WORKMANSHIP STANDARDS MANUAL

WATKINS-JOHNSON

WATKINS-JOHNSON COMPANY

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GAITHERSBURG, MARYLAND 20760

WORKMANSHIP STANDARDS MANUAL

(DOCUMENT NO. WJC-1-4)

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INTRODUCTION

This manual contains workmanship standards and basic manufacturing practices of the CEI Division of Watkins-Johnson Company.

It is the intent of this manual to define acceptable workmanship practices required to assure reliability and mechanical integrity in equipment and systems manufactured by the CEI Division.

The complexity of todays electronic devices and the many problems involved in their design and manufacture presents the problem of foreseeing some of the difficulties to be encountered. No attempt has been made in this manual to make reference to or cover the many hundreds of variables that may happen in the design and manufacturing processes. Instead the manual covers those areas of workmanship that are most commonly violated and are of a critical nature. It is expected that common sense will be employed in the straight forward areas of design and manufacture so the end result will be a satisfactorily constructed device meeting the specifications that govern its intended use.

When workmanship standards are furnished by the customer, or a contract or purchase order calls out a specific specification not covered in this manual, it will supersede all portions of this manual that are in conflict.

The procedures outlined in this manual will be revised as deemed necessary to keep pace with changes in design and manufacturing principles. Revisions which occur will be implemented and incorporated in the manual as rapidly as possible.

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MANUAL REVISION RECORD

Fabrication, Assembly and Soldering of Printed Circuit Boards

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22	6/25/73	3/6/78	WJ	3/13/78
23	6/25/73	2/24/76	DCS	2/24/76
24	6/25/73	6/25/73	DCS	6/25/73
25	6/25/73	6/25/73	DCS	6/25/73
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WORKMANSHIP STANDARDS

ISSUE DATE 3/6/78 REVISION NO. A

ORIGINATED BY [signature] AND [signature]

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TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

1. PURPOSE

1.1 The standards set forth establish acceptance criteria to assist in the manufacturing and inspection of printed circuit boards.

2. APPLICABLE DOCUMENTS

2.1 The documents listed below were utilized in the preparation of this standard. In the event of conflict between this standard and a reference document, the provisions of this standard shall take precedence.

Specifications

Federal

QQ-N-290	Nickel Plating, Electrodeposited
QQ-S-571	Solder, Tin Alloy, Lead-Tin Alloy, and Lead Alloy

Military

MIL-F-14256	Flux, Soldering, Liquid
MIL-G-45204	Gold Plating, Electrodeposited
MIL-I-46058	Insulating Compound, Electrical
MIL-P-13949	Plastic Sheet, Base Material GE, Glass Base, Epoxy Resin, General Purpose, Copper Clad
MIL-P-27538	Plastic Sheet, Fep-Flurocarbon, Copper Clad
MIL-P28809	Printed Wiring Assemblies
MIL-P-46843	Printed Circuit Assemblies, Design and Production of
MIL-P-55110	Printed Wiring Boards
MIL-S-46844	Solder Bath Soldering of Printed Wiring Assemblies, Automatic Machine Type
MIL-STD-130	Identification Marking of US Military Property
MIL-STD-275	Printed Wiring for Electronic Equipment
MIL-STD-429	Printed-Wiring and Printed-Circuits Terms and Definitions
MIL-STD-454	Standard General Requirements for Electronic Equipment

3. FABRICATION

3.1 Material

3.1.1 Printed circuit board material shall consist of glass base laminates with specified resins.

3.1.2 Types of resins, depending on electrical specifications shall be epoxy, teflon, or as specified by engineering drawing.

3.1.3 Grades of clad will be one ounce or two ounce with one or two sides as required.

3.1.4 Thickness of boards shall be .062 inch for standard production requirements. Any deviations shall be specified by applicable engineering drawings.

3.2 Approved Special Process Procedures (Applicable to PC boards)

3.2.1 Printed Circuit Board Fabrication - (Special Process Procedure WJP-1008.)

3.2.2 Tin-Lead Plating of Printed Circuit Boards - (Special Process Procedure WJP-1007.)

3.2.3 P. C. Board Through-Hole Plating (Special Process Procedure WJP-1013)

3.2.4 P. C. Board Gold Tab Plating (Special Process Procedure WJP-1014)

3.2.5 Wave Soldering - (Special Process Procedure WJP-1006.)

3.2.6 Printed Circuit Conformal Coating - (Special Process Procedure WJP-1011.)

3.2.7 Infrared Reflow (Special Process Procedure WJP-1016)

3.2.8 Identification and Marking

Where required, boards will be marked per MIL-STD-130.

Identification will be clear and legible to the unaided eye and located to identify the component.

Designations shall be visible after installation of components.

3.3. Quality Characteristics

3.3.1 Deformitives of the printed circuit board shall be inspected to determine the acceptability or rejectability of the board based on outlined criteria.

3.3.1.1 Warpage

Maximum limits shall be .010 inch per lineal inch or length for single clad and .005 inch for double clad. (Figure 1)

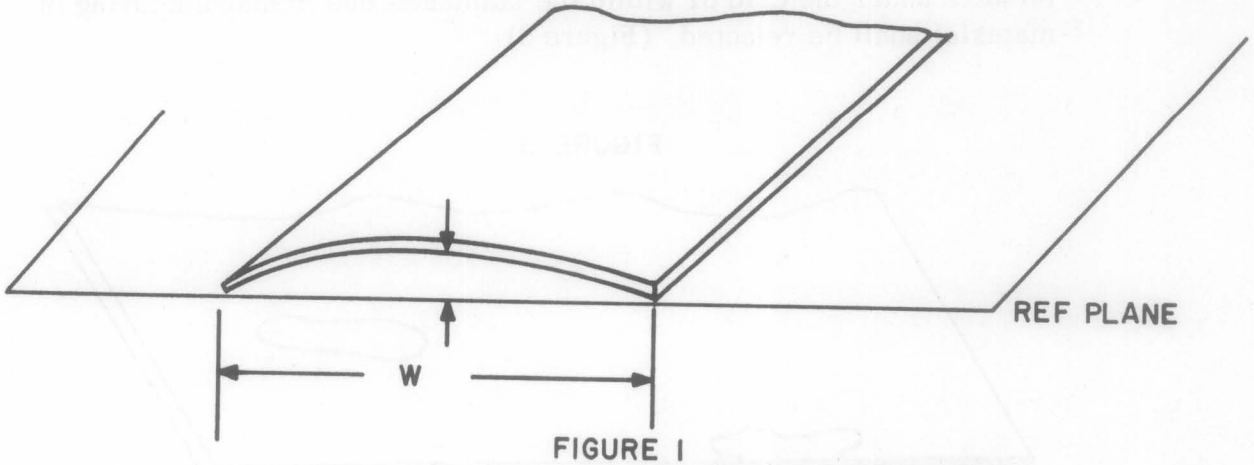


FIGURE 1

3.3.1.2 Twist

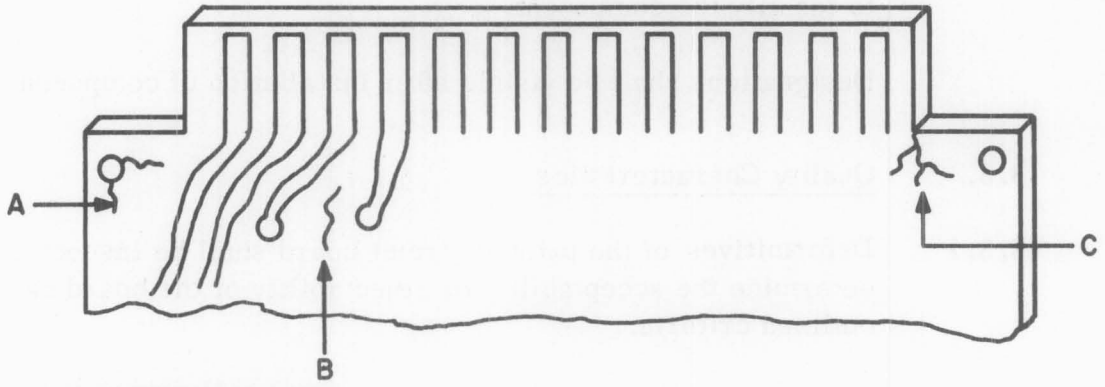
Maximum limits shall be .001 inch per lineal inch of length for single clad and .005 inch for double clad measured from adjacent corners to diagonally opposed corners.

3.3.2 Physical damage resulting from fabrication or handling will be examined for the following defects:

3.3.2.1 Cracks -

Cracks in any portion of the board will be cause for rejection. (Figure 2)

FIGURE 2

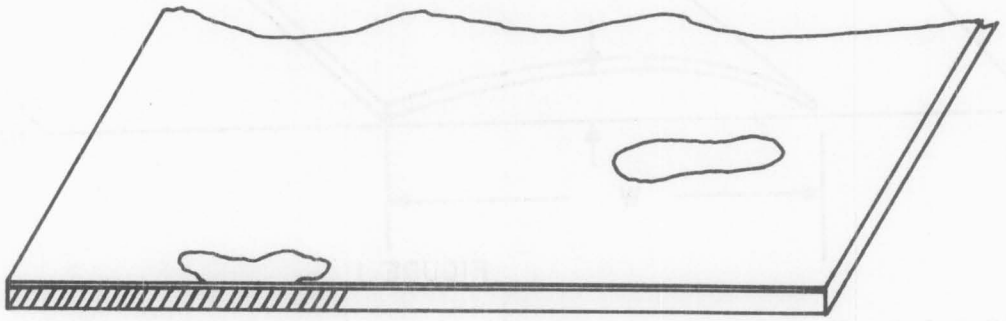


A. CRACKS AROUND HOLES
B. CRACKS BETWEEN CONDUCTORS
C. CRACKS AT NON-RADIUS CORNER

3.3.2.2 Blisters -

Blisters under the clad or within the laminates due to manufacturing of material shall be rejected. (Figure 3)

FIGURE 3



3.3.2.3 Delamination - (Figure 4)

Delamination indicated by discoloration and resulting from any fabrication phase shall not exceed the following limits.

(a) .01 inch in height per incident, or .1 total accumulations of all incidents.

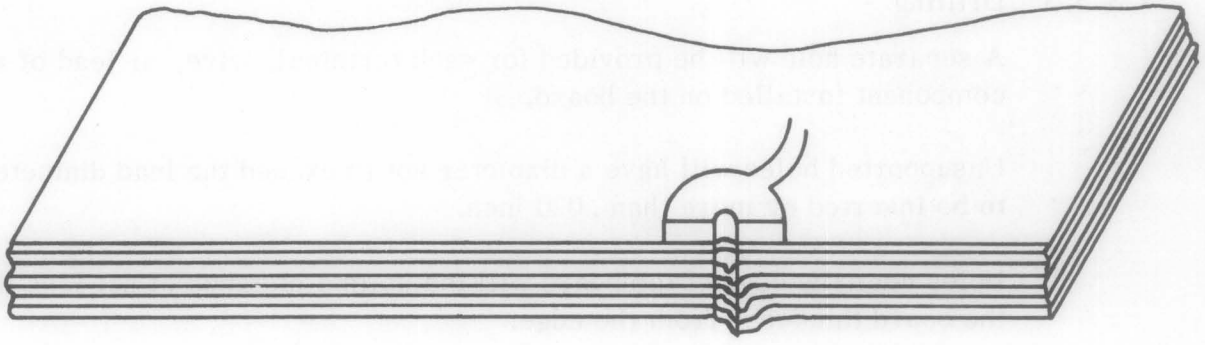
(b) .031 inch from edges of board.

(c) .250 inch in its longest dimension if not under conductor pattern.

(d) A total of 5% of the area on one side.

(e) 1/32 inch in from the edge of any hole.

FIGURE 4



3.3.3 Machining -

Machining to configure the printed circuit board to dimensions and tolerances will be done in phases.

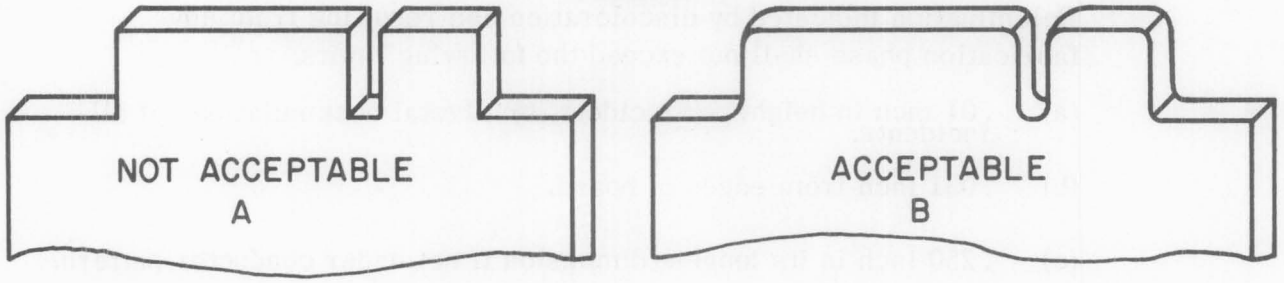
3.3.3.1 Cutting -

Cutting shall be accomplished by a shearing process with all edges finished to a clean smooth appearance by routing. Dimensions to tolerances will be specified on applicable fabrication drawings.

3.3.3.2 Notches and Cutouts -

Notches and cutouts will have the proper relief radius as required by fabrication drawings. (Figure 5)

FIGURE 5



A. CORNERS OR NOTCHES—NO RADIUS, UNACCEPTABLE
B. CORNERS INSIDE AND OUTSIDE WITH PROPER RADIUS

3.3.3.3 Drilling -

A separate hole will be provided for each terminal, wire, or lead of a component installed on the board.

Unsupported holes will have a diameter not to exceed the lead diameter to be inserted by more than .020 inch.

Holes near the edge of the board will maintain a distance of not less than the board thickness from the edge.

After plating of plated thru holes, the inside diameter will be no more than .035 inch larger than the diameter of the lead to be inserted. Where multilead components are used, maximum inside diameter will not exceed .05 inch greater than the total lead diameter.

3.3.3.4 Tapering Board Edge -

Leading edge of gold plated edge board connectors will be tapered not to exceed 1/32 inch from the edge.

3.3.4 Printed circuit conductor requirements shall comply with MIL-STD-275 with the exception of conductor width of .020 inch, minimum.

3.3.4.1 Conductor Quality - (Figure 6)

Conductor paths will have a minimum width of .020 inch.

Spacing between conductors shall not be closer than .025 inch.

Deviations of conductor width from a medial edge to any depression or to any crest will not exceed dimensions listed in Table I. In no case shall a depression reduce the conductor by more than 25% of nominal width.

FIGURE 6

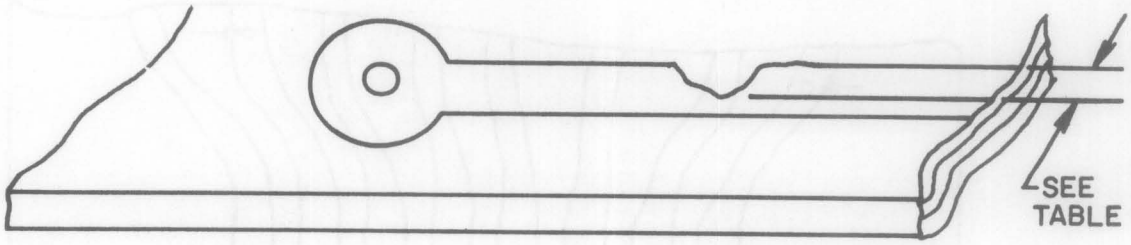


TABLE I

PERMISSIBLE MAXIMUM VARIATIONS SEE FIGURE 6	NOMINAL CONDUCTOR WIDTHS		
	.020 to .024	.025 to .099	OVER .100
	.002	.005	.020

Notches will not reduce the width of any conductor by more than 25% of nominal width, and must have a smooth radius. (Figure 7)

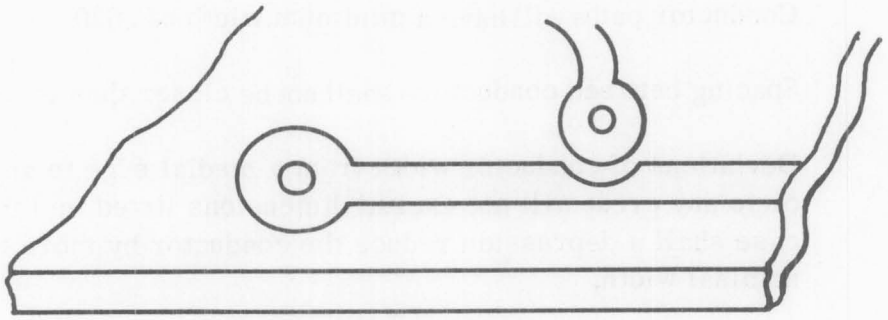
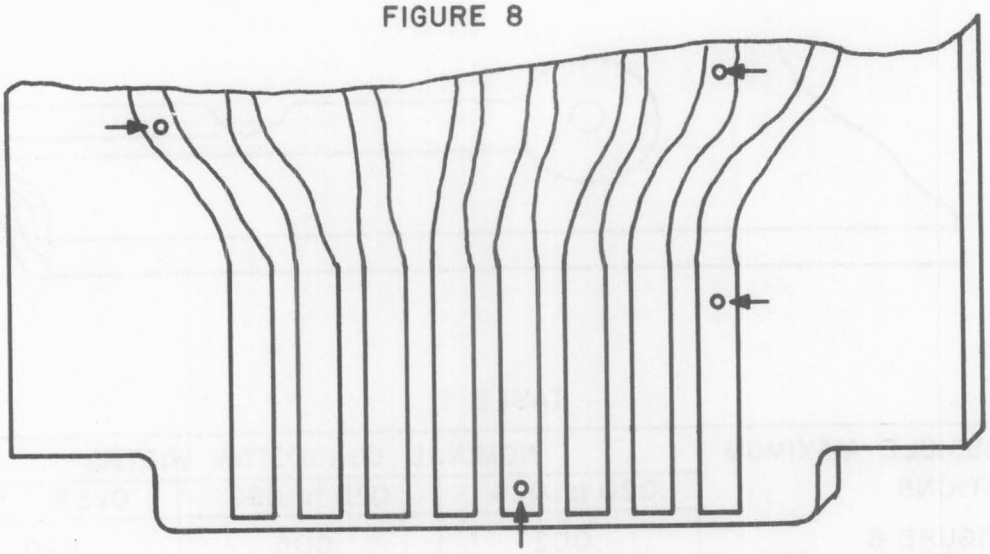


FIGURE 7

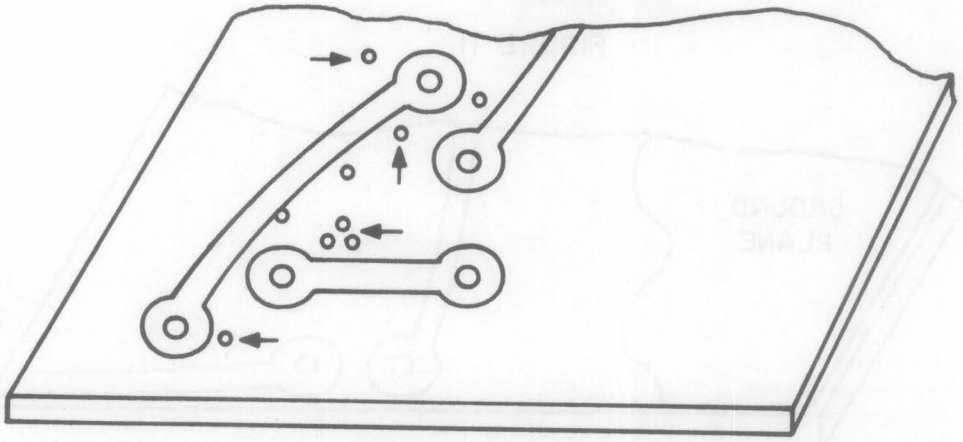
Pin holes in conductors greater than 20% of nominal width will not be accepted. In no case will pin holes reduce the effective conductor width to less than .020 inch. (Figure 8)

FIGURE 8



Copper flecks will not be accepted and must be removed. (Refer to Fig. 9)

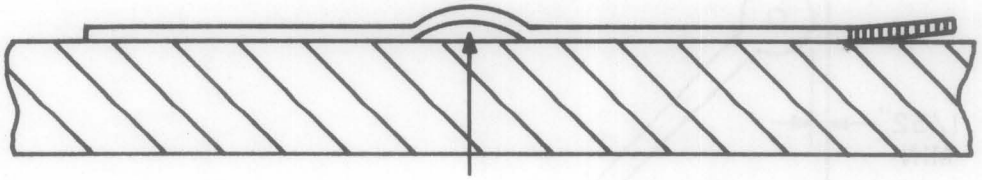
FIGURE 9



Gouges or tool marks that reduce the conductor thickness by more than 1/3 nominal are unacceptable.

