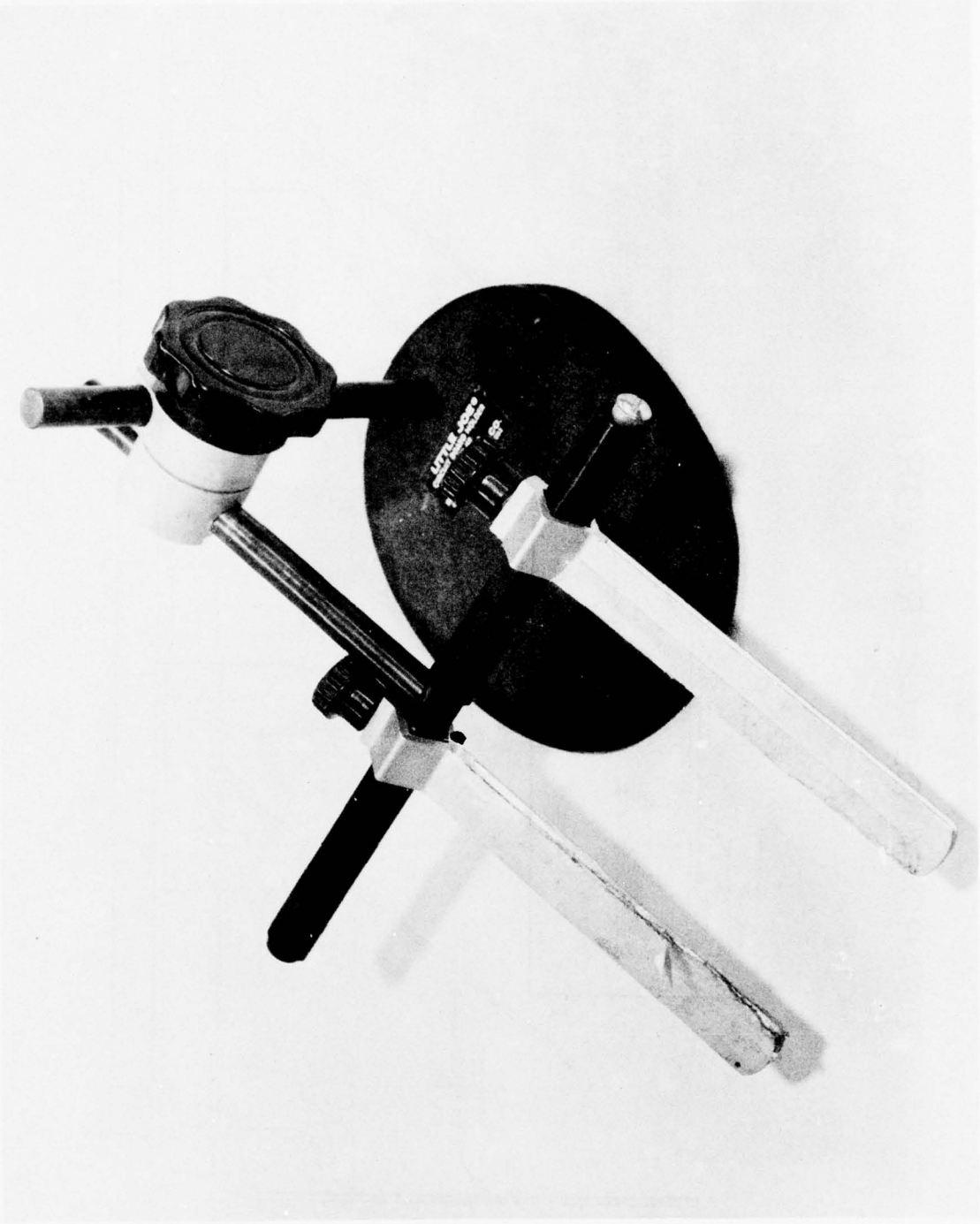
CEMENT

Same as above.



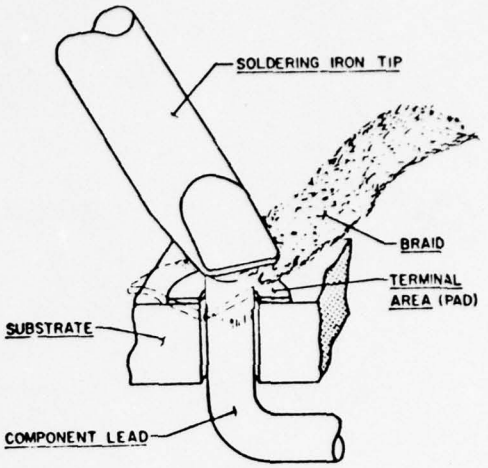
BOARD IN-DEVICE REWORK





FRAGILE
Kimwipes

SOLDER JOINT REWORK METHODS



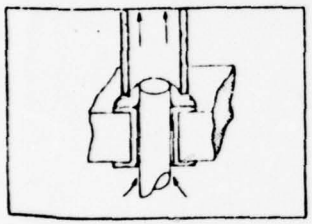
WICKING - Flux saturated stranded copper braid.
Capillary action overcomes surface tension.
Satisfactory for surface joints.
Tendency to stay on joint too long.

SOLDER SUCKER - Not used by Honeywell.

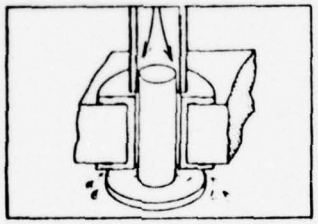
Gang Heating Devices - Not used by Honeywell.

Radiant or Infrared Pre-Heating - Special P.C. Boards.

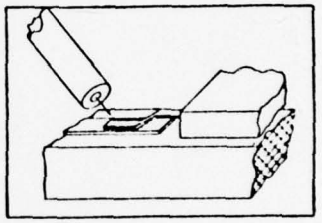
Solder Extraction - PACE Rework Machine
Controlled Heat, Vacuum, Pressure.



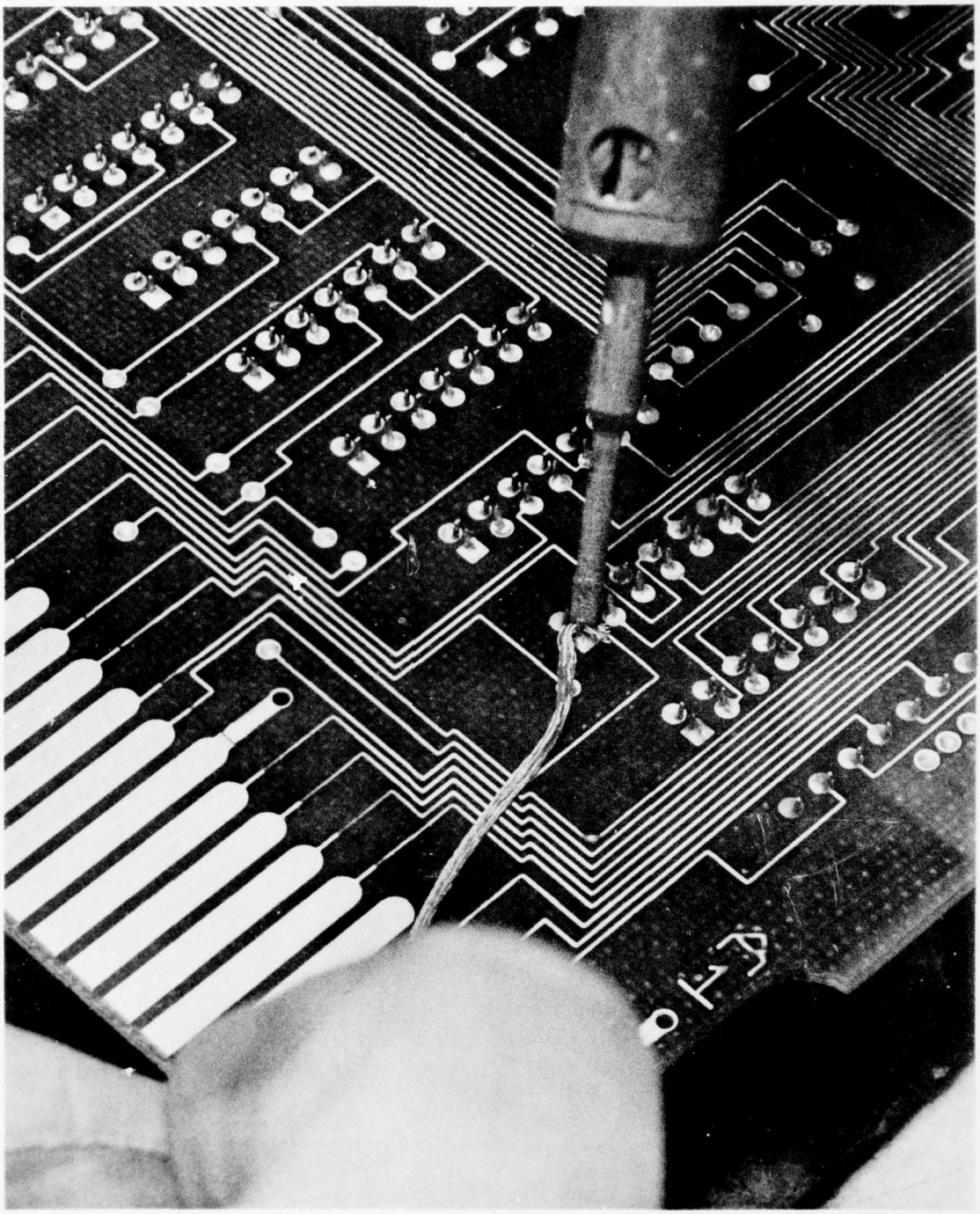
VACUUM MODE

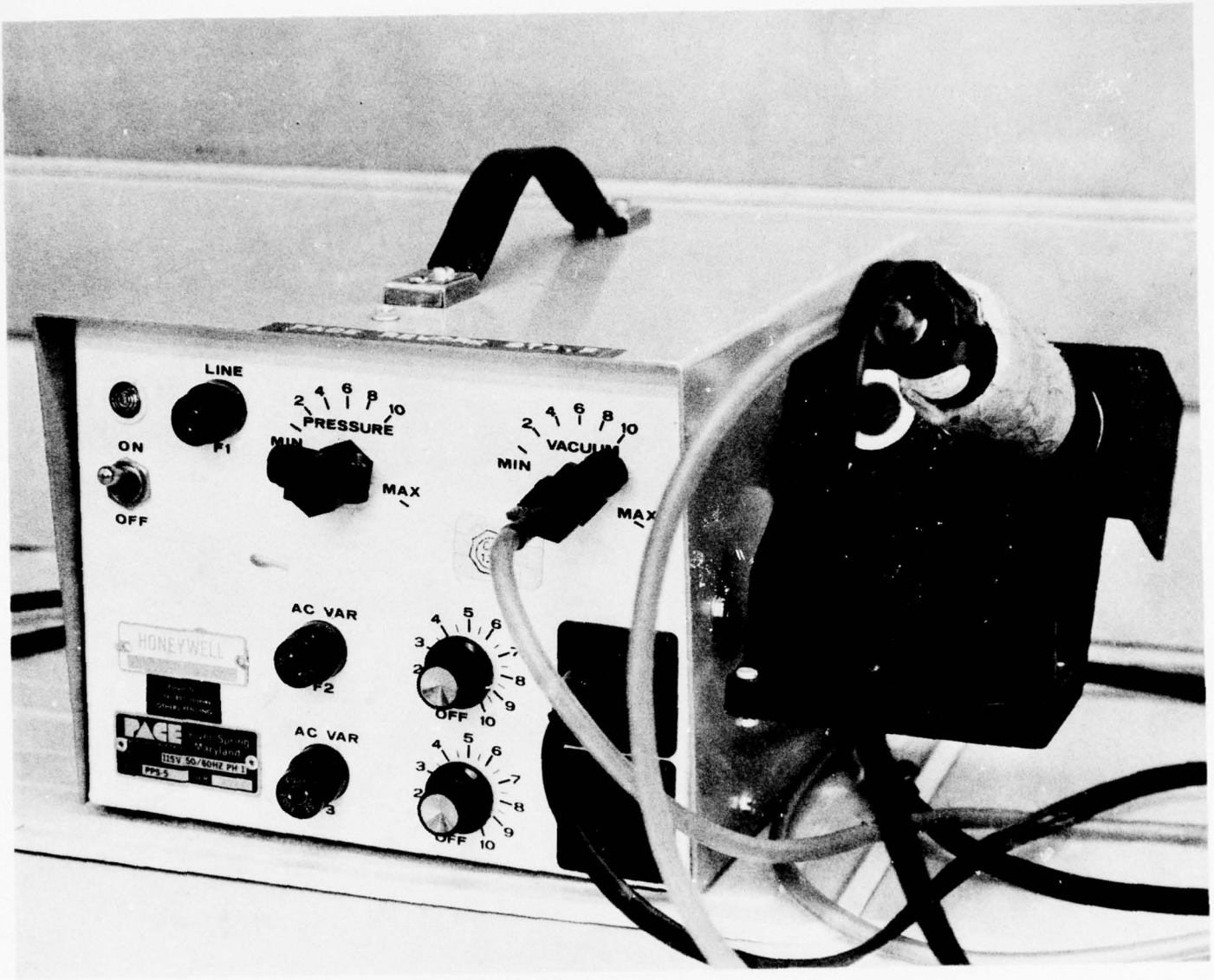


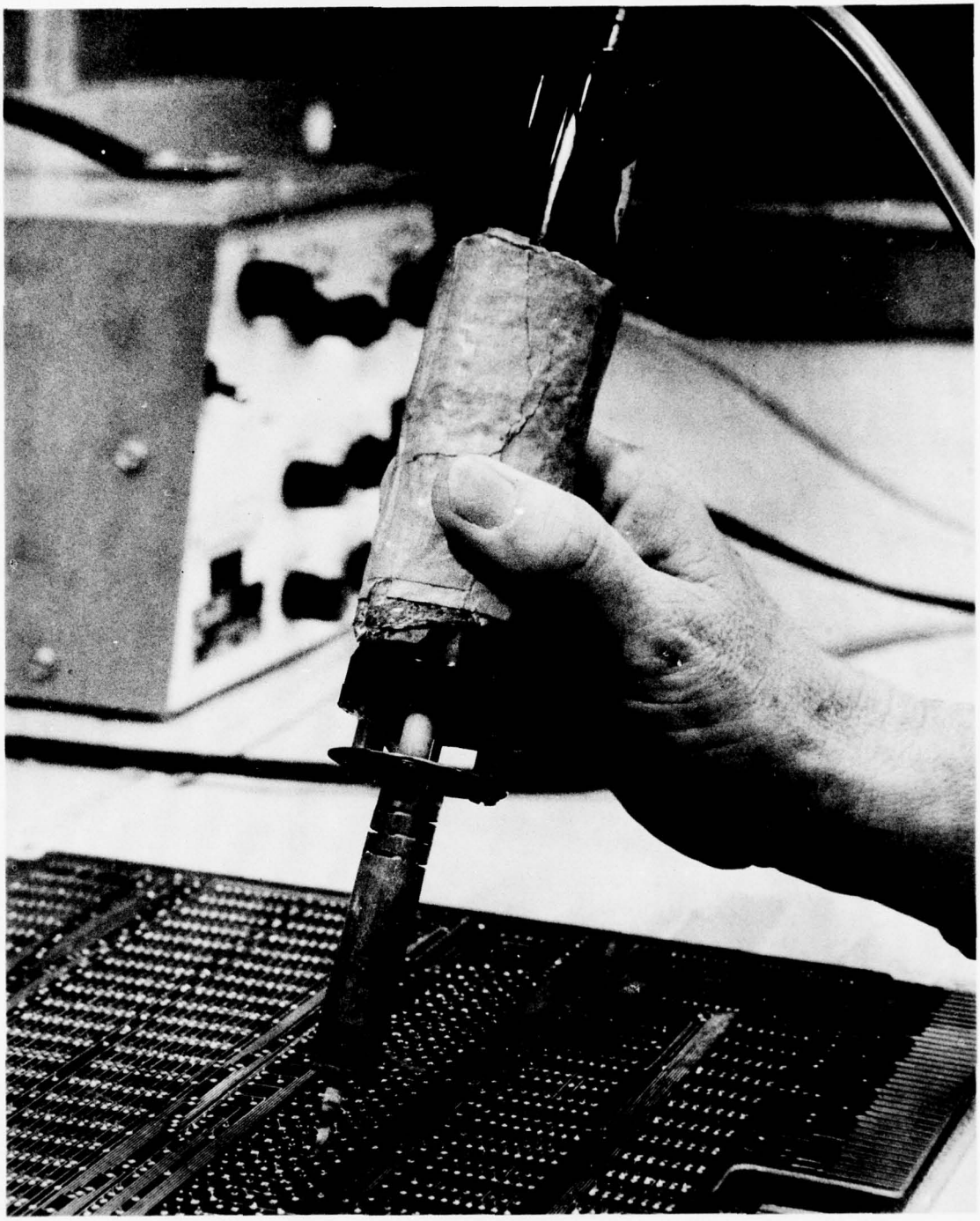
PRESSURE MODE



HOT JET MODE




LINE
F1
ON
OFF
PRESSURE
MIN
MAX
VACUUM
MIN
MAX
HONEYWELL
AC VAR
F2
AC VAR
3
OFF
OFF
PACE
115V 50/60HZ PH 1
PPS-5

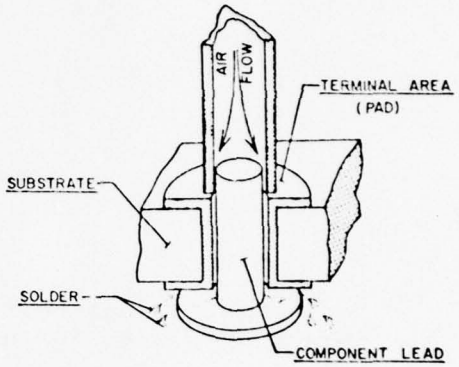


PACE TIP TYPES

	USAGE	COST	CHARACTERISTICS
PLATED COPPER		<$1.00	Max. heating capability Min. potential for pad damage Easily modified.
PLATED ALLOY	10 x Copper	1.3x	Good heating capability Easily modified More practical for continuous work.
PLATED LINED	20 x Copper	1.8x	Lowest heating capability Lining can cut copper pads Special training required.

PACE SOLDER JOINT REWORK

SOLDER JOINT	MODES
NORMAL	HEAT VACUUM
OLD SOLDER (Contaminated)	HEAT VACUUM RESOLDER HEAT VACUUM
BLIND SIDE	HEAT VACUUM HEAT PRESSURE
MULTILAYER (Heat Sinking to Ground Plane)	HEAT VACUUM SUPPLEMENT HEAT w/IRON OPPOSITE SIDE
LAP OR PLANAR	LOW PRESSURE AT REDUCED TEMPERATURE LIFT LEADS CLEAN PAD WITH HEAT/VAC FOR REMOUNTING
MULTIPIN TO CAN	ONE JOINT AT A TIME HEAT VACUUM



PACE THERMAL PART

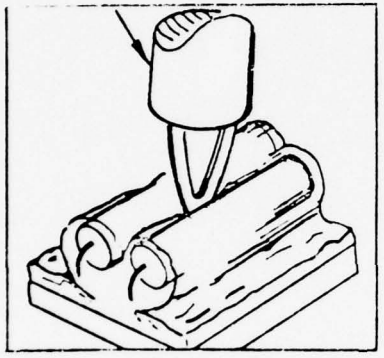
THERMAL SEPARATION (HOT KNIFE)

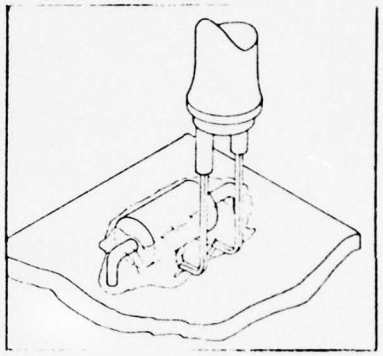
VARIOUS BLADES

SPECIAL USES

Normal temperature for removal of extremely hard two part epoxy.

Reduced temperature for removal of conformal coating when P.C. Board material will be damaged for normal soldering iron temperature.





PACE MINICHINE

USES

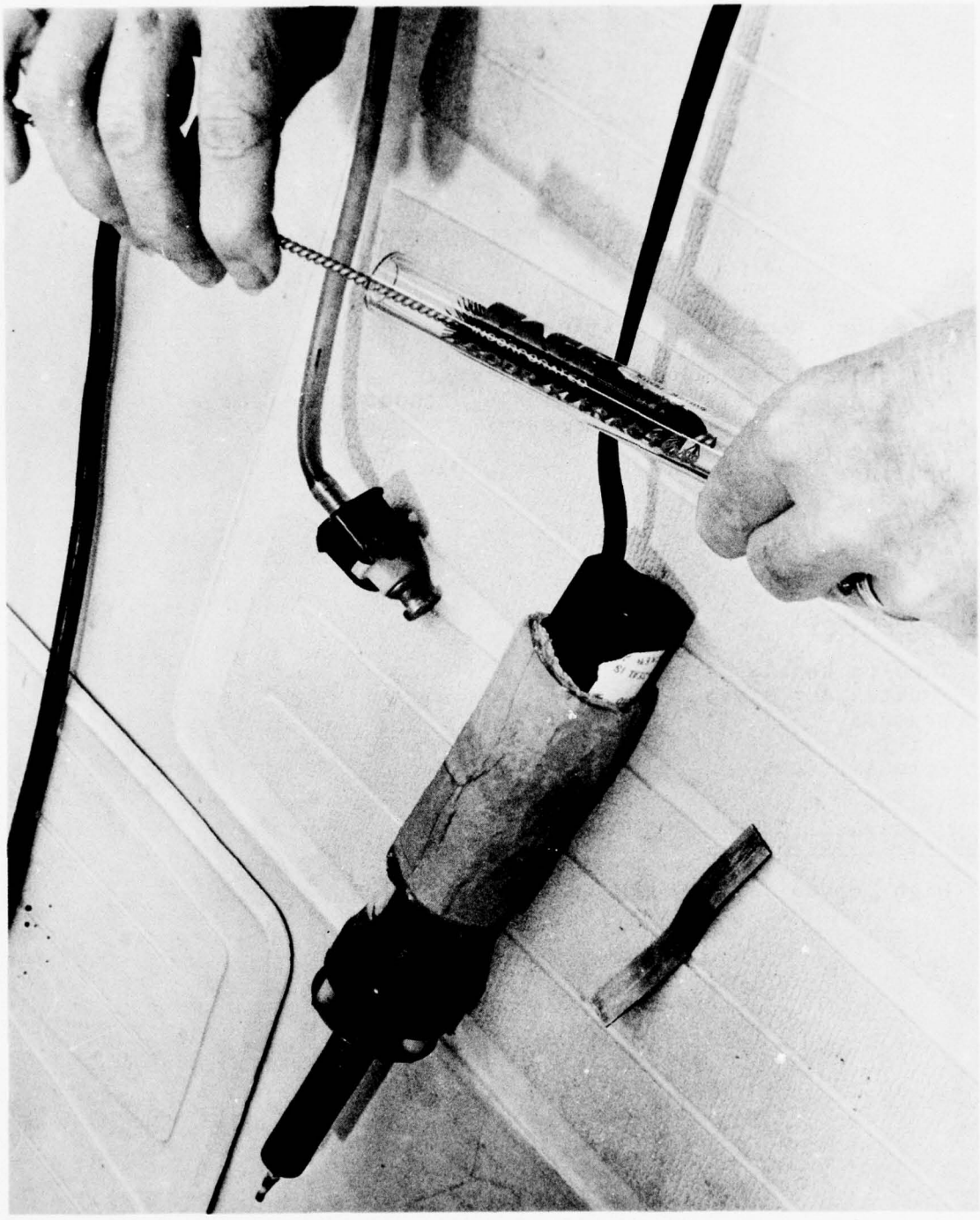
Abrasive Removal of coatings
Slitting In accessible part leads.
Slitting Parts, bonds and housings.
Removing Standoffs and terminals without hole damage.
Drilling small diameter holes.
Milling
Routing
Abrading
Sawing
Brushing

ACCESSORIES

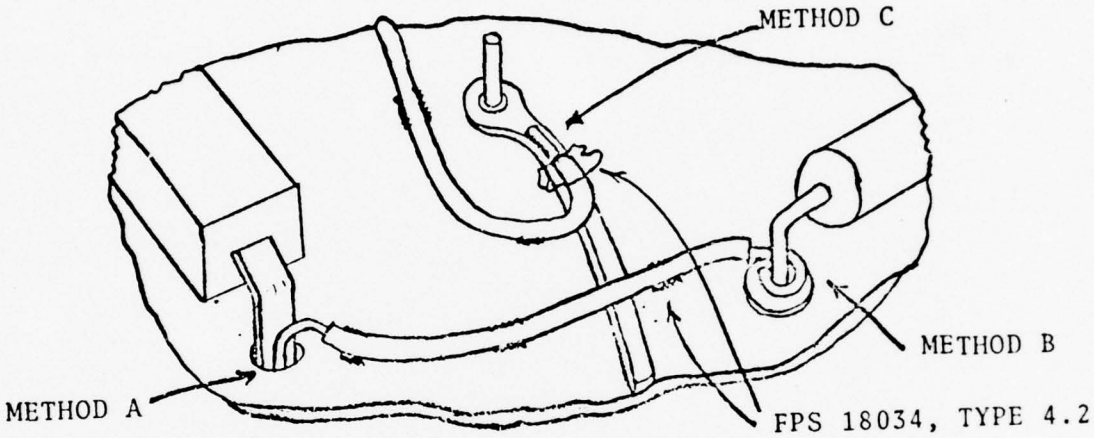
Tapered Wheels
Mounted Abrasives
Brushes
Drills
Circular Saws

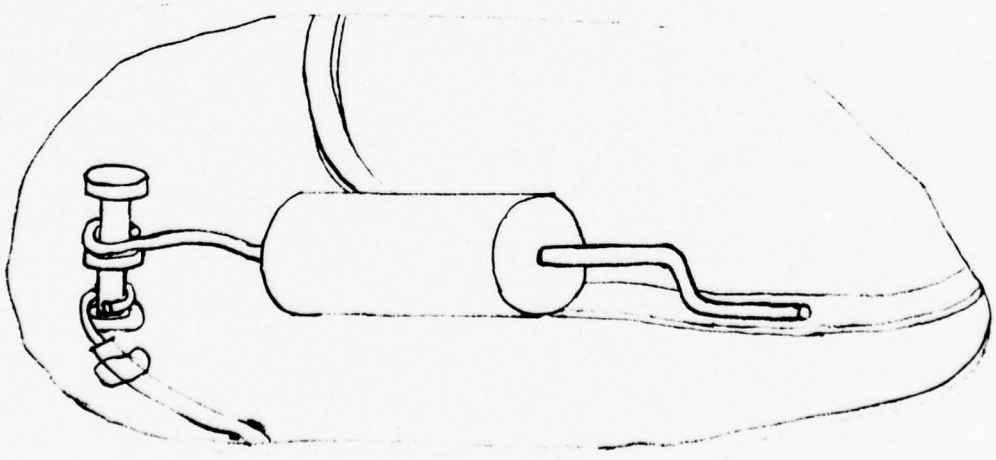
CHARACTERISTICS

High Torque - Low RPM - Low Vibration



CIRCUIT MODIFICATION OR REPAIR





APPENDIX H

POLYURETHANE COATINGS

W. Lang and K. Weeks
Space Systems Division
Lockhead Missiles and Space Company

ELECTRONIC PRINTED CIRCUIT BOARD REWORK PRESENTATION

1. REWORK OF CIRCUIT BOARD ASSEMBLIES

2. AT OPERATION 120 DURING A MANUFACTURING TEST PROCEDURE A MALFUNCTION OCCURRED.

3. A NONCONFORMANCE REPORT WAS ISSUED AT THIS POINT LISTING THE TEST CONDITIONS AND SUBMITTED TO MATERIAL REVIEW FOR DISPOSITION.

4. DETAILED INSTRUCTIONS ON THE NONCONFORMANCE REPORT CONTINUATION PAGE VERIFIED THE FAILURE CONDITIONS.

5. PER INSTRUCTIONS GIVEN ON THE NONCONFORMANCE REPORT, A REWORK SHOP ORDER WAS PREPARED TO PLAN THE REPLACEMENT OF THE COMPONENTS. THE SHOP ORDER LISTS THE DOCUMENTATION TO BE USED FOR THE REWORK OPERATION.

6. ONCE THE REWORK OPERATIONS ARE COMPLETE, THE SUPPLEMENTAL SHOP ORDER RETURNS THE COMPONENT TO OPERATION 120 OF THE ORIGINAL SHOP ORDER FOR TESTING AND CONTINUANCE OF FURTHER WORK OPERATIONS PER THE ACCEPTANCE TEST PROCEDURE (ATP) STARTING AT PARA. 3.9.

7. NORMALLY MOST OF THE COMPONENT REMOVAL AND REPLACEMENT OCCURS PRIOR TO FILLETING AND CONFORMAL COATING. PRESENTLY A NEW EDUCATION & TRAINING PROGRAM IS BEING DEVELOPED TO PROVIDE SPECIAL TRAINING FOR THOSE OPERATORS WHO WILL BE CONCENTRATING SPECIFICALLY ON CONFORMAL COATING REMOVAL AND MODIFICATIONS OF CIRCUIT BOARDS. TYPICAL WORK INSTRUCTIONS INDEX CONSISTS OF SETP-BY-STEP WRITEUP AND PICTORIAL VIEWS. THE FOLLOWING ARE EXAMPLES OF INSTRUCTIONS FOR CERTIFIED SOLDERING PERSONNEL TO FOLLOW.

8. USE OF HEAT SINK WHEN REQUIRED

9. ILLUSTRATIONS FOR SOLDER APPLICATION

10. INSPECTION CRITERIA FOR SOLDER & INSPECTION

11. CUTTING A CLINCHED LEAD

12. AN EXAMPLE OF A SUPPLEMENT NCR AND CONTINUATION PAGE WRITTEN ON DISCREPANT PIECE PARTS FOR FURTHER ANALYSIS AND CORRECTIVE ACTION AS REQUIRED.

13. THE PRODUCT ASSURANCE ACTION REPORT AND CONTINUATION PAGE PREPARED BY THE PRODUCT ASSESSMENT LABORATORY GIVES THE DETAIL OF THE ANALYSIS AND FINDINGS ON THE ITEM WHICH WERE SUBMITTED FOR DESTRUCTIVE PHYSICAL ANALYSIS

14. 1) SCANNING ELECTRON MICROSCOPE PHOTOS

15. 2) SCANNING ELECTRON MICROSCOPE PHOTOS

XXX INTRODUCE BOB DUNAETZ, HUGHES AEROSPACE DIVISION
PARYLENE REMOVAL

KATHY WEEKS

22. CONVENTIONAL REWORK STATION

23. WORKING PER THE MWIS COMPONENTS ARE MARKED AND AN OK TO DISASSEMBLE HAS TO BE GIVEN BY INSPECTION.
NOTE:

24. HEAT GUN WARMING UP CONFORMAL COATING.

25. SHAPED ORGAN STICK REMOVING MATERIAL FROM AROUND THREE COMPONENTS ON BACK SIDE OF BOARD.

26. Q-TIP AND MEK REMOVING DENNIS LACQUER

27. METAL PROBES FOR DELICATE WORK AROUND LEADS ON FRONT SIDE OF BOARD.

28. SOLDER GOBBLER USED DRY WITH A CIRCULAR MOTION WHEN THE VACUUM IS APPLIED TO REMOVE THE SOLDER FROM LEAD AND PLATED THROUGH HOLE.

29. FLAT PACK REMOVED.

30. 32 LEAD FLAT PACK REMOVAL

31. DEVICES PLACED IN CONTAINERS TO BE DELIVERED TO M. R.

32. BOARD CLEANED READY FOR OK TO INSTALL NEW DEVICES. NEW TECHNIQUES, DEDICATED AREA AND PERSONNEL ARE BEING REVIEWED PRESENTLY FOR IMPLEMENTATION.

33. REMOVAL OF FILLET MATERIAL EPON 123/9615-62 HARDENER

34. PIECE PART.

XXX LANG RETURNS TO CONCLUDE

(A) WHEN A REWORKED UNIT IS TRANSFERRED TO THE CONFORMAL COATING AREA THE MWIS WOULD CALL OUT MPS 403-060.

(B) THIS OPERATION CALLS OUT FOR A MIN. OVEN DRY OF ONE HOUR AT $150^0 \pm 10^0$ F TO REMOVE ANY TRACE OF SOLVENTS AFTER CLEANING.

(C) USE MATERIALS AS CALLED OUT ON THE DRAWING.

(D) REMOVE ASSEMBLY FROM OVEN.

(E) COOL ASSEMBLY TO ROOM TEMPERATURE.

(F) PREPARE MATERIAL PER APPENDIX D, PART V, TABLE D-2. THIS WILL GIVE MIX AND CURE PROCEDURE.

(G) THE DENNIS 1162 WILL BE USED AS THE PRIMER, HAND APPLIED WITH AN ARTISTS BRUSH, CURED FOR 1/2 HOUR AT $75^0 \pm 10^0$ F AND THEN OVEN CURED FOR 1 HOUR AT $150^0 \pm 10^0$ F.

(H) PREPARE SCOTCHCAST 221 (POLYURETHANE) PER STATEMENT (F).

(I) WHEN THE DENNIS COATED UNIT IS CURED, REMOVE FROM OVEN AND IMMEDIATELY FLOW SC 211 TO THE REWORKED AREA UNTIL THE FILLED AREA MEETS THE SURROUNDING LEVEL.

(J) CURE FOR 5 HOURS AT $75^0 \pm 10^0$ F AND FOLLOW UP WITH A 1 HOUR OVEN CURE AT $150^0 \pm 10^0$ F.

ADDITION OF MECHANICAL DEVICES, COMPONENTS AND JUMPER WIRES

36. PHOTO OF TURRETS, COMPONENTS, JUMPER WIRES.
THE ASSEMBLY SHOWN HAS TURRETS, CAPACITOR, WIRE WOUND RESISTOR AND JUMPER WIRES. THIS WAS A PRODUCT IMPROVEMENT REQUIRED TO MEET THE FINAL ACCEPTANCE TEST PROCEDURE. THE NONCONFORMANCE REPORT REQUIRED PACKAGING ENGINEERING TO PROVIDE THE LOCATIONS FOR THE TERMINALS, THE ROUTING OF AND THE BONDING OF THE WIRES TO THE MULTILAYER CIRCUIT BOARD. AT THIS POINT A MANUFACTURING WORK INSTRUCTION SUPPLEMENT

36. (CONT'D.)

WAS WRITTEN WITH THE APPROPRIATE INSPECTION POINTS. THIS IMPROVEMENT WHEN PROVEN OUT WAS DOCUMENTED BY AN ENGINEERING CHANGE ORDER FOR AN "AND UP" CONDITION WITH SPECIFIC INSTRUCTIONS FOR MOUNTING THE COMPONENTS, ROUTING THE WIRES AND TERMINATION OF THE JUMPER WIRES WITH THE LEADS OF THE INTEGRATED CIRCUIT THROUGH THE PLATED THROUGH HOLES. AT SSD ENGINEERING THERE ARE MANY SYSTEMS THAT HAVE HAD MECHANICAL DEVICES ADDED SUCH AS HEAT SINKS, STIFFENERS, TURRETS, COMPONENTS, JUMPER WIRES. THESE HAVE BEEN DOCUMENTED ON ENGINEERING DRAWINGS TESTED AND QUALIFIED AS REQUIRED.

SPACE SYSTEMS DIVISION'S CRITERIA FOR DESIGNING CIRCUIT BOARD ASSEMBLIES WITH JUMPER WIRES

1. WHEN A BLACK BOX HAS ONLY ONE BOARD THAT WOULD REQUIRE A MULTILAYER BOARD, AND IF ONLY UP TO 8 JUMPER WIRES CAN EFFECTIVELY PERFORM THE TASK, A JUMPER WIRE DESIGN WILL BE USED FOR COST EFFECTIVENESS.

2. WHEN A MULTILAYER DESIGN HAS 10 LAYERS AND A FEW JUMPER WIRES CAN AVOID ANOTHER LAYER, DESIGN ENGINEERING WILL USE JUMPER WIRES IF THE COUNT DOES NOT EXCEED 8. EXCEPTION TO THE RULE IF 10 LAYER CANNOT BE MADE ANY THICKER DUE TO SPACE ALLOCATION.

3. UNTIL A POLYAMIDE MULTILAYER PROCESS IS CERTIFIED, ALL POLYAMIDE BOARDS MAY USE UP TO 19 JUMPER WIRES IF REQUIRED.

LOCKHEED'S POSITION ON REUSING PARTS AND DEVICES ONCE REMOVED FROM A CIRCUIT BOARD ASSEMBLY

1. PARTS SUCH AS FRAMES, BRACKETS AND STIFFENERS CAN BE REUSED.

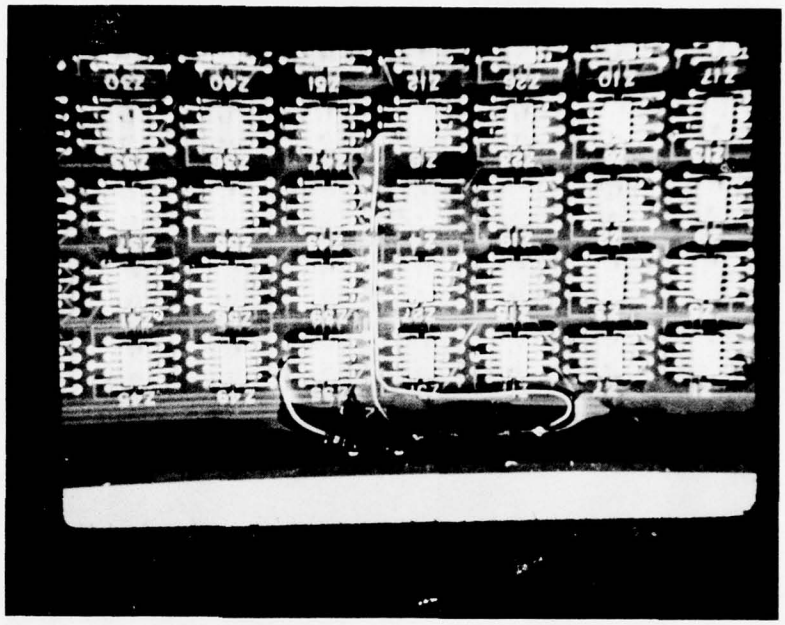
2. RELIABILITY WILL NOT PERMIT THE REUSE OF ANY ELECTRONIC DEVICE BECAUSE OF THE HI-REL REQUIREMENTS IN OUR SYSTEMS.

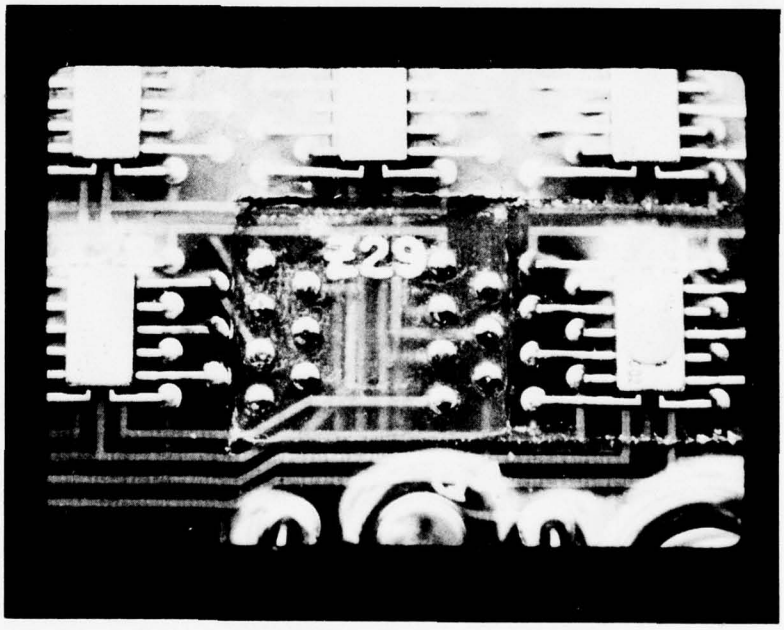
TO DATE SSD HAS HAD A SUFFICIENT SUPPLY OF SPARE DEVICES SO THAT EVEN WHEN A COMPONENT IS REMOVED FROM THE CIRCUIT DURING TROUBLE SHOOTING THAT COMPONENT IS NOT REINSTALLED BUT REPLACED. PERHAPS AS KATHY WEEKS STATED EARLIER, DEDICATED PERSONNEL AND AREAS FOR EACH PHASE OF THE REWORK COULD ALLOW A CHANGE TO TAKE PLACE. IF THAT DOES OCCUR, A MATERIAL REVIEW DISPOSITION WITH ALL THE AFFECTED GROUPS CONSENTING WOULD STILL HAVE TO BE MADE.

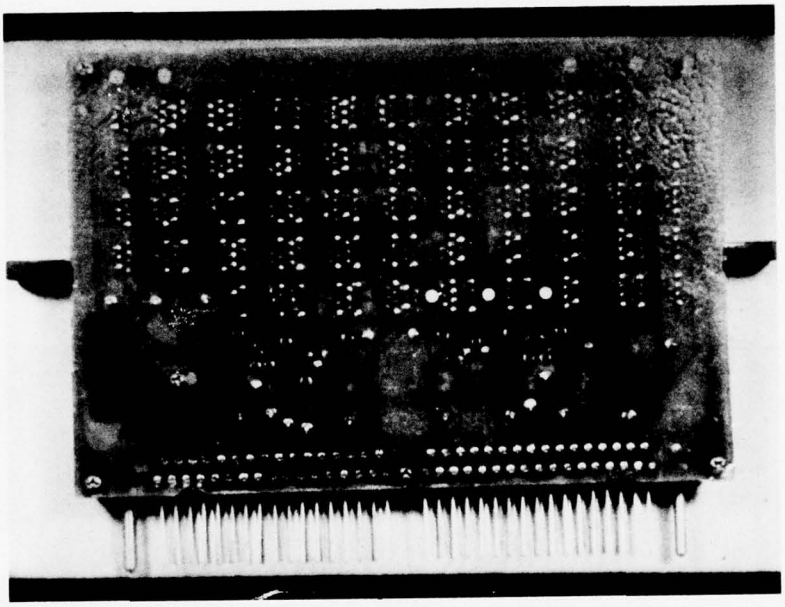
THIS CONCLUDES SPACE SYSTEMS DIVISION OF LOCKHEED'S PORTION OF THE PROGRAM.

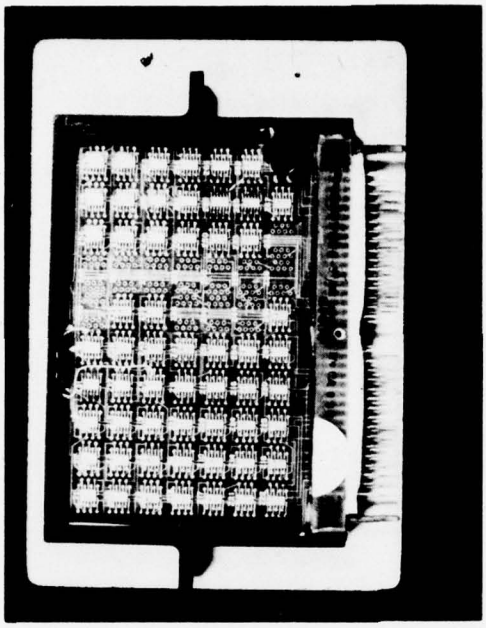
THANK YOU

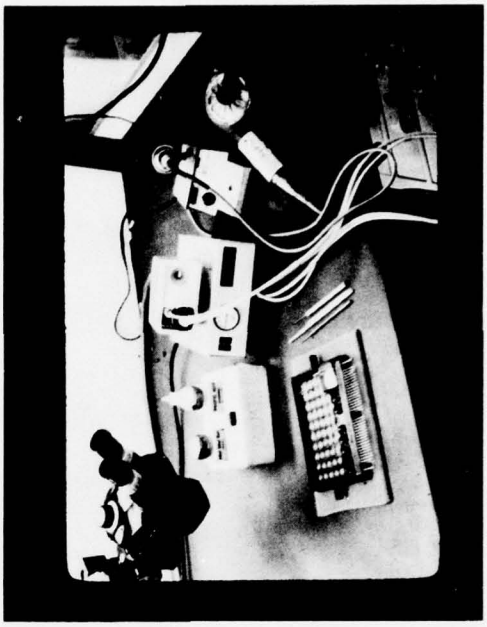
Walter A. Lang

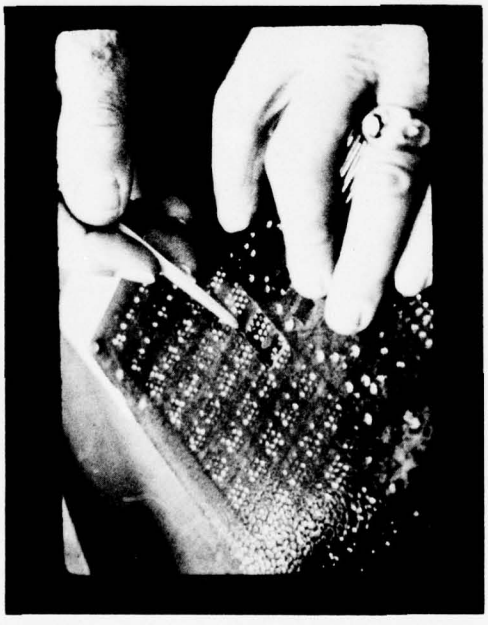


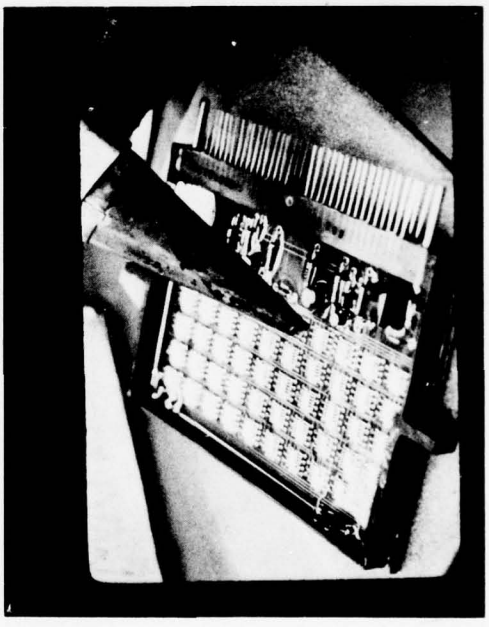


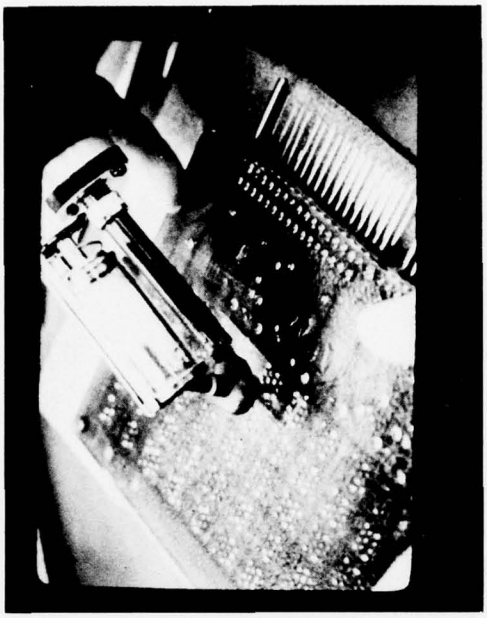


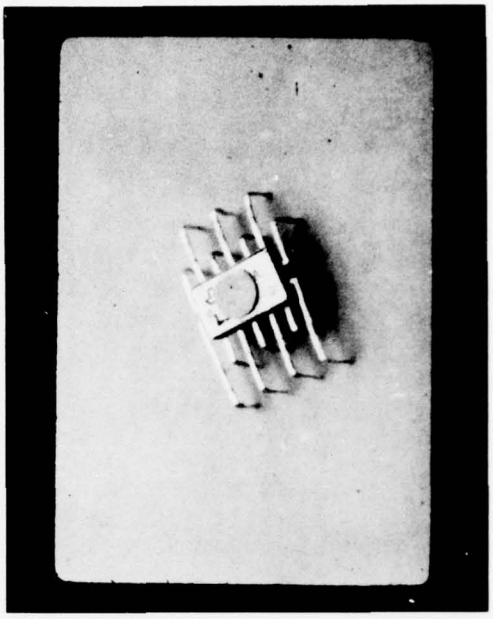


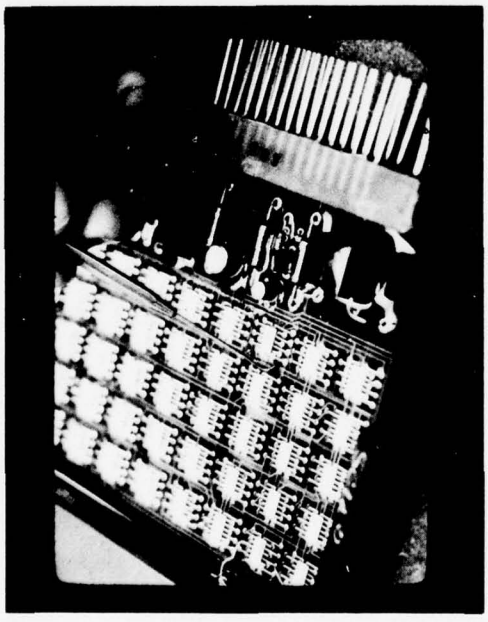














APPENDIX I

PARYLENE COATINGS

R. A. Dunaetz
Aerospace Division
Hughes Aircraft Company

REPAIR OF PARYLENE CONFORMAL COATING

HUGHES

UNIQUE PROPERTIES OF PARYLENE

HUGHES

- PROVIDES COMPLETE PIN HOLE FREE DIELECTRIC PROTECTION
- APPLIES THIN LIGHT WEIGHT, NON-STRESS COATING
- POSSESSES NON-STICKING SURFACE CHARACTERISTIC
- REQUIRES SPECIAL TECHNIQUES FOR REPAIR ADHESION

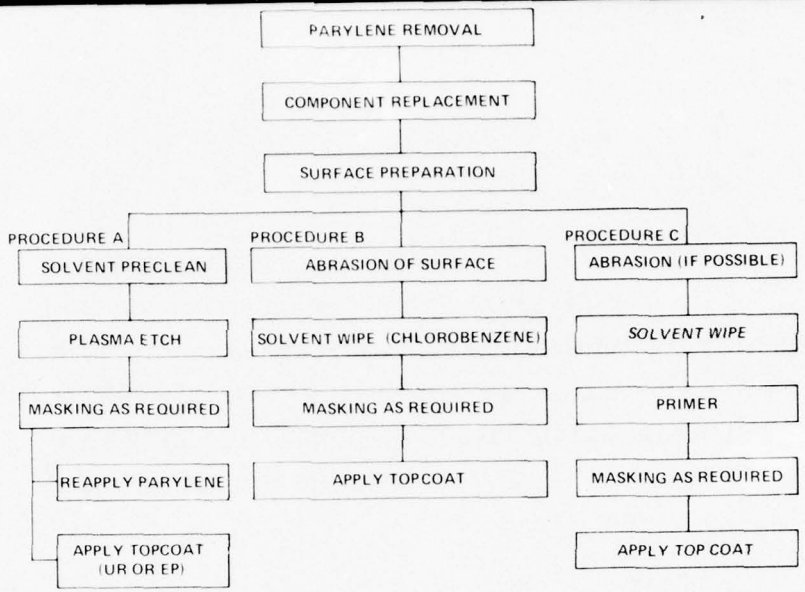
REPAIR OF PARYLENE CONFORMAL COATING

HUGHES

- NEEDS SPECIAL PROCESSING
- REMOVE PARYLENE FOR ACCESS TO COMPONENTS
- CLEAN SURFACES TO BE COATED
- ACTIVATE/PRIME SURFACES FOR ENHANCING ADHESION
- MASK AREAS TO BE FREE OF COATING
- SELECT RECOATING METHOD

TYPICAL REPAIR SEQUENCES

HUGHES



PARYLENE REMOVAL TECHNIQUES

HUGHES

MECHANICAL

- TOOLS: SCRIBE, KNIFE
- GAS CARRIED ABRASIVE:

  N_2, $N_A HCO_3$(150μ), 30 SEC/FLATPACK

THERMAL

- CAUTERIZING TOOL (MEDICAL)
- HOT KNIFE

SURFACE PREPARATION (UTILIZING PLASMA ETCHING)

HUGHES

CLEANING – FLUOROCARBON SOLVENT

PREPARING SURFACES – PLASMA PROCESSING

- CHAMBER ENVIRONMENT – HELIUM
- CHAMBER PRESSURE – 1.0 TORR
- ENERGY LEVEL – 100 TO 200 WATTS
- EXPOSURE TIME – 6 TO 12 MINUTES

PLASMA ACTION ON PARYLENE

HUGHES

- PHYSICAL BOMBARDMENT OF IONIZED PARTICLES TO SURFACE RESULTS IN EXTRACTION OF H, CI, OR OTHER ATOMS, CREATING ACTIVE SITES ON THE SURFACE TO WHICH FREE RADICAL GROUPS FROM THE PLASMA CAN ATTACH.
- DEPTH OF SURFACE AFFECTED
  500Å TO 1000Å

CONVENTIONAL SURFACE PREPARATION (ALTERNATIVE TO PLASMA ETCH)

HUGHES

CLEANING: VAPOR DEGREASE

PREPARING SURFACES: PROCESSING STEPS

- ABRASIVE RUBBER/AIR ABRASIVE
- CHLOROBENZENE
- AIR DRY (DAMP SURFACE CONDITION)

PRIMING: PRIMER COMPOSITION

- PVC/PVDC
- SOLID EPOXY RESIN
- THF SOLVENT

DRY 150° F FOR 5 - 10 MINUTES

MASKING PROCEDURES FOR RECOATING REPAIRED AREAS

HUGHES

HARDWARE TO REMAIN UNCOATED	MASKING TECHNIQUE
TERMINALS	SHRINK SLEEVING/LATEX MASKANT
ADJUSTABLE SCREWS	LATEX MASKANT
CONNECTORS	TAPE DAM/LATEX FILL, MOLDED HIGH STRENGTH SILICONE RUBBER
PWB EDGES, CONTACT SURFACES	TAPE
LARGE ADJUSTABLE PARTS	TAPE, RUBBER STOPPERS, TEFLON PLUGS, ASSEMBLY AFTER COATING OPERATION

COMPARISON OF RELATIVE MERITS OF RECOATING PROCEDURES

HUGHES

PROCEDURE A
- PROVIDES MINIMUM PROCESS VARIATION
- SHORT PROCESSING TIME
- EXPENSIVE EQUIPMENT TO SET UP

PROCEDURE B
- EARLY ESTABLISHED METHOD
- MEETS MINIMUM REQUIREMENTS
- MARGINALLY ACCEPTABLE ADHESION
- LOWEST IMPLEMENTATION COSTS

PROCEDURE C
- SUITABLE FOR REPAIR OF ANY LOCATION
- ABRADED SURFACE & PRIMER PROVIDES OPTIMUM ADHESION
- BEING PHASED IN TO REPLACE METHOD B

CRITERIA FOR SELECTION OF RECOATING METHOD

HUGHES

DEGREE OF REWORK/REPAIR	METHOD OF REWORK OR DISPOSITION
• 1, 2, OR 3 COMPONENTS REPLACED AT ONE TIME • ERRONEOUS MASKED SPOT	• TOUCH UP WITH PRIMER & CONVENTIONAL CONFORMAL COATINGS (NORMAL PROCESS COMPLETION, TOUCH-UP OR REWORK)
• MAJOR SURFACE AREA CONTAINS DEFICIENCIES • MORE THAN 10% OF COMPONENTS REQUIRE REMOVAL	• SCRAP HARDWARE • REWORK WITH PARYLENE 1) REMOVE DEFECTIVE PARYLENE 2) SOLVENT CLEANING 3) PLASMA ETCH 4) REAPPLICATION OF PARYLENE

APPENDIX J

FOAM TYPE CONFORMAL COATINGS

R. Kiesell
Motorola, Inc.

MOTOROLA, INC.
GOVERNMENT ELECTRONICS DIVISION
SCOTTSDALE, ARIZONA

DICK KIESELL, MANAGER
PRODUCT QA SECTION

BEST AVAILABLE COPY

PERFORMING REWORK ON HI-REL
SUBASSEMBLIES ENCAPSULATED WITH
URETHANE OR SYNTACTIC FOAMS.

EQUIPMENT BUILD-UP

PRIOR TO THE FOAMING OPERATION, THE EQUIPMENT HAS BEEN 100% INSPECTED FOR CONFIGURATION AND WORKMANSHIP TO THE APPLICABLE CONTRACT SPECIFICATIONS AND TESTED ELECTRICALLY TO THE APPROVED TEST SPECIFICATION INCLUDING THE INSTALLATION OF ANY TEST SELECTS AND THE TUNING/ADJUSTING OF ANY VARIABLE COMPONENTS

FOR EXAMPLE:

USE SPECIAL CONSIDERATIONS FOR VARIOUS PART TYPES:

CERAMIC CHIP CAPACITORS
WET SLUG TANTALUM CAPACITORS
CERAMIC VARIABLE CAPACITORS
AIR VARIABLE CAPACITORS
GLASS VARIABLE CAPACITORS
FIXED MICA CAPACITORS
EMI FILTERS
VARIABLE RESISTORS
FIXED CHIP RESISTORS
QUARTZ CYRSTAL UNITS
RF CABLE ASSEMBLIES
MAGNETIC LATCHING RELAYS
DIODES
TRANSISTORS
MICROCIRCUITS

IF A PART IS BEING CONSIDERED FOR REUSE THE FOLLOWING GENERAL GUIDELINES APPLY:

1. COMMUNICATE THE POSSIBILITY TO ALL CONCERNED PRIOR TO REWORK SO THAT PROPER REWORK METHOD CAN BE SELECTED.

2. PERFORM MICROSCOPIC EXTERNAL VISUAL EXAMINATION PRIOR TO REMOVING PART AND AFTER PART IS REMOVED

3. PERFORM AMBIENT ELECTRICAL TESTS AND COMPARE DATA WITH ORIGINAL PARAMETER VALUES.

4. X-RAY TO EVALUATE INTERNAL INTEGRITY (ESPECIALLY IF PART HAS INTERNAL SOLDER JOINTS)

5. PERFORM PARTICLE IMPACT NOISE DETECTION (PIND) TEST IF PART HAS INTERNAL CAVITIES.

6. PERFROM FINE AND GROSS LEAK TESTS

(NOTE: REMOVE SLEEVING FROM TANTALUMS).

REUSING COMPONENTS

GENERAL POLICY IS TO NOT REUSE HIGH-REL PARTS.

THERE ARE, HOWEVER, MITIGATING CIRCUMSTANCES WHICH CAN DICTATE THAT PARTS BE <u>CONSIDERED</u> FOR REUSE.

E.G. REPLACEMENT PART NOT AVAILABLE
DELIVERY TIME VS. MISSION EFFECTS
SPECIAL COST CONSIDERATIONS

DECISION TO RE-USE A PART MUST BE A CONSCIENTIOUS ONE WITH ALL AFFECTED PARTIES INVOLVED (DESIGN ENGINEERING, PARTS ENGINEERING, QUALITY ASSURANCE PRODUCTION, CUSTOMER AND GOVERNMENT, ETC.).

METHODS

(DETERMINED BY PROCESS ENGINEER)

SOLDER REMOVER UNIT, AMISTAR CORP., MODEL SR100

WITH NO. SR-103-2 AND SR-104-1 TIPS

BAZOOKA SOLDER GOBBLER WITH 5NP AND 7NP TIPS

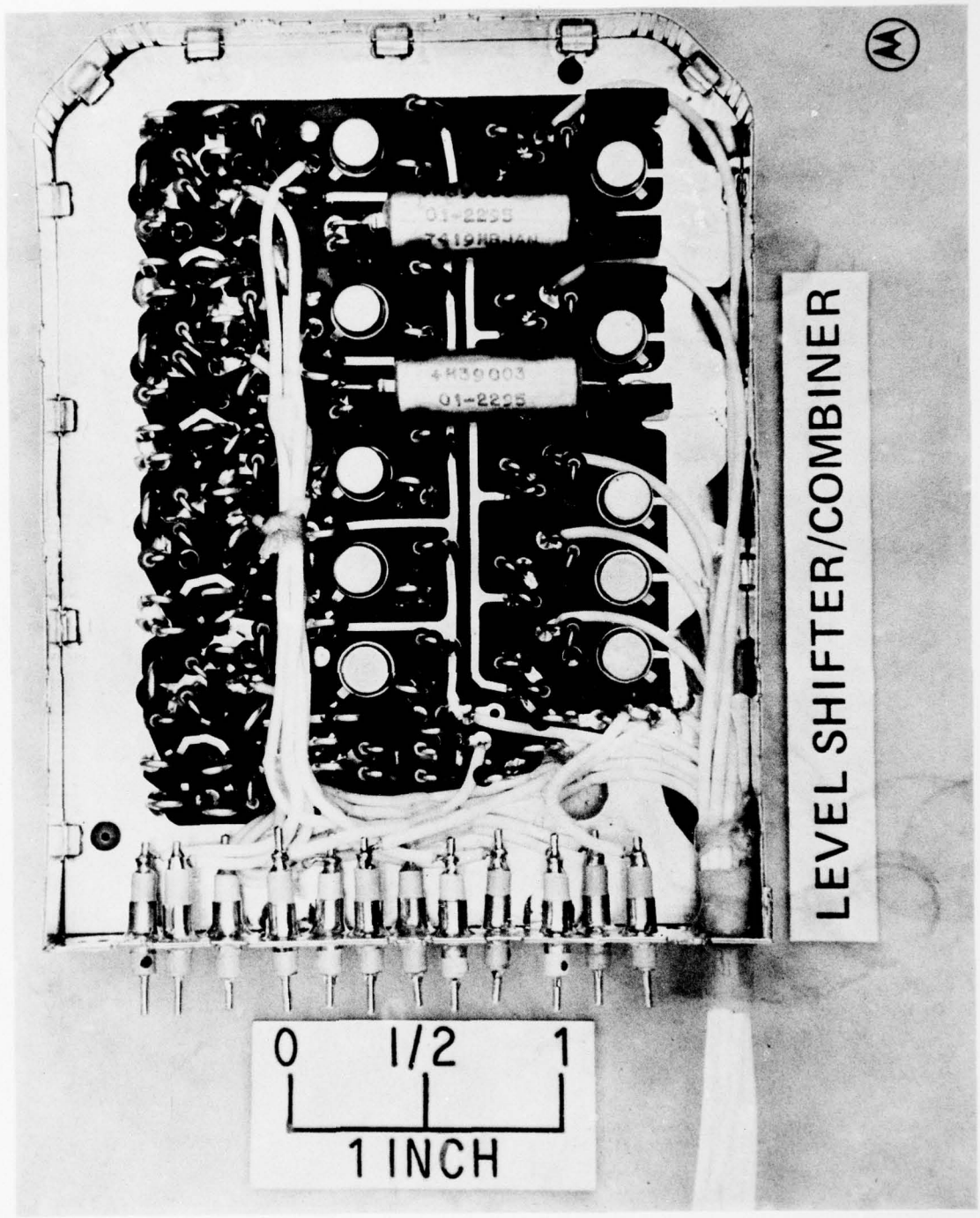
RESISTANCE SOLDER IRON, HOT TIP T-10SA

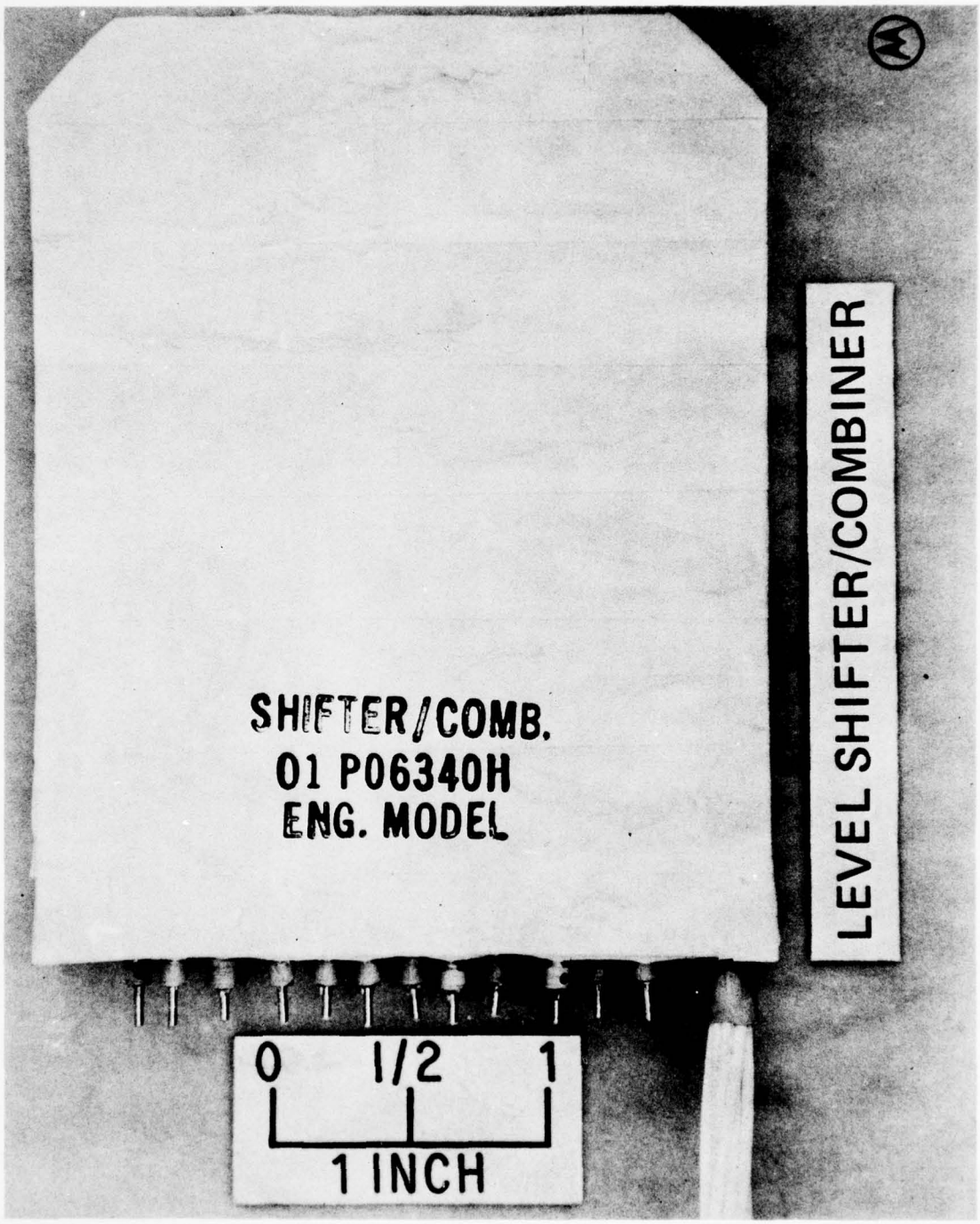
SOLDERING IRON, HEXICON 26S50 AND WICKING BRAID

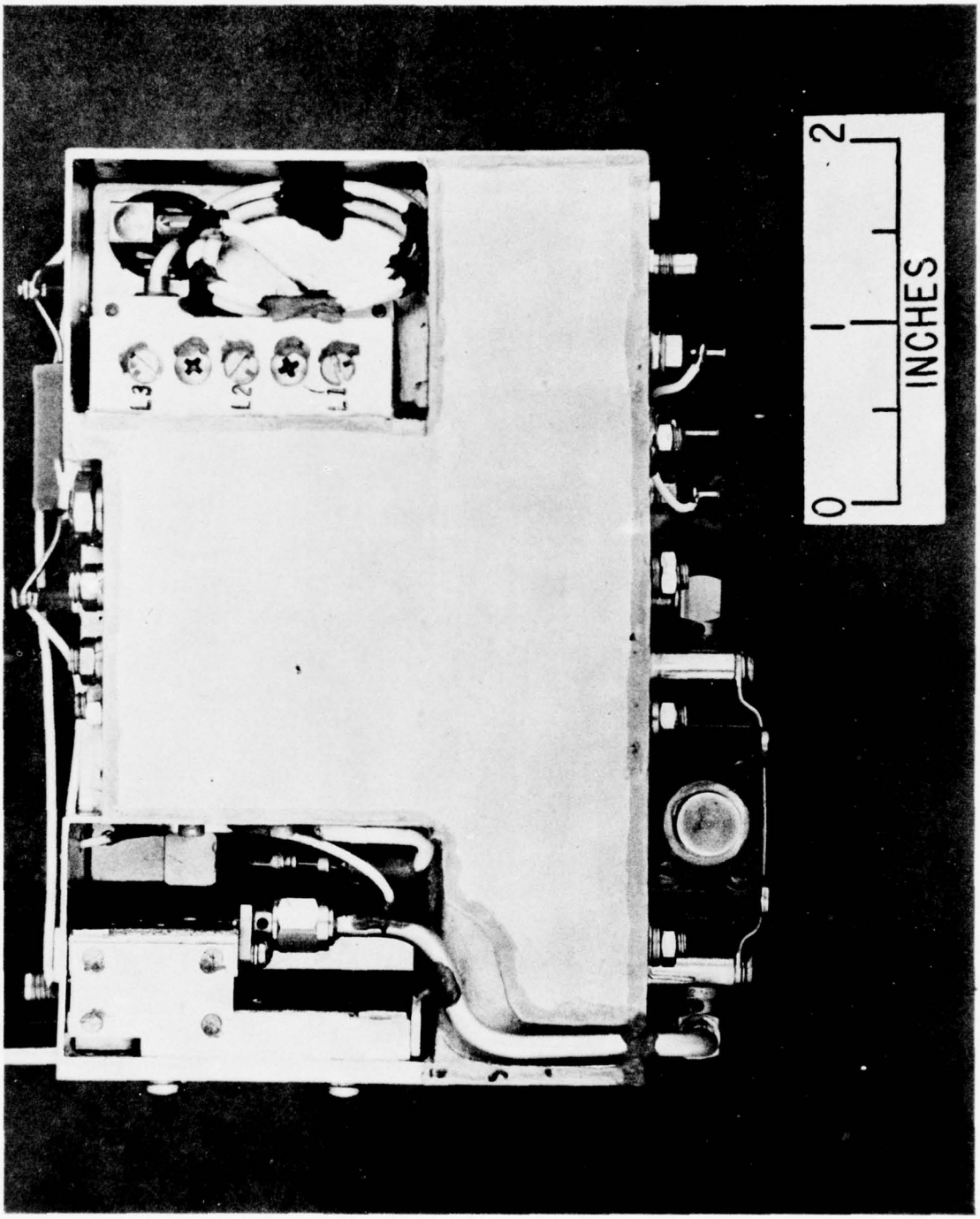
REMOVING COMPONENTS

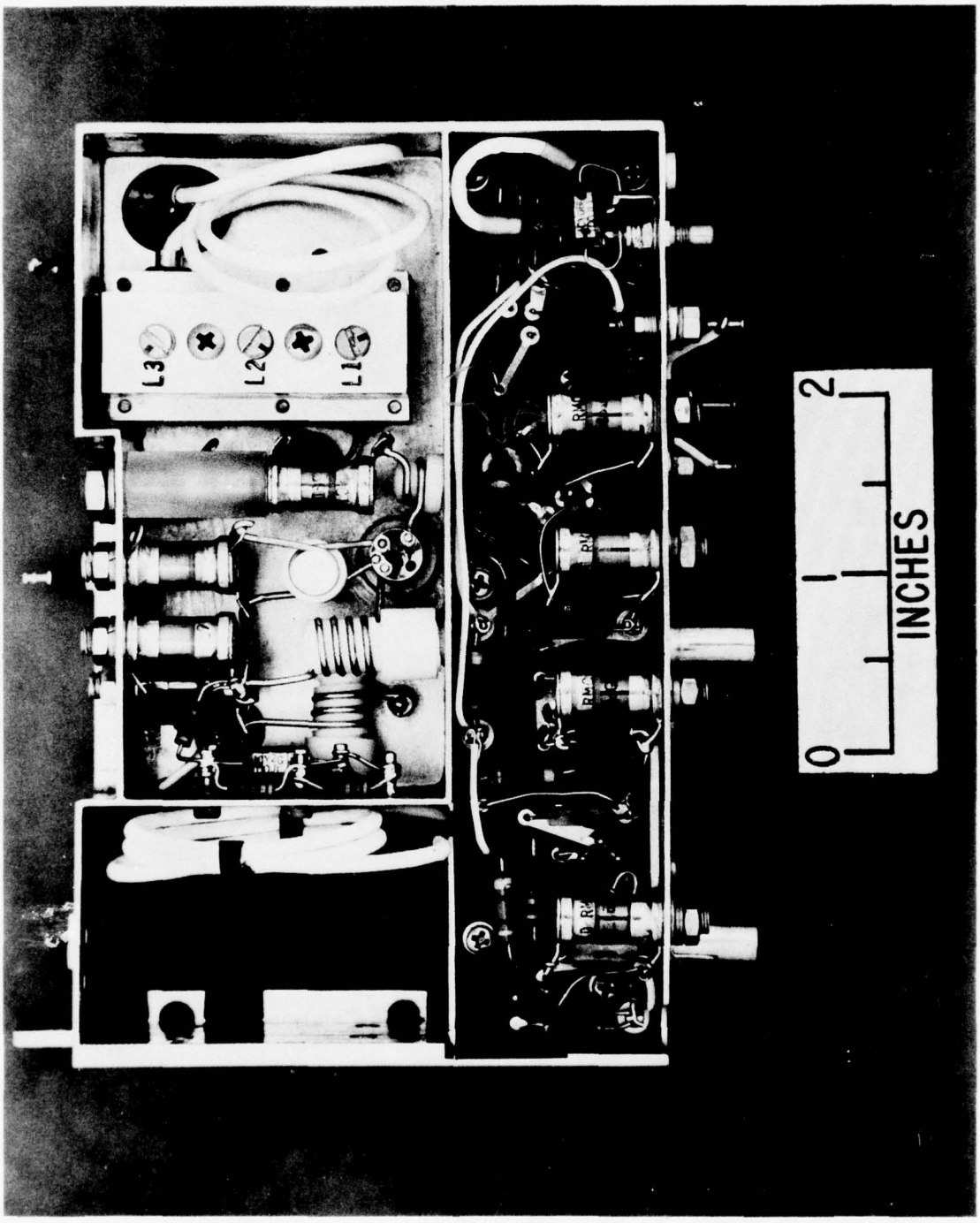
CONDITIONS:

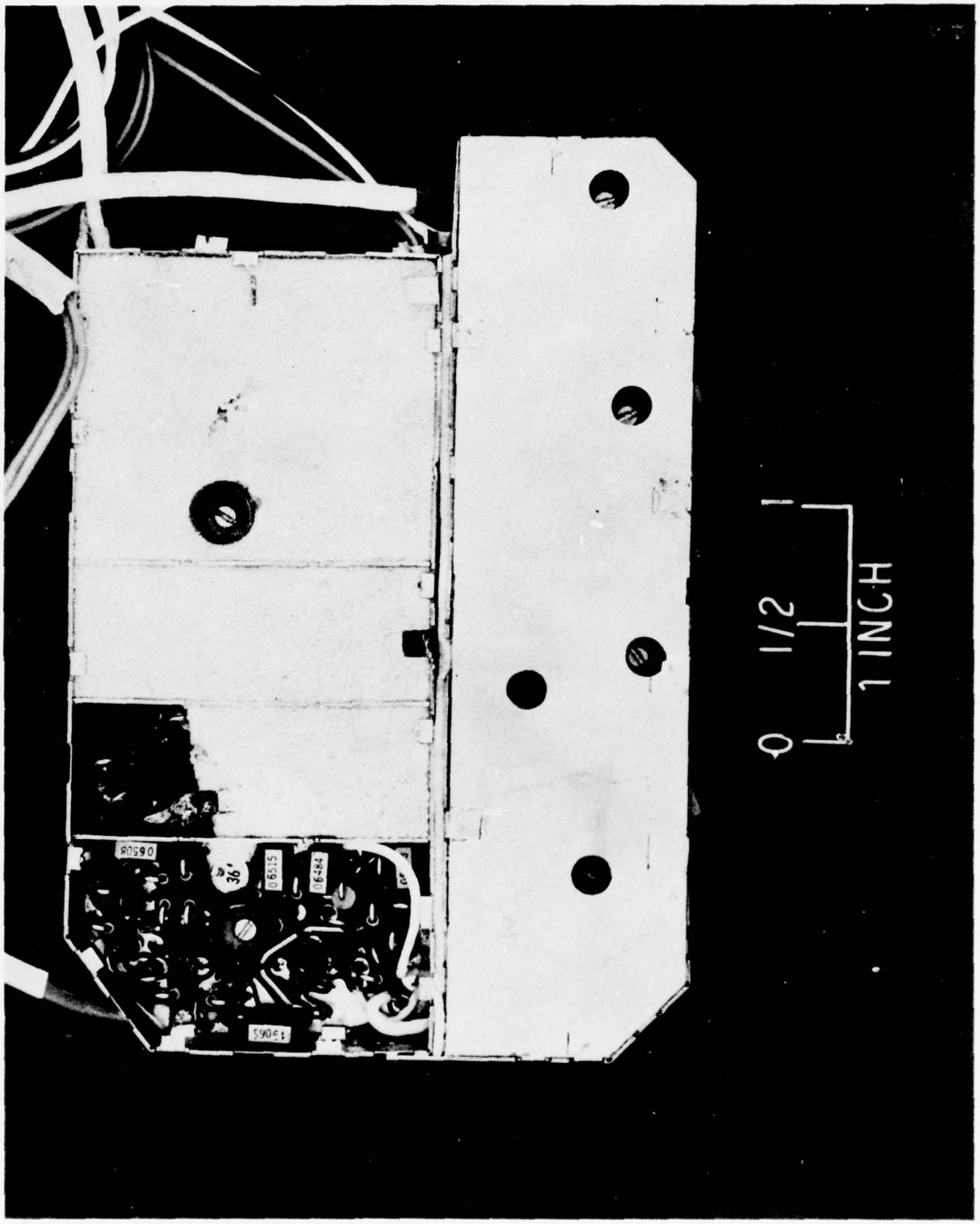
AUTHORIZATION:	QA INSPECTION DISCREPANCY REPORT QA FAILURE DISPOSITION REPORT
CERTIFICATION:	OPERATORS REQUIRE CERTIFICATION TO CONTRACT SPECIFICATION.
	AMISTAR SOLDER REMOVAL MACHINE OPERATORS REQUIRE ADDITIONAL CERTIFICATION.
SENSITIVE DEVICES:	STATIC OR TEMPERATURE SENSITIVE DEVICES/ASSEMBLIES REQUIRE SPECIAL HANDLING.
ENVIRONMENT:	SAME AS ORIGINAL BUILD.

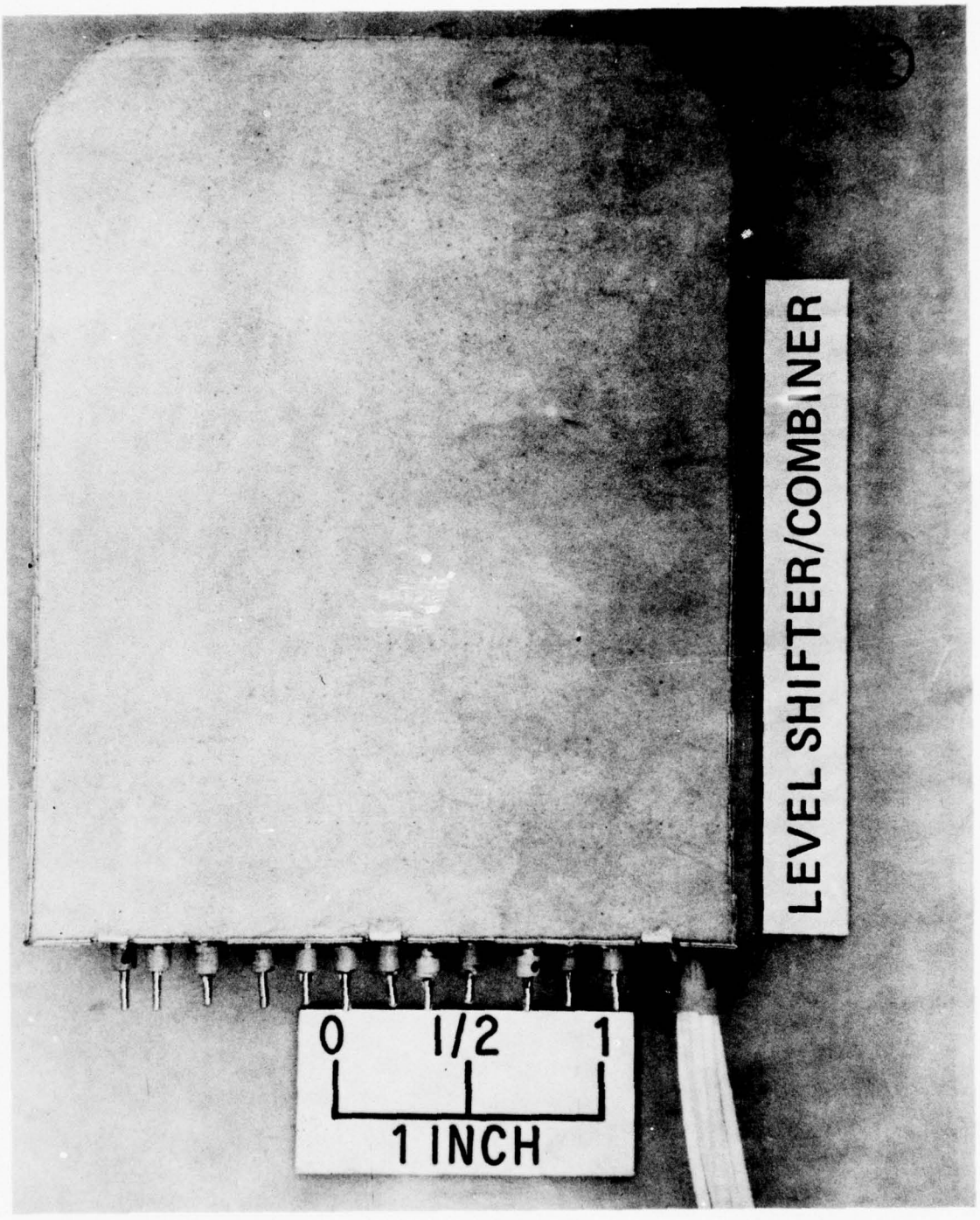

LEVEL SHIFTER/COMBINER
0 1/2 1
1 INCH


LEVEL SHIFTER/COMBINER
SHIFTER/COMB.
01 P06340H
ENG. MODEL
0 1/2 1
1 INCH


L3
L2
L1
0
1
2
INCHES


L3
L2
L1
0
1
2
INCHES


0 1/2 1
1 INCH


LEVEL SHIFTER/COMBINER
0 1/2 1
1 INCH

APPENDIX K

CONITHANE/SOLITHANE

M. Singleton and F. Hornbuckle
SCI Systems

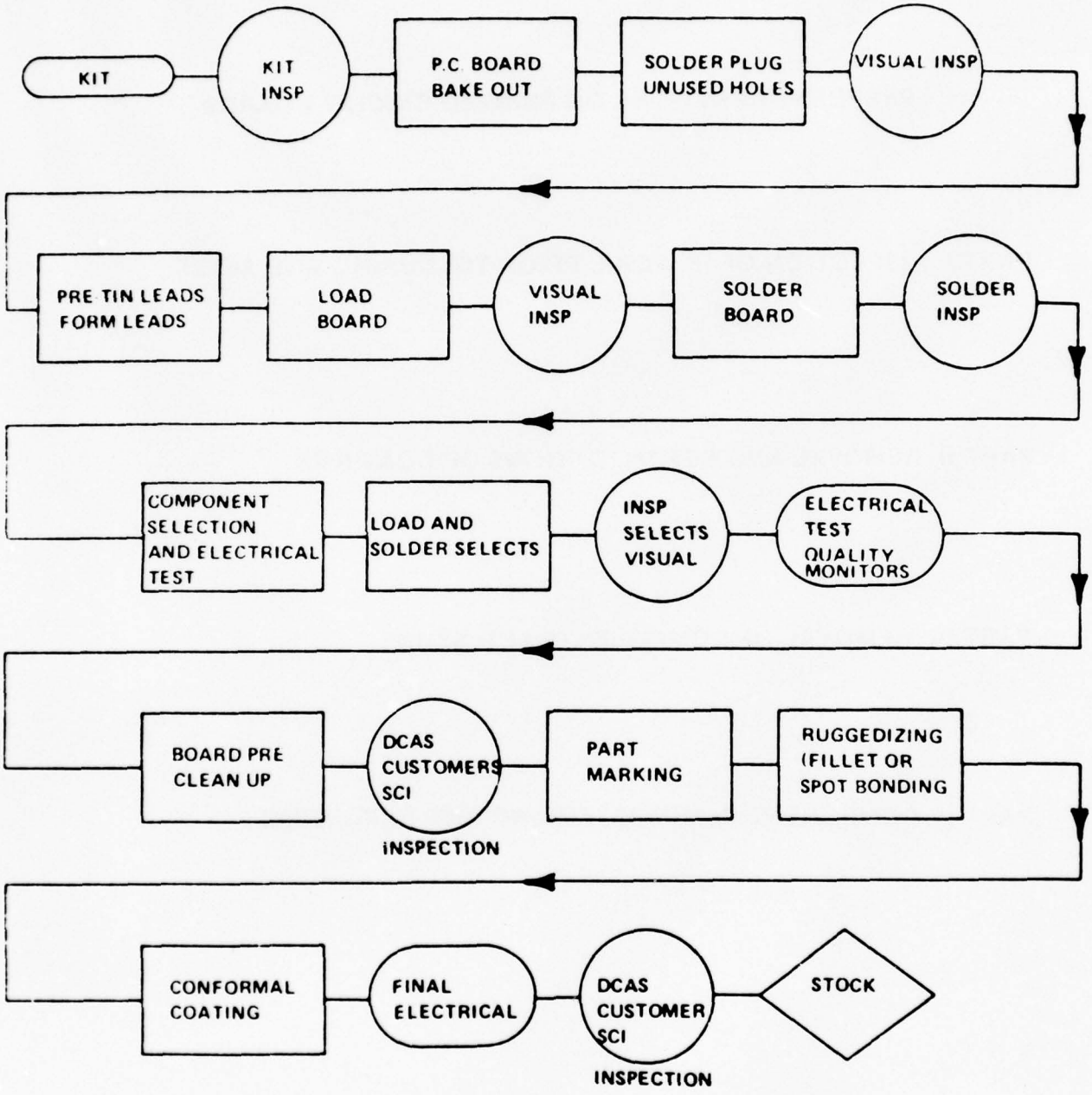
PERFORMING REWORK ON PRINTED CIRCUIT BOARDS

PART I INSPECTION OF REWORK, PRIOR TO; DURING AND AFTER

PART II REMOVAL AND REAPPLICATIONS OF COATINGS

PART III REMOVAL OF COMPONENTS FOR REUSE

PART IV COMPONENT REMOVAL, ADDING AND REPLACING


KIT
KIT INSP
P.C BOARD BAKE OUT
SOLDER PLUG UNUSED HOLES
VISUAL INSP
PRE TIN LEADS FORM LEADS
LOAD BOARD
VISUAL INSP
SOLDER BOARD
SOLDER INSP
COMPONENT SELECTION AND ELECTRICAL TEST
LOAD AND SOLDER SELECTS
INSP SELECTS VISUAL
ELECTRICAL TEST QUALITY MONITORS
BOARD PRE CLEAN UP
DCAS CUSTOMERS SCI
INSPECTION
PART MARKING
RUGGEDIZING (FILLET OR SPOT BONDING
CONFORMAL COATING
FINAL ELECTRICAL
DCAS CUSTOMER SCI
INSPECTION
STOCK