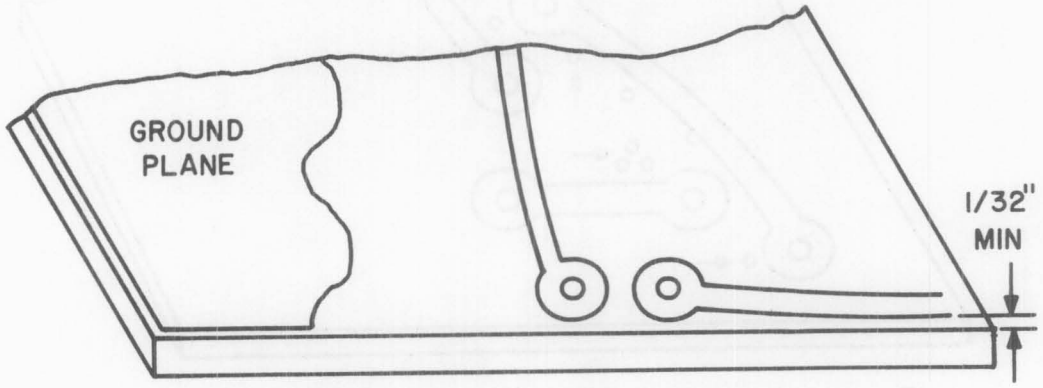
Separation of conductor bond will not be accepted. (Figure 10)

FIGURE 10



Conductor path or pattern will not be located on or closer than 1/32 inch from any edge of a board, unless such circuit path is used for ground plane. (Refer to Figure 11)

FIGURE 11



3.3.4.2 Terminal Area or Pad Requirements

Locating a pad on or closer than 1/32 inch from the edge of a board is not permitted. (Figure 12)

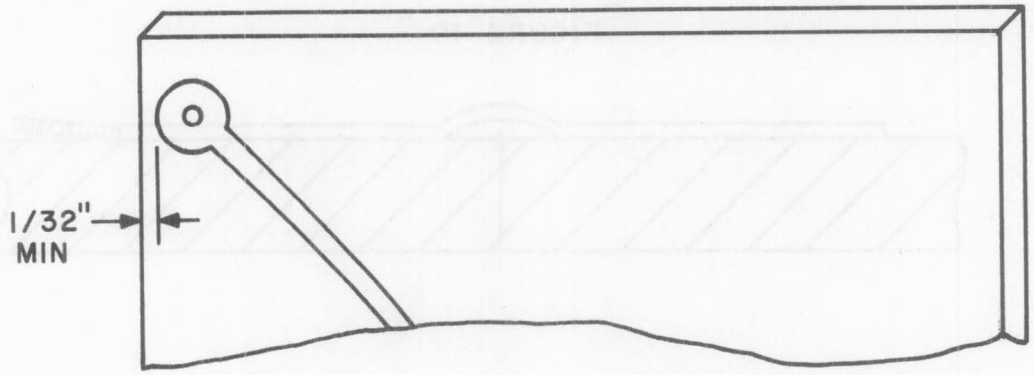


FIGURE 12

Where a terminal standoff or eyelet is used, pad diameter must extend a minimum of .010 inch from the flange of such a device. (Figure 13)

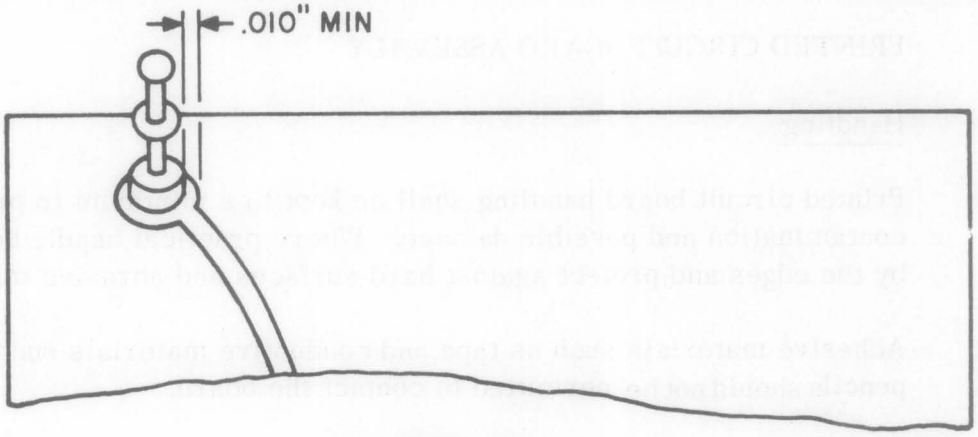


FIGURE 13

Plated thru hole pads must extend .005 inch beyond edge of hole.

Conductor pads around unsupported holes must extend a minimum of .020 inch from and around the mounting hole. (Figure 14)

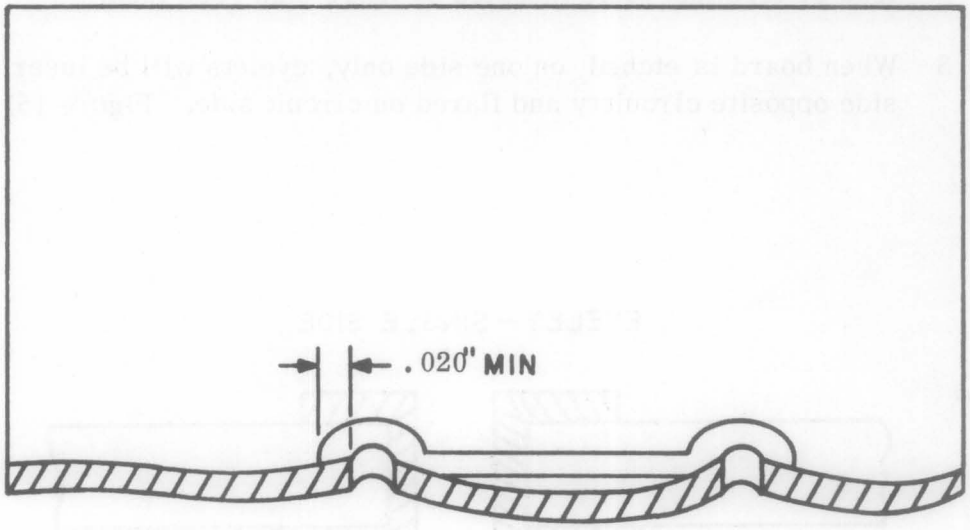


FIGURE 14

This standard may be wavered for applications of components which have lead spacing less than .060 inch as measured between LEAD EDGES.

4. PRINTED CIRCUIT BOARD ASSEMBLY

4.1 Handling

4.1.1 Printed circuit board handling shall be kept to a minimum to prevent contamination and possible damage. Where practical, handle boards by the edges and protect against hard surfaces and abrasive materials.

4.1.2 Adhesive materials such as tape and conductive materials such as lead pencils should not be permitted to contact the board.

4.2 Preparation

4.2.1 When required by contract or customer specification, eyelets will be used in conjunction with standard fabrication criteria.

4.2.1.1 Eyelet material and size will be as specified by the applicable drawing.

4.2.1.2 The inside diameter of the eyelet will not exceed the diameter of the lead or terminal to be inserted by more than .035 inch.

4.2.1.3 When board is etched on one side only, eyelets will be inserted into side opposite circuitry and flared on circuit side. Figure 15)

EYELET – SINGLE SIDE

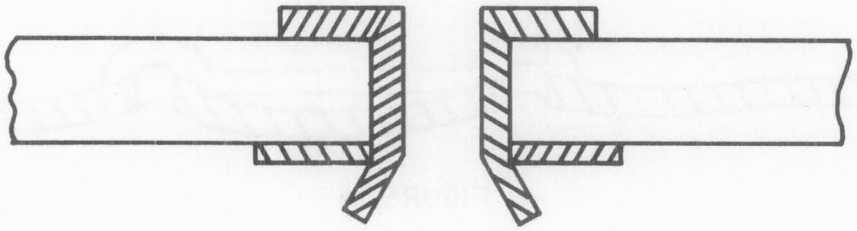


FIGURE 15

4.2.1.4 Eyelets will be mechanically snug when checked with finger pressure and will not rotate.

4.2.1.5 Cracks in eyelet head extending full length of body will not be accepted.

4.2.1.6 Eyelets after flaring will extend beyond the board a minimum of .018 inch and a maximum of .030 inch. (Figure 16)

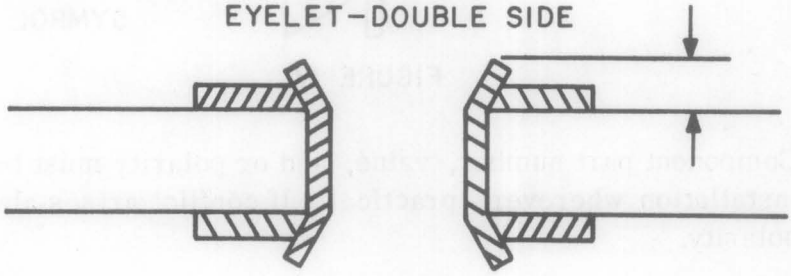


FIGURE 16

4.2.2 Component Identification and Location

4.2.2.1 Part numbers and values will be verified by reference to applicable drawings or parts lists.

4.2.2.2 Polarized components must be located as indicated on applicable drawings and symbols on the board.

Capacitors are identified by plus (+) and minus (-) designations on the component board, observe polarity.

Transistors and integrated circuits are indexed for installation by locating tabs or color dots and are oriented with corresponding symbols on the board.

Diodes make reference to a symbol showing cathode and anode. (Refer to Figure 17)

DIODES & SYMBOLS

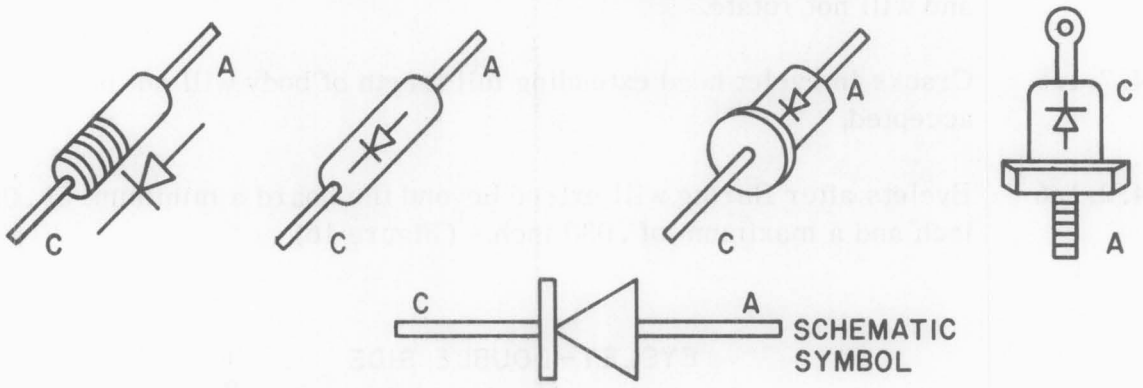


FIGURE 17

4.2.2.3 Component part number, value, and or polarity must be visible after installation wherever practical. If conflict arises always show polarity.

4.2.2.4 Where components are installed in clips or mounts, verification must be made to ensure correct part and polarity by line leader or Inspection personnel.

4.2.2.5 When component polarity does not interfere, all components will be mounted with values reading from left to right or top to bottom.

4.2.2.6 Physical Condition of Components

(a) Large chips in component body will be rejected.

(b) Burned spots on protective sleeving will be rejected.

(c) Deep identations or flats in component leads which reduce the lead diameter by more than 10% will be rejected.

(d) Broken leads on components will be rejected.

(e) Illegible component marking will be rejected.

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

4.3 Component Installation

4.3.1 Component leads will be bent and dressed as illustrated in the following diagrams.

4.3.1.1 Bend component leads by holding the leads and not the body. (Figure 18)

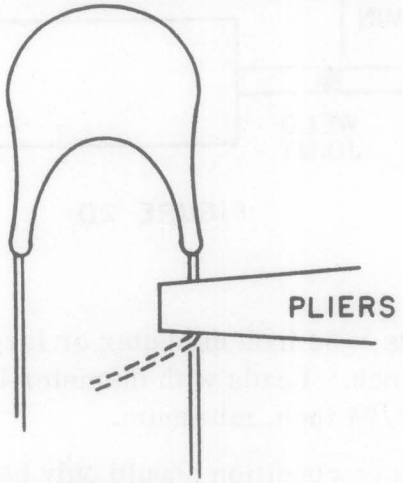


FIGURE 18

4.3.1.2 Component leads will not be bent closer than 1/16 inch from body and shall consist of a continuously smooth round bend of 90° degrees ± 2° perpendicular to the P. C. holes. (Figure 19)

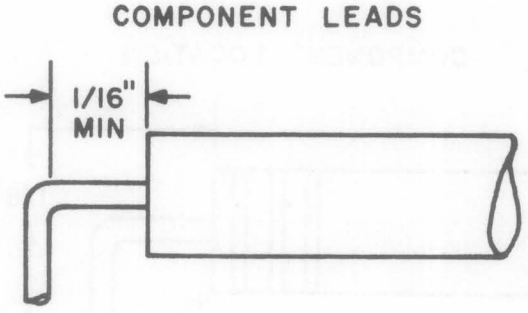


FIGURE 19

4.3.1.3 When components have welded lead extensions, leads will be bent no closer than 1/16 inch from welded junction. (Figure 20)

WELDED LEADS

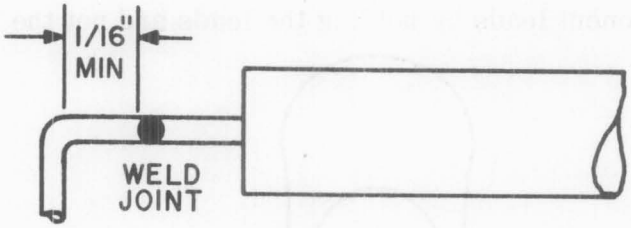


FIGURE 20

4.3.1.4 Component leads 1/32 inch diameter or larger will have a minimum bend radius of 1/32 inch. Leads with diameter less than 1/32 inch will have bend radius of 1/64 inch, minimum.

NOTE: The above condition should only be applicable to components installed on a printed circuit board. All other component lead bends shall be accomplished per Paragraph 3.2.1.1 of the Sub Chassis Assembly and Wiring.

4.3.1.5 The body of a component will not be located closer than 1/8 inch from any solder connection. (Figure 21)

COMPONENT LOCATION

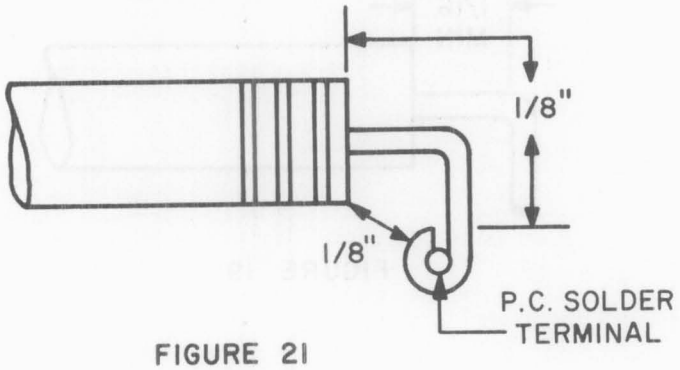


FIGURE 21

4.3.1.6 Where RF design precludes proper component location, changes will be noted by the line leader or by the inspection supervisor.

4.3.1.7 Jumper wires exceeding two (2) inches in length must be sleeved.

4.3.1.8 All components will be centered between mounting holes with equal lengths of lead extending from either end of body.

4.3.1.9 Components will be located parallel and flat against the board surface with a maximum of 1/32 inch elevation. The axial leads shall extend from the component body and remain parallel to the board up to the start of the 90° degree bend. (Figure 22)

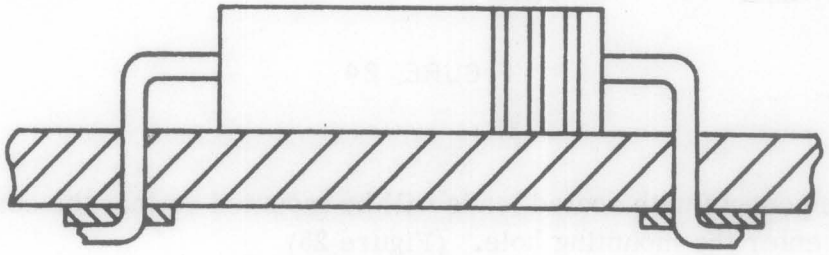


FIGURE 22

4.3.1.10 Heat generating components such as one (1) watt resistors must be elevated 1/16 inch above the board surface. (Figure 23)

Elevated components shall be supported mechanically by means of eyelets in the printed circuit board or plated-through holes.

Transistors requiring heat sinks shall be supported by means of eyelets or plated-through holes, unless otherwise mechanically secured.

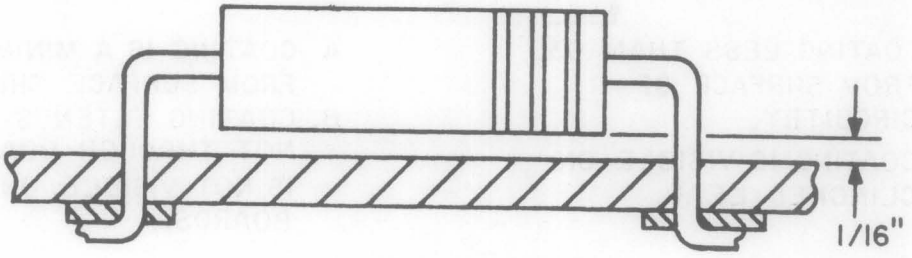


FIGURE 23

4.3.1.11 A component with a body size larger than one (1) inch in length or 1/2 inch in diameter or weighing more than 1/2 ounce must be potted or clamped to the board and cannot be retained solely by its own leads. (Figure 24) NOT REQUIRED WHEN COMPLETE BOARD ASSEMBLY IS TO BE POTTED OR ENCAPSULATED.