PART I INSPECTION OF REWORK, PRIOR TO DURING AND AFTER

NORMAL DETECTION FOR NEED TO REWORK

1. VISUAL INSPECTION
2. ELECTRICAL FAILURES
3. GENERIC CONDITIONS

DURING—

COMPONENT REMOVAL

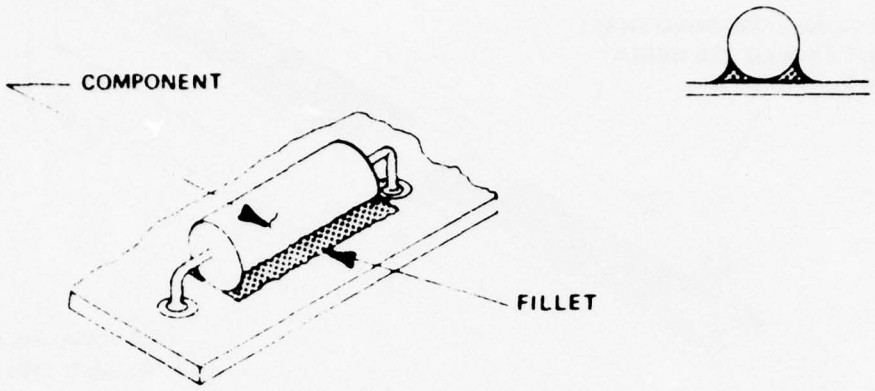
PTH VISUAL
SURROUNDING AREA

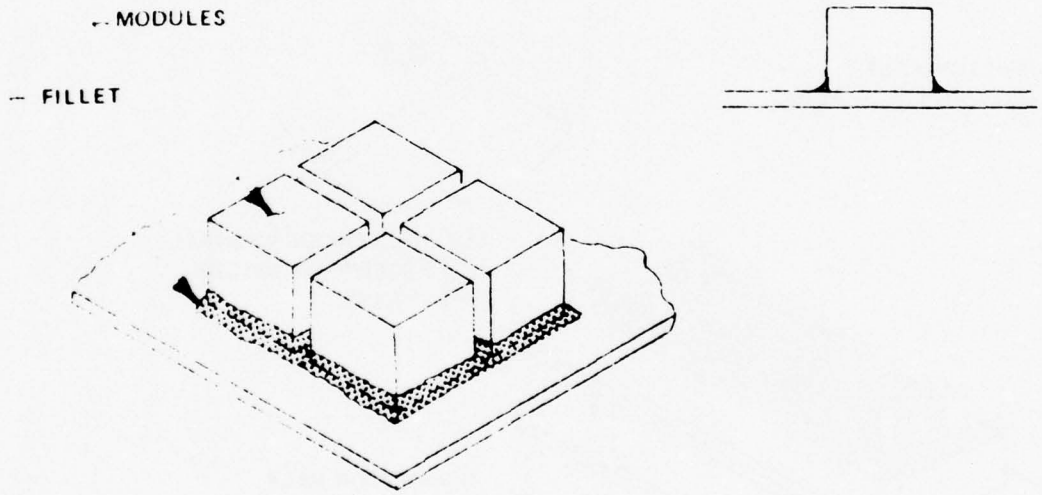
AFTER-

ORIGINAL SPECIFICATION
ELECTRICAL TEST
CONTINUE NORMAL FLOW

REMOVING AND REAPPLICATIONS OF BOARD COATINGS:

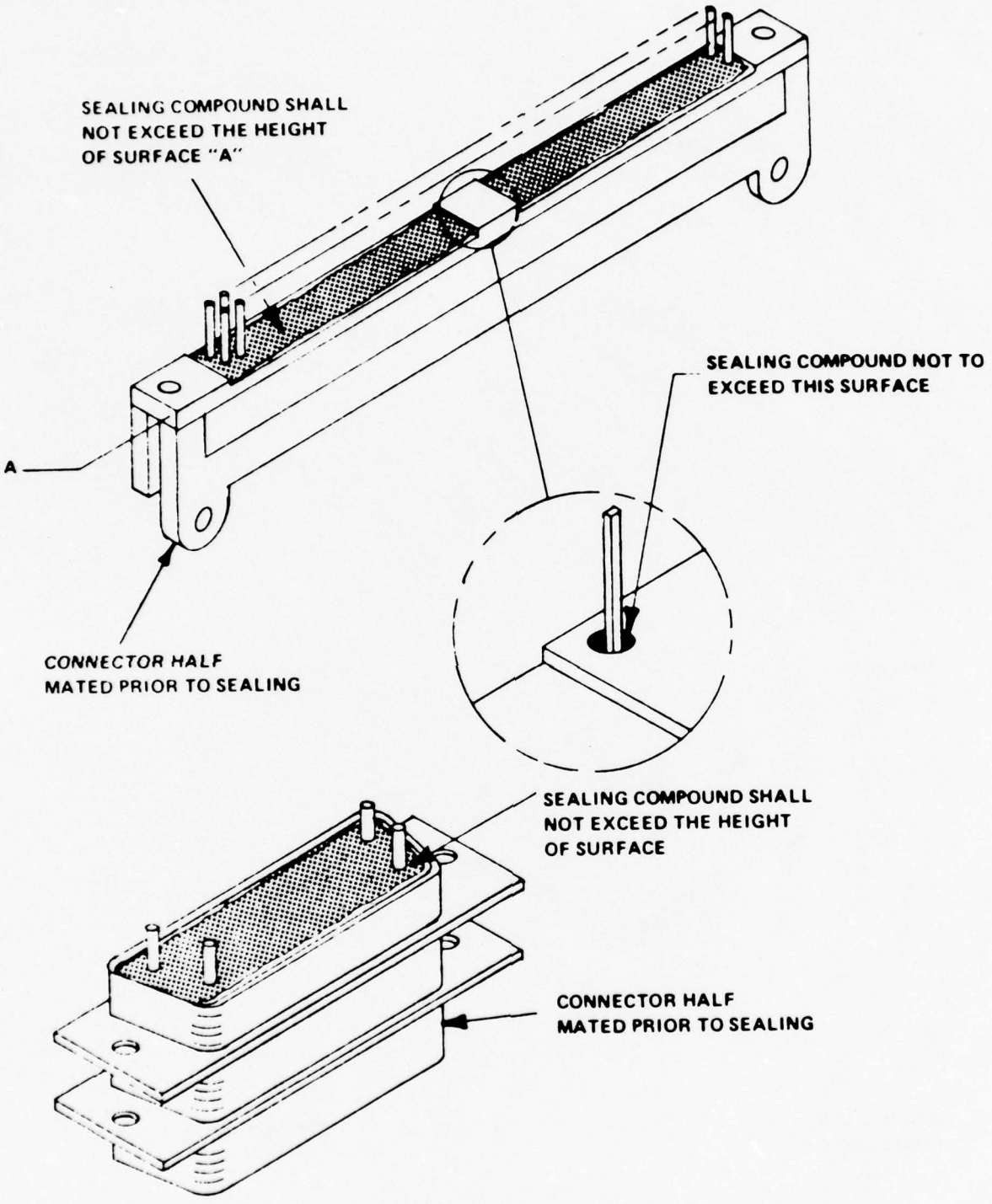
MAJOR TYPES	USAGE
SOLITHANE	CONFORMAL COATING
CONATHANE	CONFORMAL COATING
D.C. 3145	/ENCAPSULATION
SCOTCH CAST 8	SPOT BONDING/FILLETS
ARMSTRONG G1	SPOT BONDING/FILLETS
RTV 108	SEALING





SCOTCHCAST 8
ARMSTRONG C 1

SPOT BONDING FILLETS



SEALING APPLICATION

COATING REMOVAL

EQUIPMENT NEEDED

AIR CIRCULATING OVEN
VENTED HOOD
ISOPHOPYL ALCOLHOL
XYLENE
ORANGE WOOD STICK
SOFT BRISTLE BRUSH
PACE EQUIPMENT
RATIO SCALE

CONFORMAL COATINGS:

SOLITHANE

HOT AIR CIRCULATING OVEN 65° C/PACE
WITH DREMEL TOOL

ORANGE STICK

CONATHANE

MILLER STEVENS STRIP MS111 Q-TIP

D.C. 3145

TWEEZERS

SCOTCHCAST 8/C-I

PACE MACHINE — HOT AIR/ORANGE STICK

REAPPLICATION

MASKING TECHNIQUES

3M No. 60 TEFLON TAPE

PRECLEANING

MECHANICAL CLEANING

ORANGE WOOD STICK
DRY BRISTLE BRUSH
CAMEL HAIR BRUSH
AIR PRESSURE - LOW VOLUME

SOLVENT CLEANING

BRUSH WASH XYLENE
AIR PRESSURE
ALCOHOL RINSE
AIR PRESSURE
OVEN DRY

NOT RECOMMENDED

(1) ULTRASONIC CLEANING
(2) VAPOR DEGREASING(SOLVENT ENTRAPMENT)
(3) SOLVENTS NOT COMPATIBLE

RECOAT TO ORIGINAL SPECIFICATION AND REINSPECT

QUALITY REQUIREMENTS

CAUSE FOR REJECTION

- UNCURED OR TACKY ADHESIVES
- OVERCURING - CARBONIZATION
- SEPARATION
- BUBBLES IN BOND LINE
- FOREIGN MATERIAL

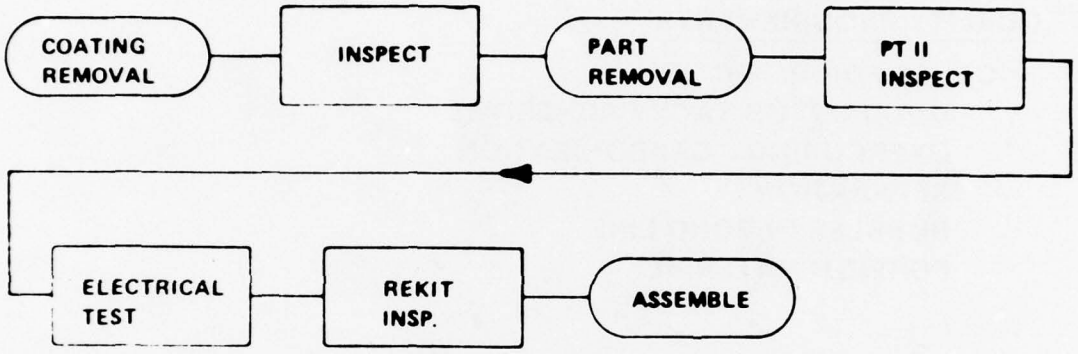
PART III

REMOVAL OF COMPONENTS FOR REUSE

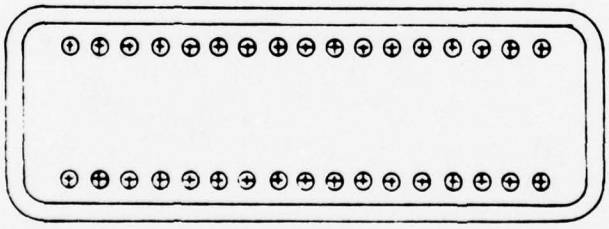
RATIONAL

1. TROUBLE SHOOTING
2. AVAILABILITY OF PARTS
3. COST FACTOR

CONTROL–TYPICAL



EXAMPLE 34 LEAD HYBRID



TOP VIEW

REMOVAL

1. HYBRID REMOVAL–PACE
2. INSPECT LEADS
3. RELIABILITY ENGINEERING
   - ELECTRICAL TEST
   - VISUAL INSPECTION
   - CLEAN UP
4. RETINNING
5. INSPECTION
6. STOCK

PART III CONTROL

REMOVING AND REPLACING PRINTED WIRING ASSEMBLY

KEY— SOLDER AND DESOLDER

ON AND OFF

EXAMPLE

MLB— HIGH DENSITY DIPS

1. CUT LEADS
2. REMOVE PARTS — SCRAP
3. REMOVE CONFORMAL COATING
4. DESOLDER LEADS — REMOVE
5. INSPECT
6. RETURN TO STOCK
7. REKIT
8. ASSEMBLE PER PRINT

PART IV

COMPONENT REMOVAL

ADDING
REPLACEMENT

EQUIPMENT USED:

PACE SYSTEM
SOLDERING IRONS
CLEANING SOLVENTS

CONTROLS USED

1. PROCESS CONTROL
   TIP TEMPERATURE
2. ANTI-STATIC ENVIRONMENT
3. CLEAN AREA
4. OPERATOR TRAINING

ADDING COMPONENTS

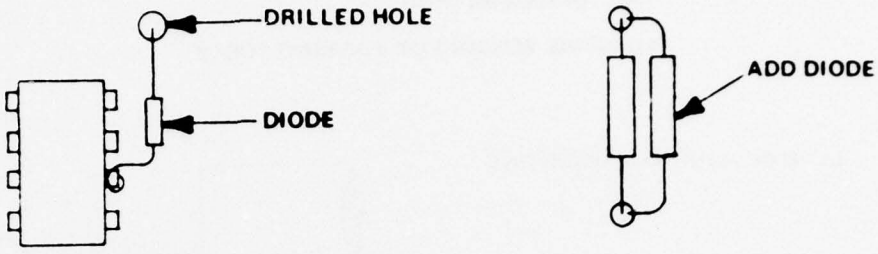
REAL WORLD —

JUMPER WIRES— NO SET RULE

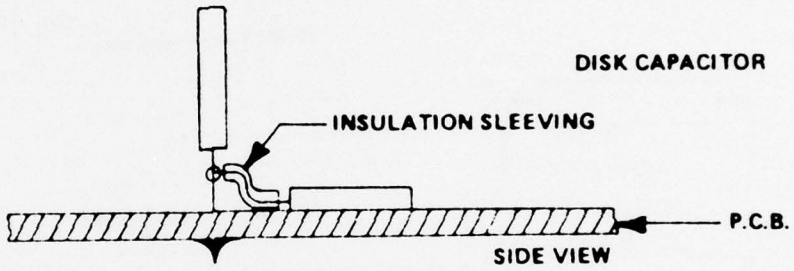
AT DESIGN STAGE—CUSTOMER/SUPPLIER

LIMITED ADDITIONS — NOT NORMAL PRACTICE

AXIAL LEADS
EXAMPLES



RADIAL LEADS



PART REMOVAL

AXIAL LEADS

RADIAL LEADS

MULTIPLE LEADS

CONNECTORS

FINE WIRE DEVICES

TERMINALS

EQUIPMENT USED

DOCUMENTATION REWORK INSTRUCTIONS

INSPECTION VISUAL PLATED THRU HOLE AND SURROUNDING AREA

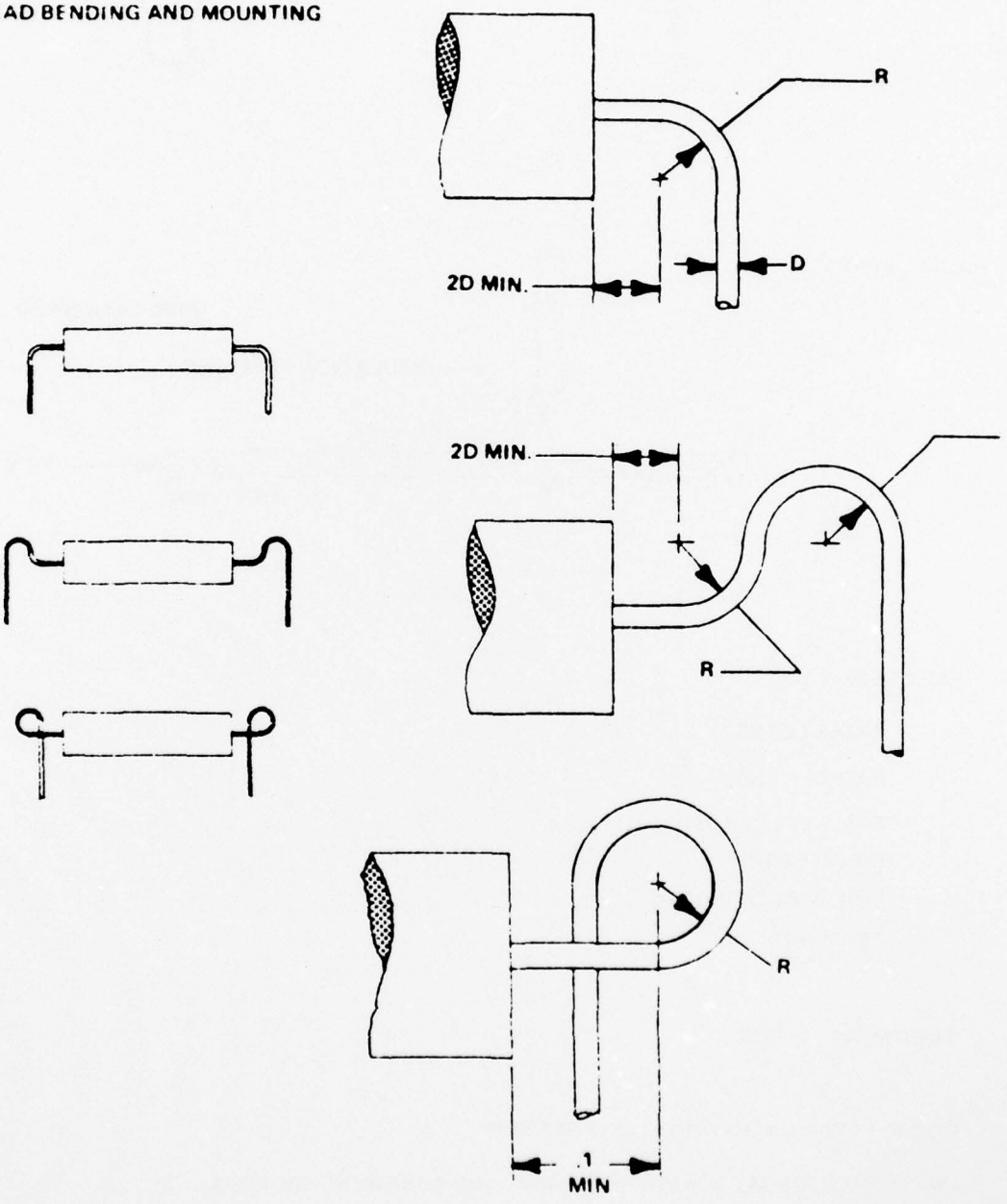
PART REPLACEMENT

COMPONENT REPLACEMENT

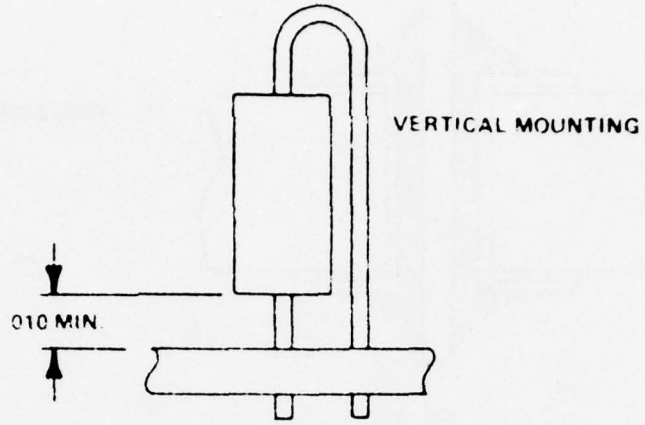
PRE-TINNING-METHOD

FORMING- BENDING OR FORMING TOOLS

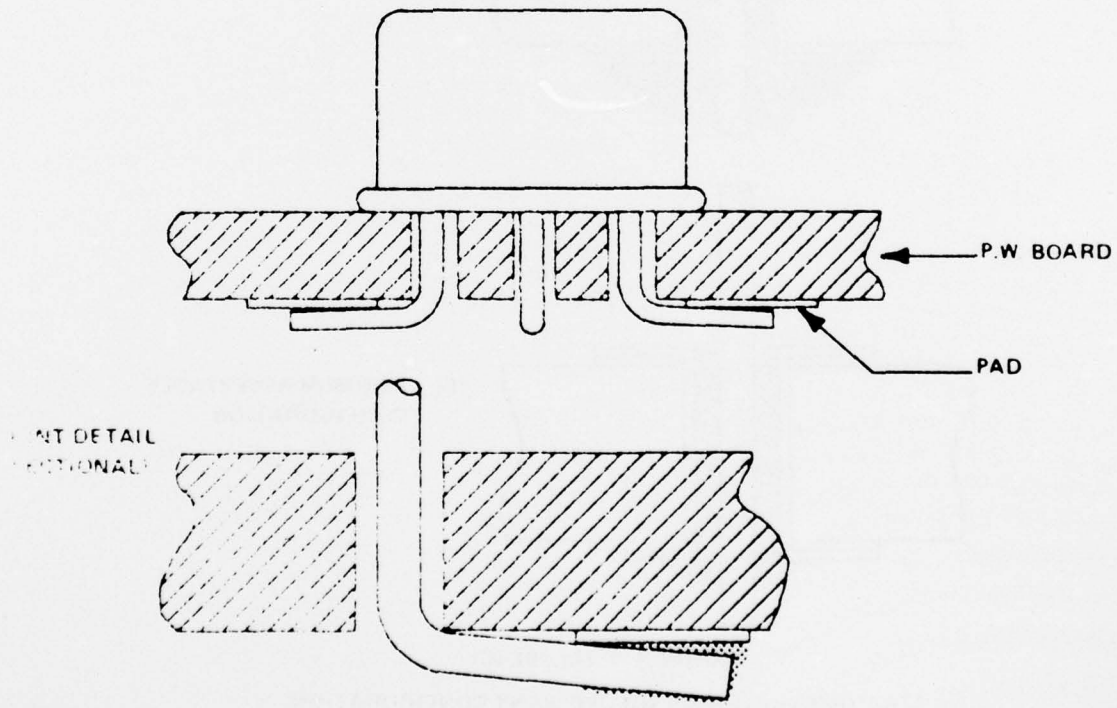
LEAD BENDING AND MOUNTING



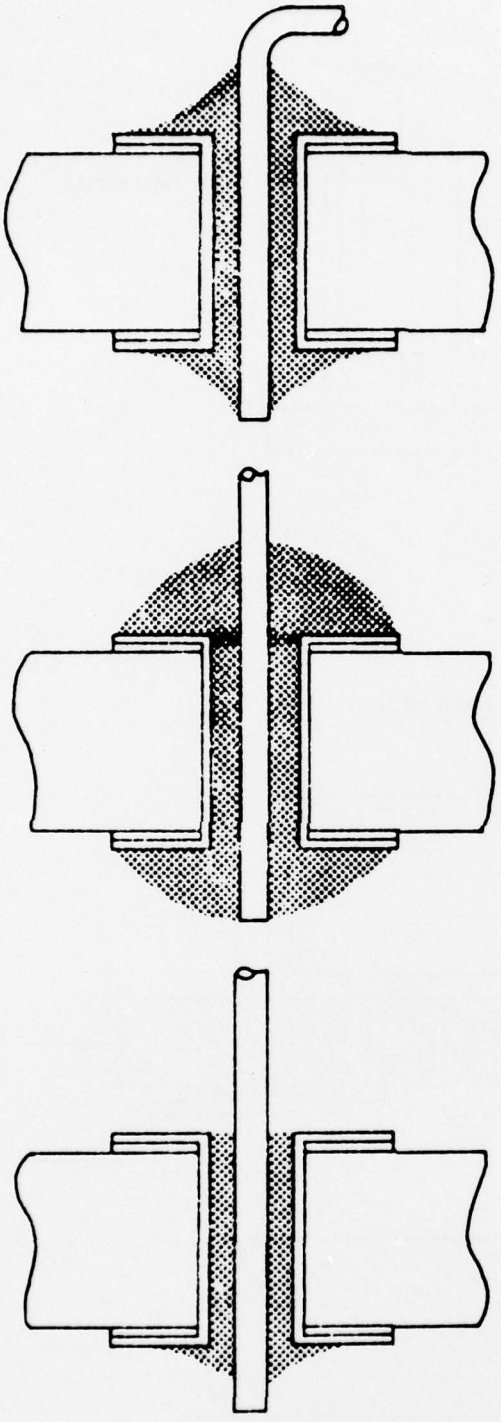
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LAP JOINT (OFF SET PADS NPTH)



SOLDER APPLICATION



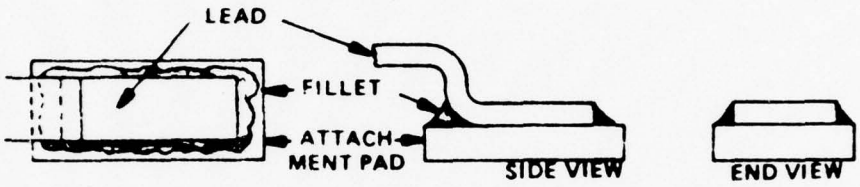
(A) PREFERRED CONFIGURATION

(B) MAXIMUM ACCEPTABLE CONFIGURATION

(C) MINIMUM ACCEPTABLE CONFIGURATION

FIGURE 1 – (A), (B), (C) –

STRAIGHT THRU LEAD SOLDER JOINT CONFIGURATION



INSPECTION

INSPECTION IS PERFORMED AT EACH REWORK OPERATION–

APPENDIX L

SUMMARY

W. Lang
Space Systems Division
Lockhead Missiles and Space Company

SUMMATION OF TUESDAY'S SPEAKERS

MY THOUGHTS ON THE PRESENTATION AS GIVEN THIS AFTERNOON SEEMS TO FOLLOW THIS PATH AND I HOPE MEETS WITH YOUR THOUGHTS ALSO. THE SUMMATION WOULD BE AS FOLLOWS:

- INSPECTION

IT APPEARS THAT WE ALL HAVE EITHER A VISUAL OR ELECTRICAL TEST REJECTION CREATING THE NEED FOR REWORK. THE NONCONFORMANCE REPORT (NCR) NORMALLY DICTATES THE START OF A MATERIAL REVIEW TO DETERMINE THE APPROPRIATE STEPS TO BE TAKEN.

DUE TO THE STATUS OF THE HARDWARE, THE REWORK IN PROCESS INSPECTIONS WILL VARY. AT TIMES, IT CAN AND WOULD INCLUDE DCAS OR THE CUSTOMER TO ALLOW AN INSPECTION THAT COULD BE COVERED DURING SUBSEQUENT OPERATIONS.

THE REWORK ACCOMPLISHED HAS TO MEET THE ACCEPTANCE CRITERIA OF THE FIRST TIME BUILD. IT WILL PASS ALL VISUAL AND ELECTRICAL REQUIREMENTS. ALSO, IF THE FAILURE WAS ATTRIBUTED TO AN ELECTRONIC MALFUNCTION DURING ACCEPTANCE TEST, ADDITIONAL TESTS OVER AND ABOVE THE ACCEPTANCE TEST PROCEDURE COULD BE STIPULATED BEFORE PROCEEDING WITH THE ACCEPTANCE TEST PROCEDURE.

UNDER THE CATEGORY OF COMPONENT REMOVAL AND REUSE, IT SEEMS THAT HONEYWELL, MOTOROLA, SCI SYSTEMS AND SPACE SYSTEMS DIVISION DO NOT PERMIT THE REUSING OF REMOVED DEVICES. HOWEVER, EVERYONE CONCEDES THAT AT SOME POINT SOMEDAY, MITIGATING CIRCUMSTANCES COULD FORCE US INTO A REUSE CONDITION. WHEN THAT OCCURS, ALL PARTIES INVOLVED WITH THE SYSTEM, OR BLACK BOX, MUST AGREE ON THE REUSE. THIS AGREEMENT WOULD INCLUDE THE RESPONSIBLE ELECTRONIC ENGINEER, RELIABILITY ENGINEERING, PARTS

ENGINEERING, PRODUCTION ENGINEERING, MANUFACTURING, QUALITY ENGINEERING, THE CUSTOMER AND DCAS. THIS GROUP WOULD ALSO APPROVE THE SPECIAL REWORK INSTRUCTIONS, INSPECTION, ELECTRICAL TESTS AND THE DOCUMENTATION REQUIRED PRIOR TO REINSTALLATION. IT IS EVIDENT THAT MECHANICAL DEVICES SUCH AS BRACKETS, FRAMES, ETC., MAY BE REUSED WITHOUT ANY SERIOUS PROBLEMS.

WITH SPECIALLY TRAINED PERSONNEL, WITH DEDICATED AREAS FOR REWORK, USING THE NEWEST TECHNIQUES FOR REMOVING SOLDER WIT VACUUM SOLDER REMOVERS, AND SPECIAL TOOLING, IT APPEARS THAT REMOVAL OF COMPONENTS CAN BE ACHIEVED IN A COMPLETELY CONTROLLED MODE, WITH SPECIAL TESTS SET UP FOR THE REUSE OF ANY DEVICE AS CIRCUMSTANCES DICTATE.

THESE AREAS ARE ALSO CONDUCIVE FOR THE MODIFICATION OF ANY ELECTRICAL SYSTEM OR BLACK BOX, DUE TO CHANGE OF SCOPE, DICTATED BY THE CUSTOMER OR PROGRAM.

IT IS APPARENT THAT ADDING TERMINALS, TRANSISTOR CLAMPS, COMPONENTS AND JUMPERS ARE BECOMING THE ACCEPTED PRACTICE FOR MEETING A CRITICAL SYSTEM DELIVERY DATE WHEN CHANGES DICTATE THEM. THIS COULD BE TO MEET THE ACCEPTANCE TEST PROCEDURE DUE TO INCIPIENT ANOMALIES WHEN THE BLACK BOX IS GOING THROUGH FINAL TEST OR A MAJOR MODIFICATION DUE TO A PROGRAM CHANGE BY THE CUSTOMER.

THE ADDITION OF JUMPER WIRES IS NOW BECOMING ACCEPTABLE, EVEN IF AESTHETICALLY IT DOES NOT MEET EVERYONE'S EYE. THIS DOESN'T DEGRADE THE HI-RELIABILITY OF THE PACKAGE BUT DOES BECOME VERY COST EFFECTIVE BY NOT HAVING TO REDESIGN AND START ANEW. THIS COST EFFECTIVENESS IS VERY IMPORTANT IN OUR NEW ENVIRONMENT OF SPENDING.

THE NEXT OBSERVATION IS ON THE REMOVAL OF FILLETING - STACKING - RUGGEDIZING AND CONFORMAL COATINGS. AS STATED UNDER THE REUSE OF COMPONENTS, EVERYONE APPEARS TO HAVE DEDICATED PERSONNEL

AND CERTAIN AREAS FOR THEIR REWORK. IT WAS RECOMMENDED THAT ADDITIONAL TRAINING AND CERTIFICATION OVER AND ABOVE THE SOLDER CERTIFICATION HAD TO BE MADE. THIS WOULD PROVIDE THE EXPERTISE NEEDED TO REMOVE THE SPECIFIC MATERIALS OF EACH COMPANY IN ORDER TO REMOVE SUCCESSFULLY ANY AND ALL COMPONENTS SO THAT THE HI-RELIABILITY OF THE BOARD, BOX OR SYSTEM WAS NOT DEGRADED WHEN REWORKED.

SOMEWHERE ALONG THE LINE I USUALLY FOLLOW THE OLD CHINESE PROVERB "PUT FOOT IN MOUTH" AND GET SOMEONE MAD AT ME -- SO HERE GOES.

WE HAVE HAD 5 SPEAKERS UP HERE THIS AFTERNOON AND EACH ONE SPOKE OF REMOVING DIFFERENT MATERIALS. AFTER ALL THESE YEARS IN THE SPACE INDUSTRY AND MANY OF THESE FINISHED BLACK BOXES RIDING SIDE BY SIDE IN THE SAME SPACE VEHICLE, WHY CAN'T WE HAVE SOME TYPE OF STANDARDIZATION.

ONE MATERIAL THAT WILL PROVIDE THE RIGID STAKING MATERIAL. ONE MATERIAL FOR THE SEMI-RIGID REQUIREMENTS. ONE CONFORMAL COATING MATERIAL THAT COULD POSSIBLY SATISFY TRANSMITTER, RECEIVER SYSTEMS AND THEN ALSO ALL THE OTHER SYSTEMS.

THE REASON FOR THIS OBSERVATION AND COMMENT TO YOU PEOPLE OUT IN THE AUDIENCE IS QUITE SELFISH. I AM THINKING OF COST REDUCTION THROUGHOUT THE AEROSPACE ELECTRONIC INDUSTRIES IN ALL PHASES OF DESIGN, PROCUREMENT, MANUFACTURING AND EVEN IN OUR OWN ORGANIZATION SUPPLIER PRODUCT CONTROL. WHEN PRODUCT ASSURANCE SUPPLIER REPRESENTATIVES ARE MOVED FROM ONE SUPPLIER TO ANOTHER, THEY WOULD NOT HAVE TO RE-EDUCATE THEMSELVES BUT USE THE SAME INSPECTION AUDIT CRITERIA. SINCE THIS WOULD EFFECT A COST SAVINGS FOR SSD, IT COULD POSSIBLY DO THE SAME FOR YOU.

THANK YOU

APPENDIX M

INSPECTION FOR BOARD DAMAGE

W. Williams
General Dynamics Corporation

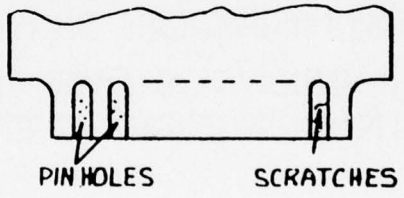
AD-A044 219 AEROSPACE CORP EL SEGUNDO CALIF F/G 9/5
PROCEEDINGS OF THE CONFERENCE ON REWORK AND REPAIR OF PRINTED C--ETC(U)
AUG 77 F04701-76-C-0077
UNCLASSIFIED TR-0077(2902)-1 SAMSO-TR-77-117 NL

3 OF 4
AD
A044 219



DEFECT: PIN HOLES OR SCRATCHES ON CONTACT TABS.

CONDITION	CLASS OF REPAIR	DISPOSITION
1. PIN HOLES GREATER THAN .010 DIAMETER THAT PENETRATE THROUGH THE GOLD	B	BRUSH PLATE PER SRR 5.0.3.3.
2. MORE THAN 2 PIN HOLES, LESS THAN .010 DIAMETER IN ANY ONE TAB, THAT PENETRATE THROUGH THE GOLD.	B	"
3. MORE THAN 6 PIN HOLES, LESS .010 DIAMETER PER SIDE OF BD.	B	"
4. SCRATCHES THAT ARE CONTINUOUS ACROSS THE CONTACT TAB AND PENETRATE THROUGH THE GOLD.	B	"



5.0.3.3.3 ACCEPTANCE CRITERIA

a. REPAIRED AREAS SHALL BE FREE OF BURNED AREAS, BLISTERS, PINHOLES, AND OTHER VISIBLE DEFECTS, AND SHALL BE SMOOTH AND GRAIN FREE.

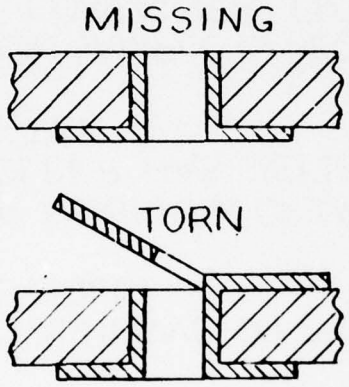
b. THE PLATING SHALL BLEND INTO THE SURROUNDING AREA WITHOUT EVIDENCE OF DELAMINATION AT THE BOUNDARY AND SHALL HAVE THE SAME GENERAL APPEARANCE AS THE ORIGINAL PLATING.

c. CHECK THE ADHESION ON EACH INDIVIDUAL REPAIR AREA BY THE FOLLOWING DRY TAPE TEST:

1. APPLY A STRIP OF TAPE (3M #470 PLATERS TAPE) TO THE PLATED SURFACE ALLOWING A SHORT TAB TO REMAIN FREE FOR HANDLING.
2. RUB THE TAPE FIRMLY AND ALLOW ABOUT 20 SECONDS FOR THE ADHESIVE TO SET
3. GRASP THE SHORT TAB, QUICKLY LIFT THE TAPE FROM THE SURFACE.
4. EXAMINE THE TESTED SURFACE USING 4X MAGNIFICATION. THERE SHALL BE NO EVIDENCE OF BLISTERING, PEELING, OR SEPARATION FROM THE BASE METAL OR UNDERCOATS.
5. A FRESH PIECE OF TAPE SHALL BE USED FOR EACH TEST.
6. REMOVE TAPE RESIDUE WITH SOLVENT (TRICHLOROETHANE) AND CHEESE-CLOTH (DDD-C-301)

DEFECT: MISSING OR TORN LAND

CONDITION	CLASS OF REPAIR	DISPOSITION
1. LAND, NORMALLY CONNECTED TO CIRCUITRY IS MISSING OR TORN.	A.	REPAIR PER SSR 5.0.3.2 CL A
2. THE HOLE LINING IS TORN.	A.	REPAIR PER SSR 5.0.3.2 CL A
3. THE MISSING LAND WAS ISOLATED.	B.	REPAIR PER SSR 5.0.3.2 CL B



REPAIR: CONDITION 1 & 2 - INSTALL REPLACEMENT LAND, THEN INSTALL EYELET, THEN INSTALL COMPONENT

5.0.3.2.2 ACCEPTANCE CRITERIA FOR LAND REPLACEMENT.

a. VERIFY THAT THE LAND IS CENTERED OVER THE HOLE AND IS NOT LIFTED MORE THAN .015.

b. VERIFY THAT THEIR IS NO ADHESIVE ON THE TOP SURFACE OF THE LAND NOR IN THE HOLE.

c. VERIFY THAT THERE IS A MINIMUM OF 1/4" OVERLAP PER FIGURE 1 AND THAT SOLDER HAS REFLOWED SMOOTHLY OVER VISIBLE PARIMETER

d. WHEN A BATCH CONTROL SAMPLE IS REQUIRED, REMOVE THE SAMPLE FROM THE CONTAINER, CUT IN TWO, AND INSPECT FOR THE FOLLOWING:

1. THE BOTTOM AND SIDES SHALL NOT BE TACKY

2. THE CUT EDGES SHALL BE FREE & UNIFORM IN COLOR & TEXTURE

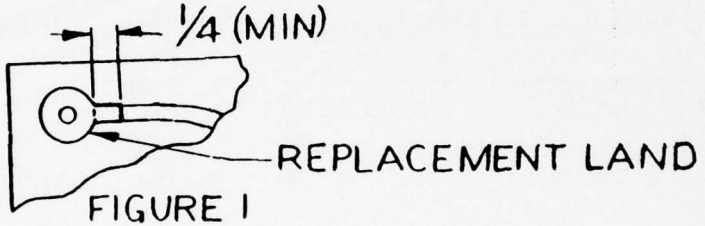


FIGURE 1

5.0.3.2.5 ACCEPTANCE CRITERIA FOR COMPONENT INSTALLATION

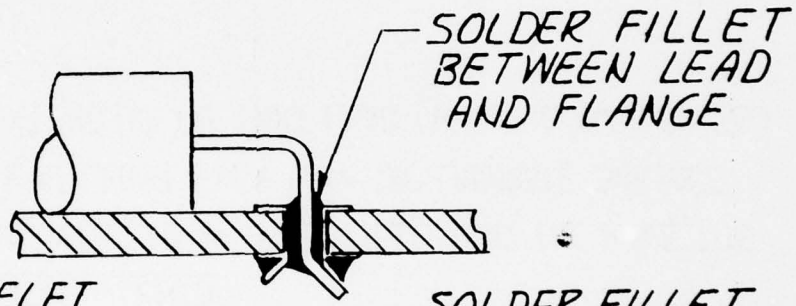
A. AFTER SOLDERING PARTS IN EYELETTED HOLES, THERE MUST BE FILLET OF SOLDER BETWEEN THE LAND AND THE FUNNEL FLANGE. FIG 4A OR 4B

B. UNLESS OTHERWISE SPECIFIED, THE COMPONENT INSTALLATION AND SOLDERING MUST MEET THE GENERAL REQUIREMENTS OF 0-73522.



DOUBLE-SIDED BOARD USING A FUNNEL FLANGE EYELET

FIG 4A



SINGLE-SIDED BOARD USING A FLAT FLANGE EYELET

FIG 4B

REPAIR: CONDITION 3. ISOLATED LANDS ARE NOT TO BE REPLACED.

5.0.3.2.1 REPAIR PROCEDURES

a. INSTALL AND CLINCH COMPONENT LEAD.

b. SOLDER PER FIGURE 5A OR 5B AS APPLICABLE

5.0.3.2.2 ACCEPTANCE CRITERIA

WHEN THE COMPONENT LEAD IS SOLDERED INTO THE HOLE, THE SOLDER SHALL BE AT LEAST EVEN WITH THE LAMINATE SURFACE AND THE FILLET EXTEND UP THE PART LEAD (REF: FIG'S 5A OR 5B)

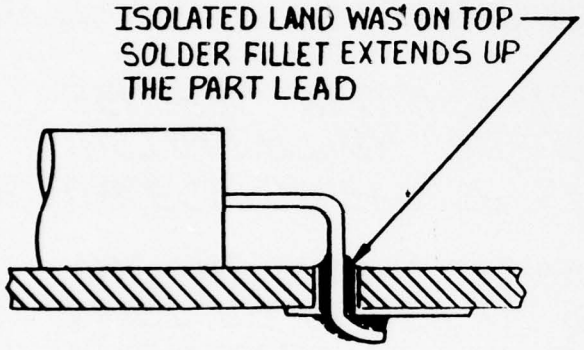


FIG 5A

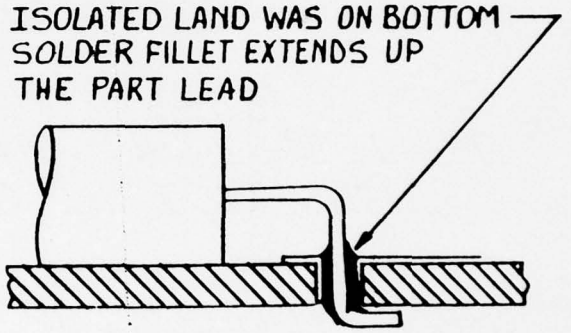


FIG 5B

5.0.3.2.3 ACCEPTANCE CRITERIA FOR EYELET INSTALLATION

a. SWAGED EYELETS SHALL MEET THE FOLLOWING CONDITIONS:

1. NO TEAROUTS, SPLITS OR CIRCUMFERENTIAL CRACKS.

2. RADIAL CRACKS ARE ACCEPTABLE UNLESS THEY EXTEND INTO THE BARREL. A CRACK IS A RUPTURE, FLAW OR FRACTURE IN THE SURFACE OF THE MATERIAL WHICH DOES NOT EXTEND COMPLETELY THROUGH THE MATERIAL IN THE THICKNESS DIMENSION, OR IF IT DOES, THE MATERIAL BORDERING THE CRACK IS SEPARATED LESS THAN 0.005 INCH.

3. THE EYELET SHALL NOT COMPRESS OR DELAMINATE THE BASE MATERIAL.

4. THE EYELET SHALL HAVE A 0.000 TO 0.003 INCH LOOSE FIT.

b. THE REPLACEMENT LAND/CONDUCTOR/EYELET SHALL MEET THE CRITERIA OF FIGURES 1, 2 AND 3.

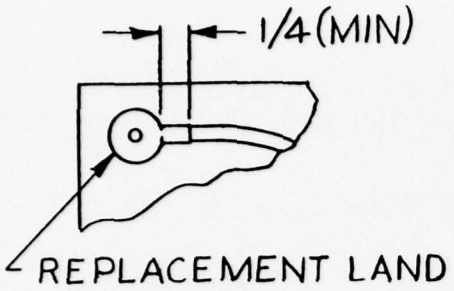
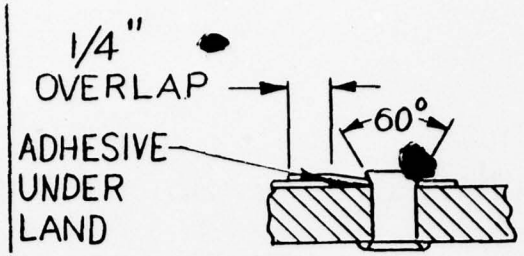


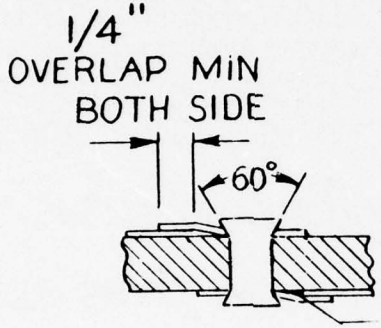
FIGURE 1.



ROLLE (OR FLAT) FLANGE,
SIDE OPPOSITE CIRCUITRY

SET EYELET TO .000" TO
.003" LOOSE FIT

SINGLE SIDEBOARD
FIGURE 2.



SET EYELET TO .000" TO
.003" LOOSE FIT

ADHESIVE UNDER LANDS
(BOTH SIDES)

DOUBLE-SIDED BOARD
FIGURE 3.

BEST AVAILABLE COPY

CONVAIR USES "STANDARD REWORK/REPAIR MANUAL" (SRRM) EFFECTIVE FOR DEFECTIVE PART.

INDIVIDUAL PROCESS SPECS HAVE "IN-PROCESS REWORK" ℄ CAN BE AUTHORIZED BY SHOP FOREMAN PLUS INSPECTOR.

SRRM COVERS STANDARD REWORK/REPAIR; CLASS "A" CAN BE AUTHORIZED BY LIAISON ENGR PLUS Q.A. ENGR, CLASS "B" CAN BE AUTHORIZED BY Q.A ENGR.

ALL OTHERS REQUIRE FULL MRB.

SIX STANDARD REWORK/REPAIR ARE IN SRRM.

DEFECTS COVERED HERE ARE IN SRRM

APPENDIX N

REPAIRABILITY OF EPOXY VS POLYIMIDE CIRCUIT BOARDS

J. J. Budna
Hughes Aircraft Company

REPAIRABILITY OF EPOXY VERSUS POLYIMIDE PRINTED WIRING BOARDS

HUGHES

REPAIRABILITY OF EPOXY VERSUS POLYIMIDE PRINTED WIRING BOARDS

HUGHES

- TYPE OF PRINTED WIRING BOARDS USED IN THE EVALUATION
- TEST PROCEDURES FOR EVALUATING POLYIMIDE BOARD MATERIAL
- RESULTS OF TESTS ON POLYIMIDE BOARD MATERIAL
- MANUFACTURING SOLDERING EVALUATION
- RESULTS OF MANUFACTURING SOLDERING EVALUATION
- MANUFACTURING EXPERIENCE
- TYPICAL ASSEMBLY USING POLYIMIDE BOARDS

TYPE OF PRINTED WIRING BOARD USED IN THE EVALUATION

HUGHES

MATERIALS

- EPOXY BASE LAMINATE – MIL–P–55617
- POLYIMIDE BASE LAMINATE – COMPANY SPECIFICATION

GEOMETRY

- TWO SIDED BOARD
- 0.020 INCH THICK
- 0.050 INCH PAD FOR THROUGH HOLE MOUNTED COMPONENTS
- 0.030 x 0.080 INCH PAD FOR SURFACE MOUNTED COMPONENTS

TEST PROCEDURES FOR EVALUATING POLYIMIDE BOARD MATERIAL

HUGHES

- MACHINABILITY – SHEARED, DRILLED, SAWED AND PUNCHED
- PROCESSING – EXPOSURE TO CHEMICAL AND PLATING SOLUTIONS USED IN FABRICATION
- HEAT RESISTANCE – 25 SOLDERING AND DESOLDERING OPERATIONS
- MEASLING – THREE CYCLES OF THE FOLLOWING:
  1) BOILED IN WATER FOR 30 MINUTES
  2) COOLED TO -65°C FOR 30 MINUTES
  3) FLOATED ON MOLTEN SOLDER AT 260°C FOR 20 SECONDS

RESULTS OF TESTS ON POLYIMIDE BOARD MATERIAL

HUGHES

- MACHINABILITY – NO EVIDENCE OF DELAMINATION
- PROCESSING – NO EFFECT
- HEAT RESISTANCE – VISUAL EXAMINATION (20X) NO LIFTED PADS, NO HOLE DAMAGE, MEASLING, SCORCHING OR BLISTERING
- MEASLING – NO MEASLING OR DELAMINATION

MANUFACTURING SOLDERING EVALUATION

HUGHES

THE PROCEDURE USED TO EVALUATE THE SOLDERING RESISTANCE OF THE POLYIMIDE VERSUS EPOXY PRINTED WIRING BOARDS WAS AS FOLLOWS:

- PROVIDED ONE BOARD OF EACH TYPE TO FOUR DIFFERENT ASSEMBLERS
- SOLDERED AND DESOLDERED A RESISTOR AND A FLATPACK TO THE BOARDS. THE SAME PAD PATTERNS WERE USED ON EACH OPERATION.
- EXAMINED BOARDS AFTER EACH SOLDERING AND DESOLDERING OPERATION TO DETERMINE PAD DAMAGE.

RESULTS OF MANUFACTURING SOLDERING EVALUATION

HUGHES

	FLATPACK		RESISTOR	
TYPE OF BOARD	NO. OF CYCLES	DAMAGE	NO. OF CYCLES	DAMAGE
EPOXY	4	1 PAD LIFTED	5	1 PAD LIFTED
EPOXY	5	3 PADS LIFTED	9	NONE
EPOXY	6	MEASLING	6	NONE
EPOXY	7	1 PAD LIFTED	7	1 PAD LIFTED
POLYIMIDE	6	NONE	6	NONE
POLYIMIDE	10	NONE	10	NONE
POLYIMIDE	19	NONE	46	NONE
POLYIMIDE	21	NONE	41	NONE

MANUFACTURING EXPERIENCE

HUGHES

THE TYPE AND NUMBER OF DISCREPANCIES FROM MANUFACTURING EXPERIENCE ON APPROXIMATELY 400 PRINTED WIRING BOARDS OF BOTH TYPES IS LISTED BELOW:

PAD LIFTING

	EPOXY	POLYIMIDE
PAD FAILURES DURING ORIGINAL ASSEMBLY	14	NONE
PAD FAILURES DURING REWORK	63	8

APPENDIX O

REPAIR OF PRINTED WIRING BOARDS BURNS, BLISTERS AND CRACKS

Y. Moriwaki
Hughes Aircraft Company

PRINTED WIRING BOARD SUBSTRATE REPAIR

HUGHES

PRINTED WIRING BOARD SUBSTRATE REPAIR

HUGHES

DECISION TO REPAIR

TYPES OF DEFECTS

- BURNED AND CHARRED AREAS
- MEASLING, CRAZING, BLISTERS, AND DELAMINATION

GENERAL CONSIDERATIONS

HUGHES

3 CHOICES – MATERIAL REVIEW BOARD (MRB) ACTION

- NO ACTION – USE AS IS
- REJECTION – SCRAP
- REPAIR – AS DIRECTED BY MRB

BASIS FOR THE ABOVE CHOICE

- EFFECT ON RELIABILITY
- COST OF REPAIR
- SCHEDULE CONSIDERATIONS
- CAUSE OF DEFECT

BURNED AND CHARRED AREAS

HUGHES

CAUSES

- OVERHEATING FROM EXTERNAL SOURCE
- TRACKING OR SHORT CIRCUIT
- COMPONENT OVERHEATING

CRITERIA

- SIZE OF DEFECT
- PROXIMITY TO UNCOMMON CONDUCTORS
- BRIDGING OF UNCOMMON CONDUCTORS

REPAIR OF CHARRED AREAS

HUGHES

TYPICAL REPAIR PROCESS

- REMOVE DEFECTIVE AREA
- FILL WITH RESIN
- CURE AND CLEAN

MATERIALS

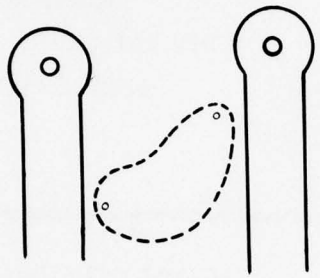
- FILLED EPOXY
- EPOXY POLYAMIDE WITH MENTHANEDIAMINE
- QUICK CURING EPOXY

REPAIRING BLISTERS

HUGHES

TYPICAL PROCESS

- DRILL ACCESS HOLES
- MIX THE MATERIAL, DEGAS, FILL, AND DEGAS
- GRADUALLY APPLY ATMOSPHERIC PRESSURE
- SUPPORT PWB TO PREVENT WARPAGE



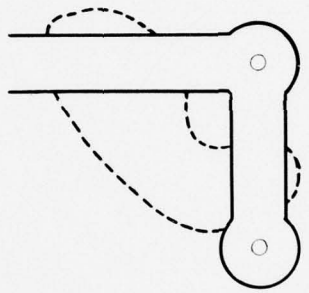
MEASLING, CRAZING, AND BLISTERS

HUGHES

PERMISSIBLE MEASLING AND CRAZING

BLISTERS THAT BRIDGE UNCOMMON CONDUCTORS

REPAIRABLE BLISTERS



APPENDIX P

GENERAL REPAIR OF PRINTED WIRING BOARD ASSEMBLIES

M. Perchick
RCA Astro-Electronics Division

1. DAMAGED PRINTED CIRCUIT CONDUCTOR (2 CHARTS)

Description of Condition

A portion of the conductor is damaged by a break, scratch, nick, or reduction in cross-section below the permitted reduction of 20%.

Limits on Application

1. No repairs to unassembled circuit boards are permitted.
2. Repair is limited to 5 conductors or 5% of the PC board conductors, whichever is the larger number.

Method Description

A solid jumper wire is soldered into a position which bridges the damaged area.

Cut any loose printed circuitry that might break off later and remove any solder in the break area (See Figure 1).

Clean both sides of break area with alcohol.

Tin printed circuit trace wire.

Center wire over damaged area, solder and clean.

2. LIFTED EDGE CRITERIA (1 CHART)

1. Repairs are only made if the lifting or separation of pads exceeds the established limits. A 0.0015 inch feeler gauge may penetrate a distance equal to no more than one half (1/2) the distance from the interface of the hole to the nearest edge of the terminal area (annular ring) for not more than 180° of the periphery.

CRITERIA FOR TARGET PADS (BOARDS SPRAYED WITH CONATHANE)

A target pad is defined as a printed circuit terminal area having no surface conductive trace extending from it.

1. A lifted target pad on the component side of a multilayer PCB is acceptable provided that it is securely soldered to the component lead and does not prevent the inspector from determining the quality and quantity of solder in the PTH.
2. A totally separated target pad on the component side of a multilayer PCB may be removed.

3. REBONDING OF LIFTED PADS (2 CHARTS)

Description of Condition

The terminal pad area of a printed circuit conductor has become lifted or otherwise separated from the basic board laminated.

Limits on Application

1. No repairs to unassembled circuit boards are permitted.
2. Repair is limited to 5 pads, or 5% of the PC board pads, whichever is the larger number.

Method

An epoxy adhesive is used to rebond the damaged pad, or a replacement pad that is soldered in place.

Remove solder component or stitch from the lifted pad.

Abrade the board surface where it interfaces with the lifted pad.

If edge is lifted bond without abrading.

Clean the under surface of the lifted pad.

Clean board and pad interface area with alcohol dried thoroughly.

Apply a thin even coat of Epon 828.

Press pad into its original position on board.

The adhesive is cured.

The component or stitch wire reinstalled.

Solder and clean.

Recoat the repaired pad on both sides of board with conathane.

4. DELAMINATION ON MULTILAYER BOARDS (3 CHARTS)

Description of Condition

A localized swelling and separation between any of the layers of the base laminate and/or between the laminate and the metal cladding.

Limits on Application

1. Repairs to delaminations which touch or cross thru-hole connections require an MRB.
2. Delamination must be less than 10% of the surface area.

Method

The delaminated areas are vacuum impregnated with an epoxy-polyamide.

Clean area(s) of board to be repaired, using TF Freon.

Using a pin vise and small drill, puncture each area in at least (2) spots, opposite each other, around the perimeter of the delamination. Remove any chipped-off material.

Place board in vacuum oven to completely dry.

Using Alba-seal, form a pocket over the area(s) to be reworked.

Fill this pocket with a sufficient amount of residweld to flood the area.

Place board in vacuum chamber at room temperature.

Remove Alba-seal and excess material.

If a bubble exists and will not be acceptable when cured, clamp a piece of teflon on the bump to eliminate it while curing.

Remove any squeezed out material.

Remove flashing and excess material - clean board.

5. REMOVAL OF UNWANTED THRU-HOLE CONNECTION (2 CHARTS)

Description of Condition

An erroneous connection of an internal circuit layer at a plated thru-hole stack.

Limits on Application

This repair cannot be used if any internal layer connections to the plated thru-hole barrell must remain intact, as all internal connections are removed.

Method

The plating in the thru-hole and all interconnections are removed by oversized drilling. Interconnection between the external circuits is made with a sleeved and soldered jumper wire.

Drill out plating with a drill .005" larger than the finished hole size.

Examine the walls of the drilled hole to insure no plating or metal smear exists. If metal still remains, redrill with the next larger size drill.

Circuit check pad on both sides of board to all inner layers to insure short has been removed.

Pretin stitch material.

Apply stitch to board in line with traces. Install insulating sleeving to prevent stitch shorting to inner layers. Sleeving must be flush with the board surface at a minimum, and as a maximum shall not extend more than 1/32" above the board surface. Solder stitch to trace only.

Acceptance Criteria

The added thru-hole insulation shall be unbroken and extend 1/32 of an inch above the pad surface on both sides. Jumper wire soldering shall be in accordance with the quality standard for the assembly.

6. PLUGGING HOLES IN EPOXY-GLASS BOARDS (2 CHARTS)

Limits on Application

1. Holes up to approximately .12" diameter may be repaired by filling directly with adhesive.
2. Holes over .12" and up to .50" diameter shall be repaired by bonding a plug of epoxy glass into a drilled or milled hole.
3. Holes under .12" diameter may be plugged if maximum strength is required or redrilling shall be performed in/or adjacent to the repaired area.

Method

Determine the size and method of repair required.

Drill or mill hole to required size.

Form plug to allow approximately .003 - .006" clearance on diameter between plug and hole (this will allow an adhesive joint thickness .004 + .002 - .001).

Clean with Acetone.

Bond with M688-CH8.

Apply adhesive to board.

Insert plug (methods 2 and 3 only).

Remove excess resin.

Place repaired area on a sheet of mylar or teflon.

Clean.

7. REMOVAL OF UNWANTED CIRCUITRY (2 CHARTS)

Description of Condition

An engineering change to the electrical circuit of a populated printed circuit board requires that a circuit trace must be cut.

Limits on Application

The cutting of a circuit trace must be authorized by engineering change notice.

Method Description

A minimum 1/32 inch section of the trace is cut and removed.

8. JUMPER BY-PASS OF MISSING OR DAMAGED PC PAD (2 CHARTS)

Description of Condition

A printed circuit pad on the part side of the board is damaged beyond repair or is missing.

Limits on Application

A maximum of three repairs is permitted for a board.

Method

Clean the circuit trace and lead of any coating.

Cut a small piece of 2010105 buss wire. Buss wire cross-sectional area must be at least equal to the trace cross-sectional area.

Form a small hump in the jumper.

Lap solder to the trace, and wrap and solder to the part lead.

9. REROUTING OF PRINTED CIRCUITRY (6 CHARTS)

Description of Condition

Non-standard attachment of jumper wires to part leads and solder traces, and terminals.

Limits on Application

1. These non-standard lead attachment methods shall be used only on populated assembly.
2. There shall be a limit of 5 jumper wires attached to a populated board assembly.

Type 1 - Wrap to Part Side Lead

Carefully remove any protective coating from the part lead and any top side solder pad at the lead using a soldering iron.

Brush clean the area with solvent and remove any solder which may interfere with a tight wire wrap. (Keep plated hole filled with solder).

Wrap the jumper wire around the part lead from 1/2 to 1 full turn.

Solder and clean the connection keeping all solder out of the stress relief bend.

Check the opposite side of the board for solder connection quality and rework as necessary.

Type 2 - Wrap to Wiring Side Lead

Remove any solder from the part lead or clinch.

Carefully straighten the lead clinch to form a vertical post. Extreme caution is required so as not to lift or tear copper circuitry.

Wrap the jumper lead 1/2 to 1 full turn around the vertical lead. There must be sufficient vertical lead to permit the observing its contour in the finished connection, and the determination of acceptable filleting.

Solder in place.

Clean flux residue from joint with solvent.

Check opposite side for connection disturbance.

Type 3 - Lap Solder to PC Trace

Clean lap solder location of protective coating using a soldering iron.

Clean with solvent and retin.

Cut exposed jumper conductor 1/16 to 1/8 inch long.

Holder in position and solder a minimum of 1/16 inch along the trace.

Clean away flux residue with solvent.

Type 4 - Flat Buss Jumper Addition to IC Lead and PC Traces

Remove coating if required.

Clean.

Tin buss wire.

Apply flux.

Position bus wire and hole in place to restrict movement during soldering. Bus wire must be positioned on I.C lead in a manner that will prevent the I.C. lead stress relief from being negated.

Clean.

Type 6 - Bond Mounted Bifurcated Terminal Assembly

Limits on Application

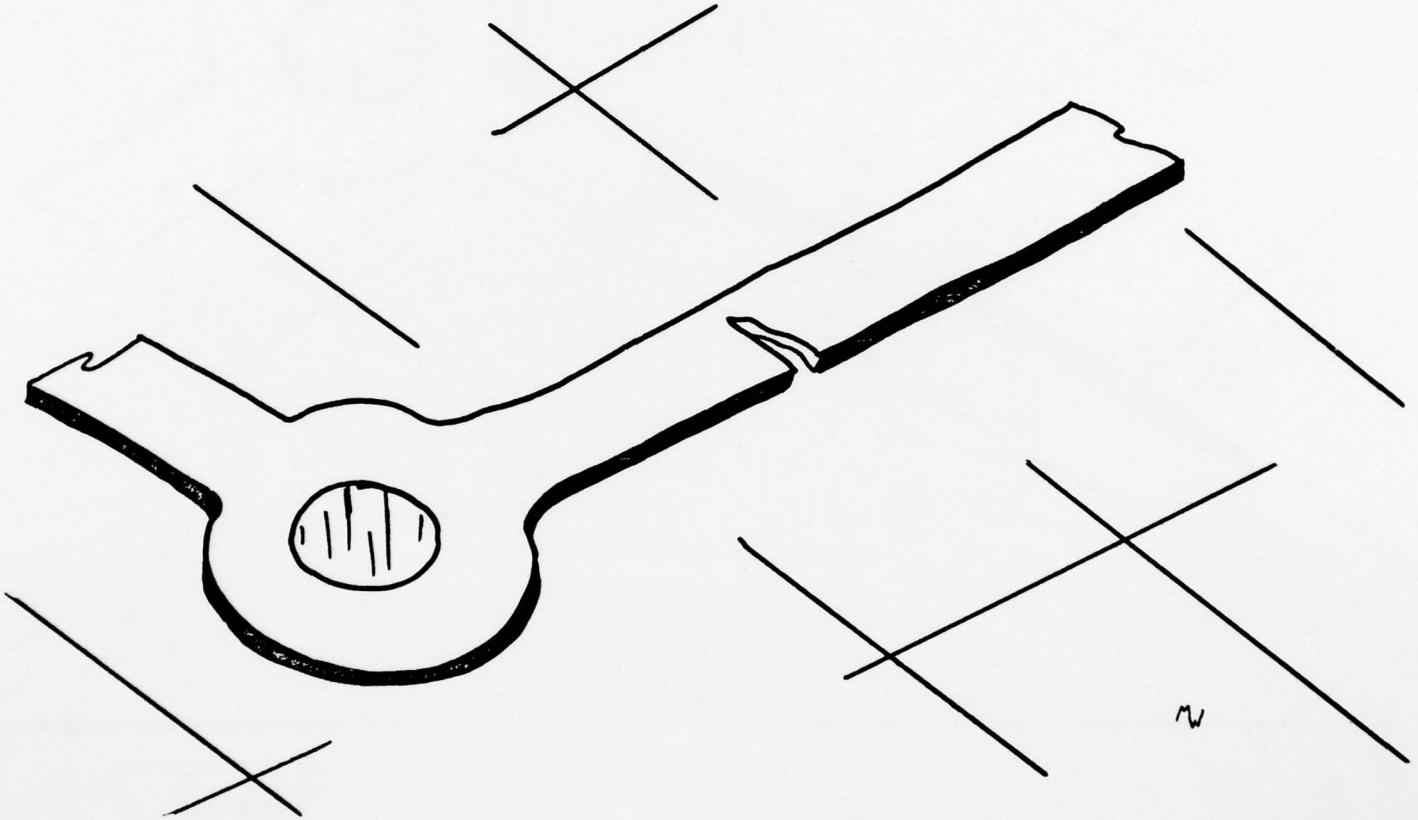
No more than 6 bond on terminals per board assembly will be accepted.

Method

The terminals are bonded in place using epoxy.

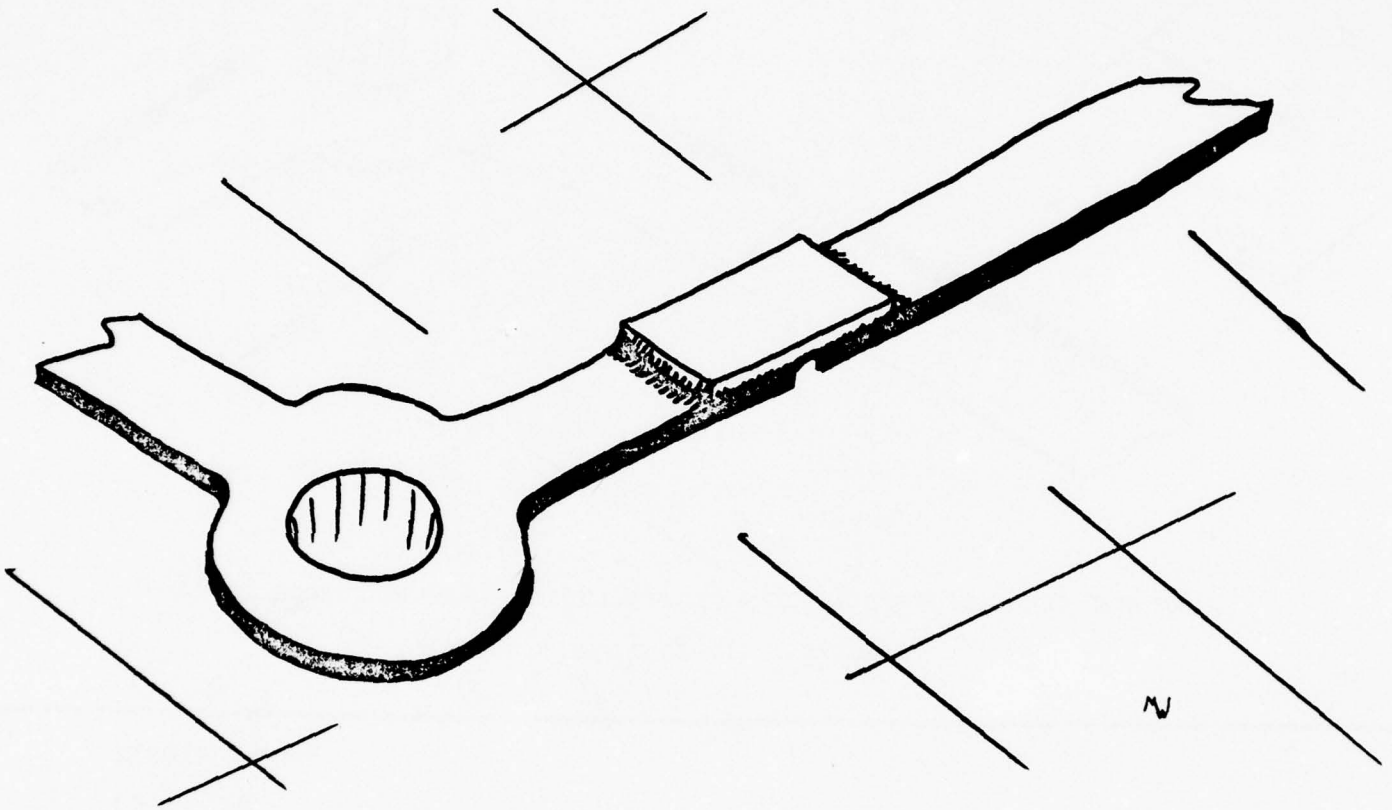
DAMAGED PRINTED CIRCUIT CONDUCTOR

(COMPLETE BREAK, ETCH OUT, OR REDUCTION OF CROSS-SECTIONAL AREA BY GREATER THAN 20%)



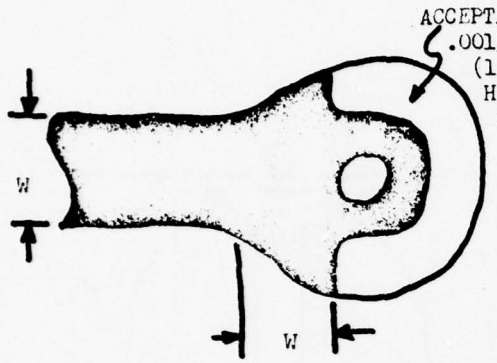
COMPLETED REPAIR

DAMAGED PRINTED CIRCUIT CONDUCTOR

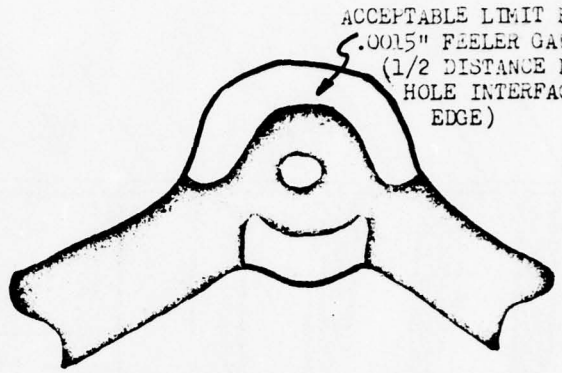


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Astro Electronics

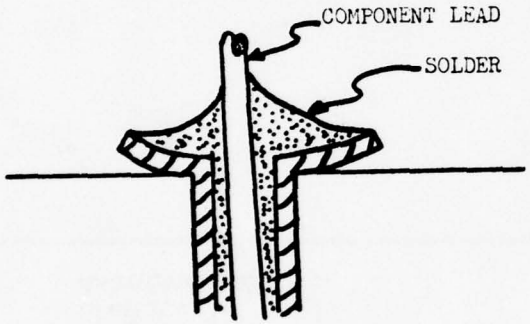
LIFTED EDGE



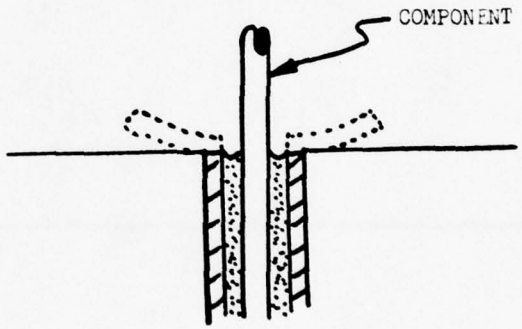
LIFTED EDGE



LIFTED TARGET PAD

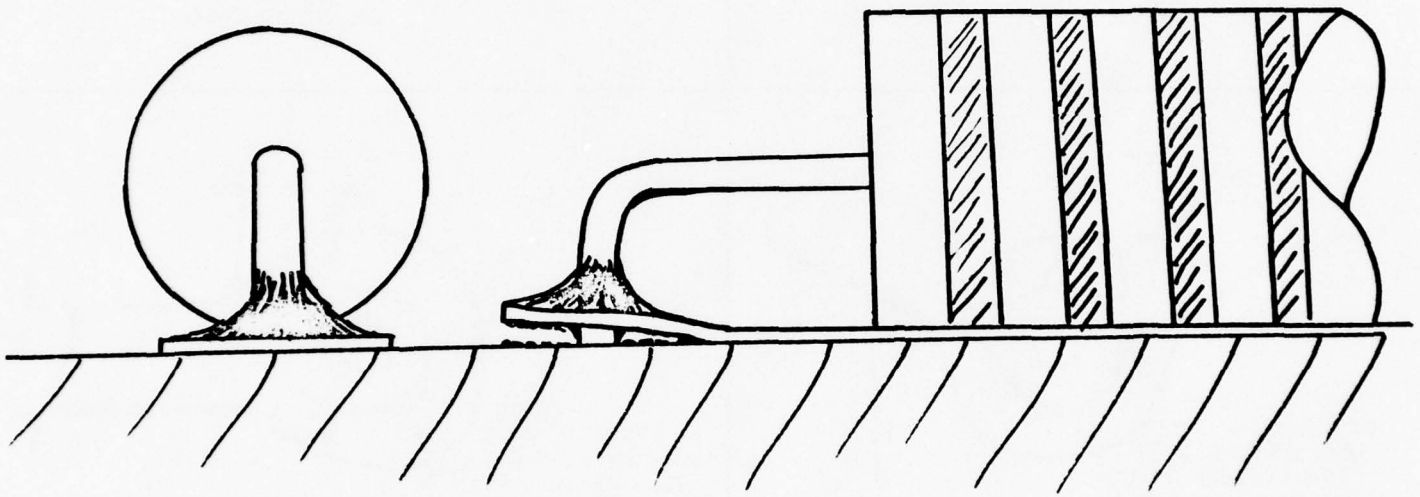


TOTALLY DETACHED TARGET PAD
SOLDER TO TOP EDGE OF HOLE



MW

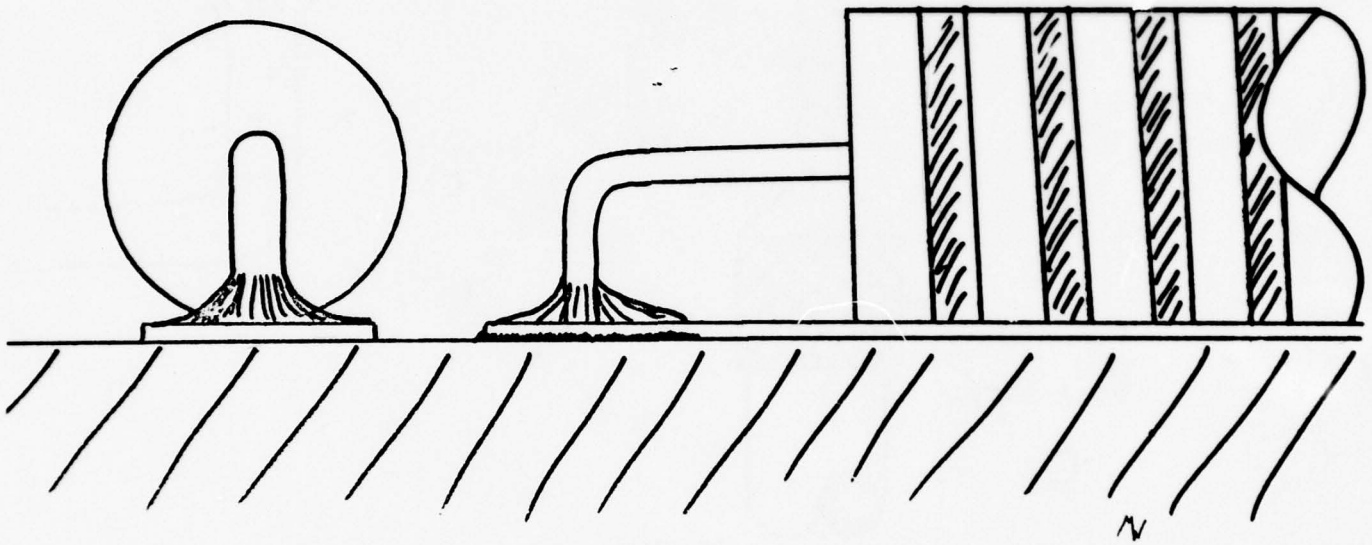
LIFTED PAD



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Astro Electronics

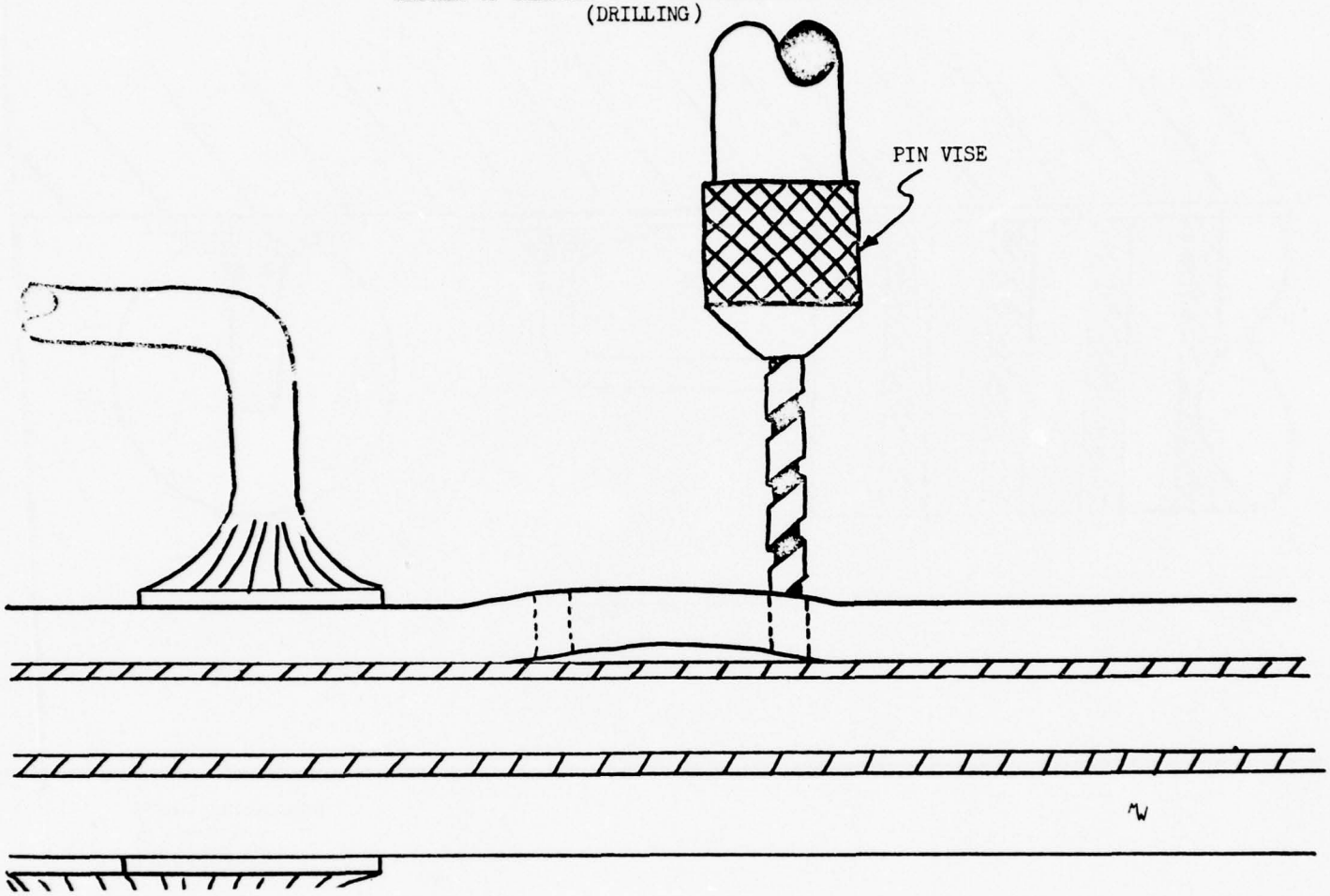
REBONDED

LIFTED PAD



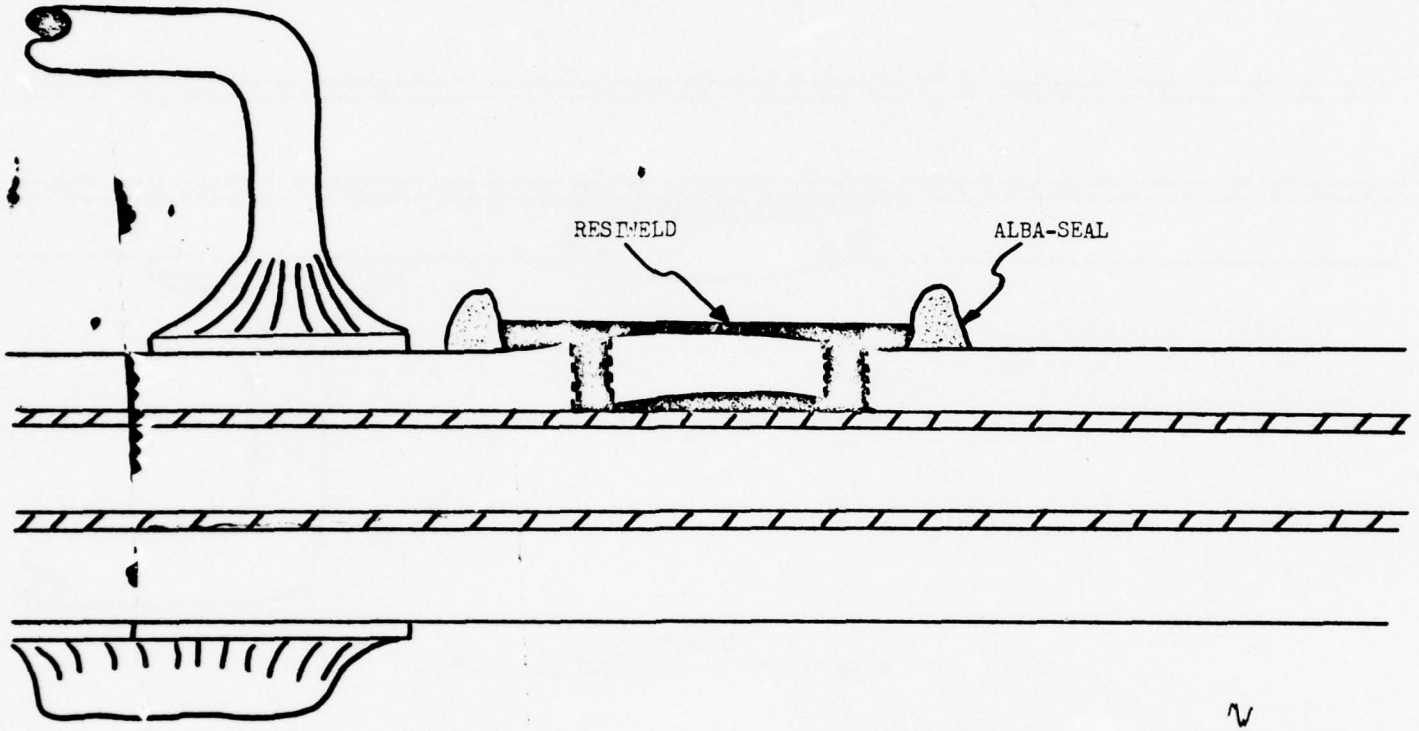
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REPAIR OF DELAMINATION ON MULTILAYER BOARDS
(DRILLING)



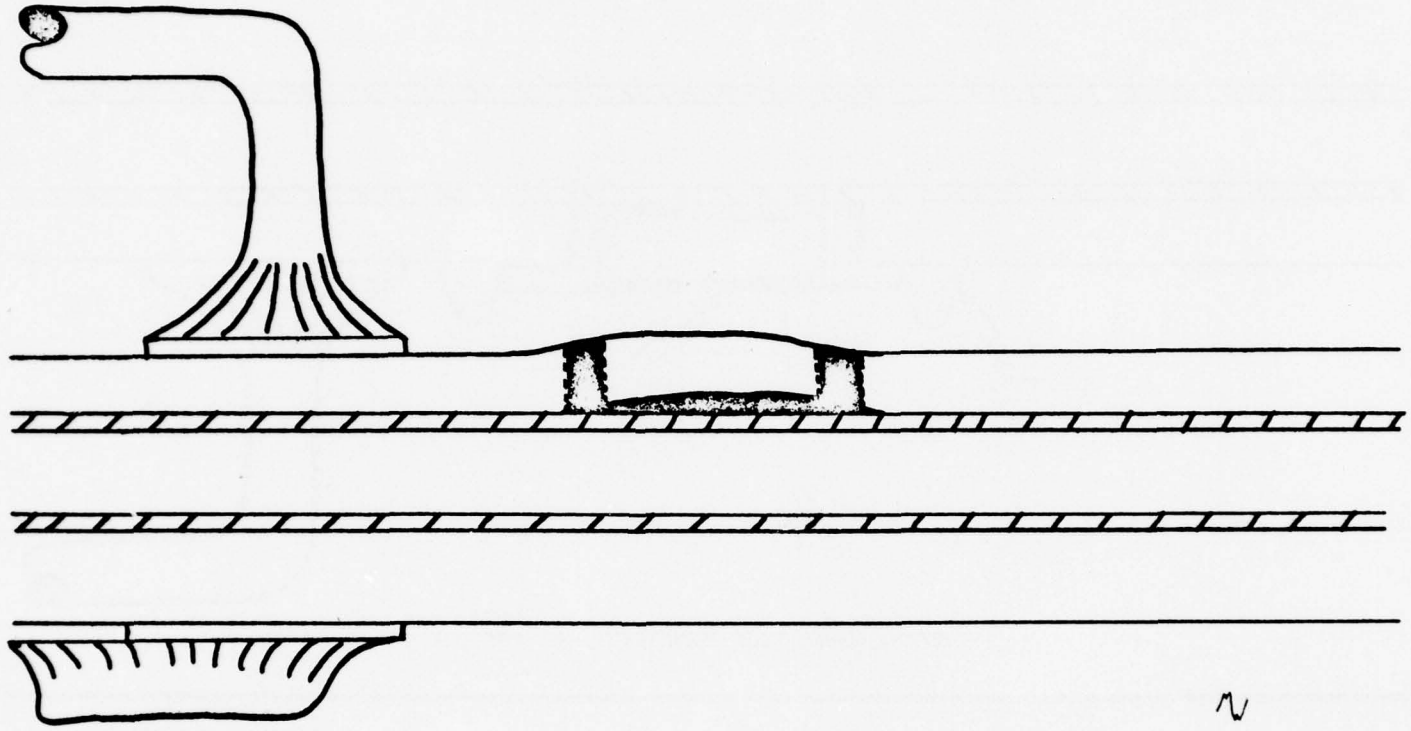
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Astro Electronics

FLOODING OF DELAMINATED AREA UNDER VACUUM



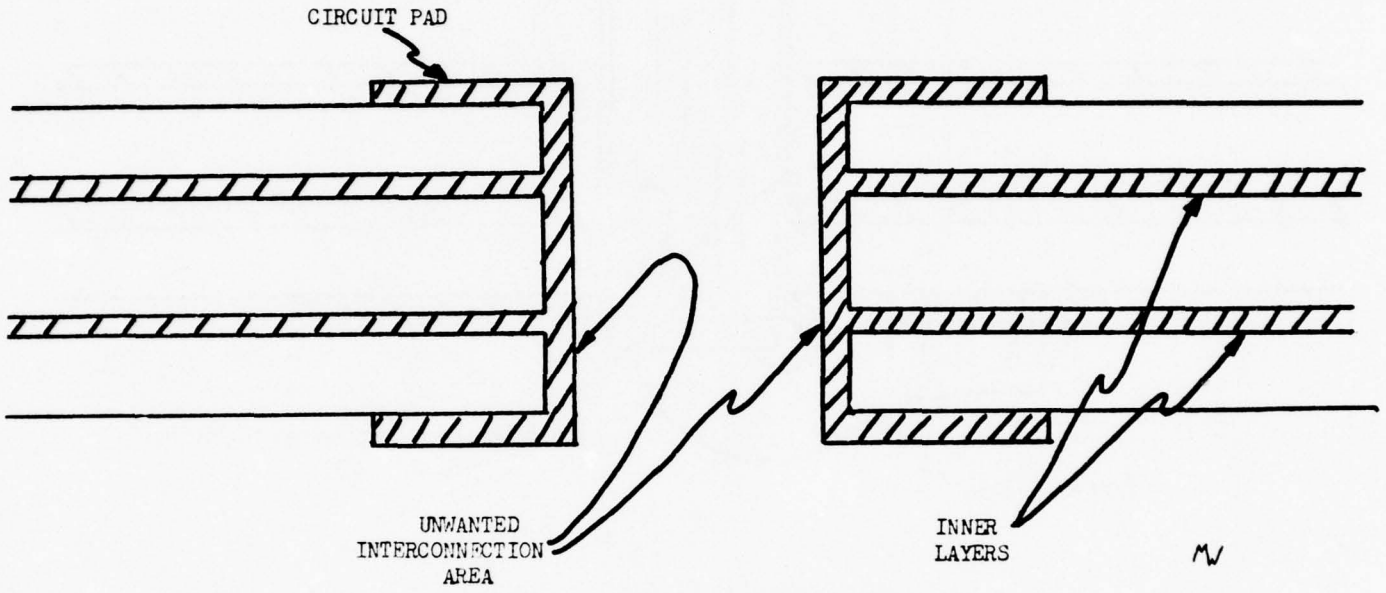
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REPAIR OF DELAMINATION ON MULTILAYER BOARDS
(COMPLETED)



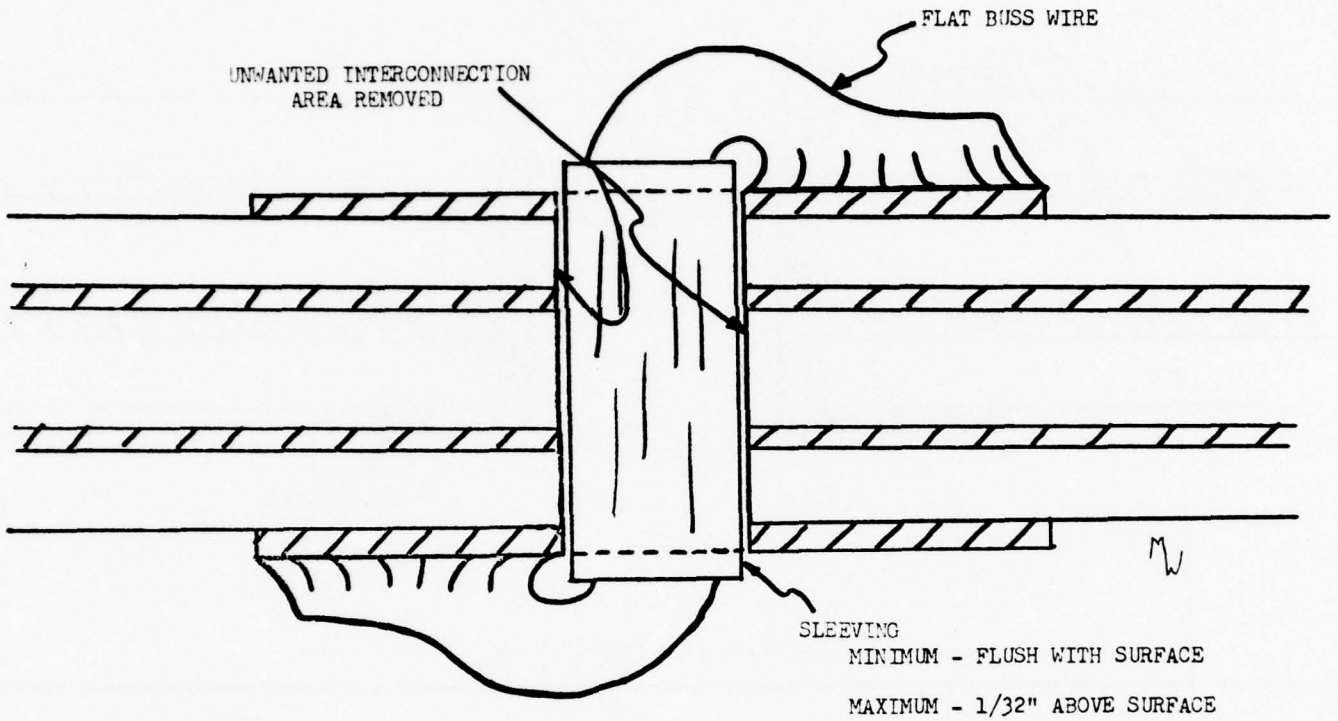
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UNWANTED THRU-HOLE CONNECTION