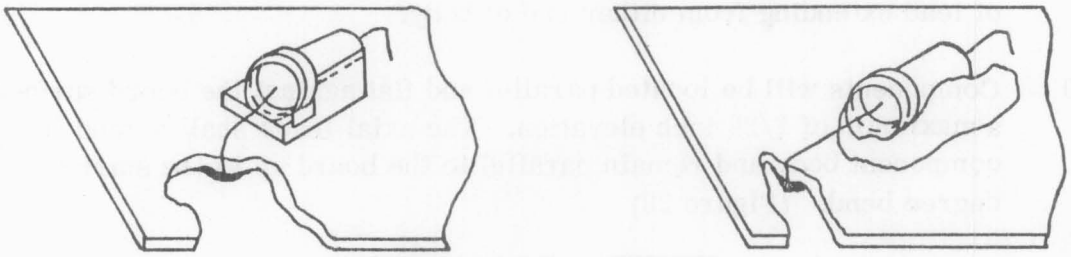
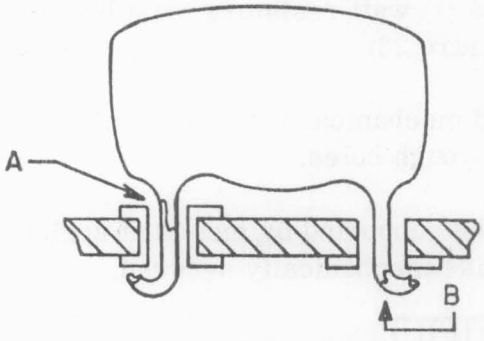


FIGURE 24

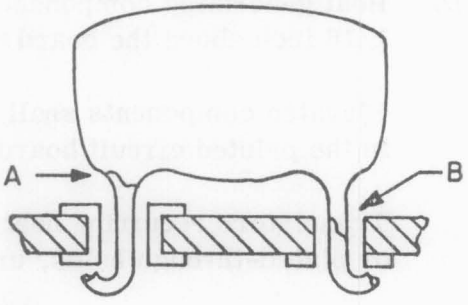
4.3.1.12 Components with coated leads will be mounted so that the coating does not enter the mounting hole. (Figure 25)

NOT ACCEPTABLE



A. COATING LESS THAN .030 FROM SURFACE OF CIRCUITRY.
B. COATING IS VISIBLE ON CLINCHED LEAD.

ACCEPTABLE



A. COATING IS A MINIMUM OF .030 FROM SURFACE CIRCUITRY.
B. COATING EXTENDS INTO BUT NOT THROUGH BOARD, AND IS NOT VISIBLE ON CLINCHED BOARDS.

FIGURE 25

4.3.1.13 Vertically mounted components shall be mounted with the body elevated 1/16 inch above the board surface. (Figure#26A) VERTICAL MOUNTING IS NOT PERMISSIBLE WITHOUT PRIOR APPROVAL OF THE WJ QA ENGINEERING DEPARTMENT.

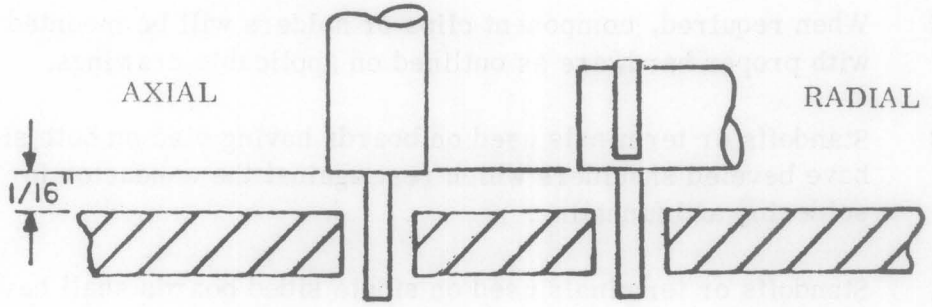


FIGURE 26A.

4.3.1.14 Components with Radial leads shall be mounted with the body elevated 1/16 inch above the board surface. (Refer to Figure #26A)

Leads of a Radial lead component shall remain parallel and shall not be bent laterally to make the leads align with the mounting holes. (Figure #26B)

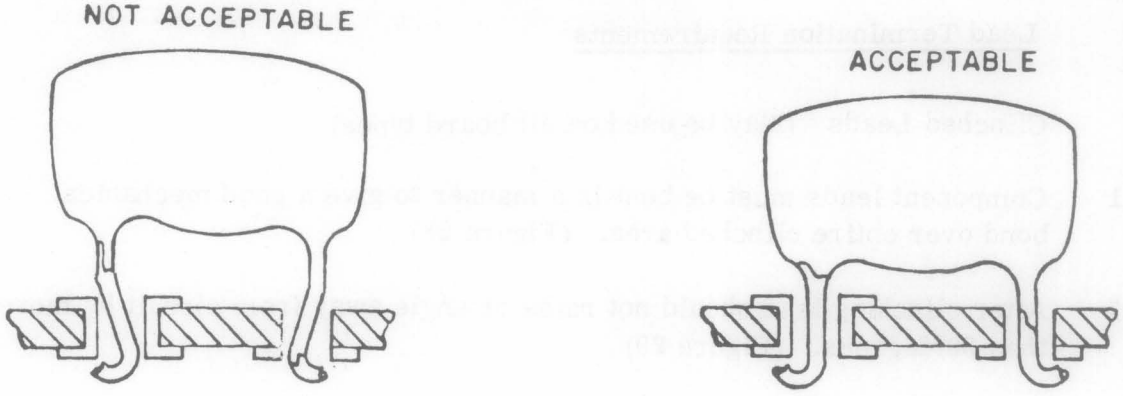


FIGURE 26B.

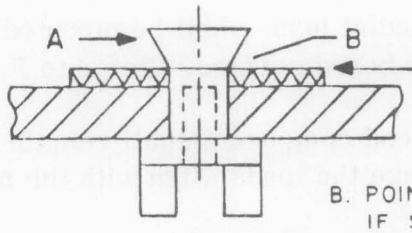
4.3.2 Mechanical Mounting of Hardware

4.3.2.1 All mechanical hardware, especially locking devices mounted on printed circuit boards will have a protective flat washer inserted against the board surface or circuitry.

4.3.2.2 When required, component clips or holders will be mounted on the board with proper hardware as outlined on applicable drawings.

4.3.2.3 Standoffs or terminals used on boards having clad on both sides shall have beveled shoulders which rest against the conductor for proper soldering and funneling.

4.3.2.4 Standoffs or terminals used on single sided boards shall have a beveled shoulder on the conductor side and a straight or flat shoulder on the board side. (Figure 27)



A. V, OR FUNNEL TYPE SWAGE.

B. POINT TO APPLY SOLDER IF SOLDER RING IS NOT USED.

FIGURE 27

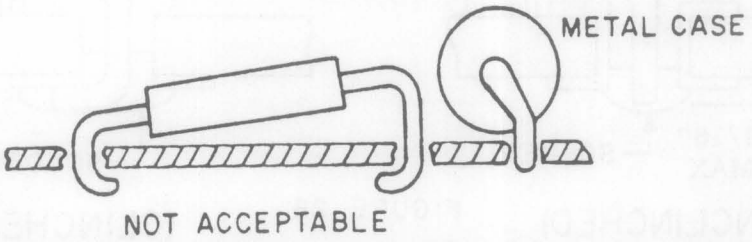
4.4 Lead Termination Requirements

4.4.1 Clinched Leads (May be used on all board types)

4.4.1.1 Component leads must be bent in a manner to give a good mechanical bond over entire clinched area. (Figure 28)

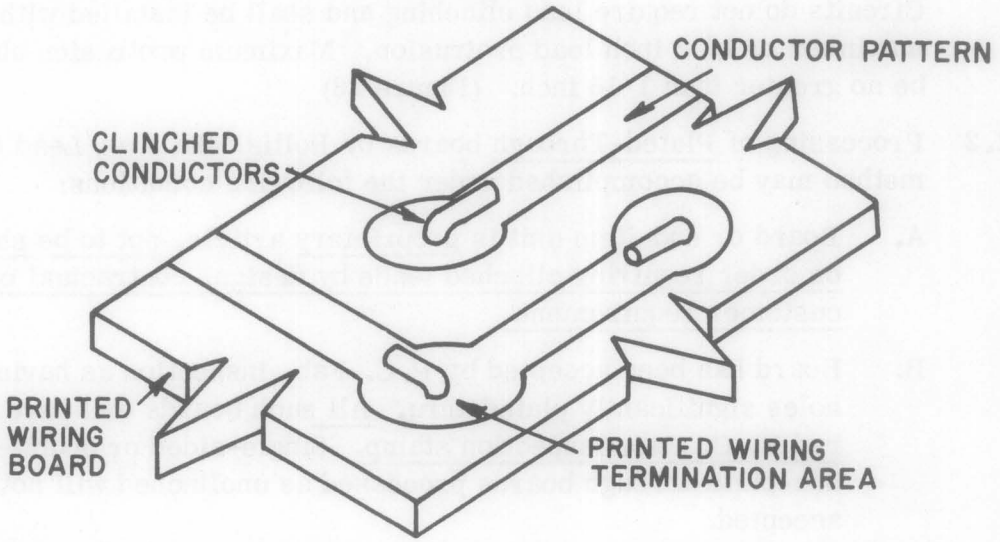
4.4.1.2 After clinching lead should not raise or angle away from circuit by more than 30 degrees. (Figure 29)

FIGURE 29



4.4.1.3 Leads will always be clinched in the direction of the circuit path. (Fig. 30)

FIGURE 30



4.4.1.4 After clinching, the lead length shall be the radius of the circuit pad minimum, and $1\frac{1}{2}$ times the radius maximum. (Figure 31)

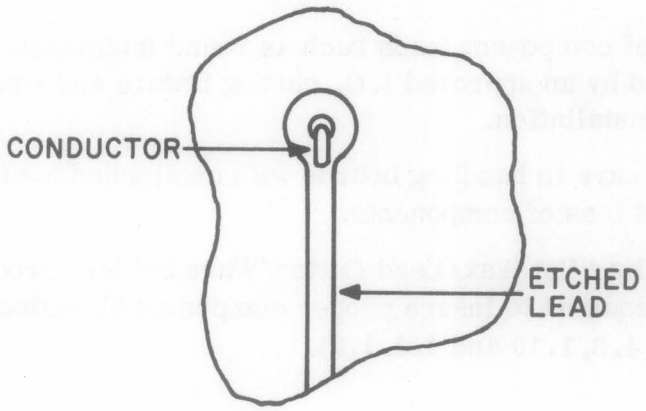


FIGURE 31

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

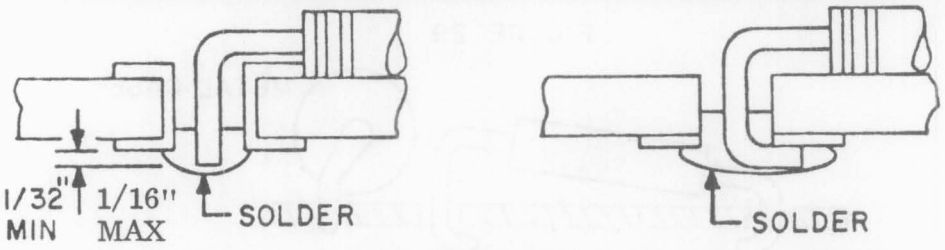


FIGURE 28

4.4.2 Unclinched Leads

4.4.2.1 Some components such as Crystals, Crystal Filters and Integrated Circuits do not require lead clinching and shall be installed with a maximum of 1/32 inch lead protrusion. Maximum protrusion shall be no greater than 1/16 inch. (Figure 28)

4.4.2.2 Processing of Plated-Through boards by Hollis "Hot Wax/Lead Cutter" method may be accomplished under the following conditions:

A. Board or end-item unit is proprietary article, not to be shipped on order requiring clinched leads by design, contractual or customer requirement.

B. Board has been accepted by P.C. Fab. Inspection as having all holes significantly plated-thru. All such boards will have a red P. C. Fab. Inspection stamp. Single-sided or double-sided non-plate-through boards processed as unclinched will not be accepted.

4.4.2.3 Clipping of component leads after soldering is not recommended, and shall require reflow of the solder connection to cover any exposed copper.

4.4.2.4 Clipping of component leads such as round Integrated Circuits shall be performed by an approved I. C. cutting fixture and shall be performed prior to installation.

4.4.2.5 Exercise care in handling boards with unclinched leads before soldering to prevent loss of components.

4.4.2.6 After Hollis "Hot Wax/Lead Cutter/Wave Solder" processing, rework may be required to insure proper component elevation. (Ref. Para. 4.3.1.9, 4.3.1.10 and 4.4.1.2)

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

5. SOLDERING OF PRINTED CIRCUIT BOARDS

5.1 Methods and Requirements

5.1.1 Wave soldering of printed circuit boards shall be accomplished per "Special Process Procedure" WJP-1006.

5.1.1.1 Each solder joint shall have a bright metallic appearance with good adherence. Solder shall cover the complete circuit paths, component lead, and the actual terminal pad area. The contour of the wire or component lead shall be visible after soldering.

5.1.1.2 There shall be no surface pitting in either the soldered circuit paths or actual soldered terminal pad areas.

5.1.1.3 There shall be no sharp solder projections. (points or icicles) protruding from either the soldered circuit paths or actual soldered terminal pad areas.

5.1.1.4 There shall be no pin holes (voids) in the solder in excess of 1/64 inch in diameter in either the soldered circuit paths or actual soldered terminal pad areas.

5.1.1.5 There shall be no signs of dewetting (waves or bubbles) in the soldered circuit paths. Dewetting is the result of improperly cleaned circuit paths or contaminated flux.

5.1.1.6 The actual board material shall show no signs of blistering, measling (heat spots), delamination, or lifted or damaged conductor foil after soldering or touch-up.

5.1.1.7 All flux residues shall be removed from the top and bottom sides of the board using solvents which will not affect the marking of components, reference designators, or damage the physical properties of the board material in any way.

5.1.1.8 No warpage of the finished PC boards is acceptable in excess of .010 inch per lineal inch measured at any point on the board.

5.1.2 Rework of Finished Boards

5.1.2.1 Rework of soldered areas found to be unacceptable is permissible provided the rework accomplished does not affect any other workmanship characteristics.

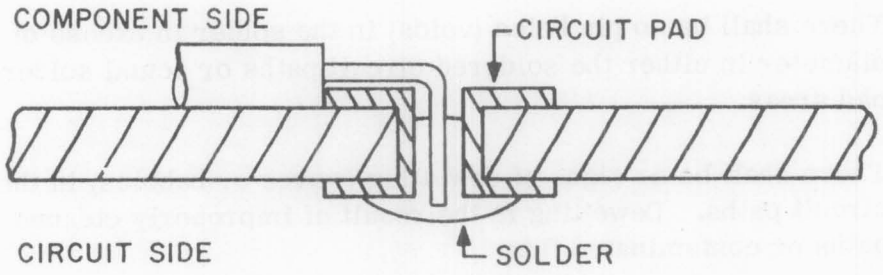
5.1.2.2 Rework of boards displaying signs of blistering, measling, delamination, lifted or damaged conductor foil is not acceptable.

5.1.3 Hand soldering of boards will be accomplished per "Special Process Procedure" WJP-1010, General Soldering Requirement.

5.1.3.1 Component leads or Z wires used for interconnecting two-sided circuitry (without plated thru holes) will be soldered on both sides.

5.1.3.2 Plated thru holes and eyelets must have 75% solder penetration from the circuit side with component leads installed. (Figure 32)

FIGURE 32



5.1.3.3 Plated thru holes used for interface connections shall contain a complete side-to-side solder plug.

6. PROTECTIVE TREATMENT

6.1 Conformal Coating

6.1.2 After assembly and soldering, printed circuit boards shall be conformal coated per "Special Process Procedure," WJP-1011. (Only when required by W-J drawing or customer specification.)

6.1.3 Tunable resistors and tunable capacitors shall be masked with tape prior to conformal coating.

6.1.4 Terminals, test points and jacks shall be protected by sleeving during the application of conformal coating.

6.1.5 Sensitive RF components and adjustable coils shall be pretuned and protected during conformal coating.

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

7. PART REMOVAL AND REWORK

7.1 Method of Extracting Parts

7.1.2 Remove defective or rejected parts by heating the solder joints and removing the solder with an acceptable solder extracting device.

NOTE: Care must be exercised when heating the solder joint to prevent lifting of circuitry.

7.1.3 Components which are unclinched or wave soldered may be removed by gently lifting the part with pliers and exerting a plucking motion. (Single sided boards with no eyelets.)

NOTE: Although an acceptable method, exercise extreme care when removing parts in the above manner.

Components clinched and hand soldered cannot be removed using this method.

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8. COMPONENT RETENTION

8.1 Mechanical Support

8.1.1 A component with a body size larger than one (1) inch in length or 1/2 inch in diameter or weighing more than 1/2 ounce must be secured to the P.C. Board by some mechanical means other than being retained solely by the leads.

8.1.1.1 Crystals shall be supported by an approved Crystal holder. The Crystal holder shall be secured by the mechanical means which offers the least amount of interference with the crystal.

8.1.1.2 Large Electrolytic capacitors shall be supported by means of an approved component clip or a Ty-Wrap. mounted with the locking mechanism on the circuit side of the board whenever possible to prevent damage to the capacitor body.

An alternate method of support shall be the application of RTV-102 between the capacitor body and the P.C. Board.

8.1.1.3 Toroid core inductors and transformers shall be secured to the P.C. Board after the final alignment of the equipment, and shall be accomplished by the application of Q Dope catalog No. 37-2 or RTV-102 depending on the electrical characteristics of the circuit and the applicable "Test and Alignment Procedure Instruction.

8.1.1.4 Variable resistors series IRC 100 shall be installed into an approved socket and shall be supported by a component clip and post configuration similar to the transistor clip.

8.2 Component Value Retention

8.2.1 Adjustable value components shall be manufactured with a self-locking mechanism or shall be externally supported by Chemical means such as Q Dope, Glyptol, or RTV-102 to retain value.

8.2.1.1 All variable Disc capacitors such as Erie series 538-xxxxx-xx Stangard /JFD series DVJ-xxx/DV11-xx/DV67A or Amperex series CO10MA/CO10KA/HT10 shall be rendered vibration proof to prevent value change by the application of RTV-102 applied at the location as outlined in the "Test and Alignment Procedure Instruction."

8.2.1.2 Variable resistors such as Beckman 62PRxxx, Bourns 3329W-1-xxx and Spectrol 62-2-1/2-xxx shall be retained by Red Glyptol, G.C catalog No. 90-2 to prevent value change under vibration. Application of Glyptol shall be accomplished per "Test and Alignment Procedure Instruction."

8.2.1.3 Variable transformers such as type 30705 shall be secured by applying RTV-102 to the square plastic adjustment slug at the entrance of the core.

8.2.1.4 Toroid core inductors shall have all windings secured in place by applying Q Dope catalog no. 37-2 after all final alignment has been completed.

8.3 Inspection Criteria

8.3.1 Inspection shall varify the mechanical or chemical support and/or value retention and shall be accomplished at the "Pre-Cover Inspection" step for Subassemblies and/or the "Final Inspection" step for the END ITEM or P.C. Assemblies.

8.3.2 Rejection of the application of the means of support shall be based on the ability of the supporting or retention device used to conform to the Fit Form. Function Reliability and serviceability of the equipment.

9.0 MODIFICATION, REWORK AND REPAIR OF PRINTED WIRING BOARDS

The procedures defined herein provide acceptance criteria for the repair, rework and/or modification of printed wiring boards (PWB's) which are deemed functionally restorable and economically repairable. In making any final decision regarding repairs or modification actions the overall final reliability, economics of time, labor, material and procedure limitations must be weighed against outright PWB replacement.

All PWB's rendered for rework or repair shall have been first processed in accordance with Watkins-Johnson Company Quality Assurance Procedure QAP-118, entitled "Nonconforming Material". Only after review by formal MRB (Level II) action shall actual rework or repair steps proceed.