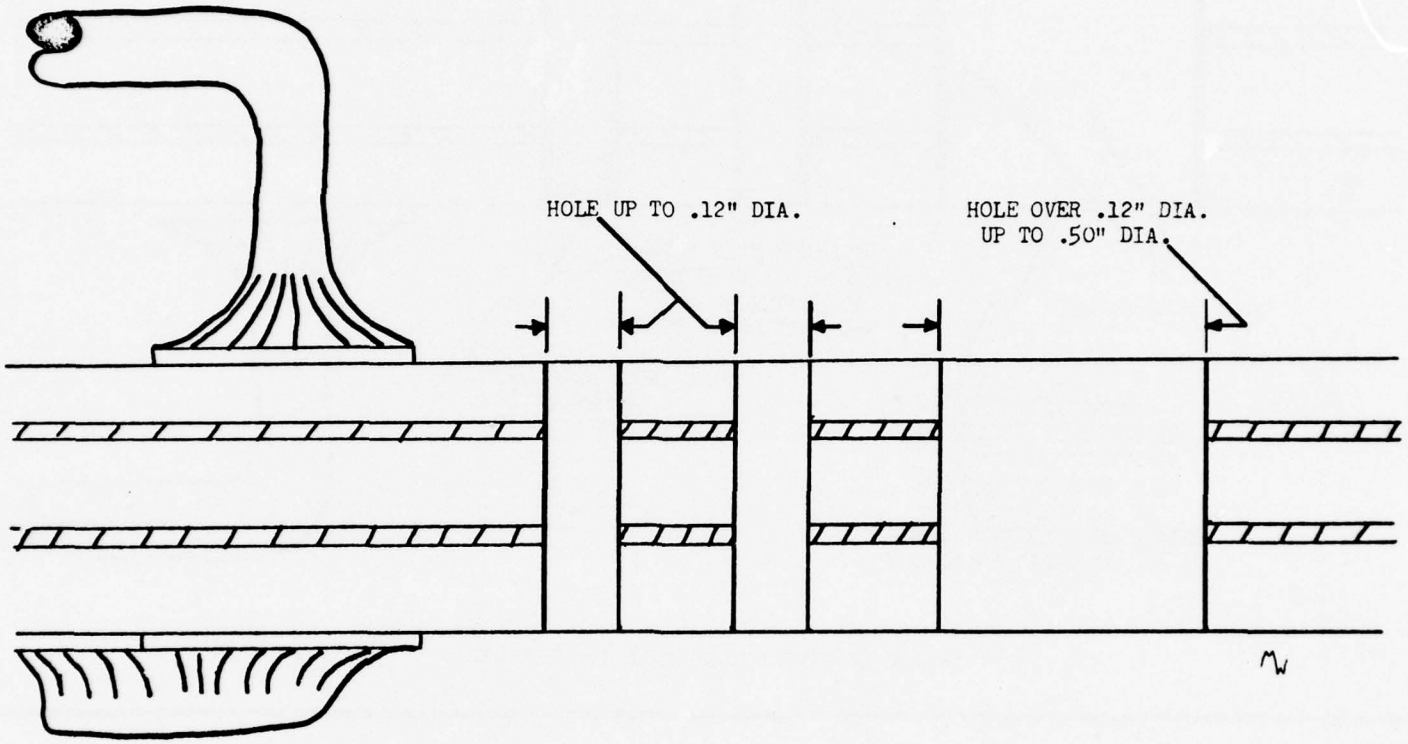
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REMOVAL OF UNWANTED THRU-HOLE CONNECTION



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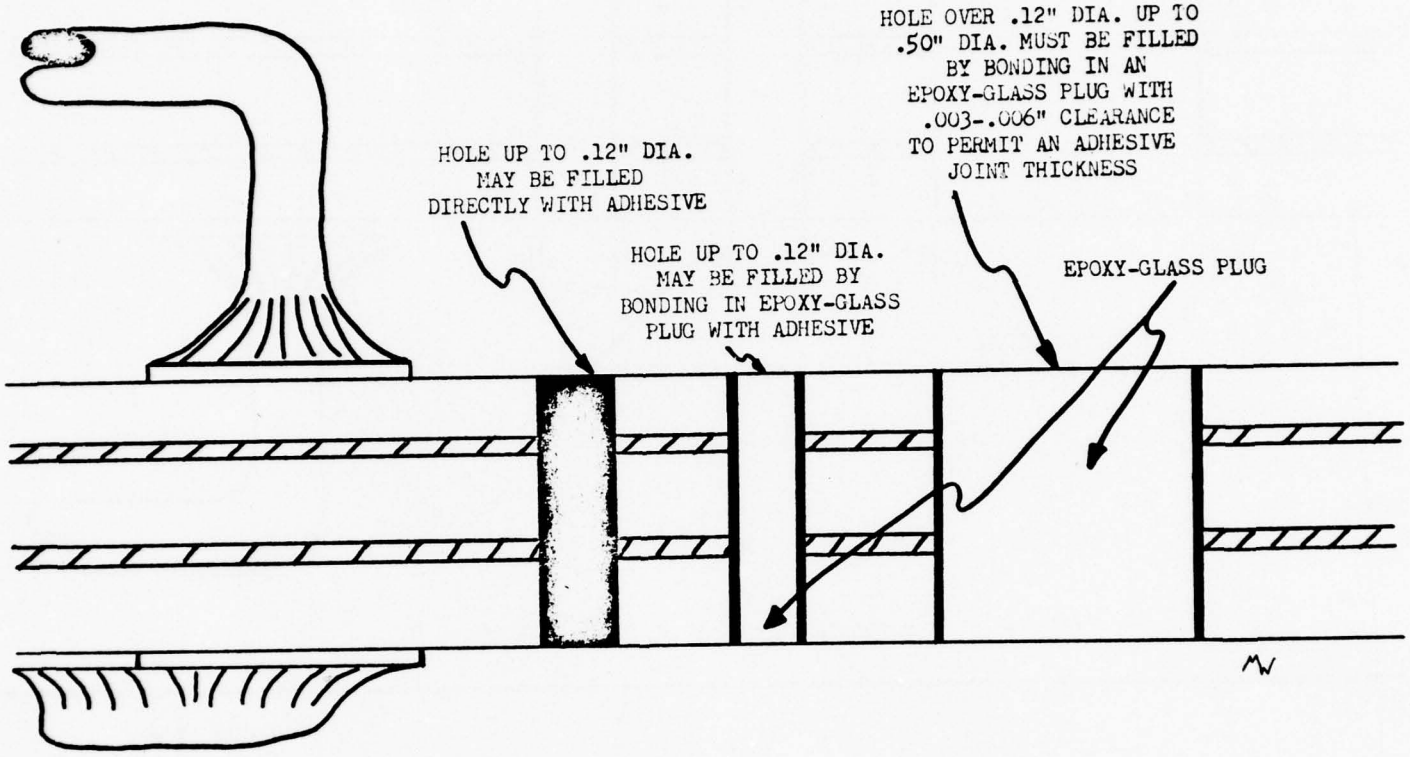
UNWANTED HOLES IN EPOXY-GLASS BOARDS



BEST AVAILABLE COPY

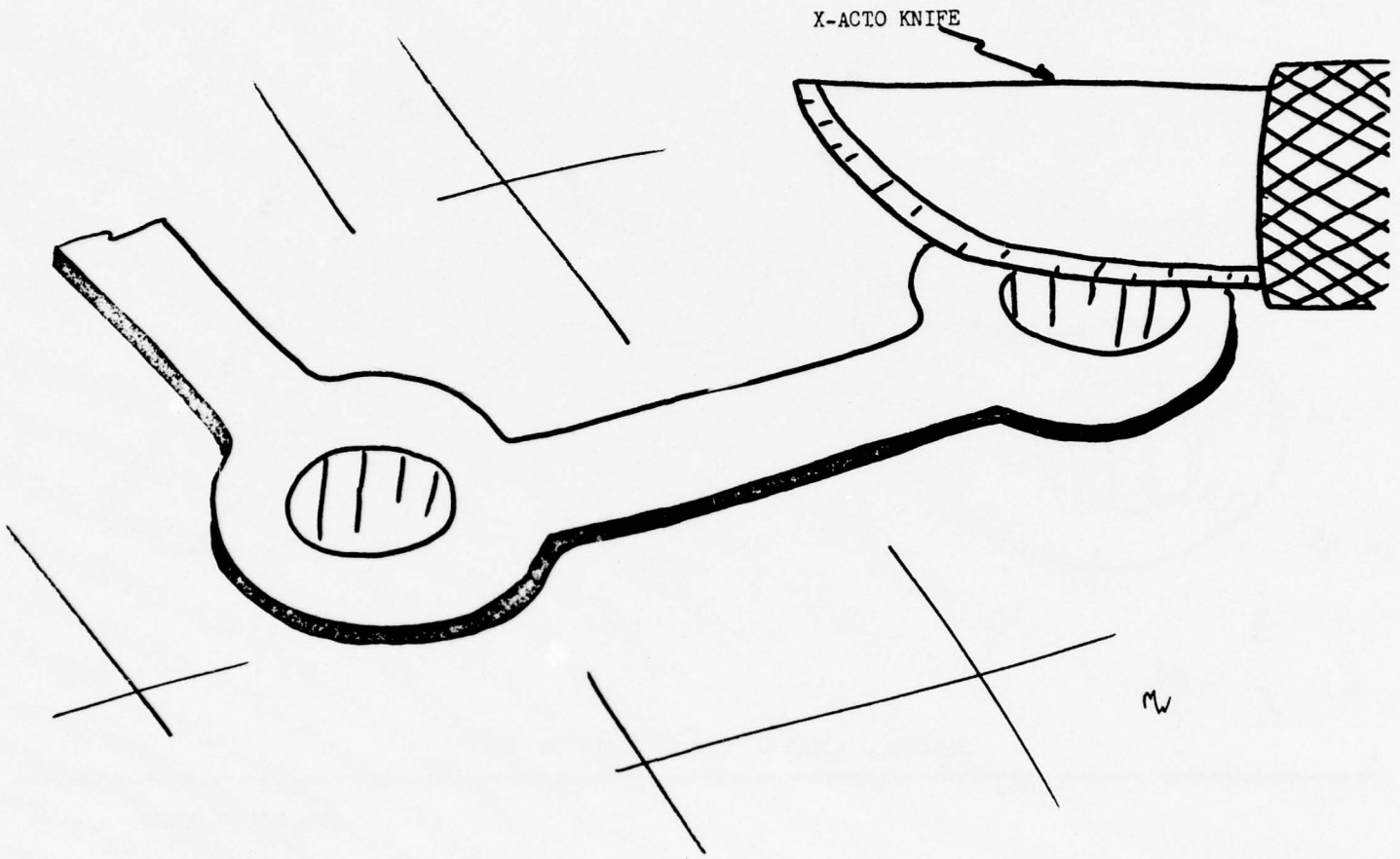
RCA
Astro Electronics

PLUGGING HOLES IN EPOXY-GLASS PC BOARDS



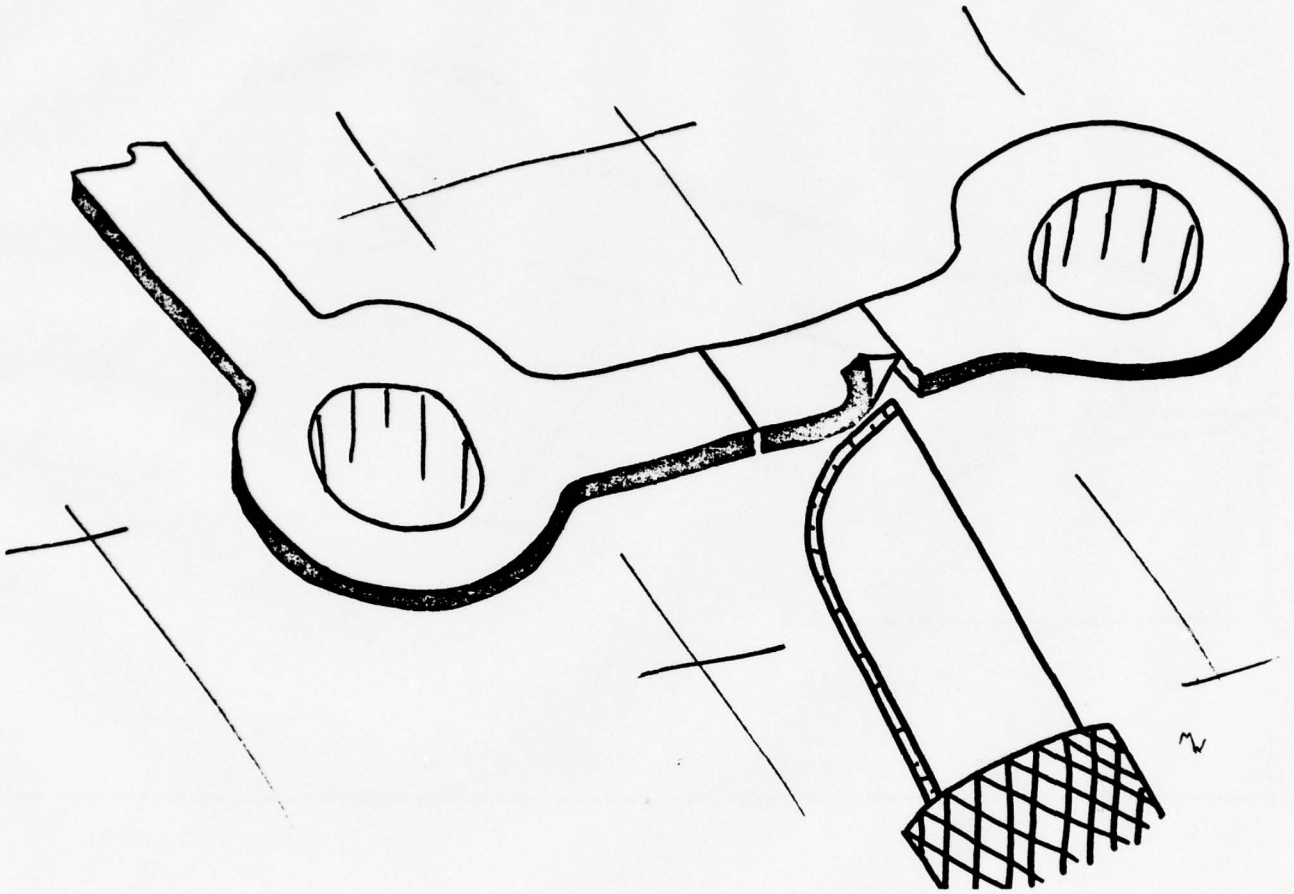
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REMOVAL OF UNWANTED PRINTED CIRCUITRY



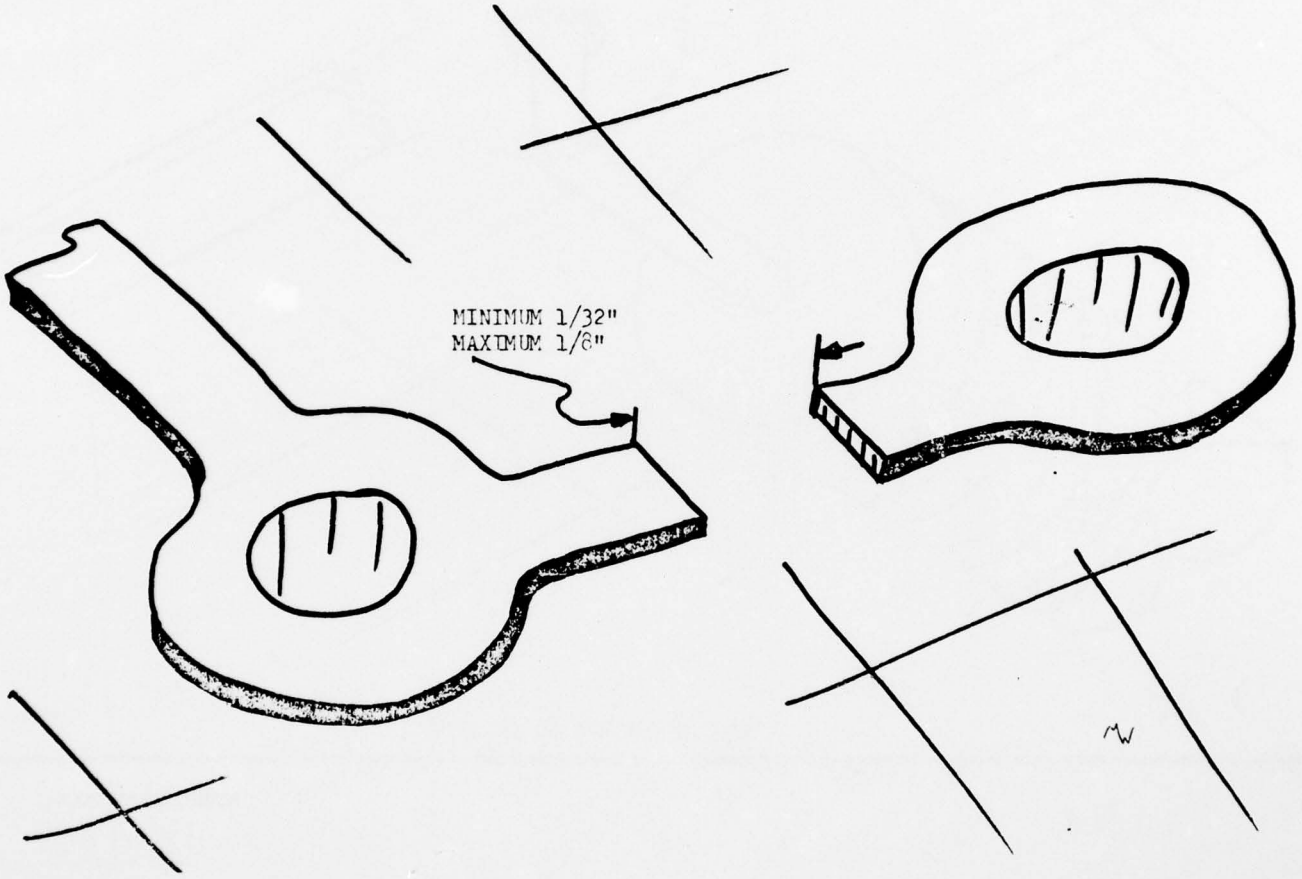
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PEELING OFF UNWANTED PRINTED CIRCUIT SECTION



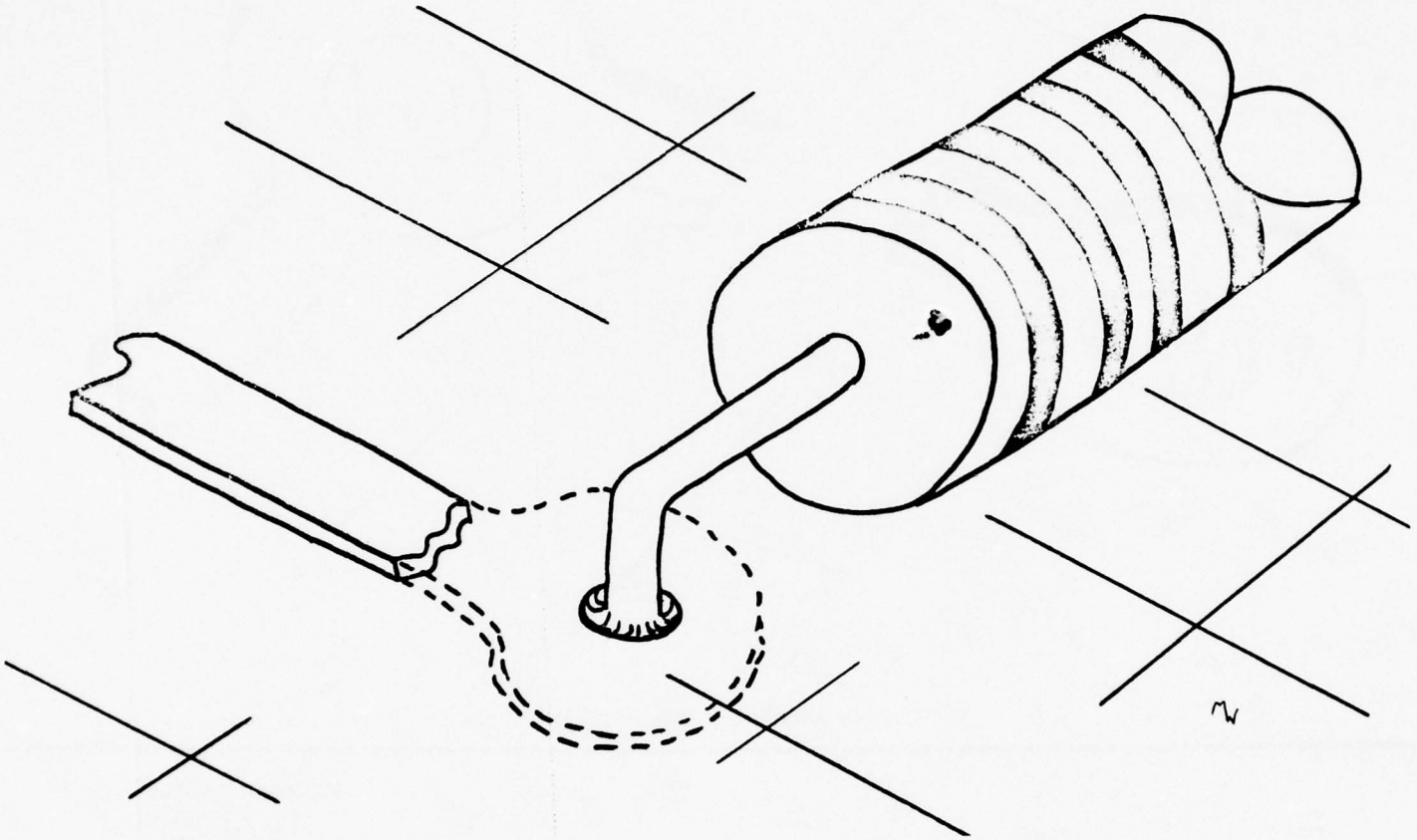
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UNWANTED PRINTED CIRCUITRY REMOVED



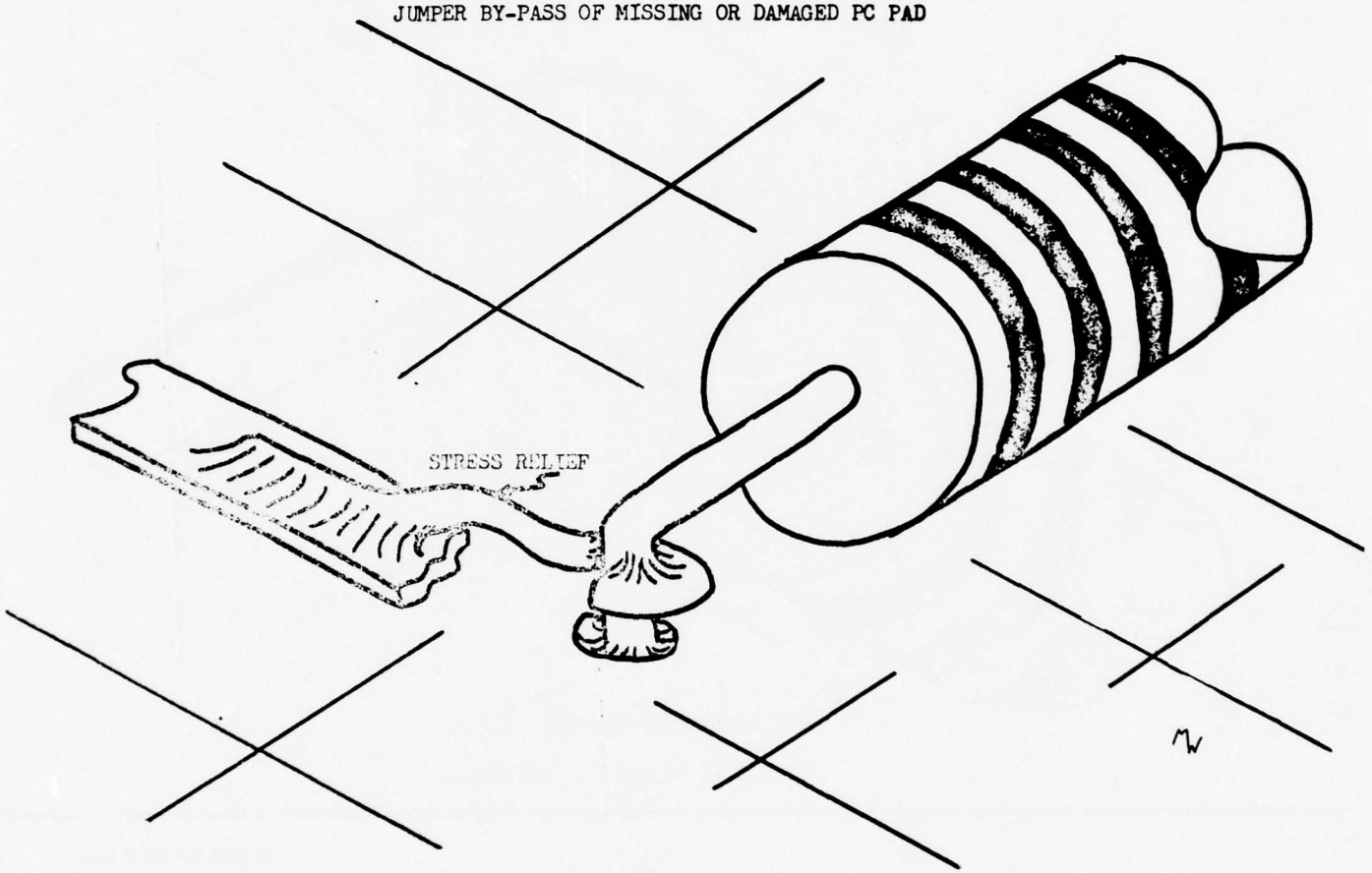
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MISSING OR DAMAGED PC PAD



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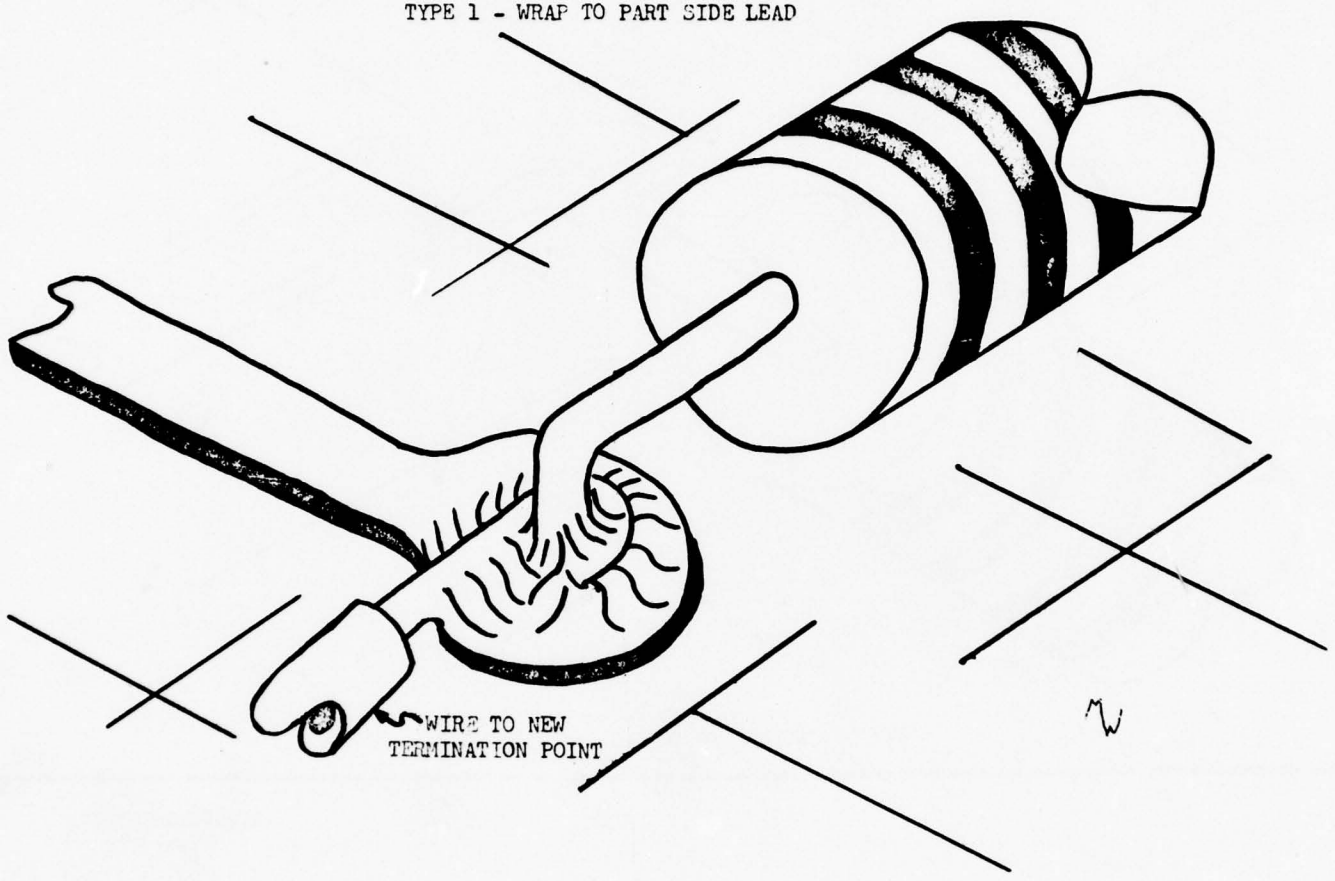
JUMPER BY-PASS OF MISSING OR DAMAGED PC PAD



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REROUTING OF PRINTED CIRCUITRY

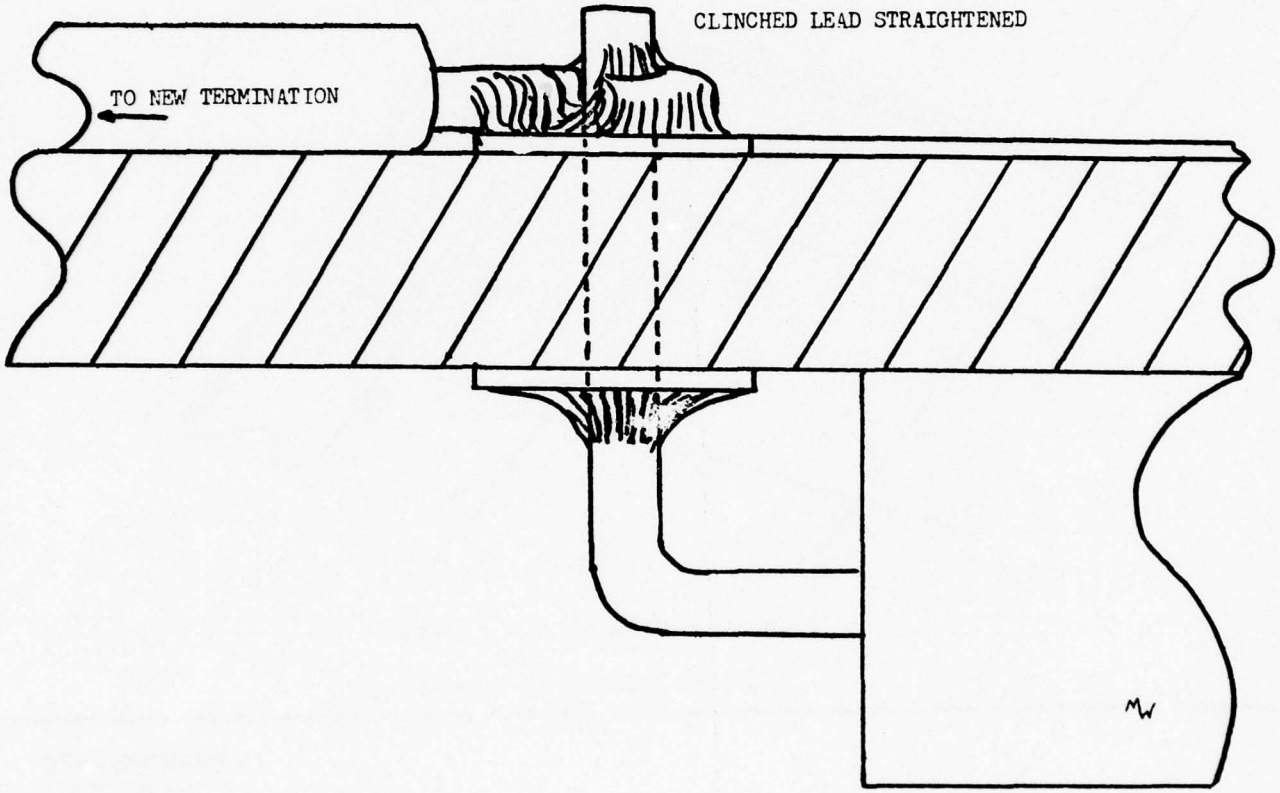
TYPE 1 - WRAP TO PART SIDE LEAD



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R'ROUTING OF PRINTED CIRCUITRY

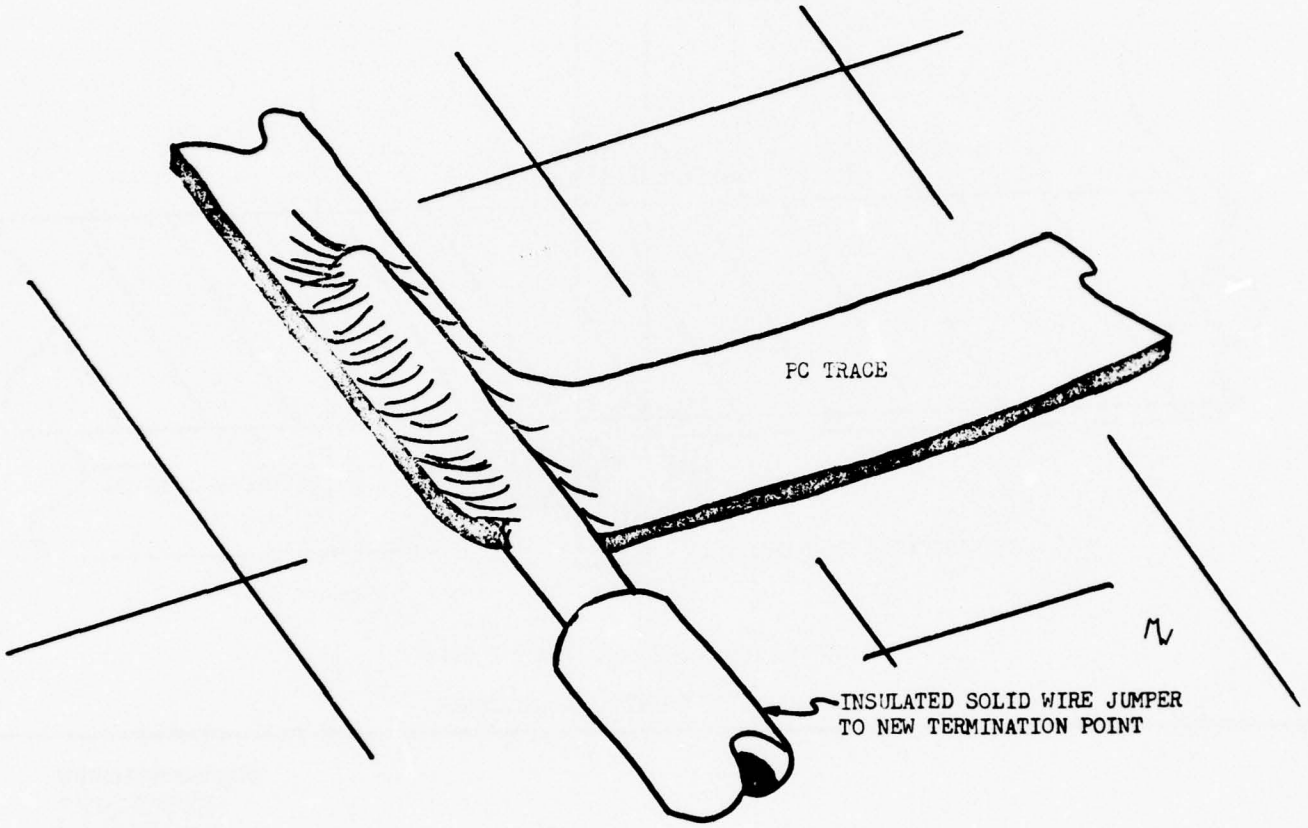
TYPE 2 - WRAP TO WIRING SIDE LEAD



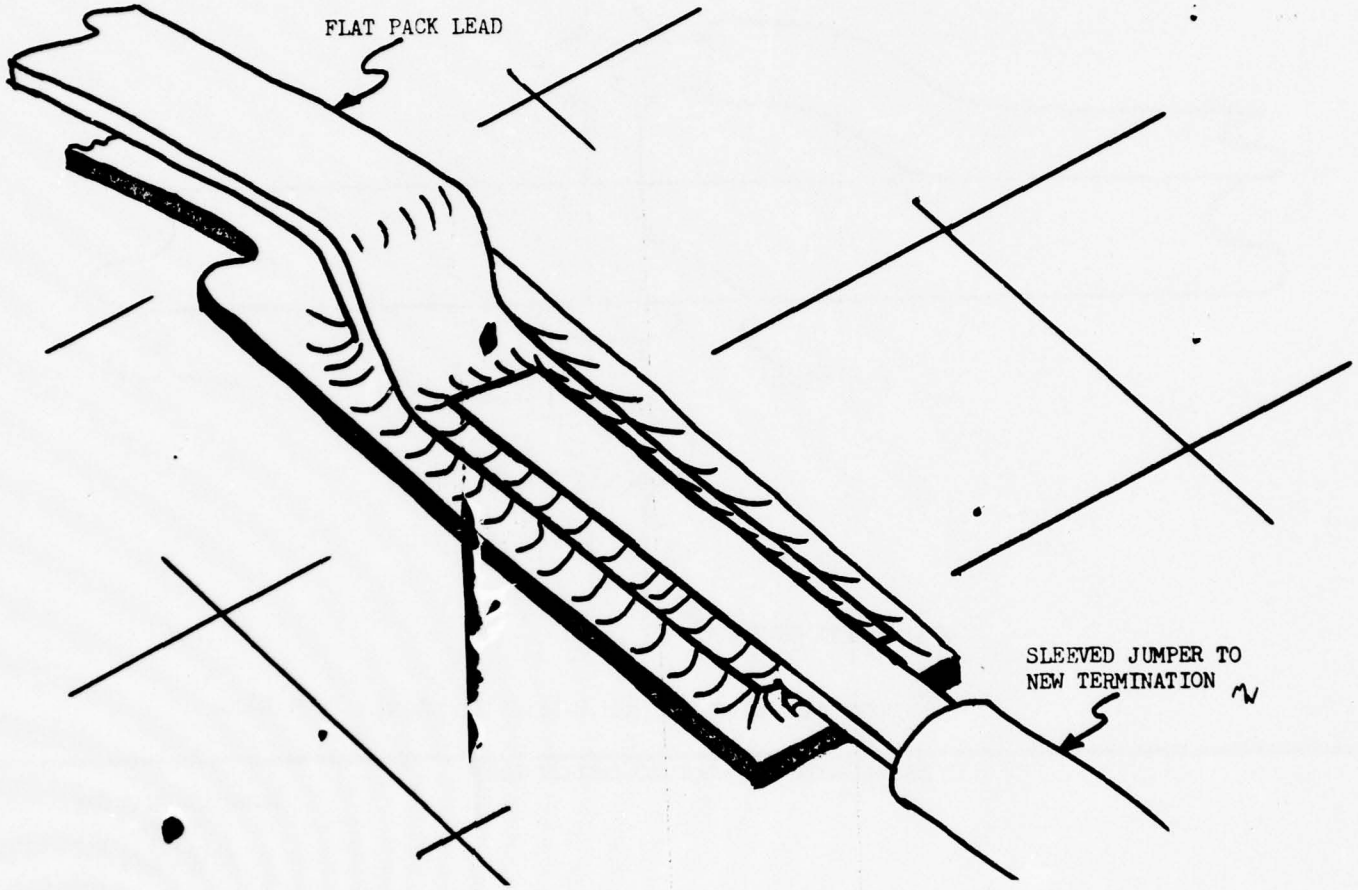
RCA
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REROUTING OF PRINTED CIRCUITRY

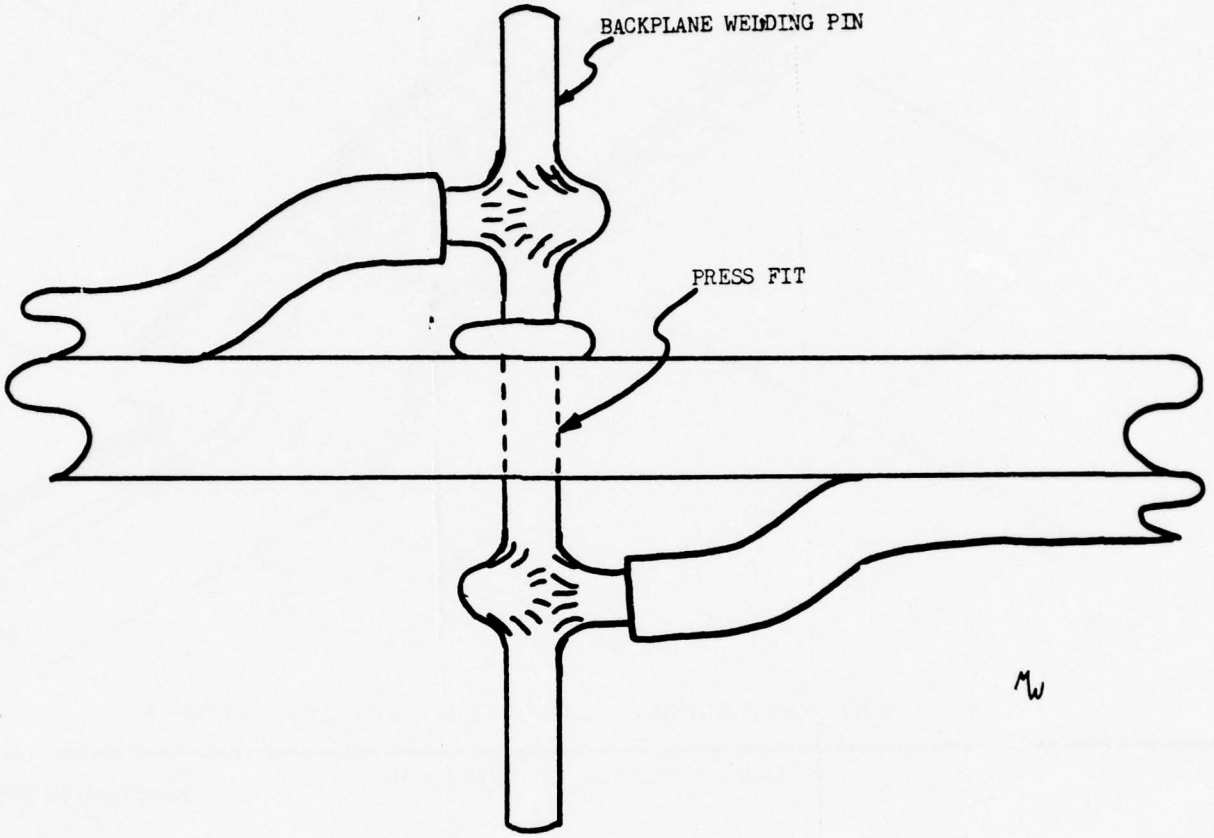
TYPE 3 - LAP SOLDER TO PC TRACE



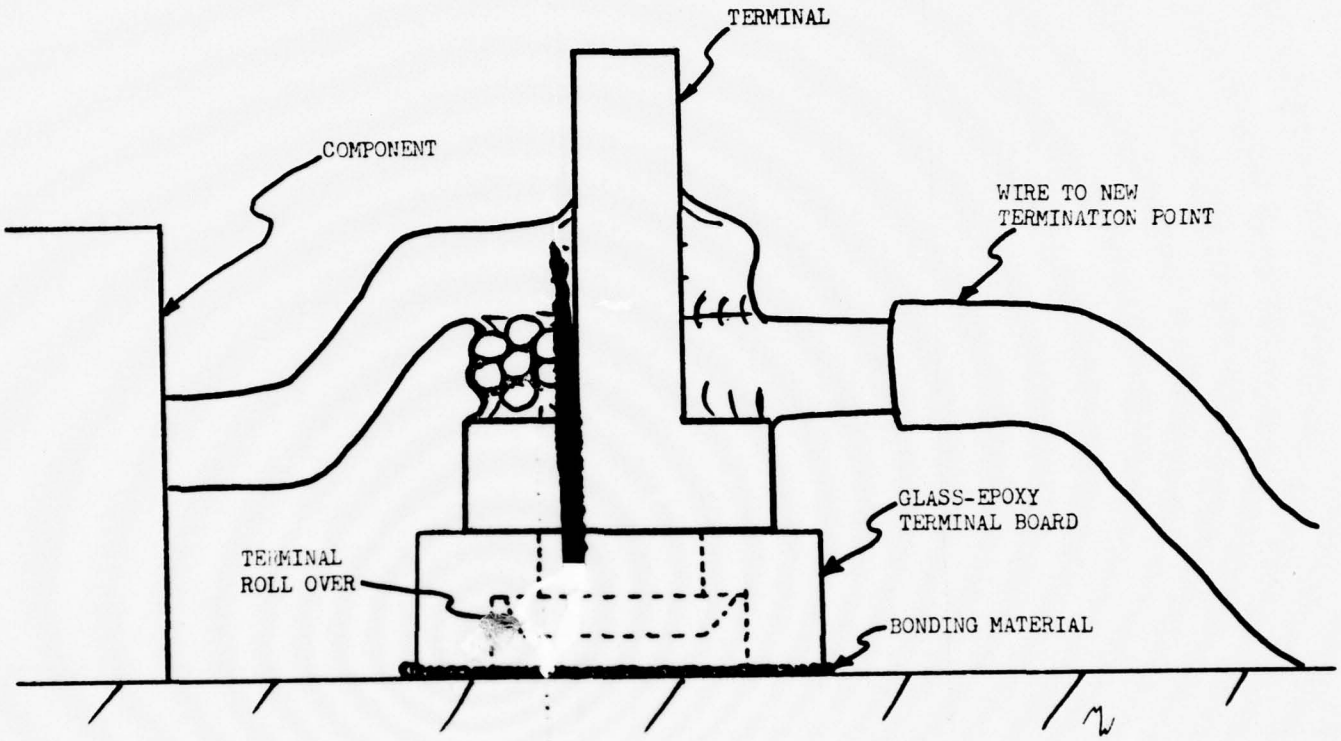
Type 4 - FLAT BUSS JUMPER ADDITION TO IC LEAD OR PC TRACE



TYPE 5 - BACKPLANE WELDING PIN AS A FEED THRU TERMINAL



TYPE 6 - PASTE ON TERMINAL



APPENDIX Q

FOAMED MODULE REPAIR

M. Furney
General Dynamics Corporation

- FOAMED MODULE REPAIR:
- FOAMS ARE USED BY CONVAIR FOR ENVIRONMENTAL PROTECTION, VIBRATION DAMPING AND LIGHT WEIGHT.
- TWO TYPES OF FOAMED MATERIALS ARE USED:
  1. RIGID POLYURETHANE
  2. FLEXIBLE SILICONE.
- ELECTRONIC MODULES ARE ENCAPSULATED IN THE RIGID FOAM
- WIRING HARNSSES USE THE FLEXIBLE FOAM

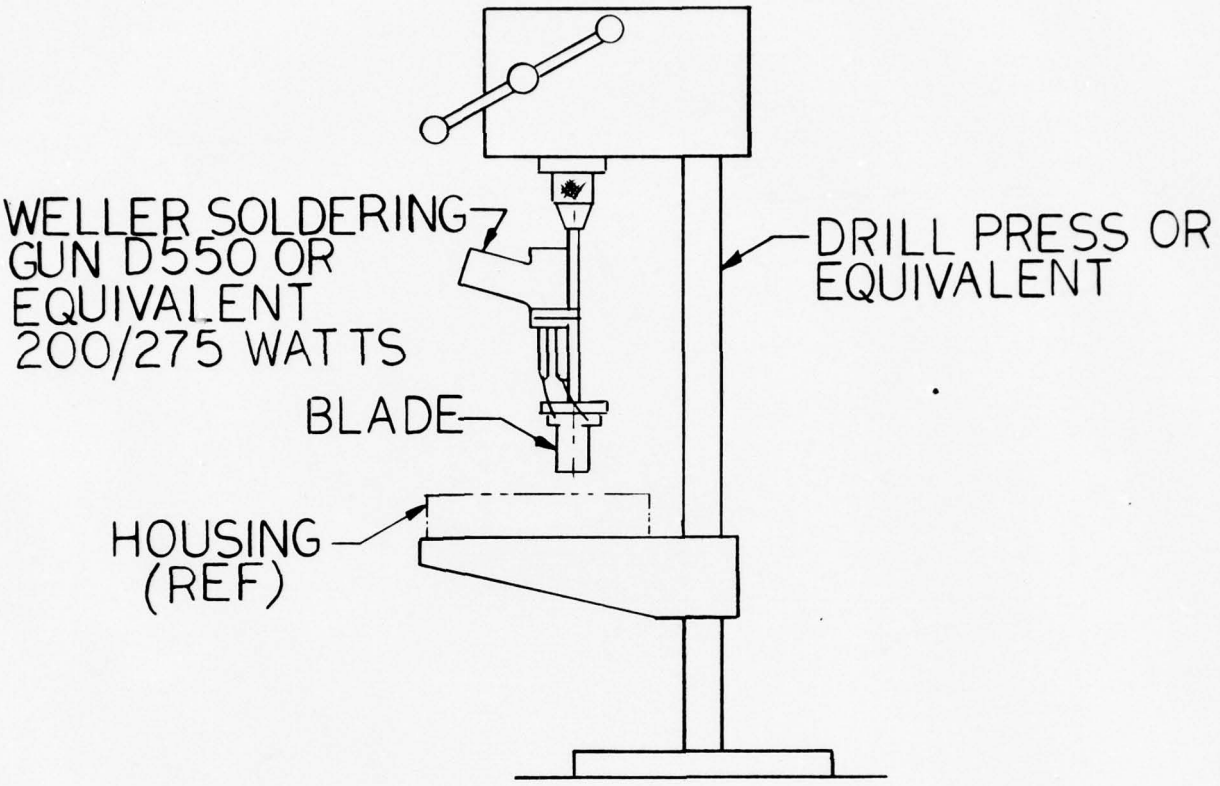
- REMOVAL OF MODULES FROM THE PACKAGE:
- EXPOSE ELECTRICAL CONNECTIONS BY REMOVING FLEXIBLE SILICONE FOAM.
- REMOVE ALL ELECTRICAL CONNECTIONS AND MECHANICAL FASTENERS FROM THE MODULE
- THE LOCATIONS OF MODULES ARE LABELED BY A STENCIL APPLIED AT THE TIME OF FABRICATION.
- A "HOT KNIFE" (170 ± 5°C) IS USED TO SEVER THE FOAM.

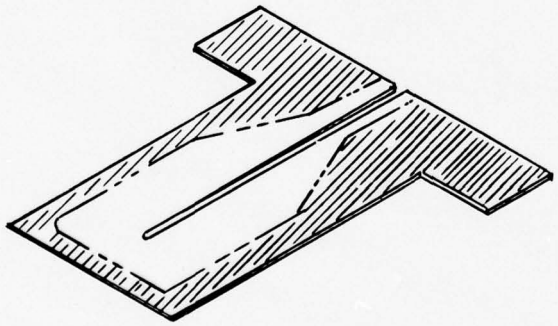
- THE PACKAGE HOUSING IS POSITIONED SUCH THAT THE BLADE CORRESPONDS TO THE STENCIL LOCATION OF THE MODULE TO BE REMOVED.
- WHEN THE BLADE REACHES OPERATING TEMPERATURE, IT IS SLOWLY AND CAREFULLY LOWERED INTO THE FOAM
- PRECAUTION - IF THE BLADE DOES NOT READLY PENETRATE THE FOAM, MANUALLY REMOVE THE SKIN LOCALLY PRIOR TO INSERTING THE BLADE.
- AFTER THE BLADE CONTACTS THE HOUSING FLOOR, IT IS REMOVED AND THE PROCEDURE IS REPEATED UNTIL THE MODULE IS SEPARATED FROM THE FOAM.

- AFTER THE FOAM HAS BEEN SEVERED WITH THE HOT KNIFE, THE MODULE IS CAREFULLY REMOVED.
- THE HOUSING IS INVERTED AND AN ARBOR PRESS IS USE TO REMOVE THE MODULE.
- IN ORDER TO EXPOSE THE SUSPECT COMPONENT, ONLY MANUAL METHODS ARE USED.
- WHEN THE FOAM HAS BEEN REMOVED FROM THE SUSPECT COMPONENT, THE BOARD IS SENT FOR STANDARD REWORK AND REPAIR.

- AFTER REWORK IS ACCOMPLISHED, THE MODULE IS REPLACED.
- BEFORE INSERTION, ALL LOOSE PARTICLES OF FOAM ARE REMOVED FROM THE ATTACHMENTS POINT ON THE FLOOR OF THE HOUSING.
- THE MODULE IS INSTALLED AND TESTED IN ACCORDANCE WITH THE ENGINEERING DRAWING.
- THE REPLACED MODULES ARE THEN REFOAMED, STENCILED AND CONFORMAL COATED.

- RATIONALE FOR MANUAL FOAM REMOVAL TECHNIQUES
- CONVAIR USES ONE MIL MYLAR SUPPORTED BOARDS
- AIR PRESSURIZED ABRASIVES GENERATE STATIC ELECTRICAL CHARGES WHICH CAN DESTROY STATIC SENSITIVE COMPONENTS.
- GREATER CARE AND CONTROL IS ABLE TO BE EXERCISED DURING THESE HAND OPERATIONS.





TYPICAL BLADE

MATL: 020 CRES SHEET
SHADED AREAS INDICATE COPPER-NICKEL PLATING

APPENDIX R

REPAIR OF PRINTED WIRING BOARD ASSEMBLIES

R. C. Block
Hughes Aircraft Company

MODIFICATION OF PRINTED WIRING ASSEMBLIES TO INCORPORATE ENGINEERING CHANGES

HUGHES

MODIFICATION OF PRINTED WIRING BOARD ASSEMBLIES TO INCORPORATE ENGINEERING CHANGES

HUGHES

- REMOVAL OR ADDITION OF PWB CIRCUIT CONDUCTORS
- DRILLING HOLES IN PWB'S TO ADD NEW COMPONENTS
- COMPONENT REMOVAL AND REPLACEMENT ON PWB'S

CONDUCTOR REMOVAL

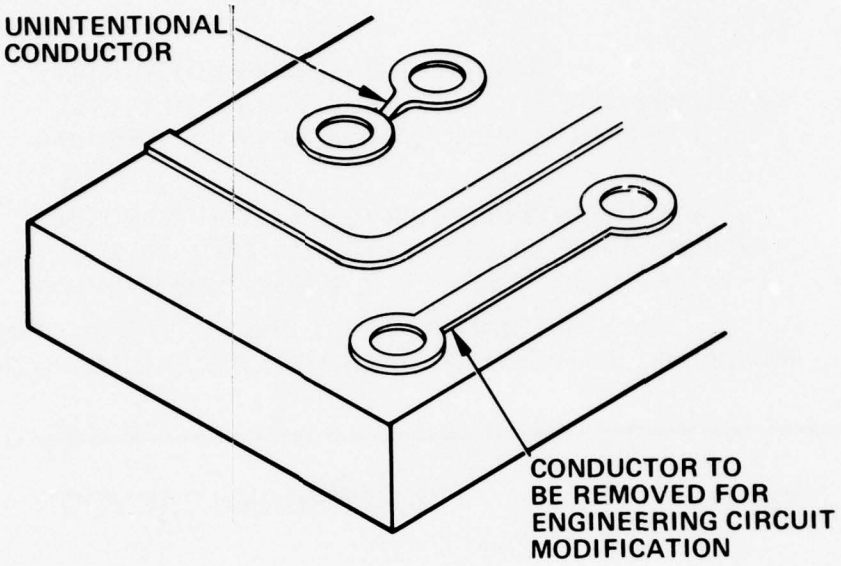
HUGHES

CIRCUIT CONDUCTORS ARE REMOVED FROM PRINTED WIRING BOARD ASSEMBLIES FOR THE FOLLOWING REASONS:

- DURING FUNCTIONAL ELECTRICAL TESTS, IT IS DETERMINED THAT A "DESIGNED IN" CONDUCTOR IS NOT REQUIRED AND THUS THE CIRCUIT MUST BE MODIFIED
- DURING VISUAL EXAMINATION AND/OR ELECTRICAL TEST IT BECOMES EVIDENT THAT AN "UNINTENTIONAL,, CONDUCTOR EXISTS IN THE CIRCUIT

TYPICAL EXTERNAL CONDUCTORS TO BE REMOVED

HUGHES



TOOLING FOR CONDUCTOR REMOVAL

HUGHES

THE TOOLS REQUIRED FOR REMOVING CONDUCTORS FROM PRINTED WIRING BOARD ASSEMBLIES ARE:

- X-ACTO KNIFE WITH CURVED BLADE (EXTERNAL CONDUCTORS)
- SOLDERING IRON (600°F TIP) (EXTERNAL CONDUCTORS)
- DRILL PRESS, DRILL BIT, END MILL (INTERNAL CONDUCTORS)

EXTERNAL CONDUCTOR REMOVAL PROCEDURE

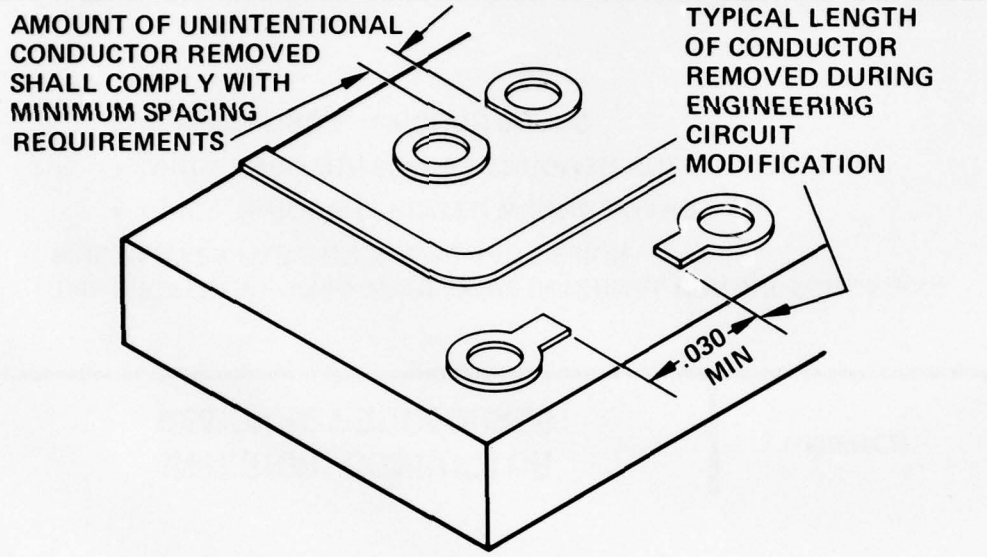
HUGHES

THE FOLLOWING PROCEDURE HAS BEEN ESTABLISHED FOR REMOVING EXTERNAL CONDUCTORS FROM THE SURFACE OF A PWB ASSEMBLY

- CUT CONDUCTOR AT TWO PLACES USING AN X-ACTO KNIFE
- HEAT THE PORTION OF THE CONDUCTOR TO BE REMOVED WITH A SOLDERING IRON TO REDUCE ITS ADHESION TO THE BOARD
- PEEL AWAY SEVERED PORTION OF CONDUCTOR

TYPICAL REMOVED EXTERNAL CONDUCTORS

HUGHES



INTERNAL CONDUCTOR REMOVAL PROCEDURES

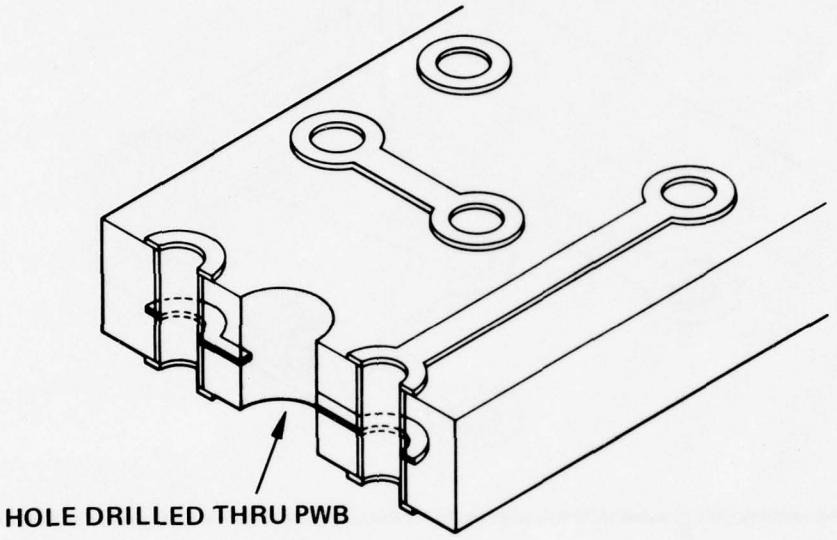
HUGHES

THE PROCEDURE USED TO REMOVE INTERNAL CONDUCTORS FROM MULTILAYER PWB'S ON THE BOARD DESIGN

- DRILL THROUGH PRINTED WIRING BOARD
- DRILL THROUGH PLATED THROUGH HOLE
- PARTIAL DRILL THROUGH BOARD

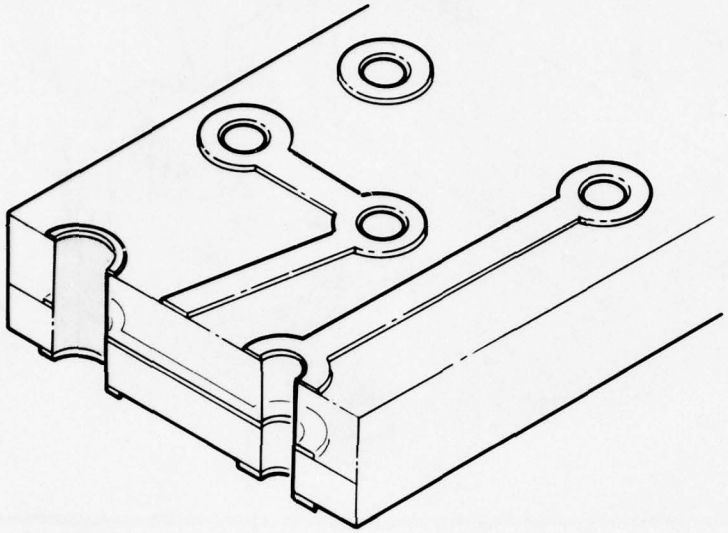
DRILL THROUGH PRINTED WIRING BOARD

HUGHES



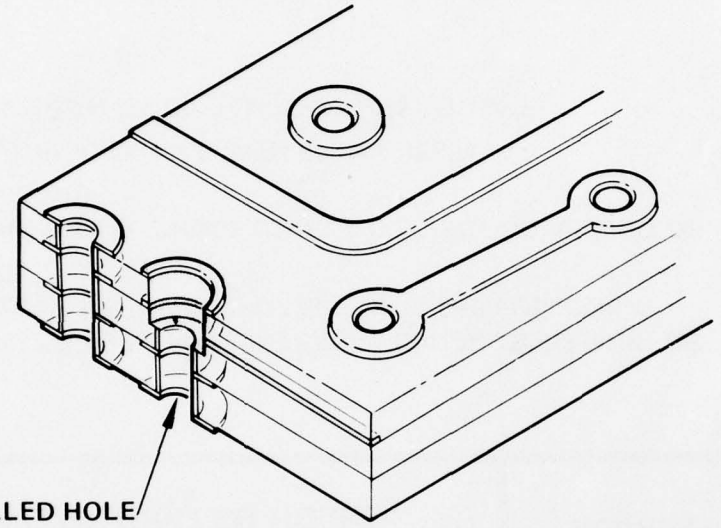
DRILL THROUGH PLATED THROUGH HOLE

HUGHES



PARTIAL DRILL THROUGH BOARD

HUGHES



FILLING OF DRILLED HOLES

HUGHES

HOLES DRILLED TO REMOVE INTERNAL CONDUCTORS MUST BE FILLED WITH RESIN IN ACCORDANCE WITH THE FOLLOWING PROCEDURE:

- CLEAN DRILLED HOLE USING A SOLVENT OR A BLAST OF CLEAN AIR
- FILL DRILLED HOLE WITH EPOXY RESIN
- CURE RESIN (ROOM TEMPERATURE TO 160°F)

ADDITION OF CONDUCTORS TO PWB ASSEMBLIES

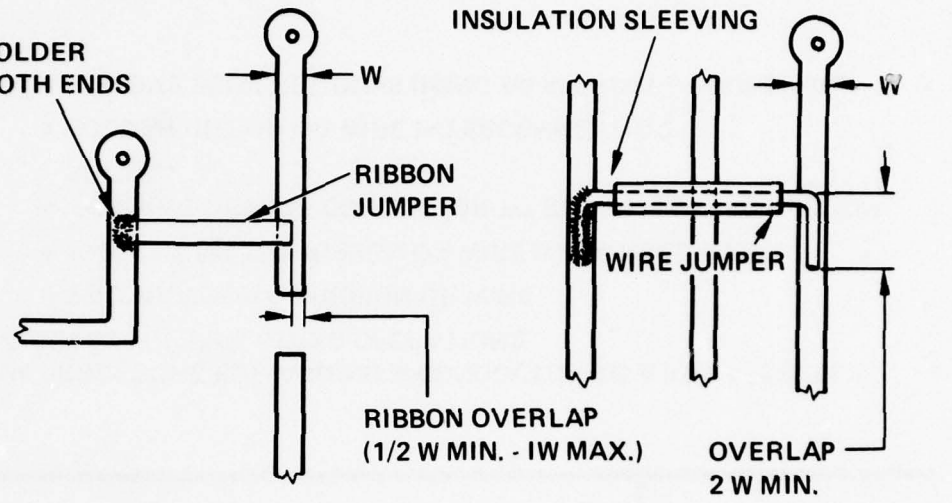
HUGHES

THE PROCEDURE FOR ADDING A CONDUCTOR TO A PWB ASSEMBLY INVOLVES THE FOLLOWING OPERATIONS:

- PREPARATION OF RIBBON OR WIRE
- INSULATING THE RIBBON OR WIRE WHEN REQUIRED
- FORMING OF WIRE CONDUCTOR TO REACH ITS TERMINATION POINTS
- SOLDER RIBBON OR WIRE INTERCONNECTION
- REMOVE FLUX RESIDUES USING AS APPROVED PROCEDURE

ADDITION OF SURFACE CONDUCTORS

HUGHES



DRILLING HOLES IN PWB'S FOR ADDING COMPONENTS

HUGHES

- TYPES OF COMPONENTS ADDED TO PWB'S

  AXIAL DISCRETE COMPONENTS – RESISTORS, CAPACITORS, DIODES, ETC.

- FACTORS TO CONSIDER RELATIVE TO THE LOCATION OF HOLES AND COMPONENTS

  1. MAINTAIN MINIMUM SPACING FROM CONDUCTORS AND COMPONENTS
  2. BOTTOM MOUNT VS. TOP MOUNT

TOOLS FOR ADDING NEW COMPONENTS TO PWB ASSEMBLIES

HUGHES

THE FOLLOWING TOOLS ARE REQUIRED TO ADD ADDITIONAL COMPONENTS TO PWB ASSEMBLIES:

- DRILL PRESS AND DRILL BITS
- PIN VISE
- TERMINAL SWAGING TOOL

METHODS FOR ADDING COMPONENTS TO PWB ASSEMBLIES

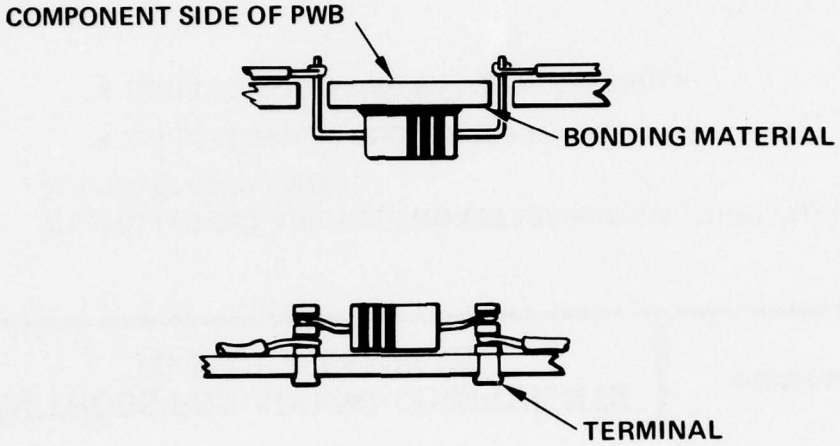
HUGHES

THE FOLLOWING ARE THE TWO ESTABLISHED METHODS FOR ADDING COMPONENTS:

- DRILLED HOLES AND JUMPER WIRES
- DRILLED HOLES AND SWAGED TERMINALS

TYPICAL INSTALLATIONS IN DRILLED HOLES

HUGHES



POTENTIAL PROBLEM DURING COMPONENT REPLACEMENT

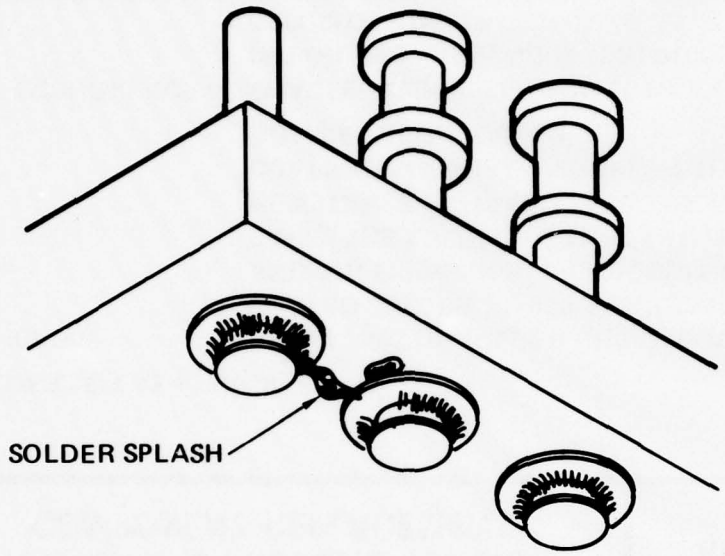
HUGHES

SOLDER "SPLASH" PROBLEM

- CAUSE – REMELTING OF SOLDER UNDER COVERED OR COATED SOLDER JOINTS RESULTS IN SOLDER AND AIR EXPANSION. THIS CONDITION MAY CAUSE THE SOLDER TO SEEK THE LOWEST RESISTANCE PATH AND FLOW UNDER COATING MATERIAL AND SHORT TO AN ADJACENT CONDUCTOR
- OCCURRENCE – SWAGED SIDE OF TERMINALS WHEN SOLDERING OR DESOLDERING IS PERFORMED ON OPPOSITE SIDE OF TERMINAL

TYPICAL "SPLASH" OCCURRENCE

HUGHES
HUGHES AIRCRAFT COMPANY



PREVENTION OF SOLDER "SPLASH"

HUGHES

SOLDER "SPLASH" PROBLEM

- PREVENTION – BREAK OR REMOVE COATING FROM SWAGED SIDE OF TERMINAL PRIOR TO SOLDERING
- PROCEDURE
  1) REMOVE COATING FROM SWAGED SIDE
  2) SOLDER OR DESOLDER LEADS OR WIRES
  3) INSPECT
  4) RECOAT TERMINAL

APPENDIX S

REPAIRING PRINTED CIRCUIT CARD ASSEMBLIES

J. P. McGrady
ITT

PART I

THE FOLLOWING REPAIRS

CAN NOT BE MADE

UNLESS THEY ARE

AUTHORIZED BY THE

MATERIAL REVIEW BOARD

DEFENSE COMMUNICATIONS AGENCY

REPAIRING PRINTED

CIRCUIT CARD ASSEMBLIES

DOUBLE SIDED AND MULTILAYER

BOARDS

DEFENSE COMMUNICATIONS

RESTRICTIONS: THESE PROCEDURES

SHALL APPLY TO

ASSEMBLED PRINTED

CIRCUIT CARDS - ALL

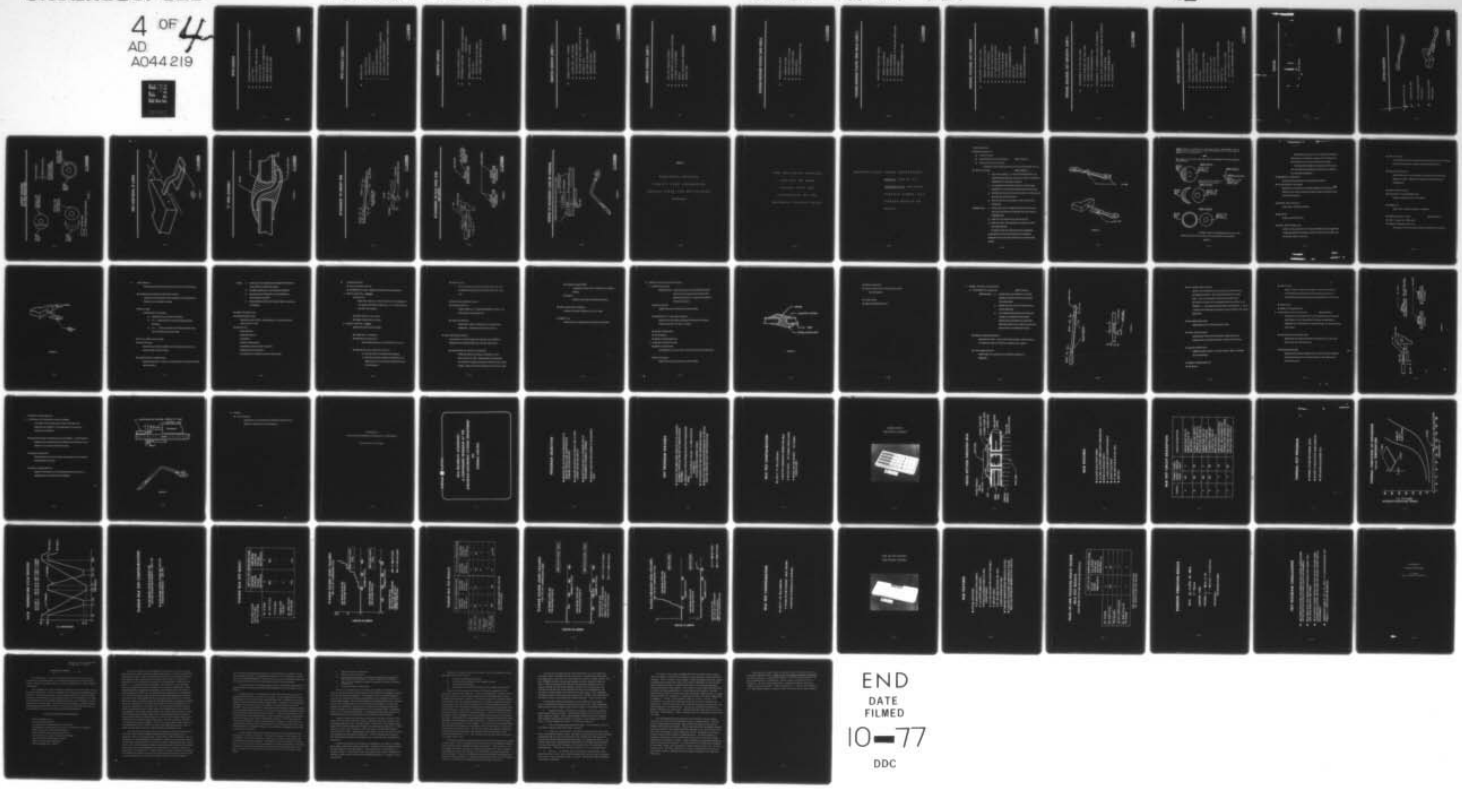
OTHERS SHOULD BE

RTV'D

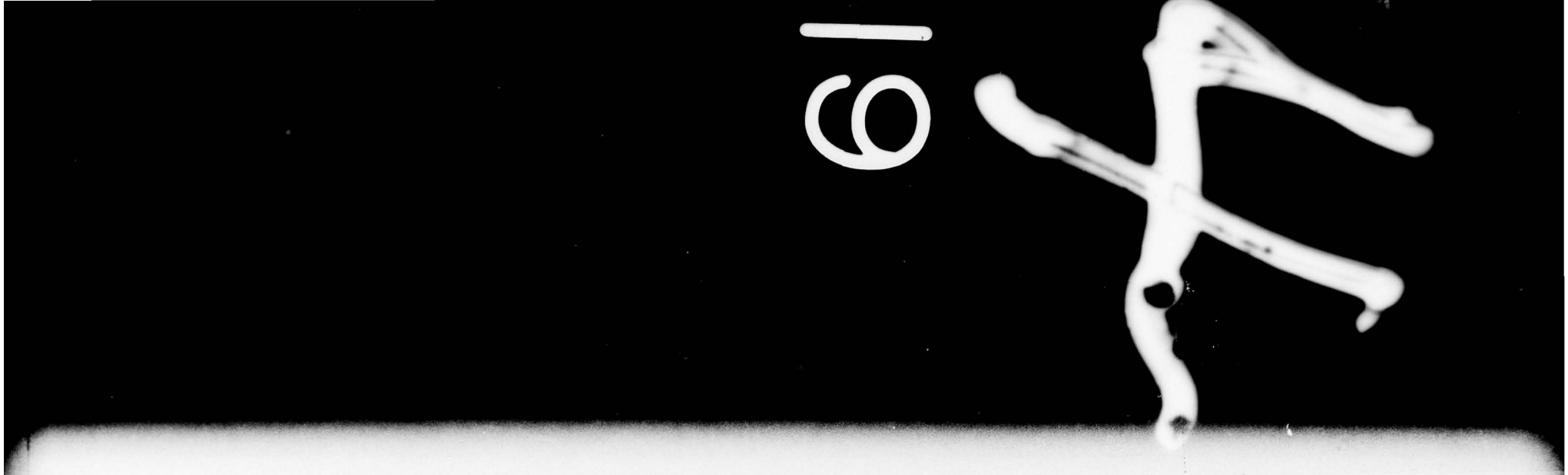
DEFENSE COMMUNICATIONS AGENCY

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PROCEEDINGS OF THE CONFERENCE ON REWORK AND REPAIR OF PRINTED C--ETC(U)
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OPEN CIRCUITS

- DETERMINE END POINTS OF DEFECTIVE CIRCUIT
- SELECT WIRE
- CUT TO LENGTH AND TIN WIRE
- ROUTE ON CARD
- SOLDER WIRES TO TERMINATIONS
- REMOVE MASKING TAPE
- CEMENT WIRE TO CARD

OPEN CIRCUITS (CON'T.)

- INSPECT FOR:
  - OPEN CIRCUITS
  - SHORTED CIRCUITS
  - CONTINUITY
  - SOLDER WORKMANSHIP
  - COMPONENTS ARE SECURELY MOUNTED
  - WIRING IS ROUTED PROPERLY
  - NO EVIDENCE OF BROKEN/DAMAGED CONDUCTORS

SHORTED CIRCUITS

- ISOLATE SHORTED CIRCUIT
- DETERMINE LOCATION - SHORTED CONDUCTORS ELECTRICALLY

A. REMOVE CIRCUITRY - EXPOSED
   - KNIFE CUT
   - APPLY EPOXY TO CUT AREAS
   - VERIFY SHORT DOES NOT EXIST

DEFENSE COMMUNICATIONS ITT

SHORTED CIRCUITS (CON'T.)

B. REMOVE CIRCUITRY - HIDDEN

- CLAMP PWB - ON FIXTURE
- POSITION DIAL INDICATOR
- POSITION END MILL OVER LINE TO BE CUT
- CONNECT VOM
- SET VOM DC RESISTANCE SCALE
- ADVANCE END MILL
- LOSS OF CONTINUITY

DEFENSE COMMUNICATIONS

SHORTED CIRCUITS (CON'T.)

- TEST FOR INDUCED SHORTS
- PROBE POINTS OF ADJACENT LAYER/LINE
- IF SHORT IS DISCOVERED
- VERIFY
- APPLY INSULATING COMPOUND
- INSPECT 10X

DEFENSE COMMUNICATIONS ITT

MISSING/DAMAGED PLATED THRU HOLES

A. INTERFACIAL HOLES

- REMOVE SOLDER
- INSERT SOLID "Z" WIRE
- SOLDER JUMPER WIRE
- CLEAN BOARD
- INSPECT WORKMANSHIP 10X

DEFENSE COMMUNICATIONS ITT

MISSING/DAMAGED PLATED THRU HOLES (CON'T.)

B. COMPONENT MOUNTING HOLES

- REMOVE COMPONENTS
- REMOVE SOLDER
- INSERT COMPONENT
- SOLDER COMPONENT TO PADS ON BOTH SIDES
- CLEAN BOARD
- INSPECT WORKMANSHIP 10X

DEFENSE COMMUNICATIONS ITT

MISSING, DAMAGED, CUT CIRCUITRY

A. ATTACHMENT TO CIRCUIT RUN

- REMOVE DAMAGED CIRCUITRY
- CLEAN BOARD SURFACE
- COVER CUT AREA WITH EPOXY
- CUT JUMPER WIRE/SLEEVING
- TIN JUMPER WIRE ENDS
- PLACE WIRE ON BOARD
- SOLDER JUMPER WIRE
- INSPECT WORKMANSHIP 10X
- MIX EPOXY
- APPLY EPOXY
- CURE EPOXY
- INSPECT WORKMANSHIP 10X

DEFENSE COMMUNICATIONS IT&T

MISSING, DAMAGED, CUT CIRCUITRY (CON'T.)

B. ATTACHMENT TO FLAT PACK LEAD

- PLACE WIRE ON FLAT PACK LEAD
- SOLDER JUMPER WIRE
- INSPECT WORKMANSHIP 10X

C. ATTACHMENT TO COMPONENT LEADS OR TERMINAL

- WRAP WIRE AROUND COMPONENT LEAD OR TERMINAL
- SOLDER JUMPER WIRE
- INSPECT WORKMANSHIP 10X
- DO NOT REPAIR

DEFENSE COMMUNICATIONS ITT

LIFTED CIRCUITRY (CON'T.)