Any PWB nonconformities which are MRB classified "deviations" (Type I) shall not be considered acceptable for any repair or modification actions. Where such nonconformities could (regardless of rework or repair) result in catastrophic equipment failure or malfunction, involve the safety of operating personnel, adversely affect performance, reliability, interchangeability, or otherwise result in the failure of the end product or system to perform its intended function.

All PWB's rendered for modification due to master artwork (MAW) errors, photo artwork errors, Engineering hardware changes, or customer sponsored changes, shall first be handled in accordance with Watkins-Johnson Quality Procedure QAP-122, entitled "Drawings, Documentation and Change Control". A formally generated and approved ECN may eliminate the need for further redundant MRB review, provided Quality Assurance personnel agree the modification is warranted.

APPLICABLE DOCUMENTS

The following documents were utilized in the preparation of this procedure. The latest issue in effect shall be the invoked issue.

Industrial Standards

IPC-R-700B	Modification and Repair for Printed Boards and Assemblies.

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

Military Standards

MIL-STD-1569 (17) Requirement, for the Repair and Modification Printed - Wiring Assemblies.

DEFINITIONS

Modification. Modification is defined as a revision to the interconnection features on a printed-wiring assembly accomplished by interrupting conductors and/or adding wires. Modification of a printed-wiring assembly is done in lieu of using a new-design assembly with the changes incorporated in the conductor pattern, drilled features, or other characteristics changed by the revision. Modification also includes adding of components.

Standard Modifications. Standard modifications are those rework techniques described by this procedure, not exceeding the numerical limits set. Any modifications made on a printed-wiring assembly by previous revisions shall be counted when determining compliance with numerical limits.

Repair or Rework. Repairing or reworking is the act of restoring the functional capability of a printed-wiring assembly that has been damaged during assembly or test without necessarily restoring appearance and uniformity.

Approved Standard Repairs. Standard repairs are those repair techniques described by this procedure, not exceeding the numerical limits sets.

REWORK OR MODIFICATION INSTRUCTIONS

Prior to the start of any approved rework, repair, or modification actions a written set of instructions (marked drawings, schematics, photo artwork, etc.) shall be generated along with the MRB or ECN disposition instructions to aid in the final rework or modification steps.

This information shall detail specific routing direction, conductor cut areas, wire type, run lengths, bonding aids, etc; which are not covered by this standard procedure.

9.1 Interruption and/or removal of conductor clad to facilitate a change in conductor routing.

9.1.1 Maximum permitted interruptions and removals.

The maximum number of conductors permitted to be removed or interrupted per PWB shall be as follows:

BOARD SIZE (X)	MAXIMUM NUMBER ALLOWED
SQUARE INCHES	
X <20	3
20≥ X <50	6
50≥ X <100	9
100≥ X	12

9.1.2 Minimum removal for interruptions of the conductor chad shall be 0.030 inch. The conductor shall not be removed or interrupted closer than 0.010 inch to any terminal or pad junction area. The maximum allowable removal for interruptions shall be 0.080 inch. (See Figure 9-0)

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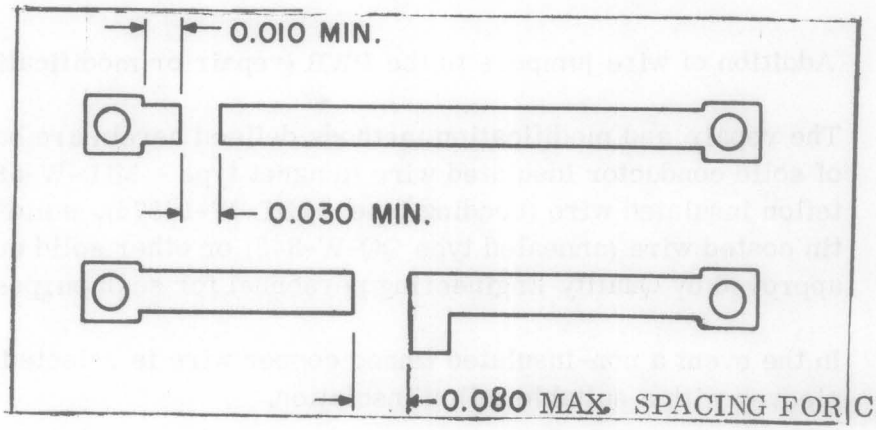
FIGURE 9-0



SPACING FOR CLAD REMOVAL

9.1.3 The conductor may be cut with an exacto-knife having a round blade or a narrow chisel point using pressure only (high speed sawing or routing are optional methods). Make cuts at each end and in the center of the conductor to be removed. Peel the conductor from the card surface starting at the center cut and working outward toward the end cut.

Inspect the area where the conductor has been removed to verify complete removal of the conductor and that there has been no damage to the printed wiring board.

9.1.4 After removal of the conductor clad the area shall be cleaned and brushed free of any foreign matter which could possibly create a shorting potential. The glass cloth surface of the board shall not be scraped into, cut as to expose fiber, blistered by heat application, or crazed by excessive pressure, as the result of the conductor interruption or removal process.

Cleaning solvents shall be standard (approved) CEI types.

9.1.5 All exposed copper clad shall be touched-up with a composition 60/40 solder in order to prevent ozidation or further contamination.

9.1.6 The application of a sealing coat of INSL-X E-26 is a precautionary requirement. E-26 may be used provided the end-item specification for the PWB does not require an expoxy conformal coat or other adhesive humidity seal. The areas to be sealed shall be a minimum of 1/2 inch in diameter around the affected breaks.

9.2 Addition of wire jumpers to the PWB (repair or modification).

The repair and modification methods defined herein are based on the use of solid conductor insulated wire (magnet type - MIL-W-583), solid conductor teflon insulated wire (bonding type - MIL-W-16878), solid conductor copper tin coated wire (annealed type QQ-W-343) or other solid conductor wire approved by Quality Engineering personnel for such purposes.

In the event a non-insulated tinned copper wire is selected it shall be sleeved with a suitable teflon insulation.

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Four (4) methods of jumper wire attachment are illustrated herein and are all considered acceptable provided conductor removal criteria and other quality considerations have been satisfactorily met.

The maximum number of added jumper wires shall be as follows:

BOARD SIZE (X)	MAXIMUM NUMBER ALLOWED
SQUARE INCHES	
X <20	3
20≥ X <50	6
50≥ X <100	9
100≥ X	12

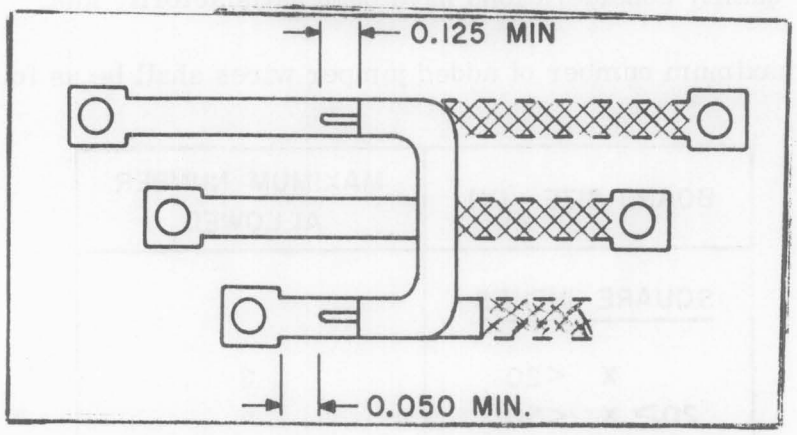
9.2.1 Surface to surface jumper method (See Figure 9-1). This illustration shows a typical modification action. However, a repair action would follow the same procedure.

NOTE: The surface to surface jumper method is the technique most widely used in industry where jumper wires are desired only on the circuitry side.

- Clean both areas of conductor to be joined at least 1/4 inch on each clad with rubber eraser and solvent.
- Pretin jumper wire end with solder (If necessary).
- Strip piece of applicable wire a minimum of .125 inch (maximum 0.20 inch).
- Slightly flatten wire to minimize rolling of the wire during soldering.
- Hold wire on centerline of conductor and solder in place with 60/40 composition solder.
- Keep jumper lead end .050 inch from any conductor pad.

9.2.1 Clean flux residue from joints and immediate area with solvent

FIGURE 9-1



NOTE:

Circuit side shown.

NOTE:

Shaded areas indicate missing conductor clad.

9.2.2 Through - board jumper method (See Figure 9-2). This illustration shows a repair action. However, a modification action would follow the same procedure.

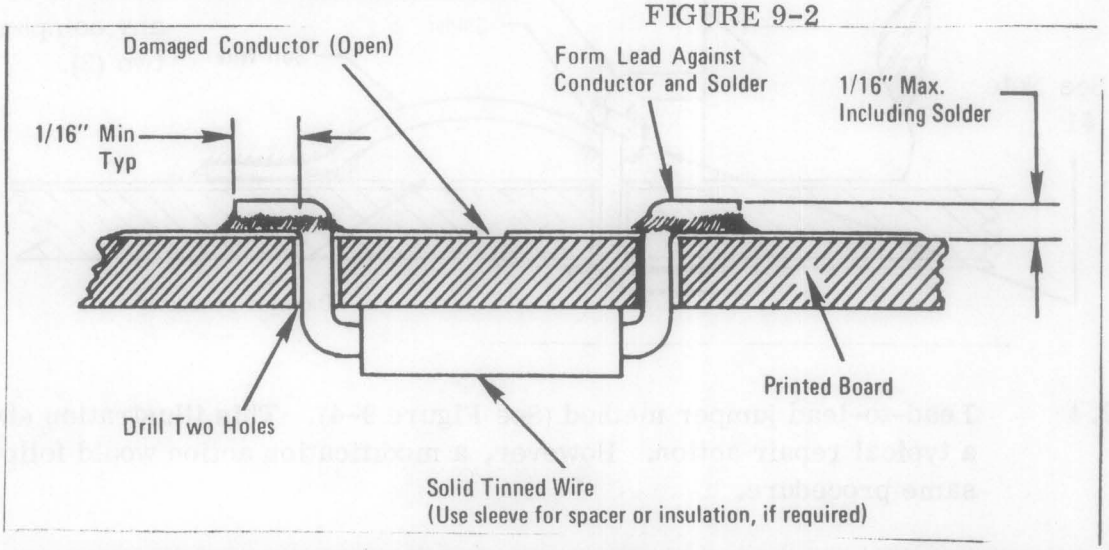
NOTE: The through-board jumper method is the technique most widely accepted in industry where jumper wires are desired only on the component side.

- *Drill two (2) holes approximately .005 inch larger than jumper wires on each side of break at centerline of conductor. (If a repair action)
- Clean both areas of conductors to be joined beyond each hole with rubber eraser and solvent.
- Cut piece of applicable wire and feed through the holes. Insulation tubing may be used as required.
- Form wire flat against conductor on centerline; cut to dimensions indicated.

9.2.2 . Solder in place with 60/40 composition solder. Clean both joints with solvent.

* Holes may be drilled adjacent to conductor paths if the width of circuitry prohibits.

FIGURE 9-2



9.2.3 Surface-to-lead jumper method (See Figure 9-3). This illustration shows a repair action. However, a modification action would follow the same procedure.

NOTE: This method is not widely used in industry and should be avoided except for short run modification connections, close proximity circuitry breaks, etc.

. Clean both areas of conductor and lead to be joined with a rubber eraser and solvent.

. Wrap wire around component lead (90° to 270°).

. Cut wire a minimum of 1/4 inch past the break if a repair. Hold wire on centerline of conductor and solder both ends in place with 60/40 composition solder.

9.2.3 . Clean flux residue from joints with solvent.

FIGURE 9-3

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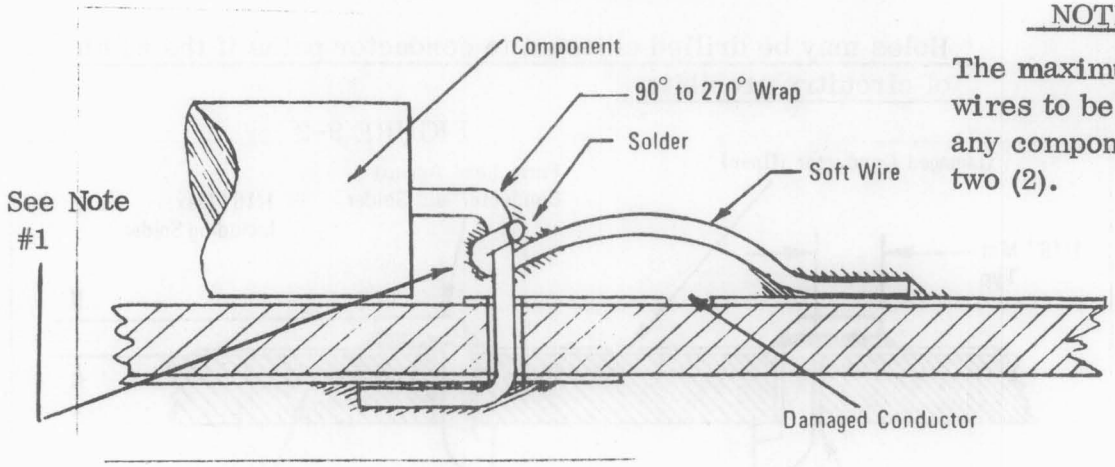

NOTE #1

The maximum allowable wires to be attached to any component lead is two (2).

9.2.4 Lead-to-lead jumper method (See Figure 9-4). This illustration shows a typical repair action. However, a modification action would follow the same procedure.

NOTE: This method is not widely used in industry and should be restricted to adjacent component modifications or repairs where lead lengths permit jumper wire attachment.

The jumpers may be connected to the top (component) side leads if the rear leads are cut short.

- Clean both components leads to be joined with abrasive cloth and clean with solvent.
- Wrap the jumper wire around the component leads (90° to 270°) on rear as shown. Front lead attachment may be utilized where rear leads are cut short.
- Solder leads with 60/40 composition solder and clean with solvent.

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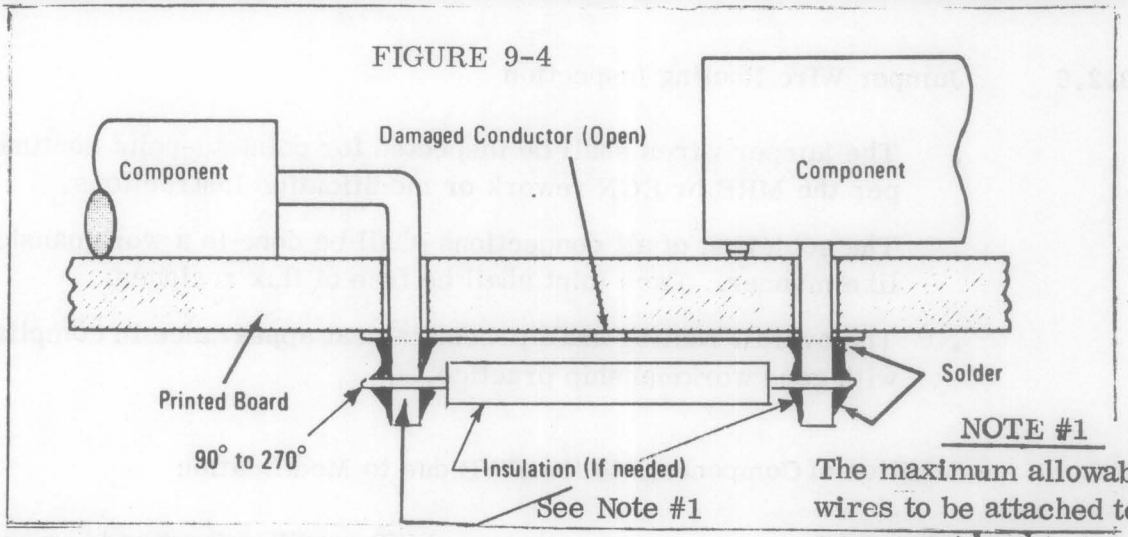
9.2.4

FIGURE 9-4



NOTE #1

The maximum allowable wires to be attached to any component lead is two (2).

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9.2.5 Jumper wire routing.

- Jumper wires installed for repair, rework, or modification purposes shall be routed (wherever possible) in the X and Y directions. Diagonal routing across the boards is not desirable and should be avoided.
- Supporting engineering data such as modified photo artwork, PWB layout diagrams, modified PWB assembly drawings, etc; shall show the desired routing method. This supporting data shall be provided with the MRB or ECN rework or modification instructions.
- Bend radii shall be a maximum based on available space, with a desired minimum of 2 wire diameters.
- In no case shall jumper wires be routed under any component body or component lead or over lead tips.

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- Jumper wires shall be supported by means of a poly adhesive (spot tacking) or epoxy adhesive (spot tacking) at intervals not to exceed 1 inch. Coating or sealing of jumper wires between tacking points is not required.
- Jumper routing shall be bundled wherever mutiple routing is used.

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- Holes drilled to accomodate jumper wire 'through board routing" shall be 0.005 inch larger than the wire used.

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- Service loops between drilled holes and connection points shall be kept to a minimum.

9.2.6 Jumper Wire Routing Inspection

- The jumper wires shall be inspected for point-to-point continuity per the MRB or ECN rework or modification instructions.
- The soldering of all connections shall be done in a workmanship like manner. Each joint shall be free of flux residues.
- The overall routing shall present a neat appearance in compliance with good workmanship practice.

9.3 Addition of Components to the PWB due to Modification

When it becomes necessary through PWB modification to add components where no mounting provisions exist (holes, pads, terminals) the components shall be mounted on the PWB per instructions of the approved ECN or deviation notice.

9.3.1 The maximum number of components that may be added to any PWB are as follows:

BOARD SIZE (X)	MAXIMUM NUMBER ALLOWED
SQUARE INCHES	
$X < 20$	2
$20 \geq X < 50$	4
$50 \geq X < 100$	6
$100 \geq X$	8

9.3.2 In all cases components shall be mounted on the top side (component side) of a PWB unless otherwise directed by applicable engineering modification drawings or instructions.

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

9.3.3 Only standard two lead components (resistors, capacitors, diodes, coils, etc.) shall be installed without the benefit of additional engineering drawings or instructions for the PWB in question.

Engineering modification drawings for multi-lead components such as transistors, pots, variable capacitors, etc; are required in order to show detailed information relative to lead (leg) placements, support requirements, attachment points, or any other data not provided in this general workmanship procedure.

9.3.4 Standard two lead components shall be installed via the use of eyelets and/or terminals. Exception is made where one lead is to be inserted into the PWB ground plane. In this case the lead may be soldered directly to the top side ground clad or conductor. If no ground connection is available on the top side a hole (.005 inch larger than the component lead) shall be drilled through the board as close to a circuit side ground clad as possible.

Eyelets and/or terminals are not required for ground plane connecting leads.

9.3.5 Hole patterns for eyelets or terminals shall first be layed out on the PWB. Attempts shall be made to keep the components to be added in the same approximate X - Y grid alignment.

9.3.6 All holes drilled for eyelets and/or terminals shall be as specified by ECN modification instructions.

9.3.7 Component leads may be soldered directly to the conductor path on the circuit side if attachment to an existing pad is not practical.

9.3.8 Wherever possible the use of holes and eyelets is preferred over solder terminals for top to bottom connections involving added components.

9.3.9 Added component leads shall not be soldered directly to existing component leads unless mechanical or electrical design dictates. Where such "lead to lead" soldering is required, special engineering modification instructions shall be generated and approved by Quality Engineering.

TITLE: Fabrication, Assembly and Soldering of Printed Circuit Boards

9.3.10 Inspection of Components Added through Modification

After component installation operations have been inspected for compliance to the revised circuit configuration, a thorough inspection of lead attachment, solder, flux residue, etc; shall be made.

MANUAL REVISION RECORD

Sub Chassis Assembly and Wiring

PAGE	Original Issue Date	Latest Revision	Approved	Date
1	6/25/73	6/25/73	DCS	6/25/73
2	6/25/73	6/25/73	DCS	6/25/73
3	6/25/73	2/24/76	DCS	2/24/76
4	6/25/73	6/25/73	DCS	6/25/73
5	6/25/73	6/25/73	DCS	6/25/73
6	6/25/73	11/1/73	DCS	11/1/73
7	6/25/73	11/1/73	DCS	11/1/73
8	6/25/73	6/25/73	DCS	6/25/73
9	6/25/73	6/25/73	DCS	6/25/73
10	6/25/73	6/25/73	DCS	6/25/73
11	6/25/73	6/25/73	DCS	6/25/73
12	6/25/73	6/25/73	DCS	6/25/73
13	6/25/73	6/25/73	DCS	6/25/73
14	6/25/73	6/25/73	DCS	6/25/73
15	6/25/73	6/25/73	DCS	6/25/73
16	6/25/73	6/25/73	DCS	6/25/73
17	6/25/73	6/25/73	DCS	6/25/73
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19	6/25/73	6/25/73	DCS	6/25/73
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21	6/25/73	6/25/73	DCS	6/25/73
22	6/25/73	6/25/73	DCS	6/25/73
23	6/25/73	2/24/76	DCS	2/24/76
24	6/25/73	2/24/76	DCS	2/24/76
25	6/25/73	6/25/73	DCS	6/25/73
26	6/25/73	6/25/73	DCS	6/25/73
27	6/25/73	6/25/73	DCS	6/25/73
28	6/25/73	6/25/73	DCS	6/25/73
29	6/25/73	6/25/73	DCS	6/25/73
30	6/25/73	6/25/73	DCS	6/25/73
31	6/25/73	6/25/73	DCS	6/25/73
32	6/25/73	6/25/73	DCS	6/25/73
33	6/25/73	6/25/73	DCS	6/25/73
34	6/25/73	6/25/73	DCS	6/25/73
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WATKINS - JOHNSON CO.

WJ

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Sub Chassis Assembly and Wiring

WATKINS – JOHNSON CO.

WJ

WORKMANSHIP STANDARDS

ISSUE DATE 6/25/73 REVISION NO.

ORIGINATED BY D. Stalcup AND D. Smith

APPROVED BY K. W. Wright

TITLE: Sub Chassis Assembly and Wiring

1. PURPOSE

1.1 The standards established in this procedure for assembly and wiring of sub chassis modules will provide an acceptable criteria for sound basic workmanship practices to insure consistency of high quality and uniform appearance in electronic equipment manufactured by the CEI Division.

2. APPLICABLE DOCUMENTS

2.1 The documents listed below were utilized in conjunction with accepted manufacturing practices in establishing sub chassis workmanship standards. In the event of conflict between this standard and a reference document, the provisions of this standard shall take precedence.

Specifications

Military

MIL-STD-130	Identification Marking of US Military Property
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-E-5400	Electronic Equipment, Airborne, General Specification for
OP-2230	Workmanship and Design Practices for Electronic Equipment

Watkins-Johnson

WJP-1010	Soldering, General

3. HANDLING AND MOUNTING OF COMPONENT PARTS

3.1 Component Identification

3.1.1 Component parts will be located and mounted so that part identification, marking, value and polarity remain visible, unless critical RF design prohibits.

3.1.2 Reference designations of component parts will be marked next to the location of that part and shall be visible after installation.

3.1.3 When space does not permit marking on the equipment, other aids will be provided, pictorial diagrams or photographs attached to the equipment or included in maintenance handbooks.

3.1.4 Each sub chassis will be serialized with a nonrecurring number.

3.1.5 Model numbers will be designated by a combination of letters and numbers indicating specific functions of that sub chassis.

3.1.6 If a system contains two or more identical sub chassis types, the reference designations of the parts in each sub chassis will be identical.

3.1.7 Mechanically mounted receptacles will be identified by a reference symbol "J" and number combination distinguishing that receptacle from all others.

3.1.8 All interconnecting cable plugs will be identified by a symbol "P" and number combination.

3.2 Component Preparation

3.2.1 Proper lead forming is essential to reduce component body stress and prevent strain on lead-to-body connection.

3.2.1.1 Lead Bend

Component leads shall be bent with a round smooth angle. The radius of the bend shall be equal to or greater than twice the lead diameter. (Refer to Figure 1)

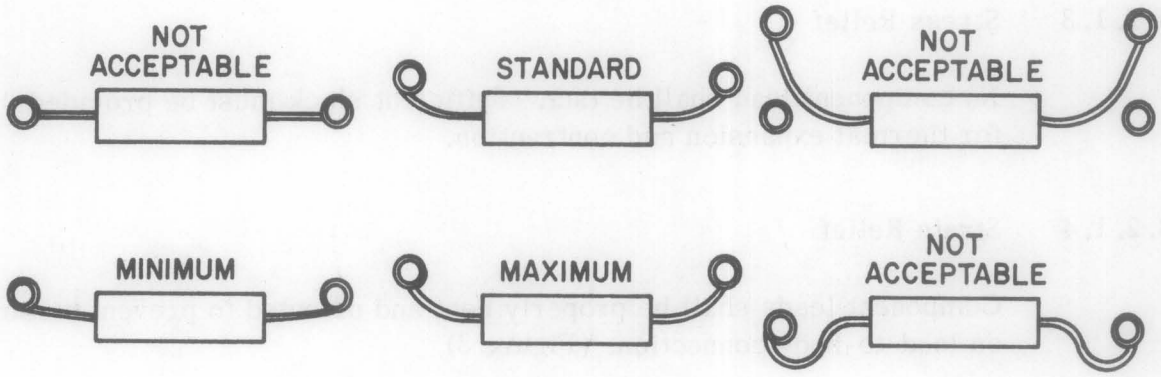


FIGURE 1

The use of components with nicked, damaged or broken leads is prohibited.

3.2.1.2 Location of Bend

Leads will not be bent closer than 1/16 inch from the component body. On components with welded leads, the bend shall be 1/16 inch minimum after the welded junction. (Figure 2)

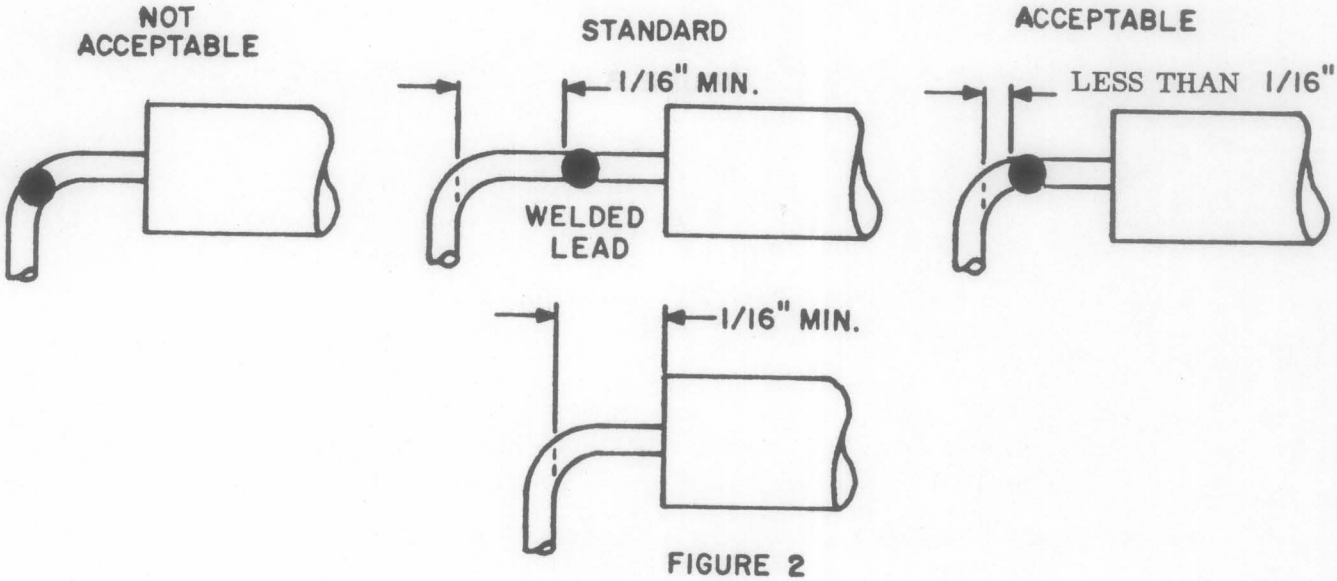


FIGURE 2

3.2.1.3 Stress Relief

No component lead shall be taut. Sufficient slack must be provided for thermal expansion and contraction.

3.2.1.4 Strain Relief

Component leads shall be properly bent and oriented to prevent strain on lead-to-body connection. (Figure 3)

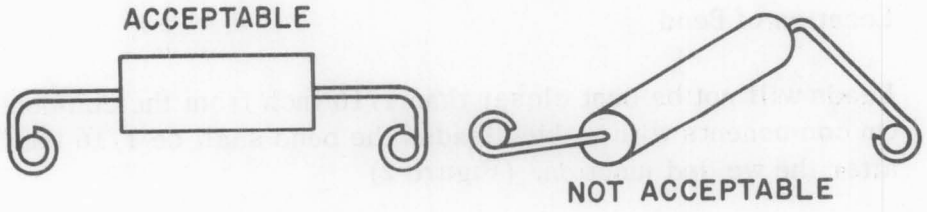


FIGURE 3

3.3 Component Mounting

3.3.1 Proper positioning of components will create uniform quality in appearance and increase reliability of the equipment.

3.3.1.1 Proper Centering

Components will be mounted between connections with equal amounts of lead at either end from the body. (Figure 4)

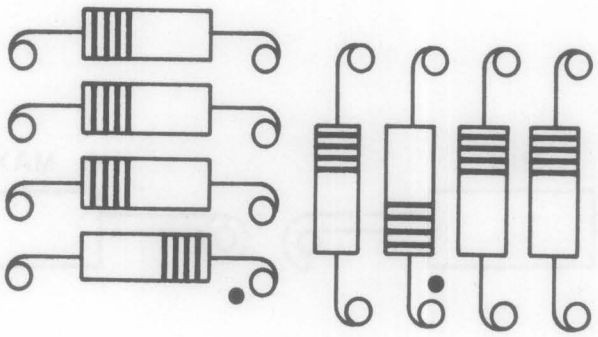


FIGURE 4

3.3.1.2 Spacing of Components

All components should be mounted within the boundaries of the sub chassis in which they are assembled. This will eliminate damage to components when covers are installed.

When critical RF design exists, avoid crossing of component leads. If necessary, it is preferred that component bodies be crossed rather than their leads. In any case, where a potential short would occur, sleeving must be installed.

A component body should not be allowed to come in contact with the body of any other component.

A component body should not be mounted closer than 1/16 inch from non-insulating hardware.

Total lead length from component body to the terminal to which the lead is attached will not exceed one (1) inch.

3.3.1.3 Proper Lead Wrapping

Component leads attached to a turret, post or terminal shall be wrapped not less than 180° around such a device, nor more than 360°, with optimum wrap being 270° or 3/4 turn. (Figure 5)

FIGURE 5

No more than four (4) connections, wires or leads, shall be made to any turret, post or terminal.

Multi-connections on a turret, post or terminal shall be made by placing the first lead on the bottom of such devices and the second lead attached above the first lead, etc., with proper lead wrap.

Component leads shall be attached to a bifurcated terminal by dressing the lead through the opening and clinching the lead with a 180° wrap. Leads larger than the opening will be wrapped around both prongs with a 180° minimum, 360° maximum and 270° optimum wrap. (Figure 6)

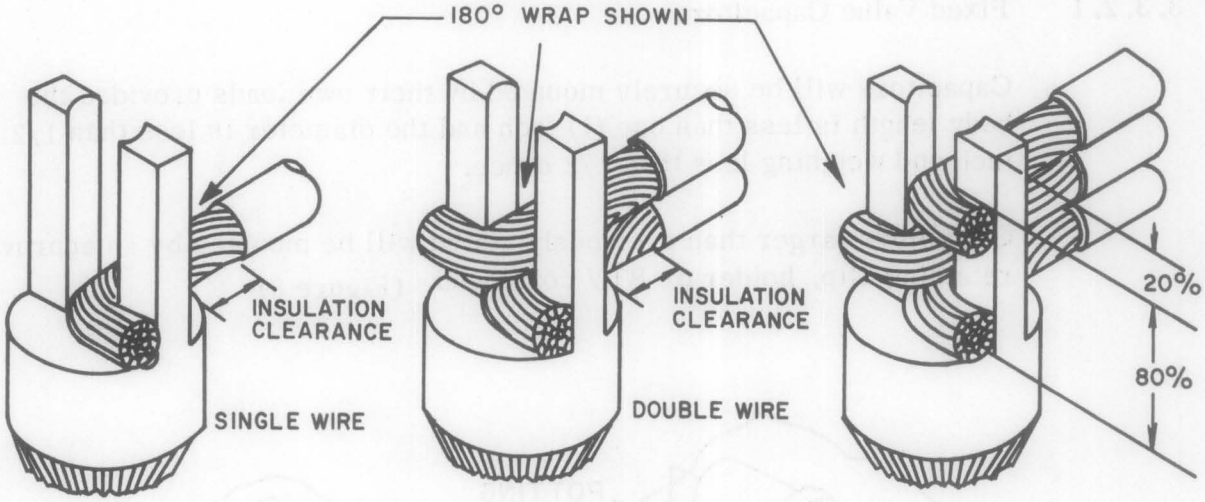


FIGURE 6

Components attached to hook terminals must be wrapped with a minimum of 270° and a maximum of 360°. (Figure 7)

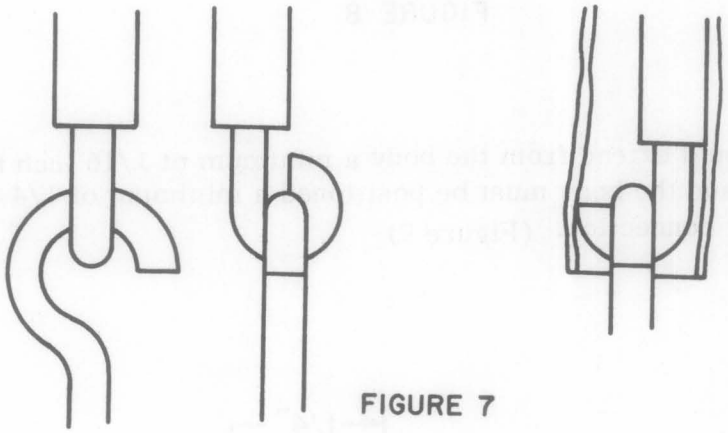


FIGURE 7

Spliced leads will not be accepted to salvage a component.

3.3.2 Mounting problems arise due to individual component characteristics, therefore, the following list of specific components and related methods will aid in the mounting of such components.

3.3.2.1 Fixed Value Capacitors

Capacitors will be securely mounted by their own leads provided the body length is less than one (1) inch and the diameter is less than 1/2 inch and weighing less than 1/2 ounce.

Capacitors larger than previously stated will be mounted by an approved retaining clip, holder or RTV compound. (Figure 8)

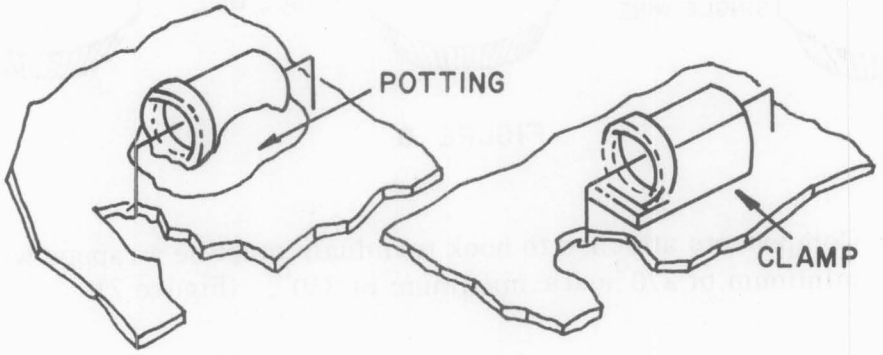


FIGURE 8

Leads should extend from the body a minimum of 1/16 inch before any bend and the body must be positioned a minimum of 1/4 inch from the solder connection. (Figure 9)

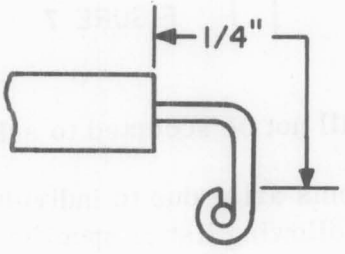


FIGURE 9

Polarized capacitors, indicated by plus (+) and minus (-), must be installed observing polarity as illustrated on applicable drawings or engineering models. (Figure 10)

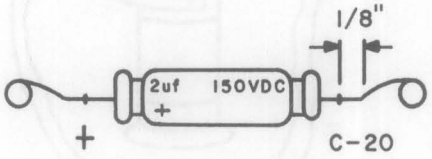


FIGURE 10

3.3.2.2 Variable Capacitors

Air dielectric capacitors must be secured by means of a mechanical support to prevent movement during adjustment.

Plates of an air dielectric capacitor must be free from dirt, grease or metallic burrs.

Glass stud mounted capacitors will be mounted by means of proper mechanical support as outlined by the manufacturer and service requirements.

Proper lead wrap to a glass stud mounted capacitor will consist of forming the lead and resting it against the contour of the foil with a minimum of 1/8 inch and a maximum of 3/16 inch lead length. (Refer to Figure 11)

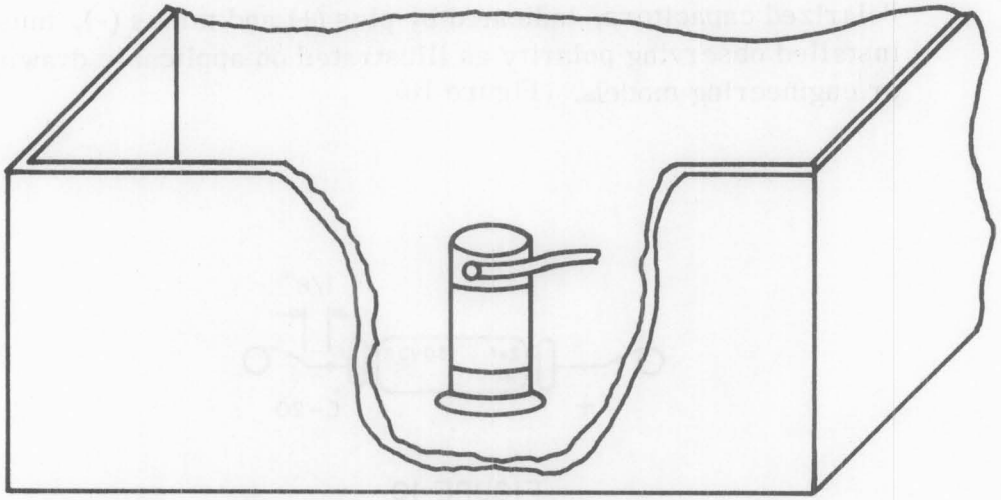


FIGURE 11

3.3.2.3 Fixed Value Resistors (Figure 12)

Fixed value resistors may be mounted by their own leads, properly dressed to allow for thermal expansion.

Resistors larger than one (1) inch in length and 3/8 inch diameter shall be mounted by an approved mechanical retaining device.

Resistors are identified by color bands which indicate the ohm's value. For a particular value refer to the following table.