- DISASSEMBLE COMPONENTS
- CLEAN CIRCUITRY AND BOARD
- EXAMINE AREA UNDER 10X
- MIX EPOXY
- APPLY UNDER ENTIRE AREA
- APPLY PRESSURE
- REMOVE EXCESS EPOXY
- ALLOW EPOXY TO CURE
- THOROUGHLY CLEAN REPAIRED AREA
- INSPECT 10X
- NON FUNCTIONAL IC LEADS
  - CUT IC LEAD(S) 1/16" FROM BODY
  - INSPECT COMPONENT BODY 20X

CRAZING

DO NOT REPAIR

DEFENSE COMMUNICATIONS DCT

LIFTED CIRCUITRY

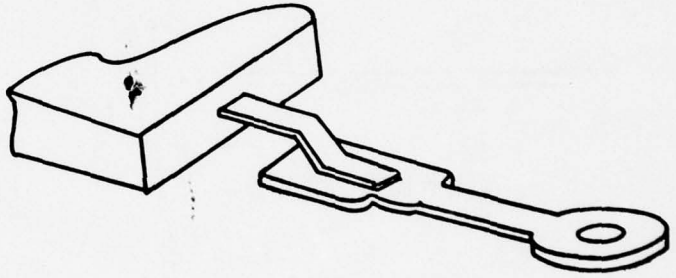


- REPAIR APPLIES TO:

  (A) CONDUCTOR RUN

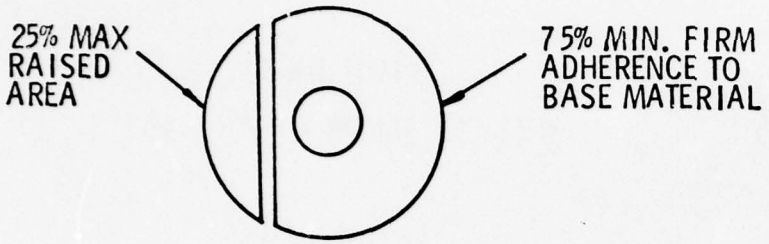
  (B) PAD WITHOUT PLATED THRU HOLE

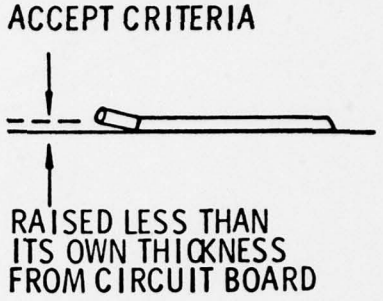
  (C) PAD WITH PLATED THRU HOLE

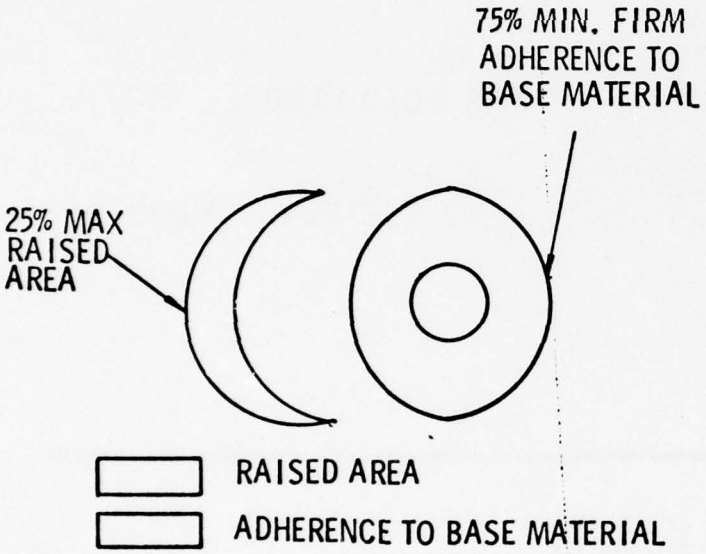


DEFENSE COMMUNICATIONS ITT

ACCEPT CRITERIA
25% MAX RAISED AREA







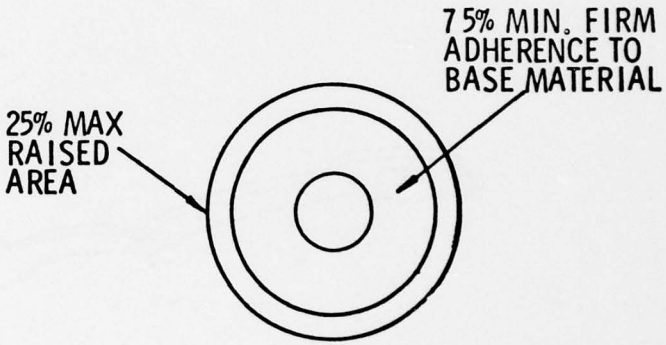
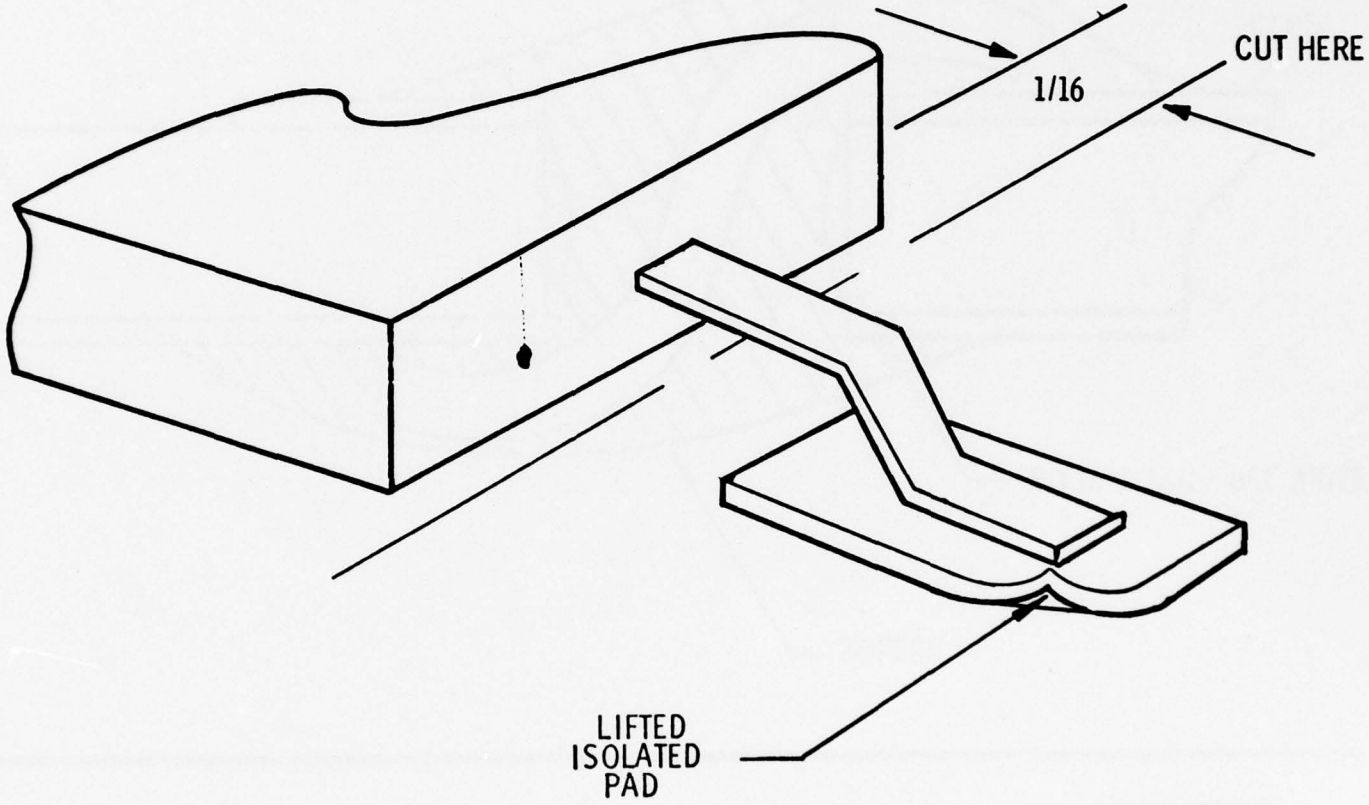


FIGURE 2

DEFENSE COMMUNICATIONS

NON FUNCTIONAL IC LEADS



DEFENSE COMMUNICATIONS ITT

FIGURE 3

"Z" WIRE ASSEMBLY

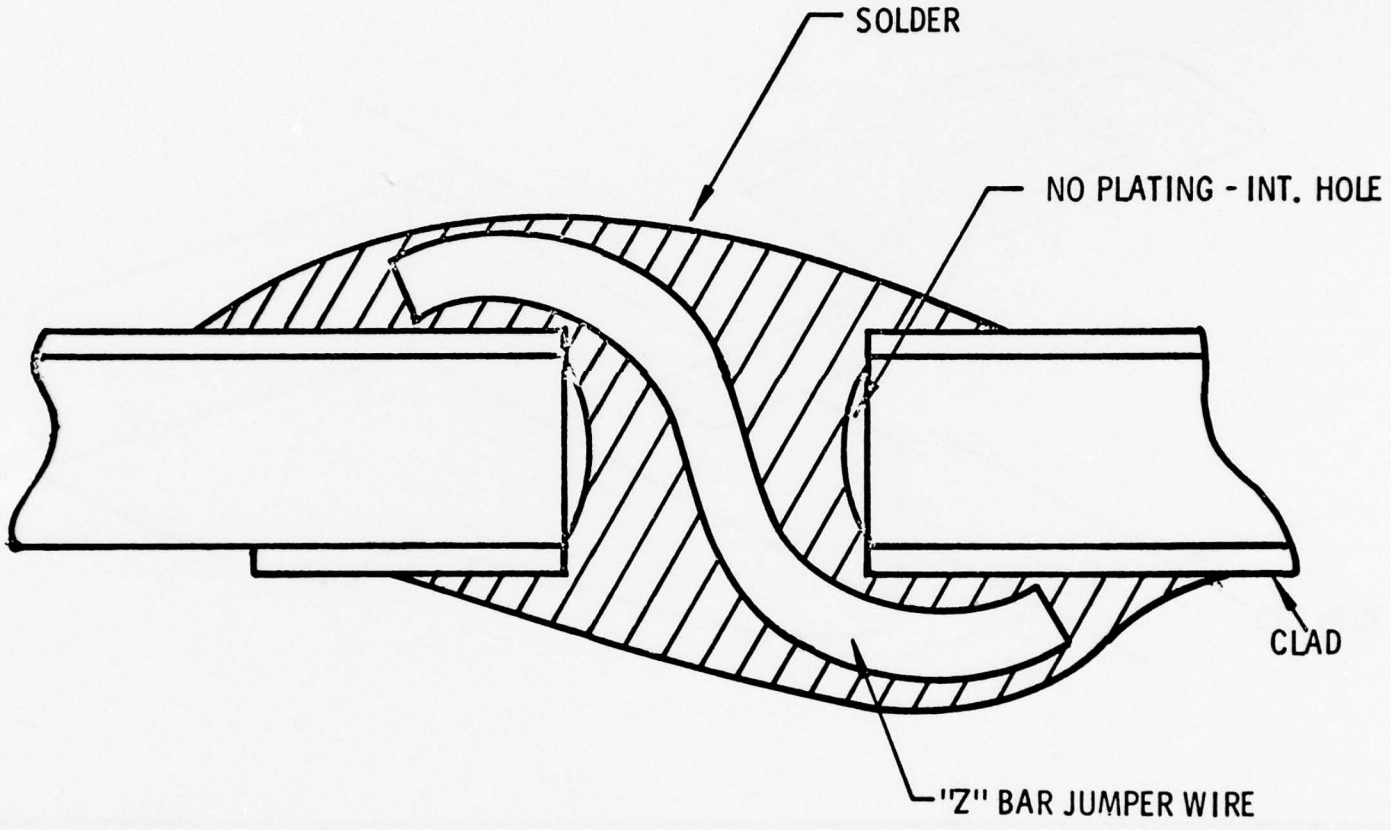
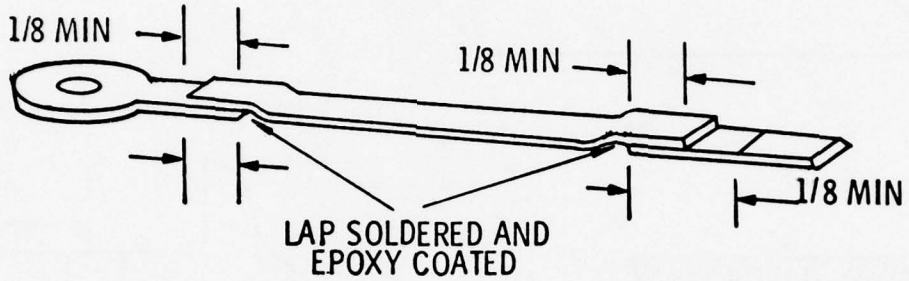


FIGURE 4

DEFENSE COMMUNICATIONS IT&T

ATTACHMENT TO CIRCUIT RUN



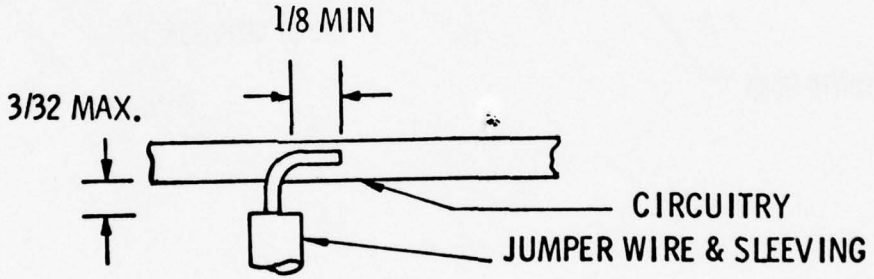


FIGURE 5

ATTACHMENT TO FLAT PACK LEAD
ONE JUMPER

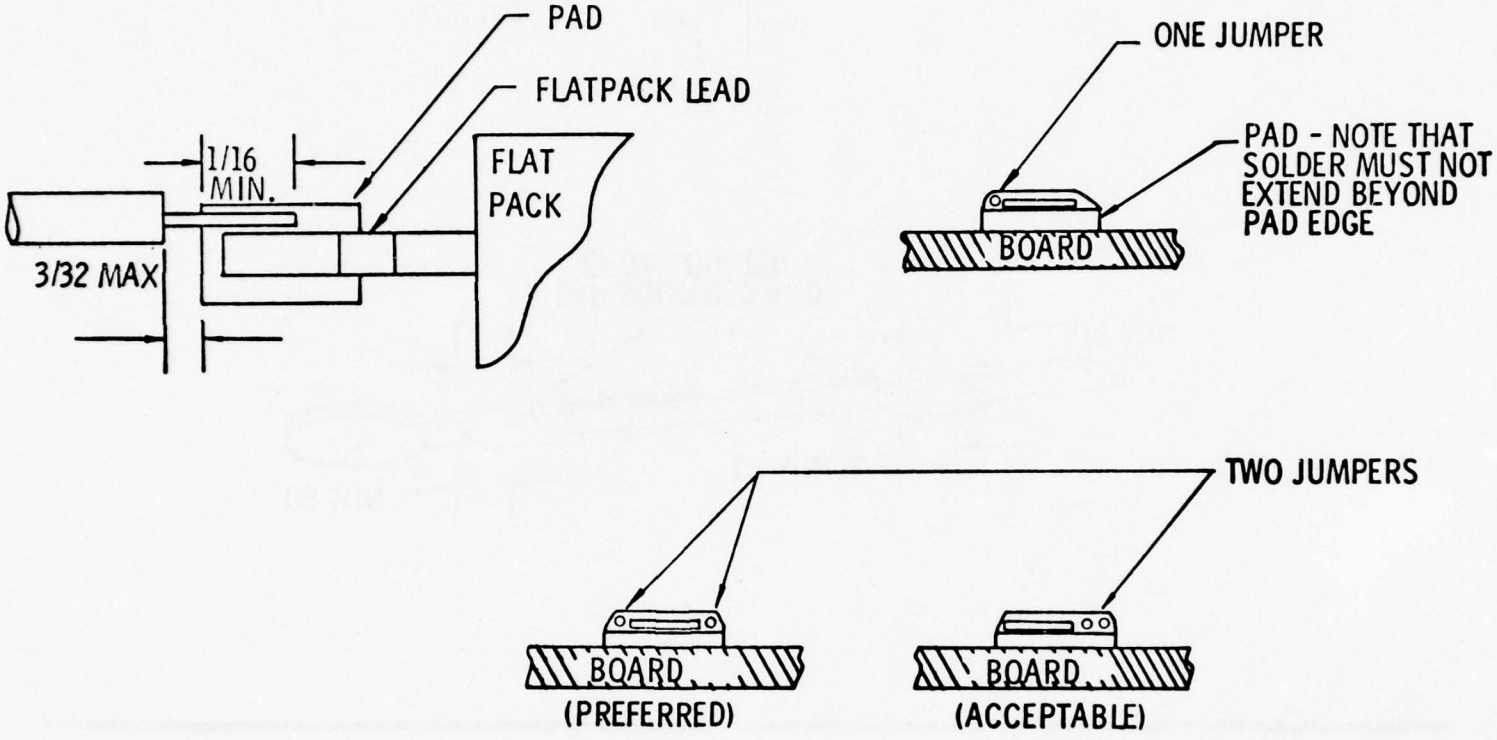
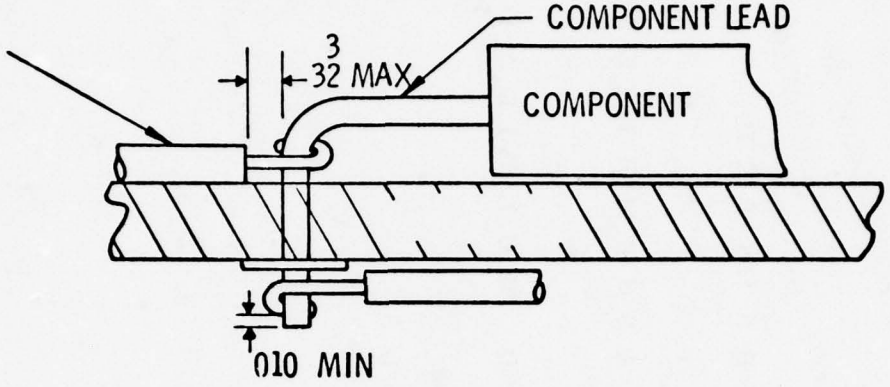
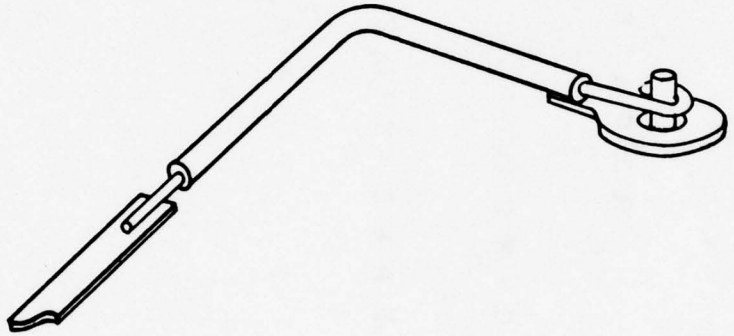


FIGURE 6

JUMPER TO COMPONENT LEAD OR TERMINAL

JUMPER WIRE AND SLEEVING: WRAP 1/2 TO 1 TURN





DEFENSE COMMUNICATIONS ITT

FIGURE 7

PART II

REPAIRING PRINTED CIRCUIT CARD ASSEMBLIES DOUBLE SIDED AND MULTILAYER BOARDS

THE FOLLOWING REPAIRS

CAN NOT BE MADE

UNLESS THEY ARE

AUTHORIZED BY THE

MATERIAL REVIEW BOARD

RESTRICTIONS: THESE PROCEDURES SHALL APPLY TO ASSEMBLED PRINTED CIRCUIT CARDS - ALL OTHERS SHOULD BE RTV'D

LIFTED CIRCUITRY

- REPAIR APPLIES TO:

  (A) CONDUCTOR RUN

  (B) PAD WITHOUT PLATED THRU HOLE (SHOW FIGURE 1)

  (C) PAD WITH PLATED THRU HOLE

  (REPAIR OF OPEN CIRCUITS MUST ALSO BE ACCOMPLISHED FOR (C))

- ACCEPT CRITERIA (SHOW FIGURE 2)

  1) PAD THAT IS RAISED < ITS OWN THICKNESS FROM THE CIRCUIT BOARD SURFACE AND HAS AT LEAST 3/4 RESIDUAL ADHERENCE TO THE BASE MATERIAL
  2) ALL RAISED NONFUNCTIONAL PADS THAT SHOW FIRM ADHERENCE TO THE BASE MATERIAL ARE ACCEPTABLE
  3) INTERFACIAL HOLES THAT SHOW EVIDENCE OF FRACTURED PLATING ARE UNACCEPTABLE
  4) THE LIFT SHALL NOT EXTEND TO THE PLATED HOLE INTERFACE

RESTRICTIONS:

1) LIFTED SECTION OF A CIRCUIT RUN MAY NOT EXCEED ONE HALF THE DISTANCE BETWEEN THE TWO CIRCUIT TERMINATIONS
2) MUST NOT BE LONGER THAN ONE HALF INCH
3) MUST NOT HAVE ANY EVIDENCE OF CREASES, FOLDS OR OTHER DAMAGE

IN THESE CASES THE REPAIR MUST BE PERFORMED IN ACCORDANCE WITH THE PROCEDURE FOR MISSING, DAMAGED OR CUT CIRCUITRY WHICH WILL BE EXPLAINED LATER

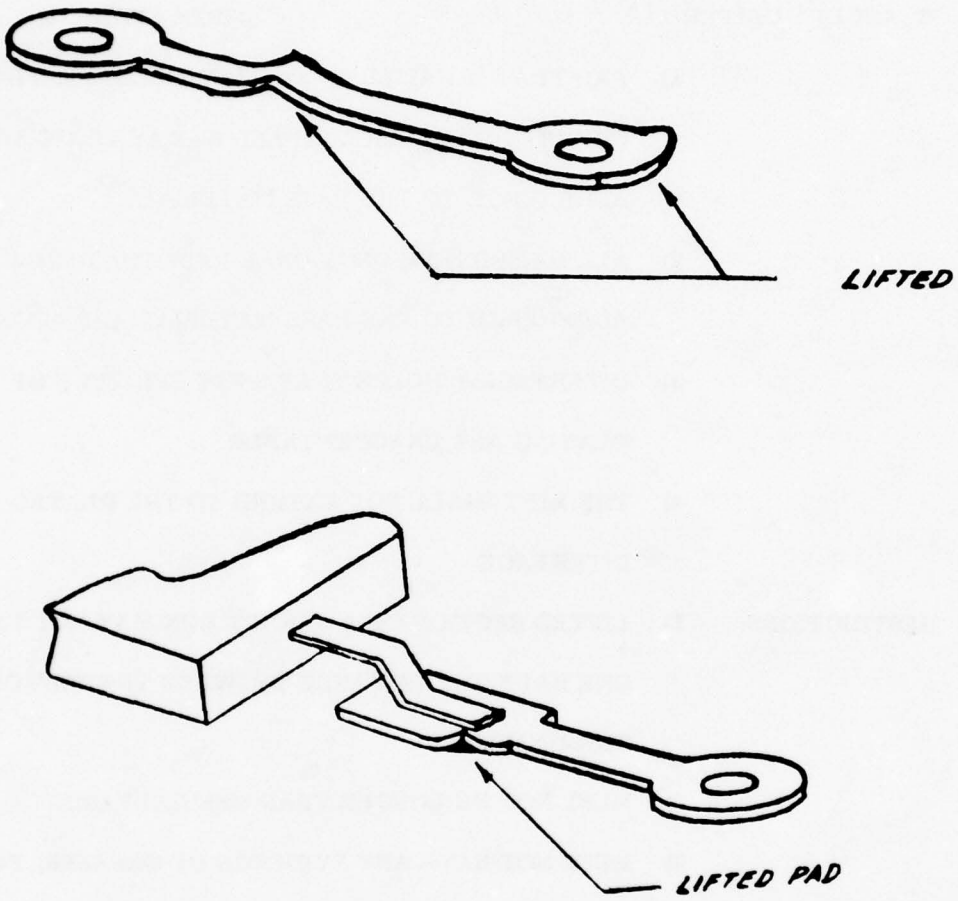
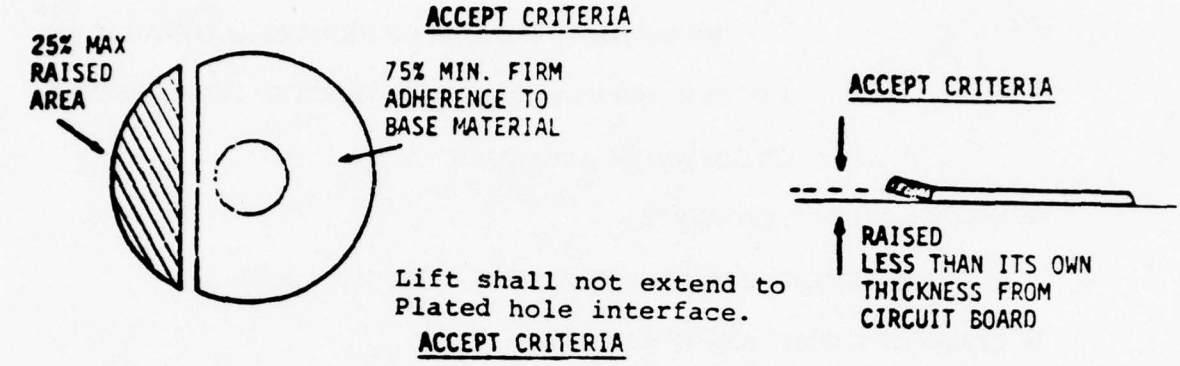


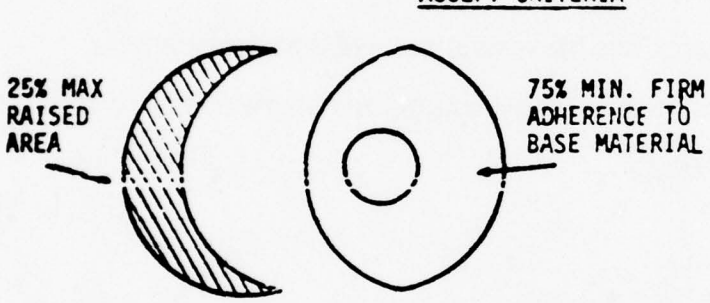
FIGURE 1

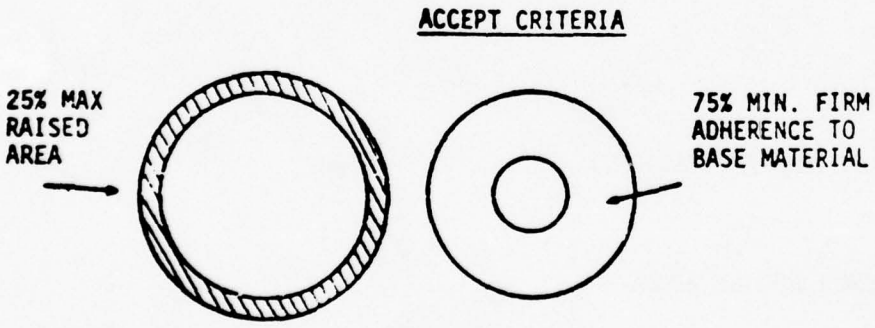
ACCEPT CRITERIA: A pad that is raised less than its own thickness from the circuit board surface and has at least three-fourths (3/4) residual area of adherence to the base material.

NOTE:

All raised non-functional pads that show firm adherence to the base material are acceptable.







Cut-away view of raised/adhering portions of pads.

Interfacial holes that show evidence of fractured plating are unacceptable.

FIGURE 2

THIS PROCEDURE SHALL NOT BE USED FOR REPAIR TO PADS USED AS ELECTRICAL CONTACT WITH MATING CONNECTORS SUCH AS ON EDGE INSERTABLE DESIGNS.

THE MAXIMUM NUMBER OF REPAIRS ALLOWABLE ON ANY ONE ASSEMBLY SHOULD BE LIMITED PER INTERNAL OR CUSTOMER AGREEMENT

- DISASSEMBLE COMPONENTS

  (TO OBTAIN FREE ACCESS TO AREA BEING REPAIRED)

- CLEAN CIRCUITRY AND BOARD

  (REMOVE ALL PARTICLES OR FOREIGN SUBSTANCES WHICH WILL PREVENT THE CONDUCTOR FROM MAKING INTIMATE CONTACT WITH THE BOARD SURFACE)

- EXAMINE AREA UNDER 10X

  (FOR VOIDS, FOREIGN MATERIAL)

- MIX EPOXY

  (HYSOL) (OR EQUIVALENT)

- APPLY UNDER ENTIRE AREA

  (APPLY A SMALL QUANTITY OF EPOXY ASSURING THAT THE MIXTURE IS APPLIED UNDER THE ENTIRE LENGTH OF THE LIFTED CONDUCTOR OR LIFTED AREA OF THE PAD)

- APPLY PRESSURE

  (TO CONDUCTOR OR PAD USING ORANGE-WOOD STICK SO THAT CONTACT IS MADE BETWEEN THE CONDUCTOR AND BOARD SURFACE)

- REMOVE EXCESS EPOXY

  (FROM SURFACES TO BE SOLDERED OR FROM PLATED THRU HOLE PRIOR TO CURING - SCRAPING OF EPOXY AFTER CURING IS NOT PERMISSIBLE)

- ALLOW EPOXY TO CURE
- THOROUGHLY CLEAN REPAIRED AREA

  (USING CLEANING SOLVENT AND BRUSH)

- INSPECT 10X

  (FOR VOIDS, FOREIGN MATERIAL, ADHESION)

- NONFUNCTIONAL IC LEADS (SHOW FIGURE 3)
- CUT IC LEAD(S) 1/16" FROM BODY
- INSPECT COMPONENT BODY 20X

  (THE AREA OF THE SEAL SHALL SHOW NO EVIDENCE OF DAMAGE)

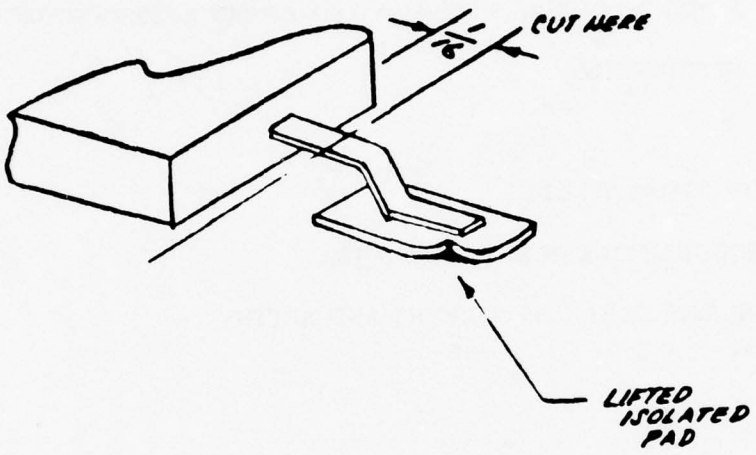


FIGURE 3

II OPEN CIRCUITS

(INCLUDES OPEN PLATED THRU HOLES ON MULTILAYER BOARDS)

- DETERMINE END POINTS OF DEFECTIVE CIRCUIT

  (FOR MULTILAYER BOARDS ALSO DETERMINE THE TERMINATION POINTS OF ALL INTERNAL LAYERS)

- SELECT WIRE

  (AS SPECIFIED BY THE MRB)

  (1) STRANDED OR SOLID INSULATED WIRE

  2) IF < 1 INCH WIRE MAY BE SOLID BUSS WIRE WITH SLEEVING

  3) IF < .5 INCH AND DOES NOT CROSS CIRCUITRY WIRE MAY BE UNINSULATED BUSS WIRE)

- CUT TO LENGTH AND TIN WIRE
- ROUTE ON CARD

  (HOLD IN PLACE USING MASKING TAPE OR ORANGE-STICK IN THE CASE OF SHORT LENGTH WIRES)

- SOLDER WIRES TO TERMINATIONS

  (SOLDER WIRES ONLY AFTER ALL COMPONENTS HAVE BEEN MOUNTED AND SOLDERED)

(NOTE: 1) WIRES SHALL BE TERMINATED ON CIRCUIT RUNS ONLY IF NO OTHER ALTERNATIVE EXISTS

2) CROSSING WIRES SHALL BE AVOIDED IF POSSIBLE

3) NO MORE THAN 3 WIRES SHALL BE SOLDERED TO ONE TERMINATION POINT

4) AVOID RUNNING MORE THAN THREE WIRES IN PARALLEL IF POSSIBLE)

- REMOVE MASKING TAPE
- CEMENT WIRE TO CARD

  (USE INSULATING CEMENT APPROXIMATELY 1 INCH INTERVALS) AND ALLOW TO CURE)
- INSPECT FOR:

  OPEN CIRCUITS

  SHORTED CIRCUITS

  CONTINUITY

  SOLDER WORKMANSHIP

  COMPONENTS ARE SECURELY MOUNTED

  WIRING IS ROUTED PROPERLY

  NO EVIDENCE OF BROKEN/DAMAGED CONDUCTORS

III SHORTED CIRCUITS

- ISOLATE SHORTED CIRCUIT
- DETERMINE LOCATION - SHORTED CONDUCTORS ELECTRICALLY

A. REMOVE CIRCUITRY - <u>EXPOSED</u>

- KNIFE CUT

  (MAKE TWO PARALLEL CUTS IN CONDUCTOR A MINIMUM OF .015 APART AND REMOVE CIRCUITRY. BE CAREFUL NOT TO CUT INTO THE LAMINA)

- APPLY EPOXY TO CUT AREAS
- VERIFY SHORT DOES NOT EXIST

B. REMOVE CIRCUITRY - <u>HIDDEN</u>

(SUCH AS IN MULTILAYER BOARDS)

- CLAMP PWB - ON FIXTURE
- POSITION DIAL INDICATOR

  (ON MACHINE SPINDLE TO MONITOR DEPTH OF CUT)

- POSITION END MILL OVER LINE TO BE CUT

  (1) UTILIZE COPY OF ARTWORK FOR POSITION

  2) END MILL MUST BE LARGER IN DIAMETER THAN LINE TO BE CUT BUT ADJACENT CIRCUITRY MUST BE CONSIDERED)

- CONNECT VOM

  (ON THE FRONT LAYER OF THE PWB CLAMP THE VOM TO COMMON POINTS ON BOTH ENDS OF THE LINE TO BE CUT)

- SET VOM DC RESISTANCE SCALE
- ADVANCE END MILL

  (VERY CAREFULLY, TAKING PROGRESSIVE CUTS OF .001 INCH DEPTH AND BACKING OFF)

- LOSS OF CONTINUITY

  (STOP UPON LOSING CONTINUITY ON A BACKING OFF OPERATION - THIS INDICATES THE LINE IS CUT)

- TEST FOR INDUCED SHORTS

  (TO ADJACENT LAYER OR ADJACENT CIRCUIT LINE CAUSED BY SMEARING THE COPPER DURING THE CUTTING OPERATION)

- PROBE POINTS OF ADJACENT LAYER/LINE

  (WITH ONE END OF VOM STILL ATTACHED TO ONE END OF THE CUT LINE. PROBE FRONT LAYER POINTS OF ADJACENT LAYER OR ADJACENT LINE WITH THE OTHER PROBE - REPEAT WITH THE OTHER END OF THE CUT LINE)

- IF SHORT IS DISCOVERED

  (CAREFULLY HAND PICK TO REMOVE THE COPPER SMEAR)

- VERIFY

  (REPEAT THE TESTS FOR INDUCED SHORTS)

- APPLY INSULATING COMPOUND

  (TO SEAL THE BARE COPPER OF THE CUT LINE)

- INSPECT 10X

  (FOR DAMAGE TO SURROUNDING CIRCUITRY AND PARTS)

IV MISSING/DAMAGED PLATED THRU HOLES

A. INTERFACIAL HOLES

(RESTRICTIONS - THIS REPAIR WILL NOT BE USED WHEN MORE THAN 5% OF THE HOLES IN THE BOARD ARE DEFECTIVE WITHOUT A COMPLETE ENGINEERING INVESTIGATION)

- REMOVE SOLDER

  (FROM THE HOLE AND CHECK PAD FOR LIFTING)

- INSERT SOLID "Z" WIRE (SHOW FIGURE 4)

  (USE 28 OR 30 AWG SINGLE STRANDED UNINSULATED JUMPER WIRE AND CRIMP BOTH ENDS - Z WIRE)

- SOLDER JUMPER WIRE
- CLEAN BOARD
- INSPECT WORKMANSHIP 10X

B. COMPONENT MOUNTING HOLES

- REMOVE COMPONENTS

  (AS REQUIRED TO OBTAIN FREE ACCESS TO AREA BEING REPAIRED)

- REMOVE SOLDER

  (FROM THE HOLE AND CHECK PAD FOR LIFTING)

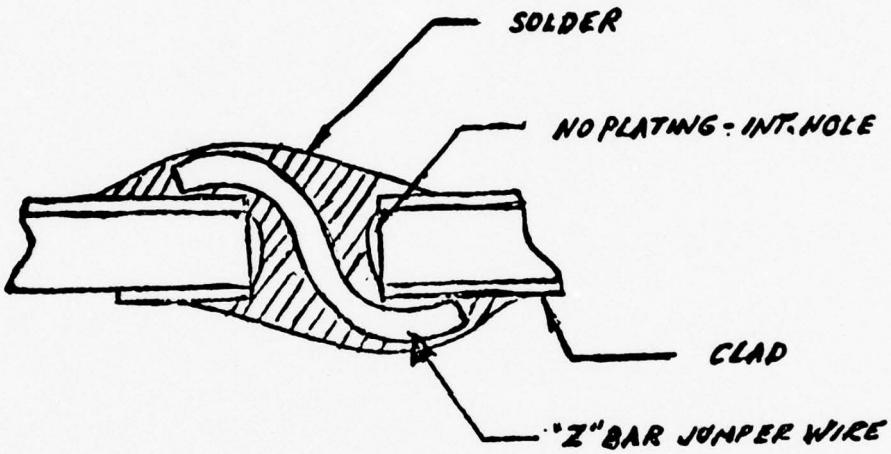


FIGURE 4

- INSERT COMPONENT
- SOLDER COMPONENT TO PADS ON BOTH SIDES

  (OF THE BOARD)

- CLEAN BOARD
- INSPECT WORKMANSHIP 10X

V MISSING, DAMAGED, CUT CIRCUITRY

A. ATTACHMENT TO CIRCUIT RUN (SHOW FIGURE 5)

(RESTRICTIONS: 1) THERE MUST BE A MINIMUM OF 1/8 INCH ORIGINAL CONDUCTOR RUN ON EACH SIDE TO BE SOLDERED

2) BROKEN OR CUT CONTACT FINGERS SHALL NOT BE REPAIRED

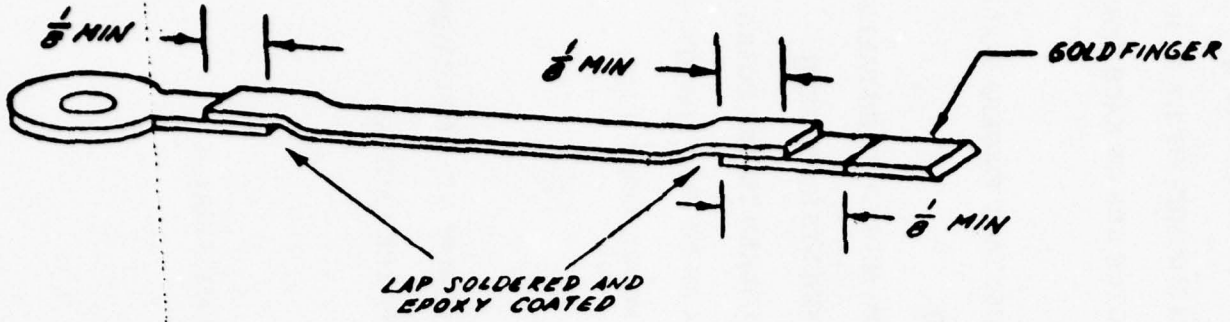
3) ALL JUMPER WIRES SHOULD BE INSTALLED AFTER ALL COMPONENTS HAVE BEEN MOUNTED AND SOLDERED TO THE BOARD THIS PROCEDURE CAN BE USED FOR STRAIGHT CIRCUIT RUNS OR NONSTRAIGHT RUNS)

- REMOVE DAMAGED CIRCUITRY

  (USE EXACTO KNIFE. PLACE KNIFE EDGE ACROSS A GOOD SECTION OF CIRCUITRY AND CUT WITHOUT DAMAGING THE LAMINA)

- CLEAN BOARD SURFACE

  (MAKE SURE ALL PARTICLES AND FOREIGN MATERIAL IS REMOVED)


1/8 MIN
1/8 MIN
GOLD FINGER
1/8 MIN
LAP SOLDERED AND
EPOXY COATED

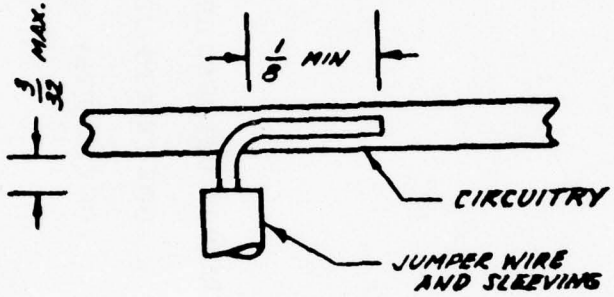

3/32 MAX.
1/8 MIN
CIRCUITRY
JUMPER WIRE
AND SLEEVING

FIGURE 5

- CUT JUMPER WIRE/SLEEVING

  (SELECT THE APPROPRIATE GAUGE WIRE AND SLEEVING SIZE AND PROPER LENGTH. PUT THE SLEEVING OVER THE BUSS WIRE. YOU CAN USE RIBBON IN PLACE OF JUMPER WIRE PROVIDING THE AREA TO BE JUMPERED DOES NOT EXCEED .5 IN. JUMPERS > 1 INCH SHOULD BE STRANDED COPPER WIRE < THAN .5 INCH DO NOT REQUIRE SLEEVING AS LONG AS THEY DO NOT CROSS CIRCUITRY)

- TIN JUMPER WIRE ENDS

  (APPROXIMATELY 1/8 INCH FROM EACH END)

- PLACE WIRE ON BOARD

  (FOR STRAIGHT RUNS FOLLOW ORIGINAL CIRCUITRY PATH. OVERLAP THE ATTACHED POINTS BY 1/8 INCH ON EACH END)

- SOLDER JUMPER WIRE

  (ASSURE SOLDER HAS SET TO AVOID LIFTING, USING A HOLDING AID IF NECESSARY)

- INSPECT WORKMANSHIP 10X
- MIX EPOXY

- APPLY EPOXY

  (APPLY A SMALL QUANTITY OF EPOXY TO THE ENTIRE LENGTH OF THE REPLACED CIRCUITRY AND OVER THE SOLDER JOINT. FOR NONSTRAIGHT RUNS USE EPOXY APPROXIMATELY EVERY INCH)

- CURE EPOXY
- INSPECT WORKMANSHIP 10X

B. ATTACHMENT TO FLAT PACK LEAD (SHOW FIGURE 6)

(CLEANING OF THE BOARD AND CUTTING BUSS WIRE AND SLEEVING AND TINNING OF THE BUSS WIRE IS THE SAME AS PREVIOUSLY DISCUSSED FOR ATTACHMENT TO CIRCUIT RUNS) (ALL RESTRICTIONS ALSO APPLY)

- PLACE WIRE ON FLAT PACK LEAD

  (WIRE MUST BE PLACED ADJACENT AND PARALLEL TO THE FLAT PACK LEAD AND HELD IN PLACE)

- SOLDER JUMPER WIRE

  (REFLOW AND SOLDER JUMPER WIRE TO FLAT PACK PAD ASSURING THAT SOLDER HAS SET TO AVOID LIFTING OF THE JUMPER AND FLAT PACK LEAD)

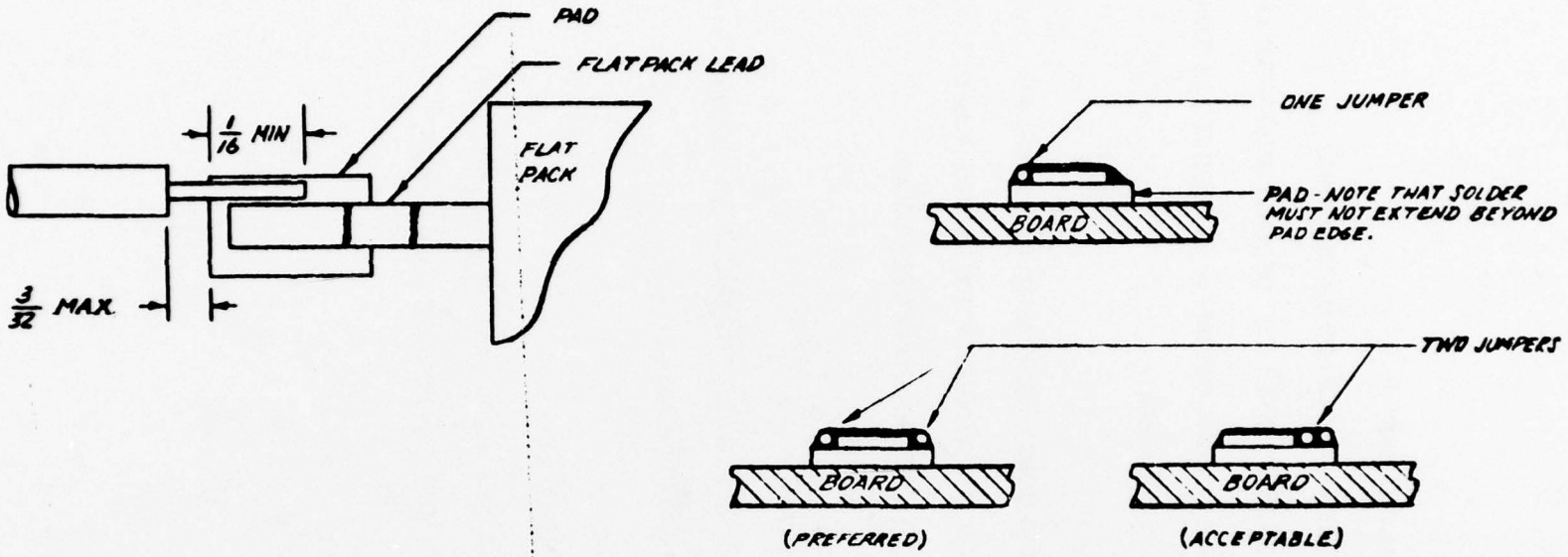

PAD
FLAT PACK LEAD
1/16 MIN
FLAT PACK
3/32 MAX
ONE JUMPER
BOARD
PAD - NOTE THAT SOLDER MUST NOT EXTEND BEYOND PAD EDGE.
TWO JUMPERS
BOARD
BOARD
(PREFERRED)
(ACCEPTABLE)

FIGURE 6

- INSPECT WORKMANSHIP 10X

C. ATTACHMENT TO COMPONENT LEADS OR TERMINAL

(CLEANING OF THE BOARD AND CUTTING BUSS WIRE AND SLEEVING AND TINNING OF THE BUSS WIRE IS THE SAME AS PREVIOUSLY DISCUSSED)

- WRAP WIRE AROUND COMPONENT LEAD OR TERMINAL (SHOW FIGURE 7)

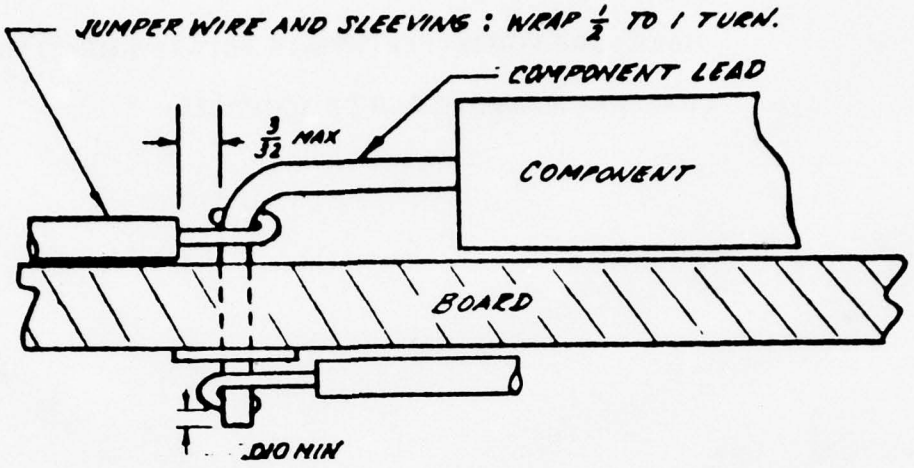
(WRAP END OF THE JUMPER WIRE AROUND THE COMPONENT LEAD MAKING 1/2 TO THE ONE COMPLETE WRAP)

- SOLDER JUMPER WIRE

(SOLDER WIRE IN PLACE UTILIZING HEAT SINKS ON ALL TEMPERATURE SENSITIVE DEVICES)

- INSPECT WORKMANSHIP 10X

(INSPECT FOR DAMAGE TO THE COMPONENT BODY AS WELL AS JUMPER WIRE AND COMPONENT SOLDERING)


JUMPER WIRE AND SLEEVING : WRAP ½ TO 1 TURN.
COMPONENT LEAD
3/32 MAX
COMPONENT
BOARD
.010 MIN

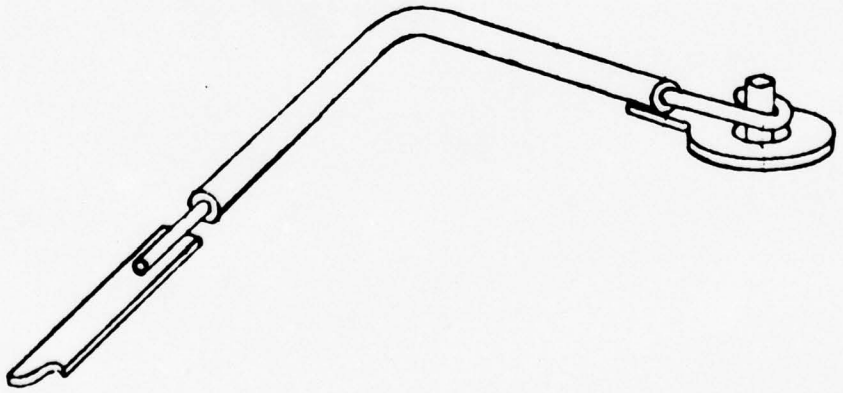


FIGURE 7

VI CRAZING

- DO NOT REPAIR

  (MAKE SURE YOU DIFFERENTIATE BETWEEN MEASLING AND CRAZING - MEASLING CAN BE ACCEPTED)