RESISTOR COLOR BAND SYSTEM

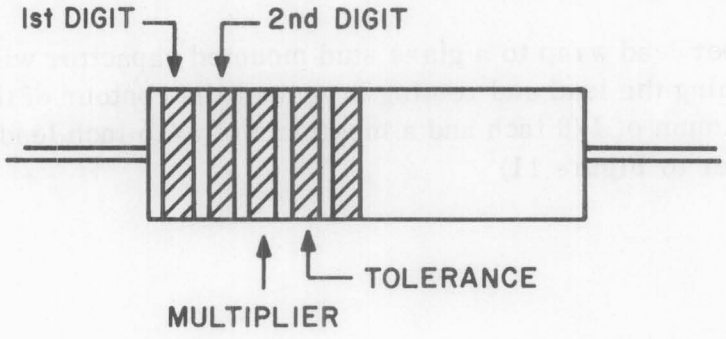


FIGURE 12

COLOR CODE STANDARD
TABLE I

COLOR	CODE
BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
SLATE	8
WHITE	9

EXAMPLE: 96=WHT-BLU, 91=WHT-BRN,
900=WHT-BLK-BLK

Power resistors larger than one (1) Watt must be located a minimum of 3/32 inch from any electrical wiring or heat sensitive component.

3.3.2.4 Variable Resistors

Variable resistors must be mounted by mechanical support to prevent movement during adjustment.

Wiring to a variable resistor will be accomplished by reference to the applicable drawing and the following illustration for correct identification of terminals. (Figure 13)

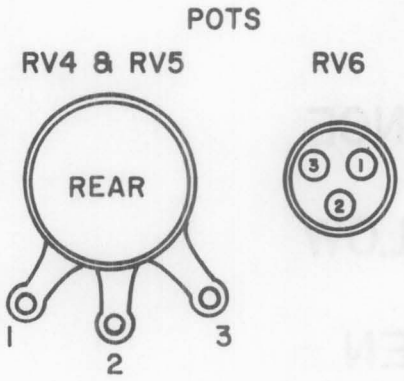


FIGURE 13

3.3.2.5 Diodes

Small glass diodes must be mounted with proper stress relief by crimping the cathode lead with "diode crimpers" or pliers. (Figure 14)

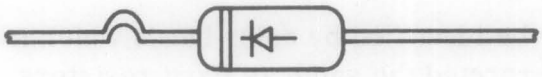


FIGURE 14

NOTE: Exercise extreme care during crimping to prevent breaking of the glass body.

Diodes are polarized and must always be installed per applicable drawing with type number and or value visible after installation. (Figure 15)

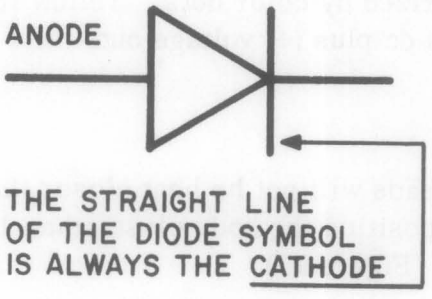
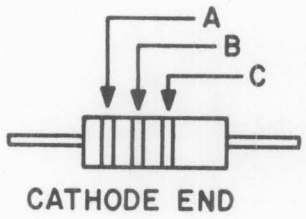


FIGURE 15

Power diodes may be mounted by leads or stud mounted, in either case, exercise care in handling during installation.

Leads should extend from the body of a diode a minimum of 1/16 inch before any bend, and a minimum of 1/4 inch from solder connection.

Diodes may be identified by color bands which indicate the value and are interpreted the same as fixed resistors. (Figure 16)



A, B AND C INDICATE THE FIRST, SECOND AND THIRD DIGIT RESPECTIVELY OF THE TYPE DESIGNATION. (PREFERRED MARKING)

NOTE: SOME MANUFACTURERS MARK THE CATHODE END WITH A "+" OR DOT DESIGNATION.

ARROW POINTS IN THE DIRECTION OF NORMAL CURRENT FLOW EXCEPT FOR ZENER DIODES WHICH WOULD BE OPPOSITE.

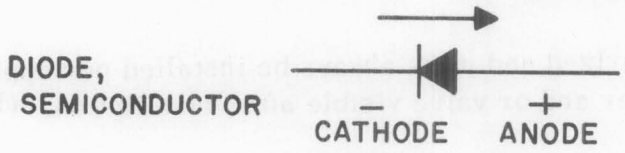


FIGURE 16

Molded diode assemblies are installed per manufacturers' instructions and are polarized by color dots. Yellow indicates ac voltage input, and red indicates dc plus (+) voltage out.

3.3.2.6 Transistors

Transistor leads will not be bent closer than 1/16 inch from the body and will not position the body closer than 1/4 inch from the solder connection. (Figure 17)

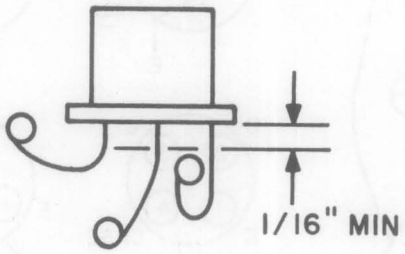


FIGURE 17

Transistors will be mounted with a transipad to prevent shorting of leads to the body.

When transistors are mounted in a socket outside the sub chassis, an approved retaining clip will be provided to maintain a secure fit.

Transistors installed inside the sub chassis should be secured with a mounting clip to prevent damage due to vibration. If RF design prohibits, an approved alternate method must be used.

Power transistors are generally mounted by mechanical means and must be located a minimum of 3/32 inch away from wiring or heat sensitive components.

Transistors are polarized and must be installed accordingly. Due to the large variety of types, always refer to the applicable drawing or manufacturer's specification sheet for clarification. (Figure 18)

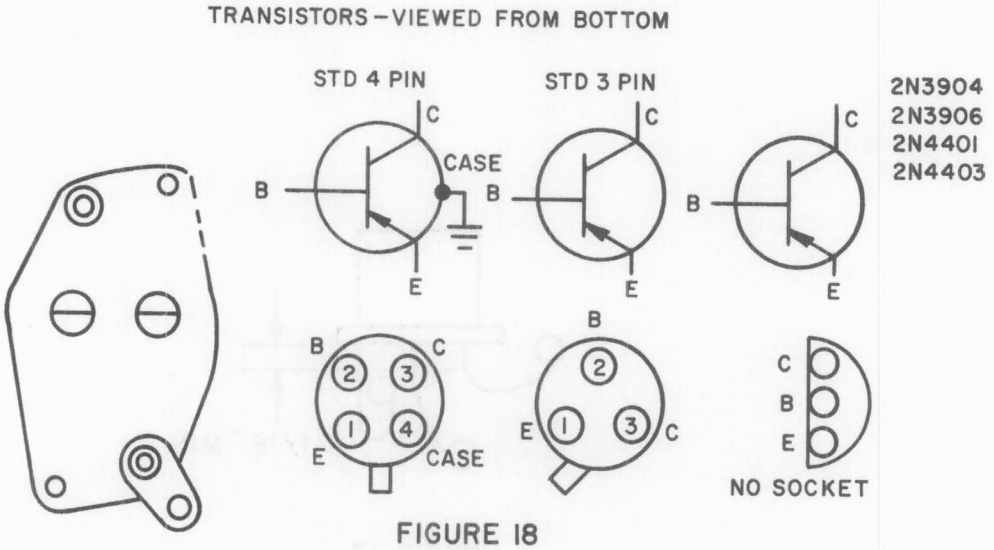


FIGURE 18

3.3.2.7 Inductors and Chokes

Encapsulated and form wound inductors will be mounted by their leads with a minimum of 1/16 inch bend relief and will be located a minimum of 1/4 inch from the solder connection.

NOTE: Exercise care in handling during mounting to prevent damage to the body or windings.

Air wound inductors shall be mounted with care not to disturb the original shape. Tack solder rather than wrap to prevent damage. Insulation must be removed a minimum of 1/32 inch and a maximum of 1/8 inch from the solder connection.

Toroids and D-roids shall be mounted by their leads with insulation clearance of 1/32 inch minimum and 1/8 inch maximum from the solder connection.

Toroids and D-roids larger than 1/4 oz. must be mechanically supported.

Bar inductors will be positioned and installed per applicable drawing by tacking the ends.

Strap inductors shall be positioned and installed with a minimum of 1/8 inch lead length, dressed and formed to fit the contour of the mounting area. Maximum wrap should be no greater than 1/4 inch.

3.3.2.8 Transformers

Transformers will be mounted by their own mechanical mounting provisions and will be oriented to facilitate ease of wiring and repair.

3.3.2.9 Printed circuit Boards

Printed circuit boards should be treated as an assembly and should be complete and inspected prior to installation.

Wiring to the printed circuit board should be accomplished in such a manner as to allow for easy access for repair.

4. WIRING OF SUB CHASSIS

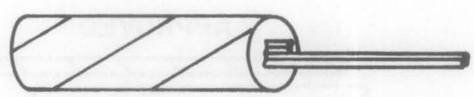
4.1 Identification

4.1.1 Wiring must be color coded or numbered per application to the circuit for which it is employed or as specified by applicable drawing.

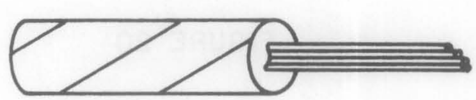
0	Black (Ground)	903	White, Black, Orange (+5V)
1	Brown (Heater ll. Voltage)	905	White, Black, Green (-5V)
1	Brown (6.3 V AC)	906	White, Black, Blue (+28V)
2	Red (+175V)	912	White, Brown, Red (+160)
3	Orange	913	White, Brown, Orange
4	Yellow	915	White, Brown, Green
5	Green	916	White, Brown, Blue (+15)
6	Blue (+24V (A))	917	White, Brown, Violet (-15)
7	Violet (Intensity (Hi Voltage))	924	White, Red, Yellow (+200V)
7	Violet (-6V)	925	White, Red, Green (+150V (Float))
8	Gray (115V AC)	926	White, Red, Blue (+120V)
9	White (Focus Hi Voltage)	927	White, Red, Violet (+60V)
90	White, Black	928	White, Red, Gray (+100V)
91	White, Brown	935	White, Orange, Green
92	White, Red (+150V)	936	White, Orange, Blue (+14V)
93	White, Orange	937	White, Orange, Violet (3V -24V)
94	White, Yellow	946	White, Yellow, Blue (+12V)
95	White, Green	947	White, Yellow, Violet (+18V)
96	White, Blue (+24 (b))	957	White, Green, Violet (-18V)
97	White, Violet (-24V)	967	White, Blue, Violet (+10V)
98	White, Gray (230V (60 Cycles)	968	White, Blue, Gray (-10V)
902	White, Black, Red (+50V)	978	White, Violet, Gray (-12V)

4.2 Stranded Wire

4.2.1 Broken strands will not exceed 10% of the total number of strands contained in the wire. (Figure 19)



BROKEN STRANDS, 10% OR MORE



NO DAMAGED OR BROKEN STRANDS.
CLEAN TRIM.

FIGURE 19

4.2.2 If strands are larger than #18, no strands may be broken.

4.2.3 Broken strands will be removed back at the termination point of the insulation to prevent shorting to adjacent connections.

4.2.4 Under no circumstances will stranded wire be spliced.

4.2.5 Stranded wire used between terminals more than 1-1/2 inchs apart must be at lease 1/2 inch longer than the shortest distance between the terminals.

4.2.6 Insulated wire will not be dressed across sharp edges which may damage the wire under vibration. (Figure 20)

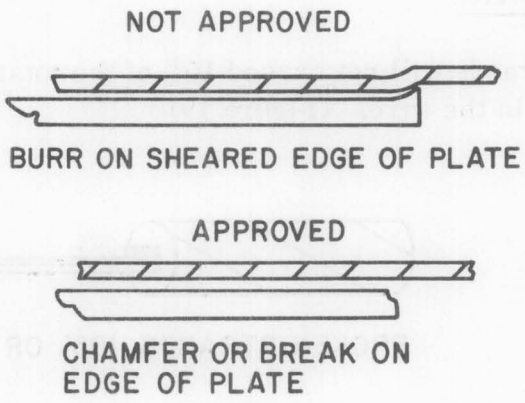


FIGURE 20

4.2.7 Insulated wires leading through a chassis hole must be protected by a grommet or other acceptable insulator. (Figure 21)

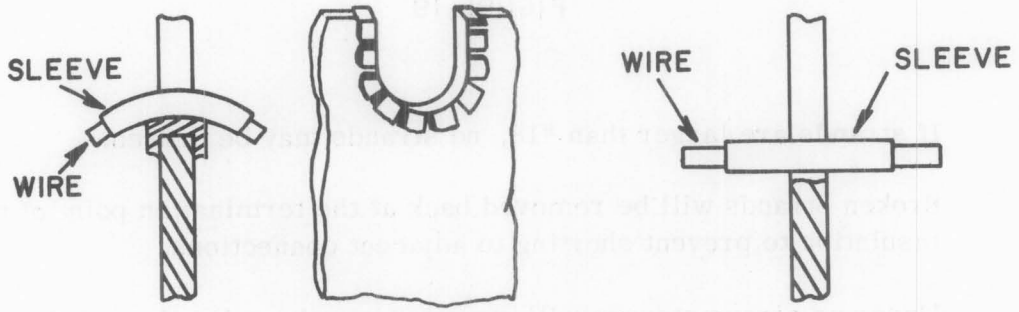


FIGURE 21

4.2.8 Insulated wire will not be routed closer than 3/8 inch to the body of a 10 to 25 Watt resistor or 1 inch closer to the body of a 50 to 200 Watt resistor.

4.3 Insulation

4.3.1 Insulation will not be burned or damaged at any point.

4.3.2 If insulation is scorched for more than 1/8 inch from the wire end it will be removed above the effected area and reconnected.

4.3.3 The end of the insulation will not exceed a distance of 1/8 inch from the solder connection, and no closer than 1/32 inch. (Figure 22)

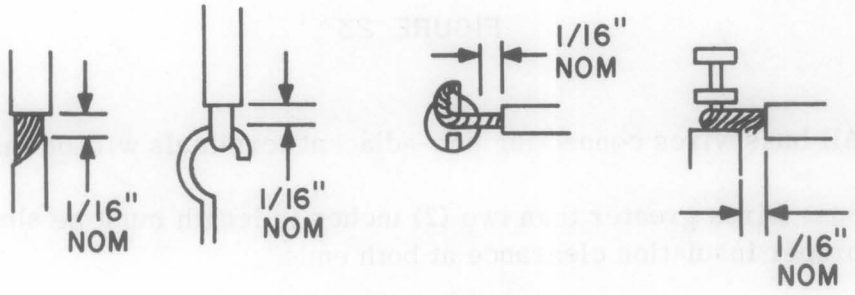


FIGURE 22

4.3.4 Wire stripping will be accomplished without nicking or cutting of strands.

4.4 Buss Wiring

4.4.1 All buss wires will be direct and neat with proper wrap and stress relief to give safe clearance to parts or wires between terminals. (Figure 23)

NOT ACCEPTABLE

NOTE:

BUSS WIRES MUST BE STRESS RELIEVED AND WRAPPED AS SHOWN:

FIGURE 23

4.4.2 All buss wires connecting non-adjacent terminals will be insulated.

4.4.3 Buss wires greater than two (2) inches in length must be sleeved with proper insulation clearance at both ends.

4..4.4 A continuous run of buss wire may be used to jumper terminals, provided each connection is made with the proper wrap. (Figure 24)

PREFERRED

IF NECESSARY

FIGURE 24

4.4.5 Flat buss wire or strapping must be installed with respect to the following criteria.

4.4.5.1 When used as a continuous run, strapping will be routed through the terminals at each connection with minimum slack. (Figure 25A)

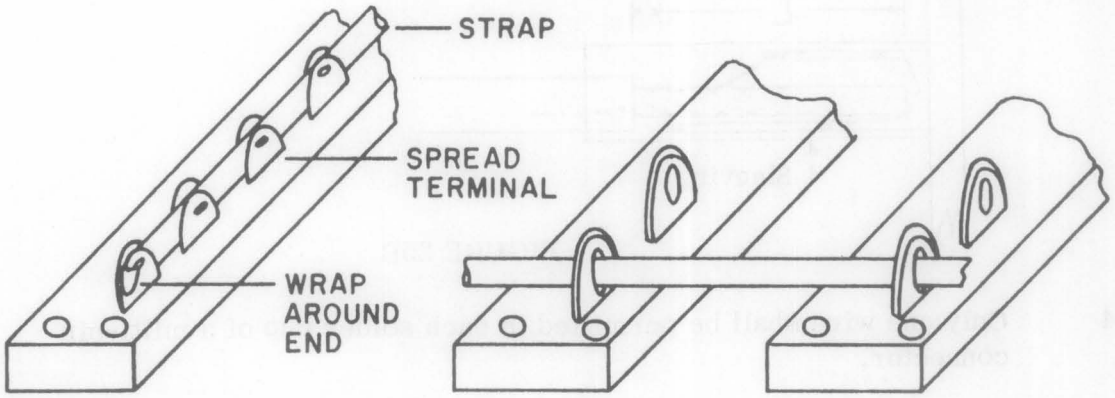


FIGURE 25A

4.4.5.2 Strapping buss will be wrapped or formed to insure a minimum 1/8 inch contact area on any terminal or connection. Maximum wrap will not extend beyond the connection.

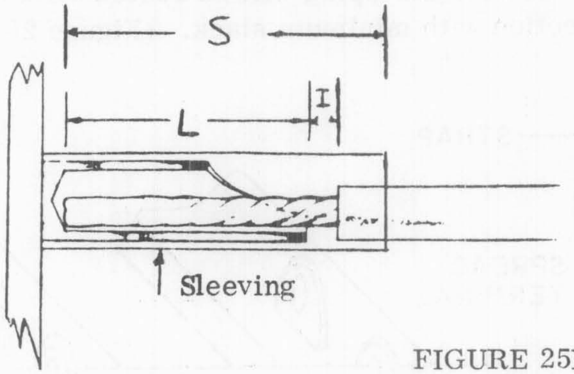
4.4.5.3 Strapping buss for grounding will be formed around the terminal and dressed to form the body of the terminal.

4.5 Sleeving Requirements for Multi-Pin Connectors

4.5.1 Multi-pin connectors which have solder-cup pins shall require sleeving on all pins to prevent short circuits between adjacent pins.

4.5.2 The sleeving diameter shall be such that a comfortable snug fit shall result thus maintaining the sleeving location.

4.5.3 The sleeving length shall be the length of the solder cup (L) plus twice the insulation spacing (I) thus providing a 105% minimum to a 150% maximum coverage (Figure 25B)



S = L (2 x I)

FIGURE 25B

4.5.4 Only one wire shall be permitted in each solder cup of a milti-pin connector.

4.5.4.1 Cutting of wire strands to fit a wire into a solder cup shall not be permitted and is forbidden.

4.5.4.2 Wires added to a multi-pin connector shall be avoided where possible, however, if a wire is to be added to a connector pin it shall be wrapped on the pin base observing best workmanship practices for wire wrap, wire insulation, wire routing, wire sleeving and soldering (Figure 25C)

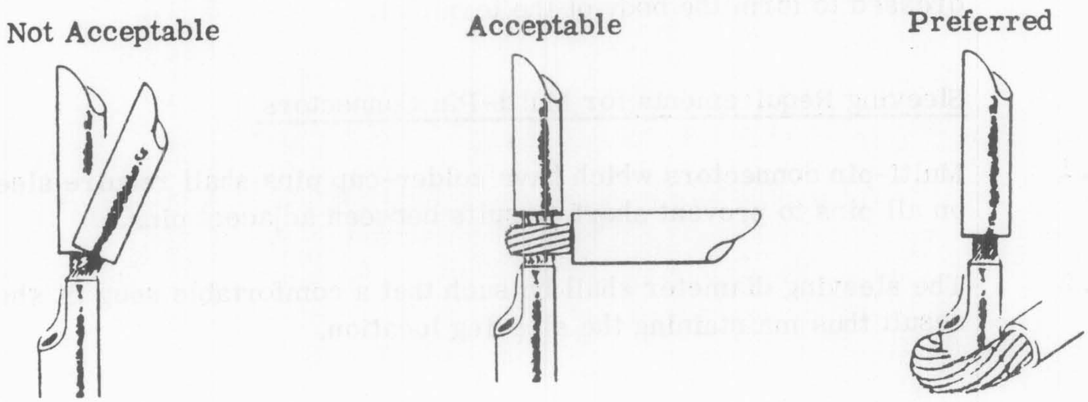


FIGURE 25C

5. SUB ASSEMBLY SOLDERING, GENERAL

5.1 Soldering Iron

5.1.1 The selection of the proper size soldering iron is very important since the areas to be joined must be heated to or above the flow temperature of the solder. A 50 watt iron is adequate for general soldering needs, an iron of lesser wattage should be used for miniature and sub-miniature work, an iron over 50 watts should be selected for heavy work such as ground soldering.

5.2 Care of Soldering Iron Tip

5.2.1 Maintain the proper angle and shape on copper tips at all times for good soldering.

5.2.1.1 Dress and shape copper tips with a single-cut flat file, only when the tip is cold.

5.2.1.2 Heat the tip to the lowest temperature required to melt solder and tin the tip fully.

5.2.2 Plated tips should be cleaned when cold with emery cloth or aluminum oxide cloth only. Clean until the surface is bright.

5.3 Preventive Maintenance

5.3.1 Tips should be checked daily to insure secure attachment to the element.

5.3.2 Oxidation scale must be removed at frequent intervals to maintain proper heat transfer from the heating element to the tip.

5.3.3 Tinning of the tip should be maintained to avoid transferring impurities to the solder connection.

5.3.4 Clean tips by wiping them lightly on a wet, fine textured, natural or synthetic sponge.

5.4 Solder Connections

5.4.1 A good solder connection will provide a positive electrical and a strong mechanical bond of parts and will be accomplished per the following outlined procedures.

5.4.1.1 Special process procedure WJP-1010 shall be used as acceptance criteria for general hand soldering.

5.4.1.2 Precautions during soldering are listed here as an extension to WJP-1010.

Wires or leads must be properly wrapped and clipped before soldering, and will not be reclipped after soldering.

After wrapping of the wires or leads, rigid support must be maintained to prevent movement of parts during the soldering process.

5.5 Inspection Criteria

5.5.1 All solder connections will be inspected 100% for quality characteristics.

5.5.1.1 The use of soldering aids or other tools to exert force on wires or leads to inspect the connection will not be permitted.

5.5.1.2 Bending or pulling of wires or components to determine the security of a connection can cause a serious reliability hazard. Visual inspection in most cases will be adequate.

5.5.2 The quality and reliability of a solder connection can be determined by the following visual characteristics.

5.5.2.1 Good solder connections will appear shiny and smooth with a fillet from the lead to the terminal. (Figure 26)

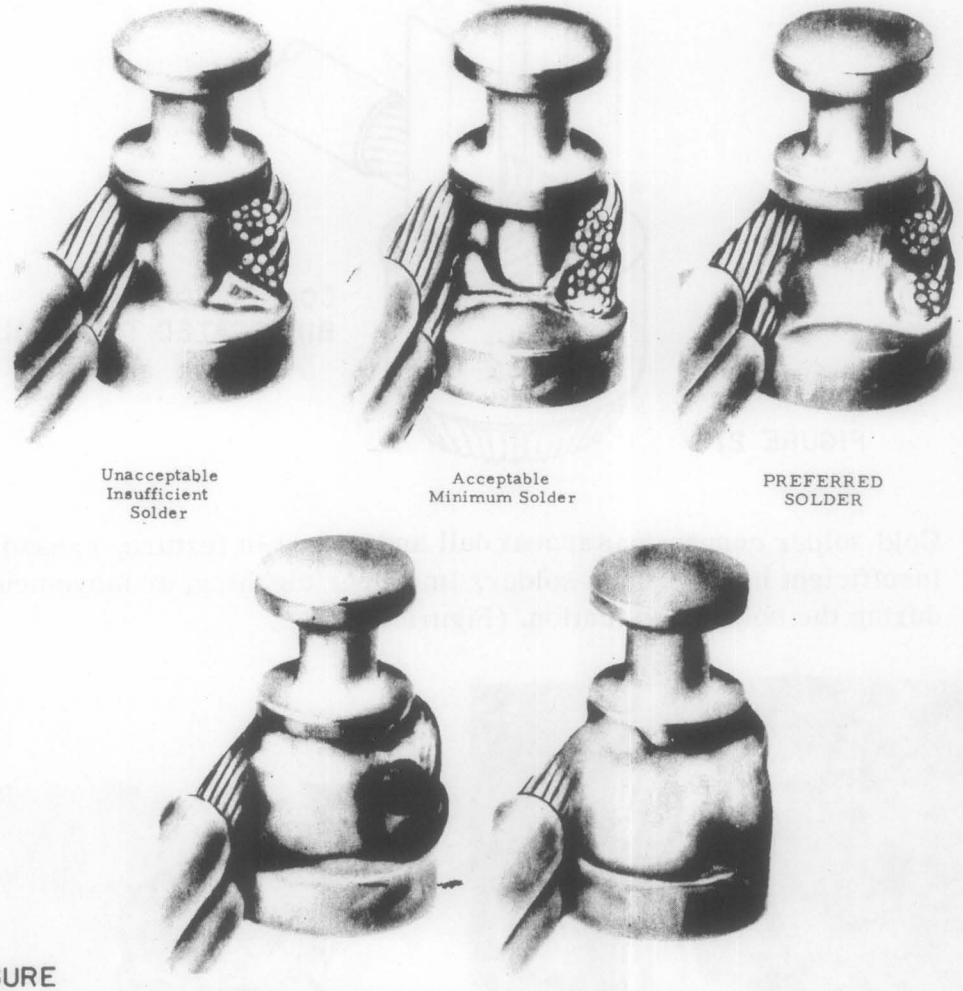
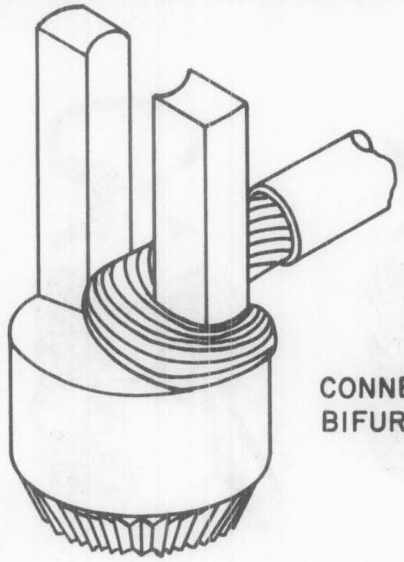


FIGURE 26

5.5.2.2 A minimum quantity of solder should be used to cover the lead and should allow the lead contour to be visible.

5.5.2.3 A solder connection shall not rely on solder alone, a good mechanical wrap must be incorporated. (Figure 27)



CONNECTION TO BIFURCATED TERMINAL

FIGURE 27

5.5.2.4 Cold solder connections appear dull and uneven in texture, caused by insufficient heat, excess solder, improper cleaning, or movement during the solder application. (Figure 28)

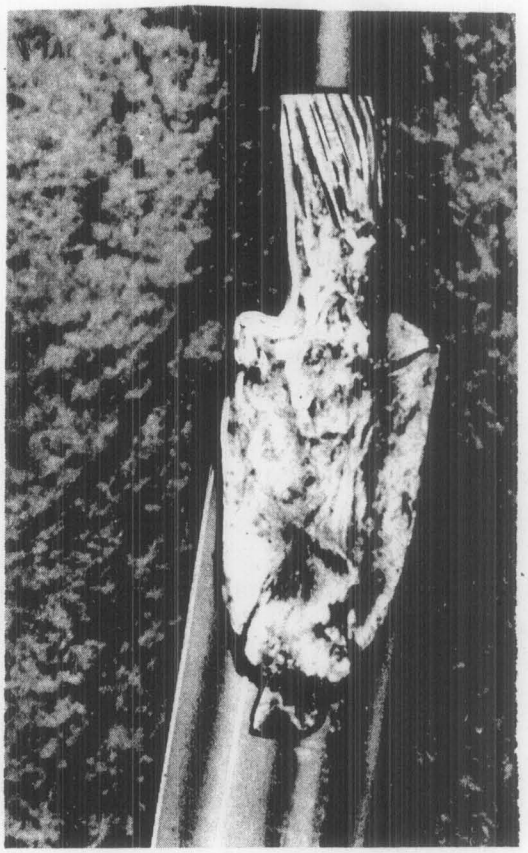


FIGURE 28

5.5.3 Ground soldering of component leads to the chassis shall be accomplished using a large wattage iron placing the majority of the heat to the chassis and sufficient heat to the component lead to insure uniform flow of solder to form a smooth even fillet. (Figure 29)

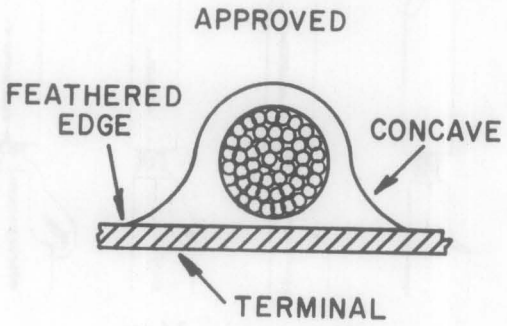


FIGURE 29

5.5.4 Illustrations and techniques for specific soldering applications are included here to aid in determining a proper solder connection.

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WORKMANSHIP STANDARDS

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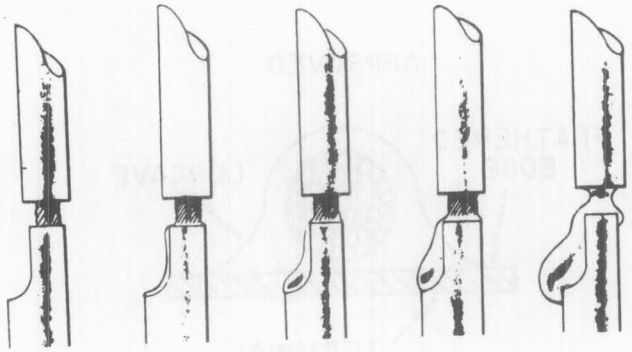
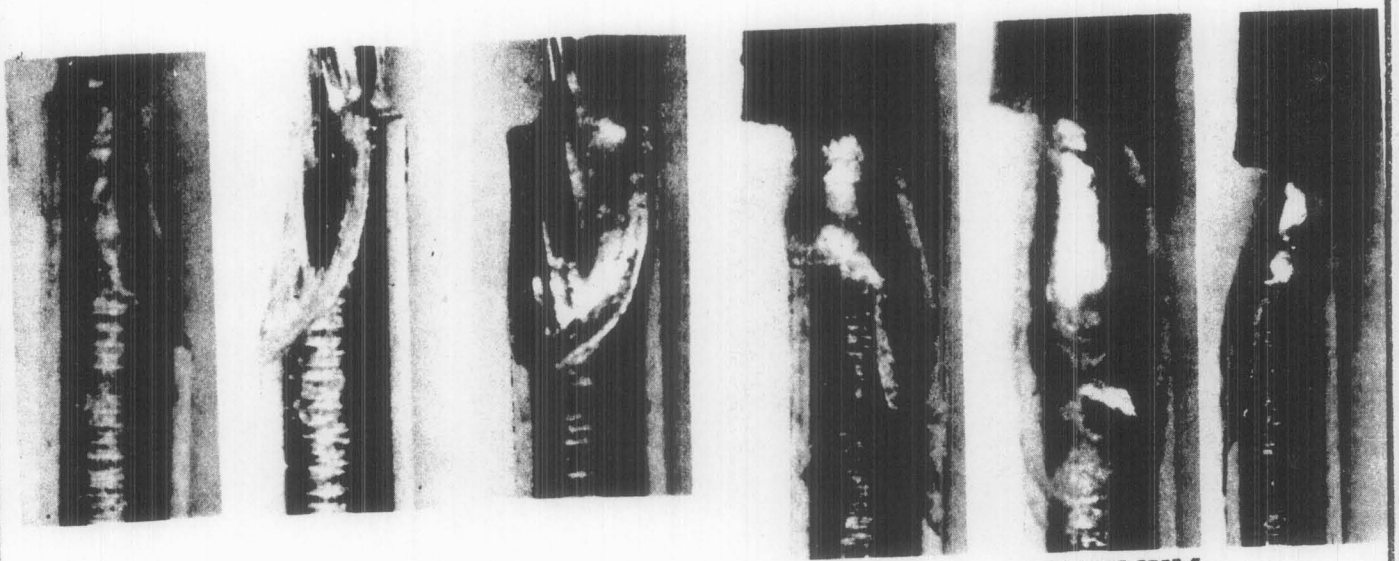
TITLE: Sub Chassis Assembly and Wiring

Minimum and maximum solder build up.



Min Standard Max



MINIMUM MAXIMUM

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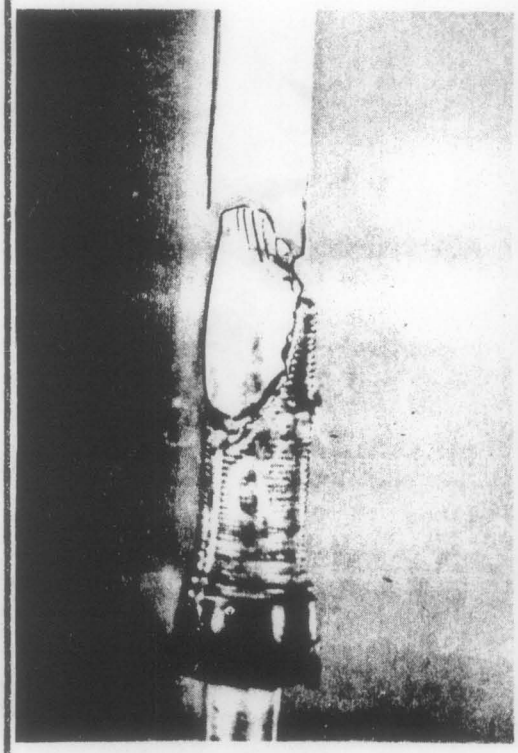
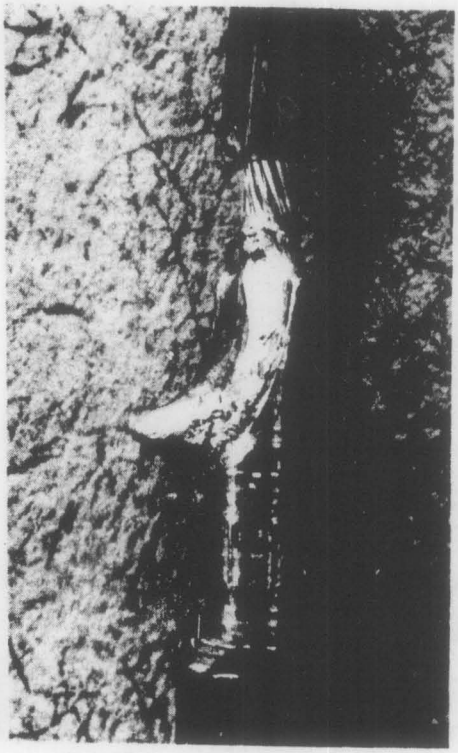
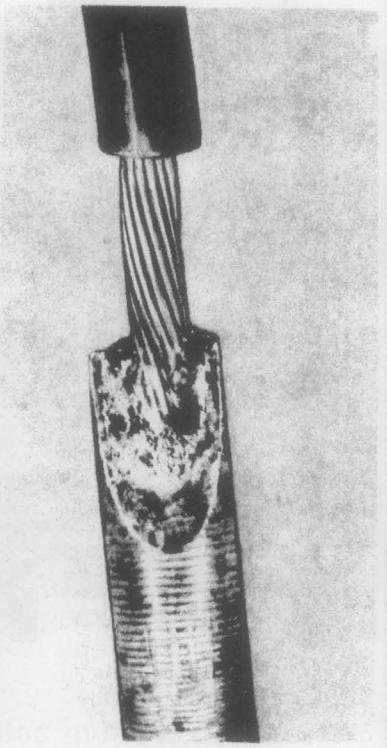
UNACCEPTABLE JOINTS



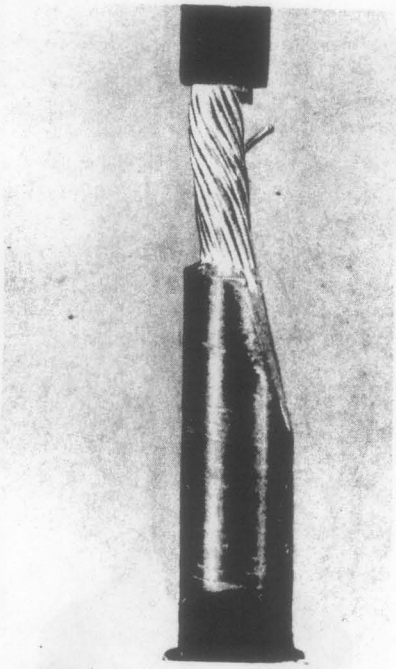
ROSIN JOINT



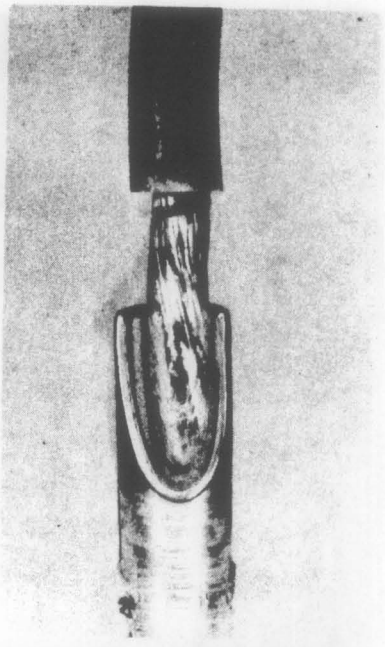
SOLDER PROJECTION



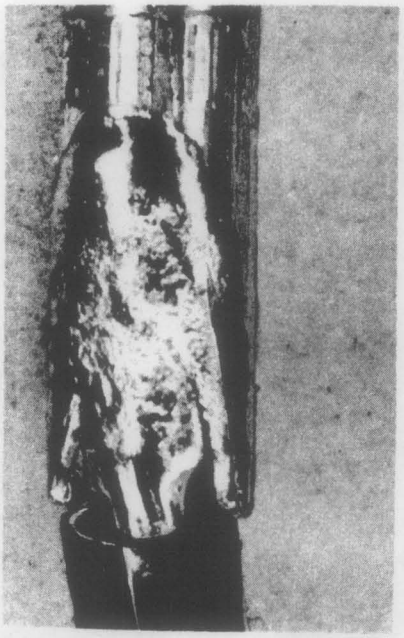
DISTURBED JOINT



BROKEN STRAND



NICKED CONDUCTOR



EMBEDDED INSULATION

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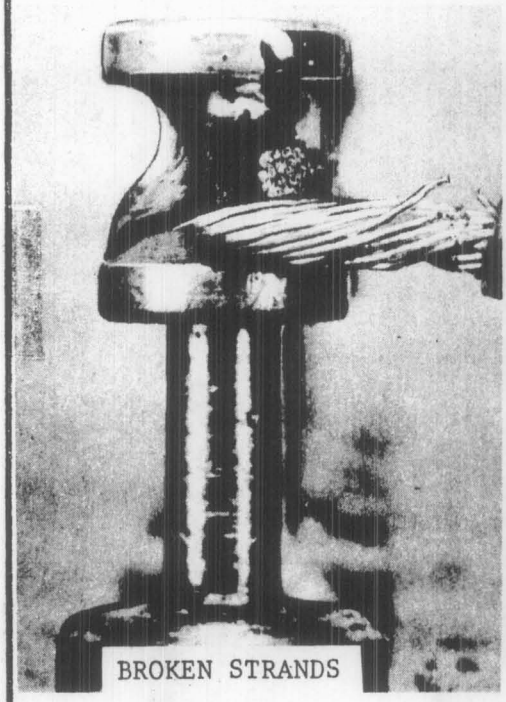
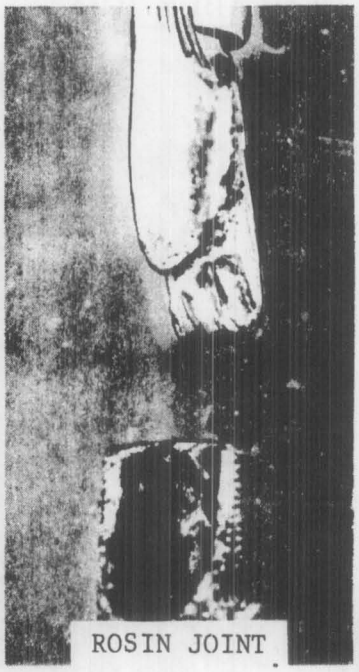
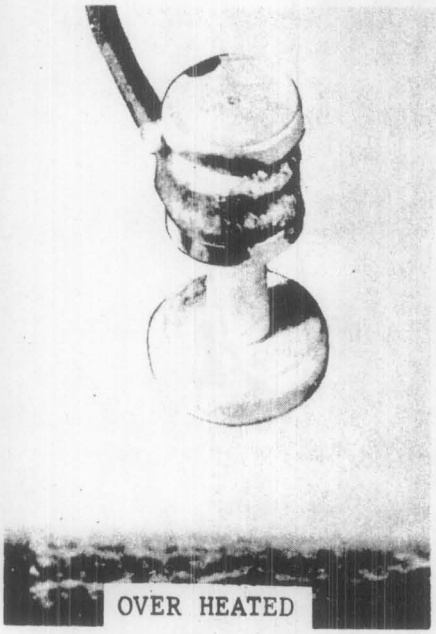