APPENDIX T

MULTILAYER ASSEMBLY RELIABILITY ASSURANCE

General Electric Company

GENERAL ELECTRIC

MLA RELIABILITY ASSURANCE - A CONTINUING PROGRAM AT THE AEROSPACE ELECTRONIC SYSTEMS DEPARTMENT OF GENERAL ELECTRIC

PROGRAM OBJECTIVES

- MEASURE THE LIFE OF MLAs MANUFACTURED TO BASELINE PROCESS AND INCORPORATING STANDARD DESIGN FEATURES
- EVALUATE THE EFFECTS OF PROCESS AND DESIGN CHANGES ON MLA RELIABILITY
- RELATE TEST RESULTS TO PROGRAM SERVICE ENVIRONMENTS (PRIMARILY THERMAL)
- PROVIDE DATA FOR DEVELOPMENT OF ACCELERATED TESTS

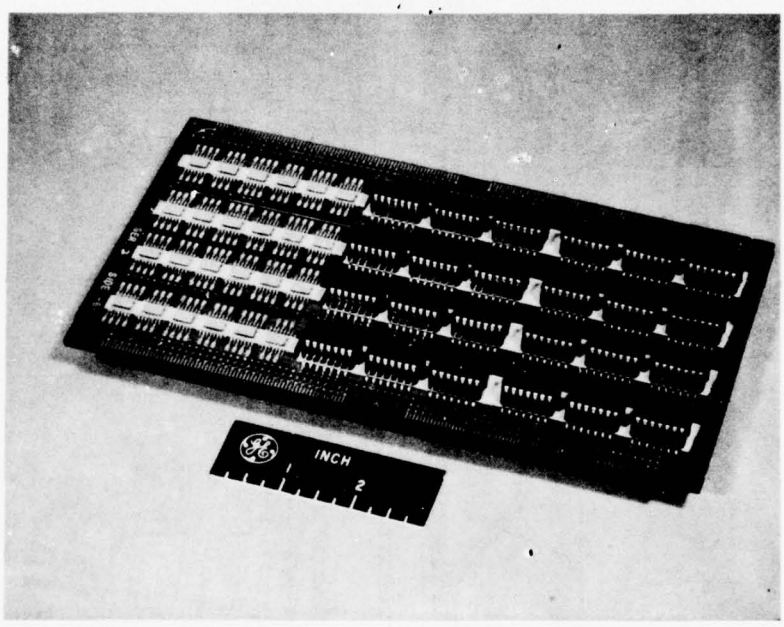
KEY PROGRAM FEATURES

- MLA TEST SPECIMENS WERE SUBJECTED TO ALL STANDARD ASSEMBLY OPERATION STRESSES BY MANUFACTURING PERSONNEL
- CONTINUOUS CIRCUIT MONITORING OVER TEMPERATURE RANGE
  - 5 ns ELECTRICAL FAILURE (>1 OHM) DETECTION CAPABILITY
  - 25 mA CONSTANT CURRENT SOURCE
- ACCELERATED TEST OVER TWO TEMPERATURE RANGES
- MLA TEST CONFIGURATION REPRESENTATIVE OF PRESENT (1973) AND PROPOSED AESD PROCESSES/DESIGNS

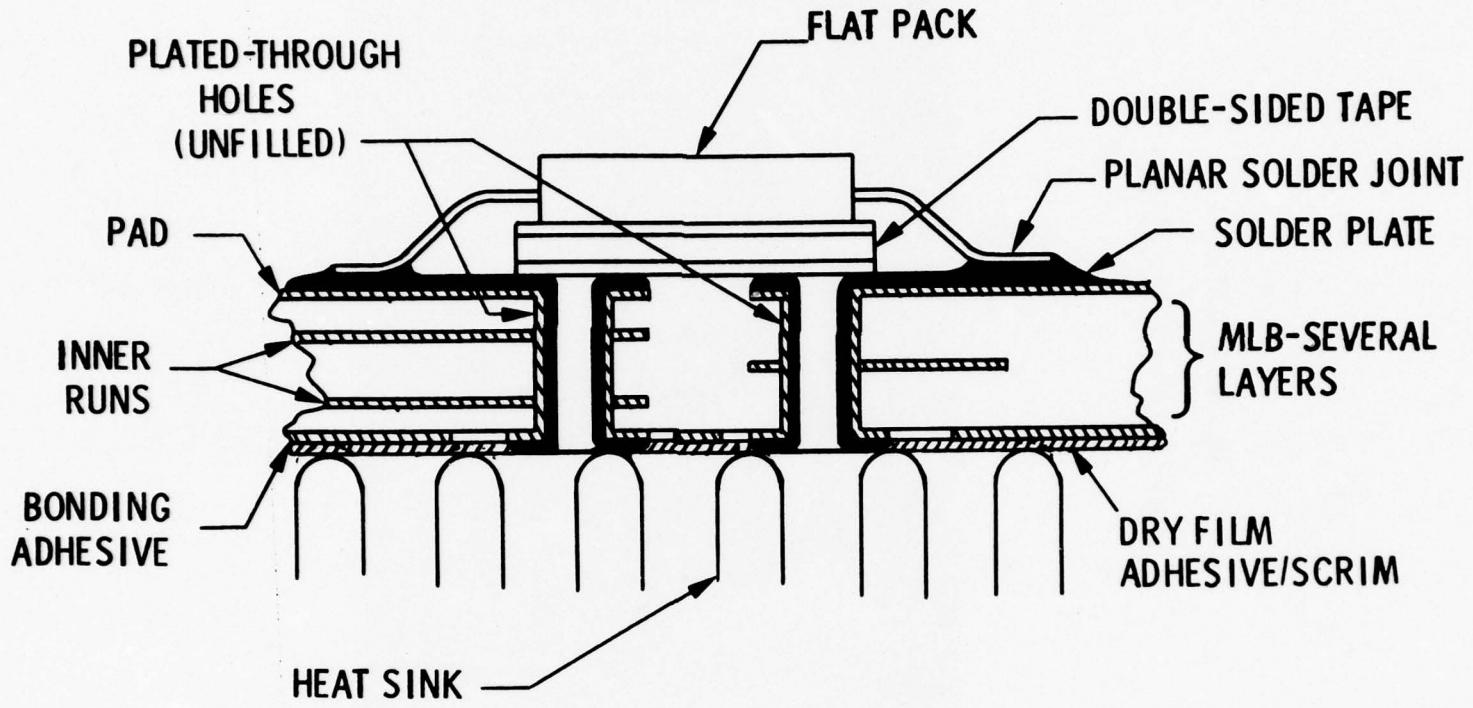
MLA TEST CONFIGURATION

- EACH 5" x 9" MLA CONTAINS:
  - HEATSINK SANDWICHED BETWEEN TWO MLBs
  - 48 FLAT PACKS - 672 PLANAR SOLDER JOINTS
  - 48 DUAL-IN-LINE SOCKETS - 672 PLANAR SOLDER JOINTS

PLANAR ATTACH
MULTILAYER ASSEMBLY



CROSS SECTION THROUGH MLA



MLB FEATURES

- 12-LAYER GLASS EPOXY BOARD
- 1 oz AND 2 oz COPPER INNER LAYER COMBINATIONS
- 40 MIL DIA DRILLED HOLES
- >1.0 MIL AVG MIN PTH COPPER THICKNESS
- SOLDER FILLED HOLES
- 13-MIL WIDE RUN ON 25-MIL GRID
- 1230 PTHs

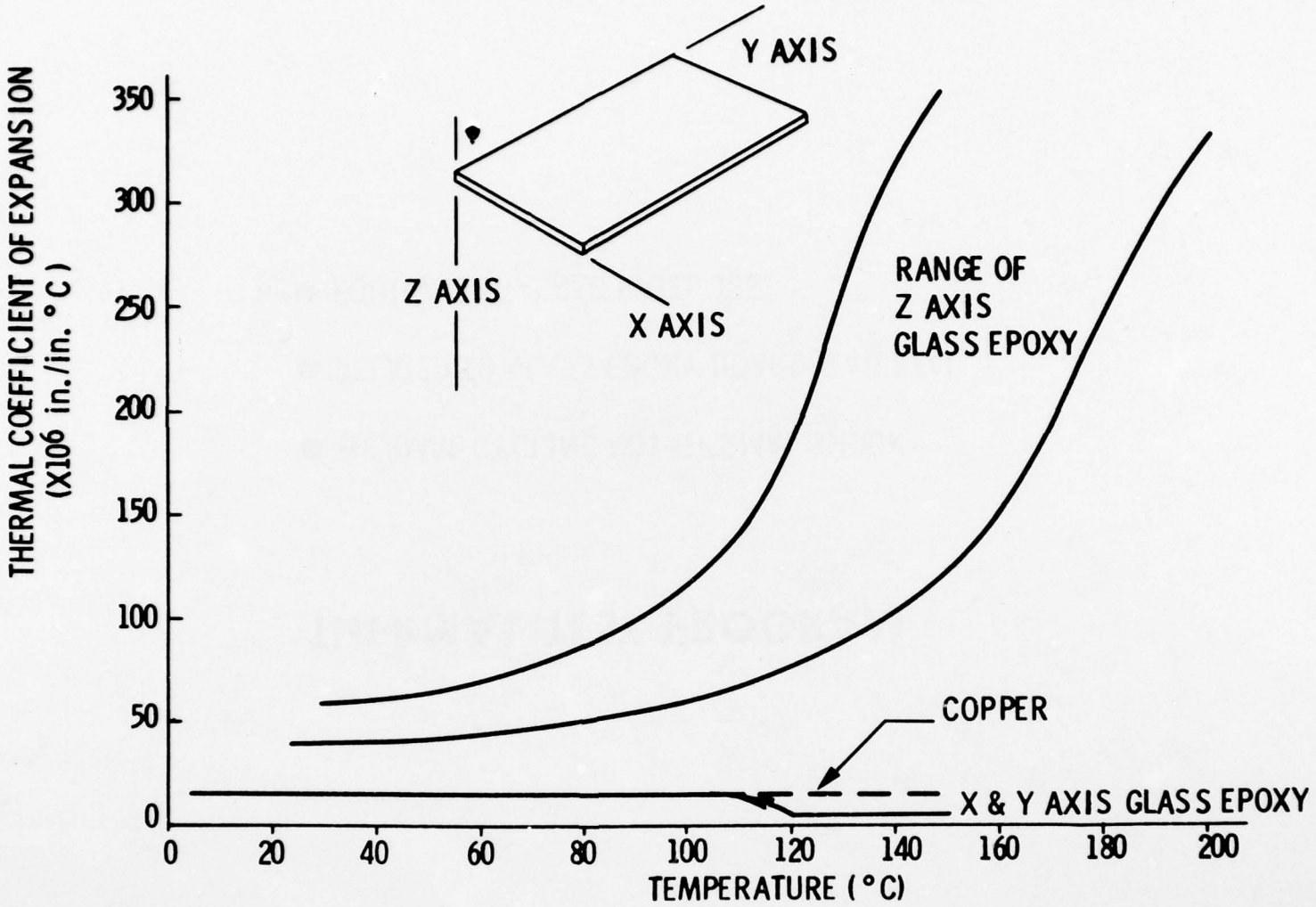
MLB TEST CIRCUIT DESCRIPTION

CIRCUIT	PLANAR SOLDER JOINTS	PLATED-THROUGH HOLES	CIRCUIT DESCRIPTION
A	168	0	SURFACE RUNS USED TO CONNECT 12 DUAL-IN-LINE SOCKETS
B	168	170	12 DUAL-IN-LINE SOCKETS CONNECTED IN SERIES VIA PTHs TO RUNS ON LAYER II
C	168	0	SURFACE RUNS USED TO CONNECT 12 FLATPACKS
D	168	170	12 FLATPACKS CONNECTED IN SERIES VIA PTHs TO RUNS ON LAYER II
E	0	22	LONG RUN WITH LONGITUDINAL, LATERAL, AND DIAGONAL LEGS EXTENDING OVER SEVERAL LAYERS
F	0	869	PTHs STITCHED TOGETHER AT VARYING CIRCUIT LAYERS

THERMAL TEST PROGRAM

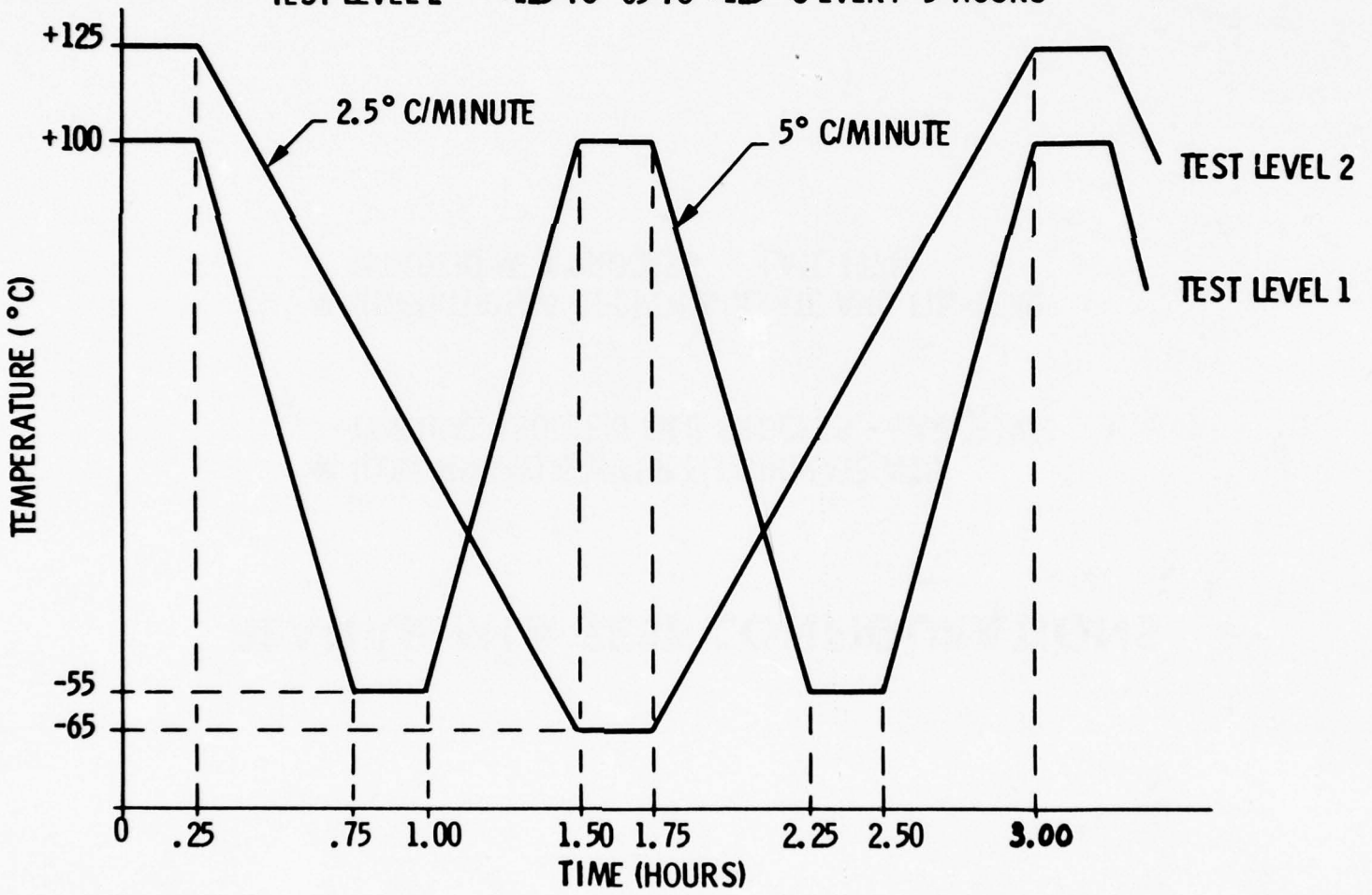
- THERMAL CYCLING NOT THERMAL SHOCK
- RELATED TO GLASS EPOXY BOARD MATERIAL
- EQUIVALENT ACCELERATED TEST

THERMAL COEFFICIENT OF EXPANSION versus TEMPERATURE



MLB TEMPERATURE CYCLE PROFILES

TEST LEVEL 1 - +100 TO -55 TO +100° C EVERY 1.5 HOURS
TEST LEVEL 2 - +125 TO -65 TO +125° C EVERY 3 HOURS



PLANAR MLA TEST CONFIGURATIONS

- (LOW THROW) COPPER FLUOBORATE AND TIN-LEAD (SOLDER) MLB PROCESS - EARLY 1973

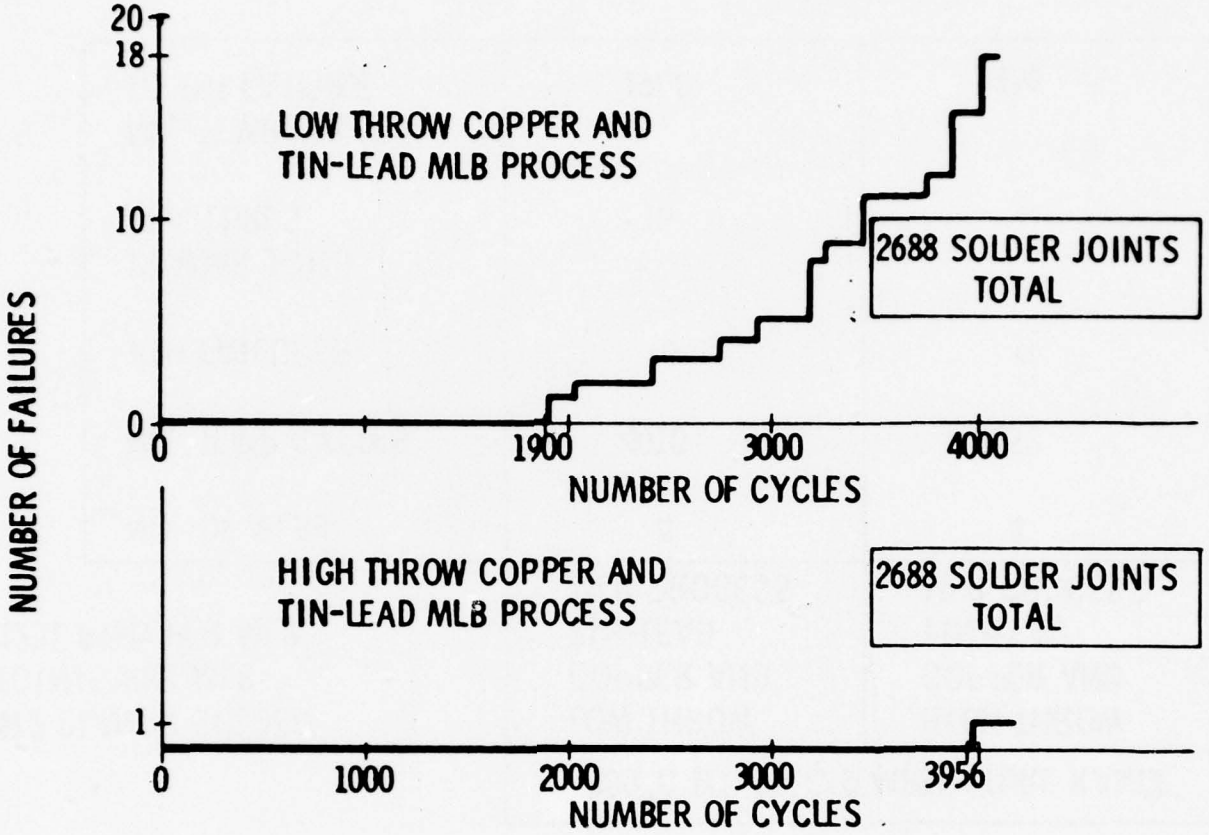
- (HIGH THROW) COPPER SULFATE AND TIN-LEAD (SOLDER) MLB PROCESS - LATE 1974

PLANAR MLA TEST RESULT

672 PLANAR SOLDER JOINTS PER MLB 1231 PTHs PER MLB	+100°C TO -55°C TEMPERATURE RANGE	
	LOW THROW COPPER AND TIN-LEAD MLB PROCESS	HIGH THROW COPPER AND TIN-LEAD MLB PROCESS
NO. OF MLBs	4	4
NO. TEMP CYCLES	4010	4152
PTH FAILURES	0	0
PLANAR JOINT FAILURES	18	1
NO. TEMP CYCLES TO 1ST FAILURE	1900	3956

PLANAR SOLDER JOINT FAILURES

+100° C TO -55° C TEMPERATURE CYCLE



EQUIVALENT LIFE FOR
+85° C TO -45° C TEMPERATURE
RANGE USING LOW CYCLE
FATIGUE EXPRESSIONS

1900 ⟺ 3800 (8 YEARS)

3956 ⟺ 7912 (16 YEARS)

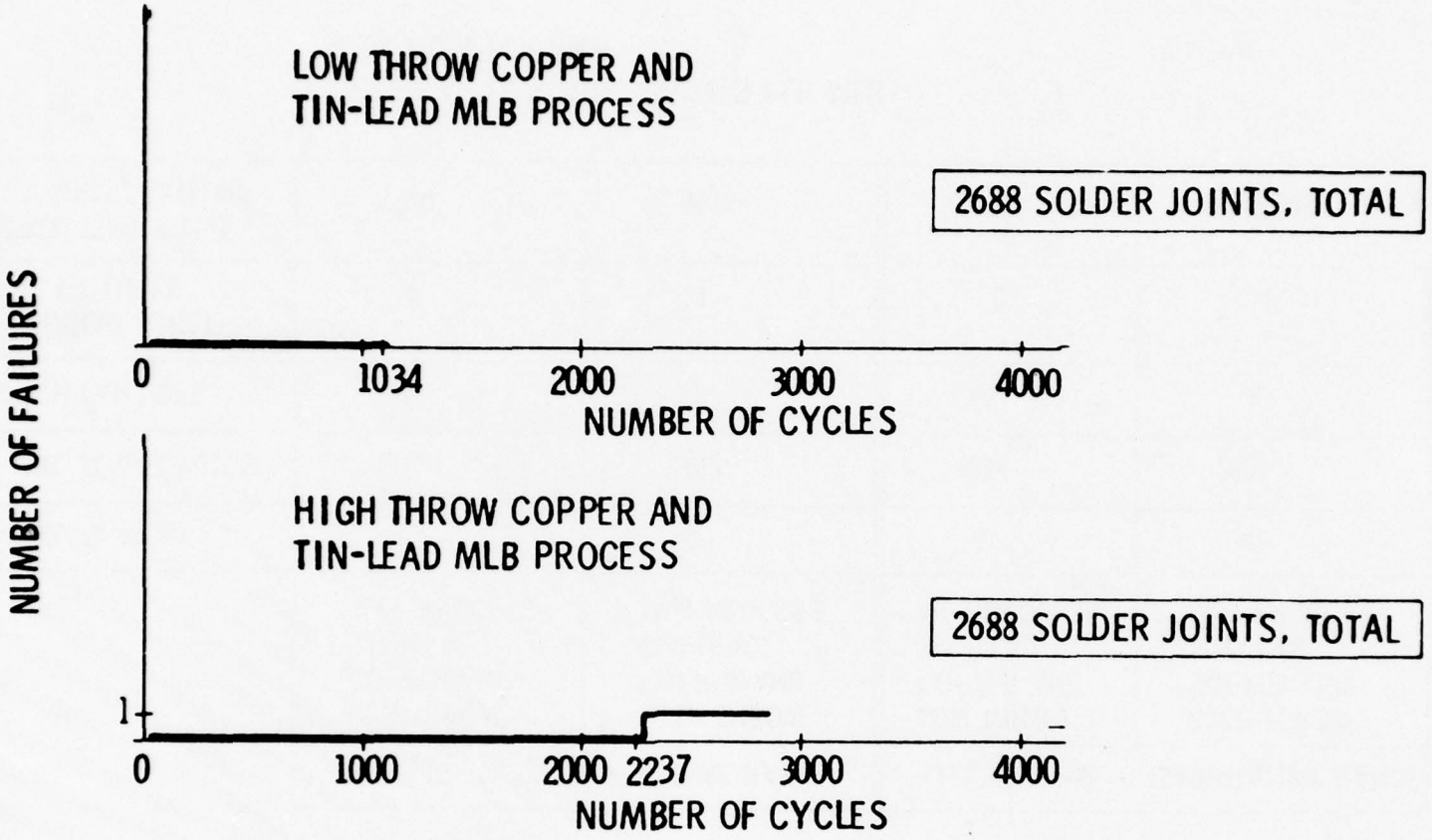
PLANAR MLA TEST RESULTS

	+100° C TO -55° C TEMPERATURE RANGE		+125° C TO -65° C TEMPERATURE RANGE	
	LOW THROW COPPER AND TIN-LEAD MLB PROCESS	HIGH THROW COPPER AND TIN-LEAD MLB PROCESS	LOW THROW COPPER AND TIN-LEAD MLB PROCESS	HIGH THROW COPPER AND TIN-LEAD MLB PROCESS
NO. OF MLBs	4	4	4	4
NO. TEMP CYCLES	4010	4152	1034	2821
PTH FAILURES	0	0	63	8
PLANAR JOINT FAILURES	18	1	0	1
NO. TEMP CYCLES TO 1ST FAILURE	1900	3956	573	2237 2493

672 PLANAR SOLDER JOINTS PER MLB
1231 PTHs PER MLB

PLANAR SOLDER JOINT FAILURES

+125° C TO -65° C TEMPERATURE RANGE



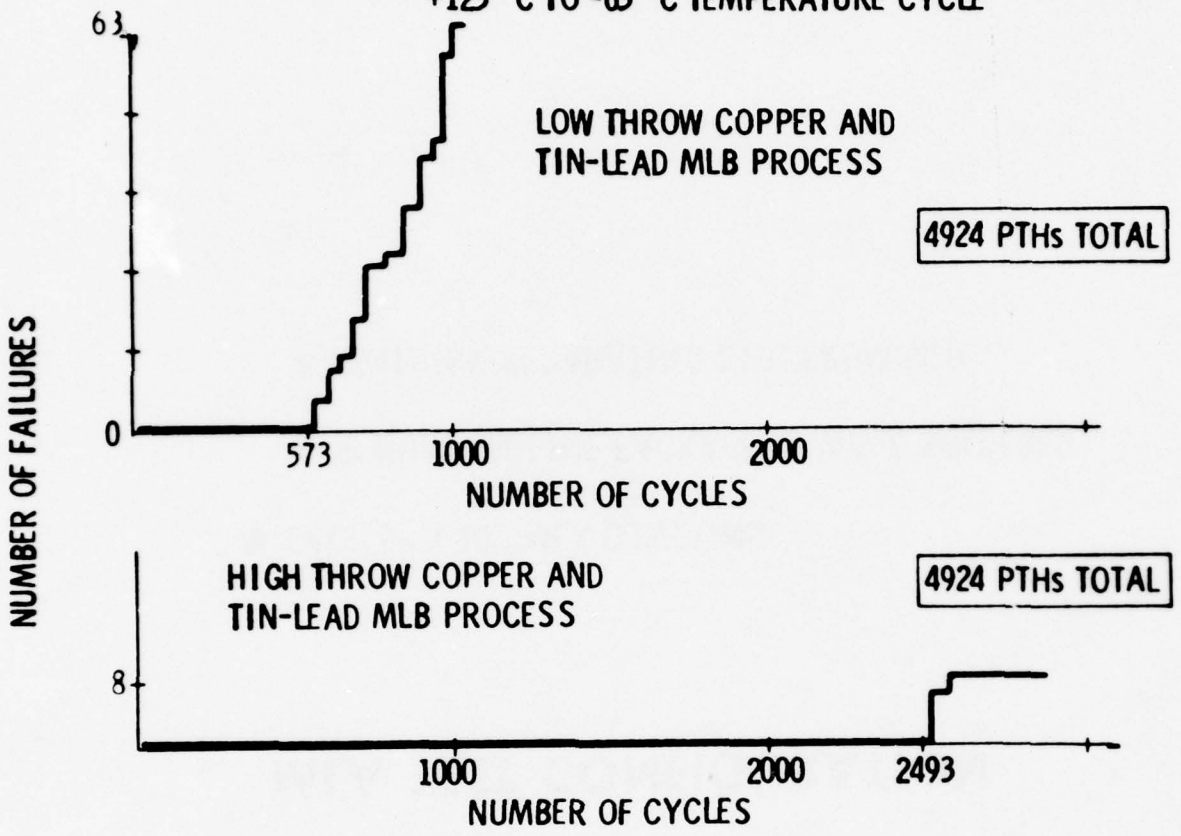
EQUIVALENT LIFE FOR
+85° C TO -45° C TEMPERATURE RANGE USING LOW CYCLE FATIGUE EXPRESSIONS

1034 ⟺ 5273 (11 YEARS)

2237 ⟺ 11408 (24 YEARS)

PLATED-THROUGH HOLE FAILURES

+125° C TO -65° C TEMPERATURE CYCLE



EQUIVALENT LIFE FOR
+85° C TO -45° C TEMPERATURE
RANGE USING COFFIN'S
LOW CYCLE FATIGUE EQUATION

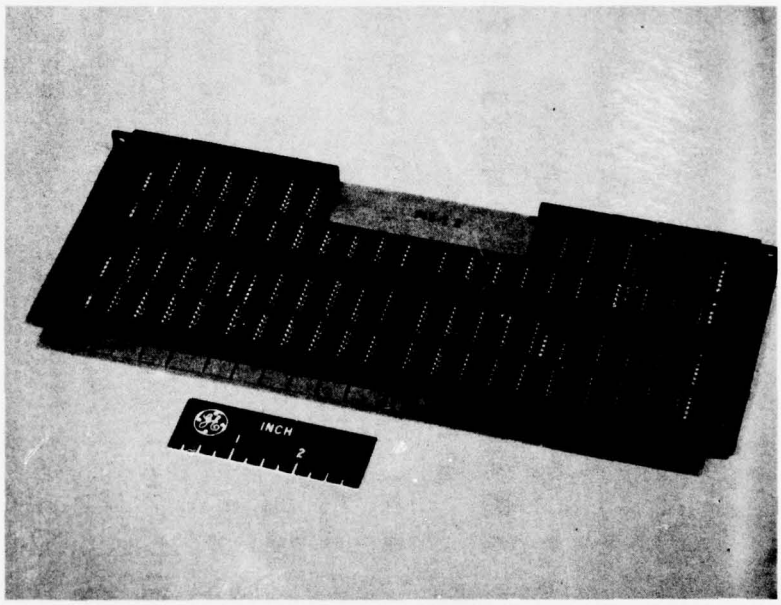
573 ⟺ 9800 (20 YEARS)

2493 ⟺ 37000 (75 YEARS)

MLA TEST CONFIGURATION

- EACH 5" x 10" MLA CONTAINS:
  - 70 DUAL-IN-LINE PACKAGES - WAVE SOLDERED
  - HEATSINK SEPARATING DIPs FROM MLB

DUAL IN-LINE PACKAGE/
WAVE SOLDER ASSEMBLY



MLB FEATURES

- TYPICAL 1973 DESIGN
  - 12 LAYER GLASS EPOXY BOARDS
  - 1 oz COPPER INNER LAYERS
  - 29 MIL DIA DRILLED HOLES (2.2 MLB ASPECT RATIO)
  - >1.5 MIL AVG MIN PTH COPPER THICKNESS
  - UNFILLED HOLES
  - 10 - MIL WIDE RUN ON 20 - MIL GRID
  - COVER PATTERN (1231 PTHs)
- STANDARD MANUFACTURING PROCESSES UTILIZED
- CIRCUITRY FACILITATED SEPARATION OF FAILURE MODES AND MINIMIZED NUMBER OF TEST CIRCUITS

DUAL-IN-LINE PACKAGE/WAVE SOLDER
MLA TEST RESULTS
(HIGH THROW COPPER AND TIN-LEAD MLB PROCESS)

	+125°C TO -65°C TEMPERATURE RANGE	
	ALL 1 oz. COPPER INNER LAYERS	2 oz. COPPER ON 2ND AND 11TH LAYERS REMAINING 1 oz.
NO. OF MLBs	6	6
NO. TEMP CYCLES	617	617
PTH FAILURES	0	0
SOLDER JOINT FAILURES	0	0
NO. TEMP CYCLES TO 1ST FAILURE	?	?

1120 LEAD SOLDERED PTHs PER MLB
110 SOLDER FILLED PTHs PER MLB

RANDOM VIBRATION RESULTS

INPUT: $W_0 = 2.0\ g^2/Hz$; 100 - 1000 Hz

$\ddot{X} = 54$ g rms

DURATION: 1 HOUR

RESPONSE: $f_n = 200$ Hz; $Q = 20$

$\ddot{Y} = 225$ g rms; $Y = 0.4$ inch rms

TEST RESULTS:

NO FATIGUE FAILURES

TEST PROGRAM CONCLUSIONS

- MLAs MADE WITH EITHER LOW THROW OR HIGH THROW COPPER/SOLDER ARE RELIABLE FOR AVIONICS/SPACE SERVICE ENVIRONMENTS
- MLAs MADE WITH HIGH THROW COPPER/SOLDER HAVE LONGER LIVES THAN THOSE MADE WITH LOW THROW
- BOTH FLATPACK (PLANAR ATTACH) AND DUAL-INLINE-PACKAGE (WAVE SOLDERED) MLA DESIGNS ARE RELIABLE FOR AVIONICS/SPACE SERVICE ENVIRONMENTS
- TEMPERATURE RANGE OF -65° C TO +125° C IS A VALID ACCELERATED TEST RANGE (i.e., SAME FAILURE MECHANISM)

APPENDIX U

TRENDS AND NEEDS

L. Katzin
The Aerospace Corporation

March 24, 1977, Session Four
1st Speaker: L. Katzin

TRENDS AND NEEDS

The conference, so far, has expressed the point of view of you, the contractors and subcontractors, your internal experiences with rework and repair, and also your experiences as related to SAMSO and to The Aerospace Corporation.

We at SAMSO and at The Aerospace Corporation are on the other side of the coin looking at you. We are constantly reviewing your documents and your hardware. We attend meetings at your facilities and catch "red-eye" flights to show up on short notice at your plants to help resolve problems. We listen very attentively to your technical discussions and to your rationales, and we present our own comments. Out of these many meetings, a group of typical and repeating answers have evolved, and just so you know that we listen, let me present to you my one and only slide of this presentation:

TYPICAL CONTRACTOR RESPONSES

"We're working on it."
"It's not in the contract."
"It conforms to our interpretation of the spec."
"Changing the dash number will cause a 6-month slip in schedule."
"This is the way we have always done it."
"Those failures were random mavericks."
"It will never see a qual environment in flight."
"We don't make it that way any more."
"That's why we have redundancy."
"We have <u>never</u> had a failure."

In a more serious vein, the things that I would like to discuss with you today are not so much on how to go about repairing or reworking an electronic assembly but rather some of the trends that I see in the advancing technology. This includes improvements that are already partly upon us, some of the things that we are overlooking, and the kinds of things that: "Wouldn't it be nice if...." Let me give you an example: The products we have been discussing, printed circuit board assemblies for spacecraft application, while functioning in their intended environment, will probably never see temperatures in excess of 150°F; yet, in producing these assemblies we subject them to a 750°F soldering iron tip, and because of this high temperature exposure we must test our unassembled boards at temperatures that have no relationship to the space environment that the assembled boards are going to encounter. All we are trying to do is provide mechanical and electrical integrity to our resistors, capacitors, transistors, etc. We have gotten ourselves into the habit of using solder joints, which require very high temperature, which in turn degrades our printed circuit boards; and we then spend our time, energy, facilities and money trying to find ways of correcting the problems that we have created rather than using these resources to evolve better joining techniques that do not require high temperature. The real problem is reliable low temperature joint technology. Such a joint can be made either with a lower melting point alloy or with a very short cycle high temperature, both of which are possible today with a little additional development work.

The printed circuit boards that we use today are primarily epoxy glass, and some of the earlier speakers addressed the polyimide-glass board material, which is an improvement. With either of these materials, a major problem is its nonhomogeneous composition. Because of woven glass fibers in the laminate, every hole that we drill will remove a different amount of glass fiber, leave different lengths of glass fibers protruding from the walls of each hole and we end up with thousands of drilled holes in a group of "identical" boards that are produced on a "batch" system; and yet, every hole is different. The different amounts of glass at every hole will dull the drill a bit more and at an inconsistent rate so that even the hole diameters will be different.

Can't we find a homogeneous material on which to build our printed circuits and multilayer boards? A homogeneous material is not vulnerable to delamination, and with homogeneity it would also be free of microcapillary paths that can trap electrolites and active neutralizers used in the processing.

If we didn't require the high temperatures for component attachment, we could consider using low temperature thermoplastics for our printed circuit boards.

An application for a homogeneous carrier that we are now using is in flexible printed circuits, or flex as it is called. In this application no fiberglass weave is used, and we deal only with the mylar or Kapton carrier, the adhesive layer and the electrolytic copper sheet. With flex, we have different problems: One is that we use it as a hinge, a use for which it was never intended. We have not devised a way to evenly distribute the flexture stresses over the length of the flex, and as a result we end up with sharp bends (hairpin bends) that can cause cracks in the conductors. One way to avoid this is not to use the flex as a mechanical hinge. Add a mechanical hinge to the product and let this hinge carry all the mechanical stressing. This hinge will also void a second problem, that of using the flex as a handle or a tow rope. By having the two members that are electrically interconnected with the flex also held together by a mechanical hinge, all the pulling and tugging will be on the hinge and not on the flex.

A "new" type of printed circuit that has not yet been discussed at this meeting is the metal core board. The metal core board is not really a new technology. It has been around for a long time, but has not as yet been accepted by the aerospace industry. Although the metal core board is no panacea, it does have some definite advantages for certain applications. This type of board is made with an aluminum core rather than the conventional epoxy glass. Because of its "different" construction it offers the following advantages:

1. Superior thermal conductivity
2. May be used as structure
3. Can have the aluminum core extended beyond the circuitry and then bent to form a chassis, a tray, a closure or a bracket.
4. The "Z" axis expansion problem disappears because of matched coefficients.
5. Provides a heavy ground plane

There is a reluctance to go to metal core boards partly because of inertia, and partly because the printed circuit industry has created an empire for their raw material suppliers. The suppliers derive financial benefits from the conventional laminates and they, like us, are reluctant to seek out or even accept changes. We've been designing and building hardware in a certain way; we have embellished our narrow spectrum specialties to a point that change can constitute a threat to our own position of recognized expertise. We are reluctant to try something new even on a parallel basis, a prototype basis, or on a developmental basis. We should remember that tomorrow's technology can be no more than what we develop and cultivate today.

I spoke of solder and soldering a bit earlier, but let me return to that subject for just a few moments. If you remember yesterday, someone was discussing syntactic foam. Syntactic foam, as you know, is a thermosetting binder that is heavily loaded with hollow microspheres (usually glass). These spheres, in bulk, look like flour, and if you were to sneeze they would be blown away in a cloud. The purpose of this foam is to allow for stress relaxation especially during thermal expansion. As the embedded parts expand, they push against the glass microspheres and crush them thus relieving the pressures.

Would it be possible to take these microspheres, etch them to roughen the surface, electroless copper plate them, and then put them (approximately 80% by weight) into a solder binder? This would give us, by definition, a syntactic solder. This solder would not develop stress cracks, because any stresses would be taken up by the cracked glass spheres. It might be worth looking into.

While on the subject of foams, lets take a look at the wonderful advantages that foam has to offer us:

1. Provides mechanical protection
2. Provides the equivalent of low weight structure
3. Gives thermal stability
4. Makes the structure almost immune from shock and vibration

When we come to repair and rework of foamed assemblies we are almost in a hammer and chisel act. We try to sandblast the stuff off, pick it off, cut it off and we come to the conclusion that it probably wasn't really intended to be reworked. However, if we were to take our assembled printed circuit board, put our conformal coating on it, perhaps a little leavier than is usual now, place an RTV membrane over the cured assembly and pull a mild vacuum on it, the vacuum will pull the thin elastomeric membrane down over all the parts on the board. Pour the foam over the membrane the same way you do it now. Allow it to blow and harden. The RTV will not stick to the board or the components on it but (perhaps with a primer) it will stick to the foam. This foam-RTV encapsulation can be snapped off the board with no damage to the encapsulated or the encapsulant. It can be reused as long as part size and placement are not changed. You can even do total encapsulation (top and bottom) by placing a nylon thread around the periphery of the board and having one end extend out. You can now open the package by pulling the string all the way around much like opening a pack of cigarettes. This vacuum technique does work. I did it many years ago with beautiful success. You might want to try it.

Multilayer boards have probably been misused more than they have been properly used. Would you believe that as many as 75% of multilayer applications could have been satisfied with two-sided boards? What would you do if multilayer boards did not exist or if they were outlawed for space programs? Simplifying is always more difficult, but simplicity is usually synonymous with reliability. The use of multilayer boards should be the last design consideration, the last resort. It should be the approach that you don't consider until you've really been convinced that there's no other way to go.

Let me tell you right now that I know that there are cases where the multilayer board is the best way to go; however, I should also tell you that I have never seen a need for a 25-layer board (or even an 18-layer board). We have enough problems in producing simple two-sided, plated through hole board. When you examine the material and process complexity of such boards with the wet side of the process, the dry side of the process, the rigorous testing and the small quantities involved in our applications you know that even the simple two-sided board is not simple. Just remember yesterday's papers on the reworks and repairs to "simple" two-sided boards. We spent an entire day talking about repair problems. They must be real.

It really goes without saying that if a two-sided board is complex, then a multilayer board must be even more so, and it is. Some things that should be done when it appears that you may require a multilayer board are:

1. Keep the number of layers to a minimum. If you use computer aided design (CAD) be careful. CAD designs usually have 25 to 40% more layers than are needed. This is because the computer makes the designer lazy and when the machine reaches a crossover, it may simply say "add a layer", and the designer will buy it. It is the easy way out.

2. Don't be satisfied with the first design. A second and a third cut will almost always reduce the number of layers.

3. If you can, use bus bars. Bus bars have been around for a long time, even before printed circuits, and today we can get them as neat laminated assemblies that can carry the ground and the voltage and at the same time provide the filtering capacitance between them. By running the bus down the middle of the board, perpendicular to the board, it provides good stiffening and may raise the natural frequency of the board into a low amplitude, non-damaging zone. The bus bar will save you layers, cost, and design time.

4. Don't take the attitude that once you have concluded that a two-sided board won't cut it, you can use as many layers as you want to, because you are now in the multilayer mode. Not true. Every layer adds complexity and reduces reliability.

You know, at one time we thought that with the advent of IC's, MSI's, LSI's our systems would become smaller and our printed circuit boards less complex. This, of course, didn't happen. What did happen is that our system complexity grew at the same rate as our device complexity and we now have larger system functions on a given board than we ever dreamed possible. This has produced a new problem. The number of input-output (IO) leads has increased for many applications. To help relieve the situation, the Zero Insertion Force (ZIF) connector has come into being. When you have a couple of hundred pins on a connector, it could take two men and a boy to engage and disengage it. To date, ZIF connectors require a lever, a wrench, or a screwdriver to remove the contact pressure for zero force insertion and withdrawal. The need for better ZIF connectors is going to become more and more important to us in the future. The use of conventional connectors is going to become more restricted. We won't have the space and we won't have the force. Think about it. This is a problem that we are going to have to face very soon.

Two techniques that have started to make inroads in the aerospace hardware are wire wrap (or solderless wrap) and stitch welding. The wire wrap, although space consuming, does provide the ability to incorporate changes both easily and reliably. This is important to the aerospace designs that are produced in such small quantities that they never fully emerge from the status of prototype. Stitch welding has similar advantage but with less volume utilization and with less change flexibility. A better technique is needed for spacecraft interconnection that will provide a maximum change flexibility in a minimum of space. These attributes are especially needed for board-to-board interconnection. It is not difficult to visualize the complexity of rerouting, adding, and/or deleting a couple of dozen wires from a 12-layer mother board. We need a better way, and wire wrap and stich welding are only partial answers, although both are gaining in popularity and both have been flown.

The point that I want to make is one that I have made earlier but it is important enough to repeat. Make all of your designs as simple as possible. Any fool can design a complicated machine. It doesn't require genius to design something that is complicated. Where genius really shows up is in simplicity. It's not always appreciated. People will look at it and say: "What's so great about this? There's nothing to it." But it's the "nothing to it" that makes it great, and that in itself is the reward of a good engineer.