BROKEN STRANDS

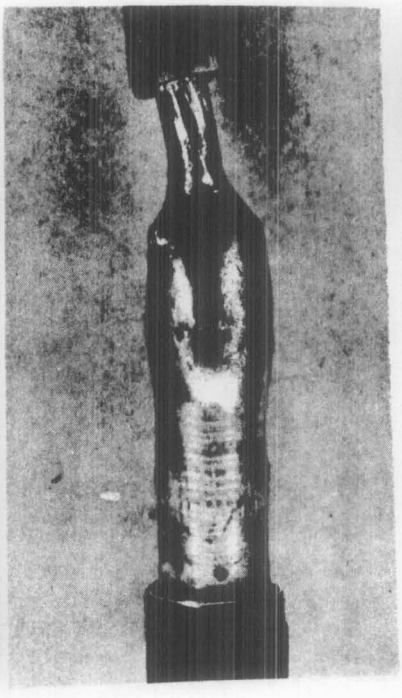


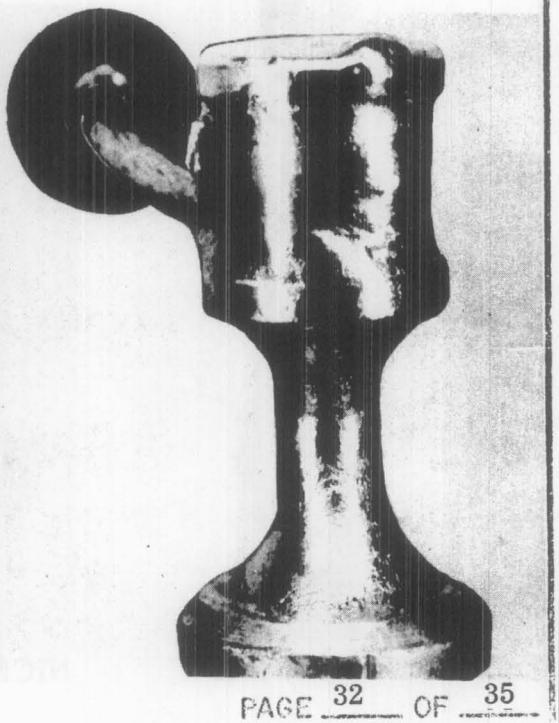
ROSIN JOINT



OVER HEATED

Excessive solder can be detected by peaks, domes or an overflow of solder. Not acceptable. When a sufficient amount of solder is used, the joint should be covered and the contour of the wire should be visible.





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WORKMANSHIP STANDARDS

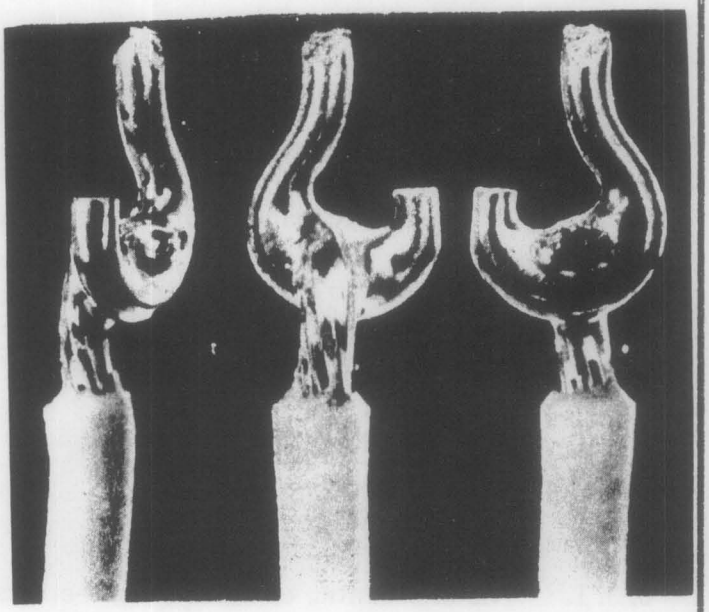
ISSUE DATE 6/25/73 REVISION NO.

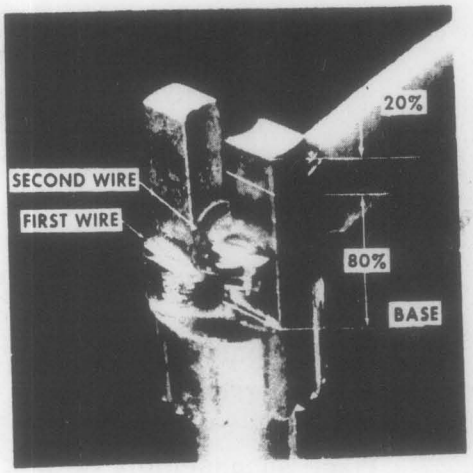
ORIGINATED BY R Stark AND D Smith

APPROVED BY B Wright

TITLE: Sub Chassis Assembly and Wiring

ACCEPTABLE SOLDER CONNECTIONS





6. SUBASSEMBLY CLEANING

6.1 Recommended Materials

6.1.1 Genesolv-D Cleaning Agent

6.1.2 Genesolv-De Cleaning Agent

6.1.3 Chlorothane-VG Cleaning Agent

6.2 Required Equipment

6.2.1 Ultrasonic Cleaner, DiSon Tegrator System 320

6.2.2 Low Pressure Filtered Air

6.2.3 Q-Tips, Sterilized

6.3 Cleaning Methods

6.3.1 Hand Cleaning

6.3.1.1 Hand cleaning of solder connections and small areas of the chassis during the assembly process will be accomplished using sterilized Q-tips and Chlorothane-VG.

NOTE: Exercise care during cleaning in order to insure that part values and identifications remain intact.

6.3.2 Ultrasonic Cleaning

6.3.2.1 Subassemblies shall be cleaned in the ultrasonic cleaner to remove all grease, flux and contaminates in a two step manner.

Place subassembly in tank labeled Genesolv-De wet bath for 60 seconds to remove grease and flux.

Place subassembly in tank labeled Genesolv-D dry bath for 60 seconds to remove residues and the remaining contaminates.

6.3.2.2 Observe the following precautions

Subassemblies containing diodes, transistors, or integrated circuits cannot be cleaned by the ultrasonic method.

Subassemblies containing inductuners cannot be cleaned by the ultrasonic method.

MANUAL REVISION RECORD

Main Chassis Assembly and Wiring

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42	11/1/73	11/1/73	DLS	11/1/73
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44	11/1/73	11/1/73	DLS	11/1/73
45	11/1/73	11/1/73	DLS	11/1/73

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WORKMANSHIP STANDARDS

ISSUE DATE 2/24/76 REVISION NO. A

ORIGINATED BY R Stiber AND D. Smith

APPROVED BY [signature]

TITLE: Main Chassis Assembly and Wiring

1. PURPOSE

1.1 The standards established in this procedure for assembly and wiring of main chassis wraparounds will provide an acceptable criteria for sound basic workmanship practices to ensure consistency of high quality and uniform appearance in electronic equipment manufactured by the CEI Division.

2. APPLICABLE DOCUMENTS

2.1 The documents listed below were utilized in the preparation of main chassis assembly and wiring standards. In the event of conflict between this standard and a reference document, the provisions of this standard shall take precedence.

Specifications

Military

MIL-STD-130	Identification Marking of US Military Property
MIL-STD-202B	Test Methods for Electronic and Electrical Component Parts
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-1130	Solderless Wrap Connections
MIL-E-5400	Electronic Equipment, Airborne, General Specification for
MIL-E-16400F	Electronic Equipment, Naval Ship and Shore General Specification

Watkins-Johnson

WJP-1010	Soldering, General

3. WIRE AND CABLE ROUTING

3.1 Routing Techniques

3.1.1 Wire and cables shall be routed and dressed by the shortest practical method, leaving sufficient slack at termination points. (Figure 1)

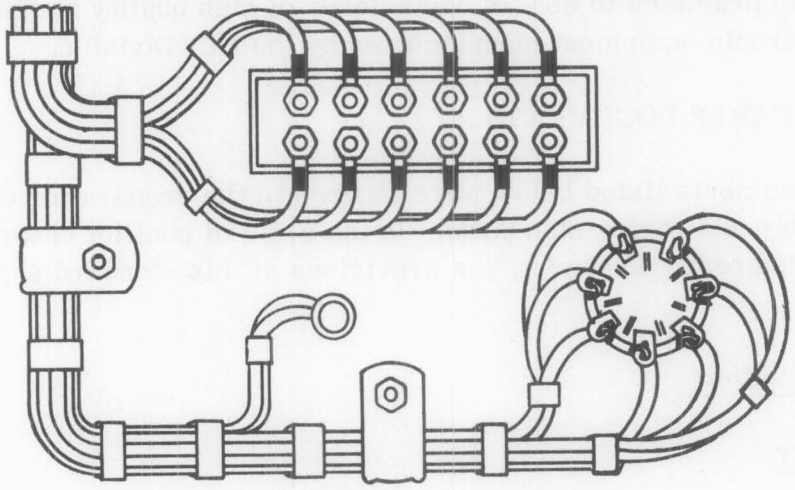


FIGURE 1

3.1.2 Wires or cables shall not be routed closer than 3/16 inch to any mounting hardware.

3.1.3 Wires or cables routed near moving parts, such as gear trains, must be routed around the frame of such devices with sufficient mechanical support to maintain correct positioning. (Figure 2)

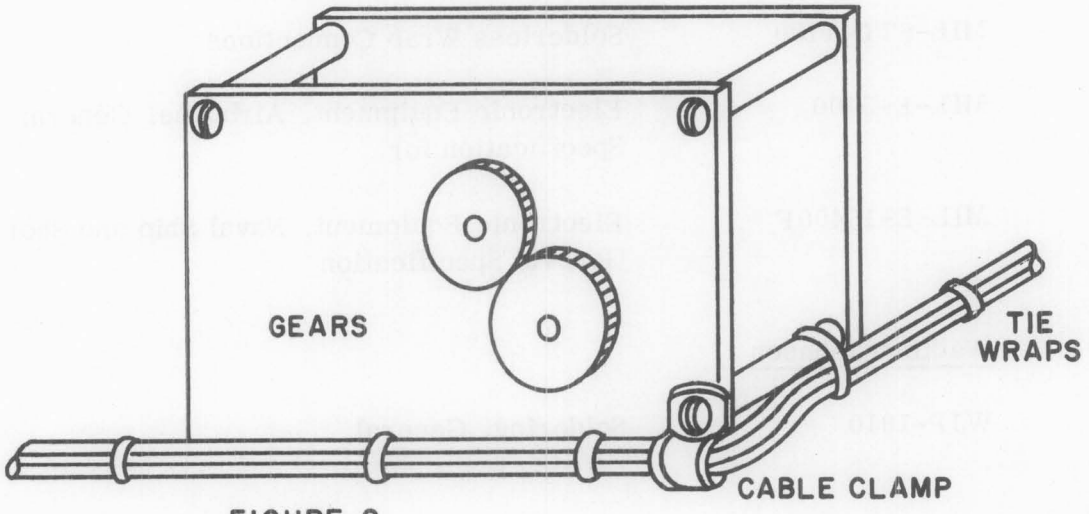
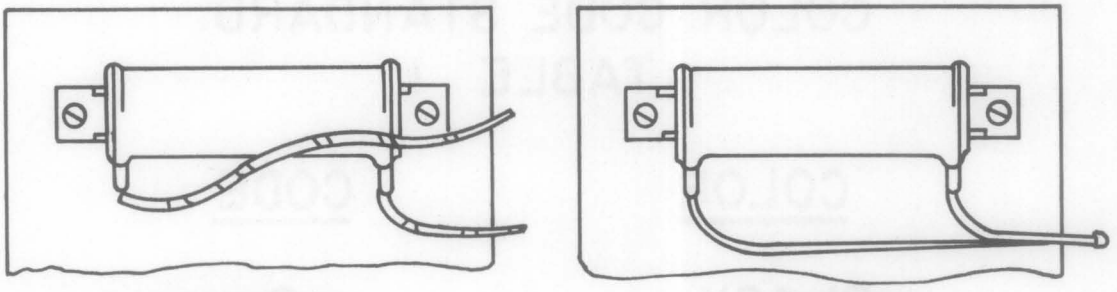


FIGURE 2

3.1.4 Wires and cables shall be dressed away from heat generating components a minimum of 3/16 inch. (Figure 3)



NOT APPROVED

LEADS NEAR HOT COMPONENTS, SUCH AS RESISTORS, TUBES, LAMPS, ETC.

APPROVED

LEADS DRESSED AWAY FROM HOT COMPONENTS.

FIGURE 3

3.1.5 Wires and cables shall be routed in such a manner as to clear any access holes or identification data.

3.1.6 Wires and cables shall lay parallel to and not interlace any other wires or cables with the exception of twisted pairs. (Figure 4)

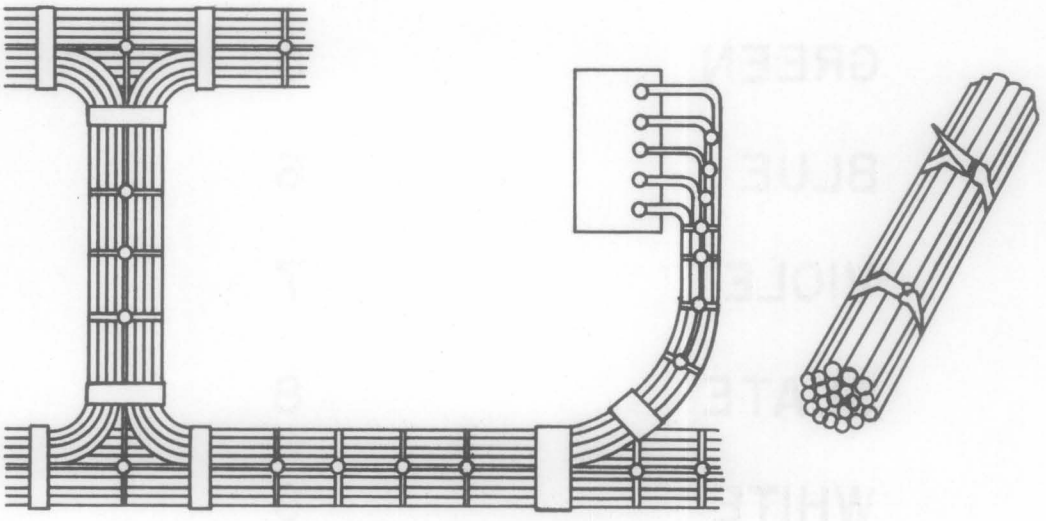


FIGURE 4

3.1.7 Wires shall be color coded and identified as to their respective circuit and function in the unit. (Table 1)

COLOR CODE STANDARD
TABLE I

COLOR	CODE
BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
SLATE	8
WHITE	9

EXAMPLE: 96 = WHT-BLU, 91 = WHT-BRN,
900 = WHT-BLK-BLK

3.1.8 Wherever possible a wire harness shall be used to increase efficiency and inhance the overall quality of the equipment.

3.1.8.1 Wire harnesses shall be routed in a manner which allows breakout of individual wires to their respective terminations without excess length. (Figure 5)

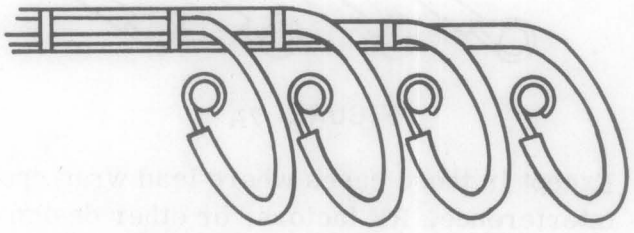


FIGURE 5

3.1.8.2 Wires shall break out as close as possible to the point to which the wire is to be attached. (Figure 6)

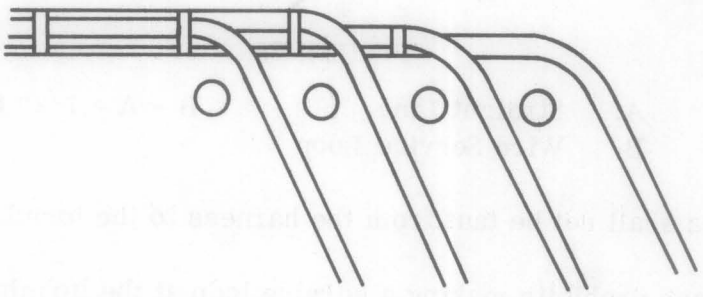


FIGURE 6

3.1.8.3 Wires that break out from the harness shall have sufficient length for a service loop capable of being reworked for two connections. (Figure 7A)

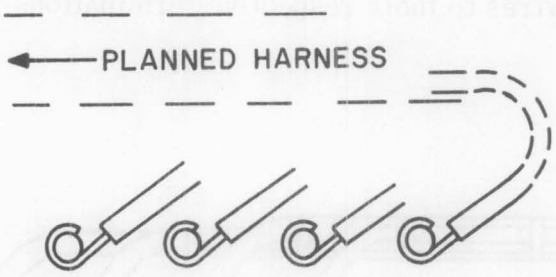


FIGURE 7A

NOTE: Except in those cases where lead wrap application, mechanical interference, RF factors, or other design or contractual consideration prohibit such limitation, the service loop will be between 1/2" and 3/4", when measured as below. (Figure 7B)

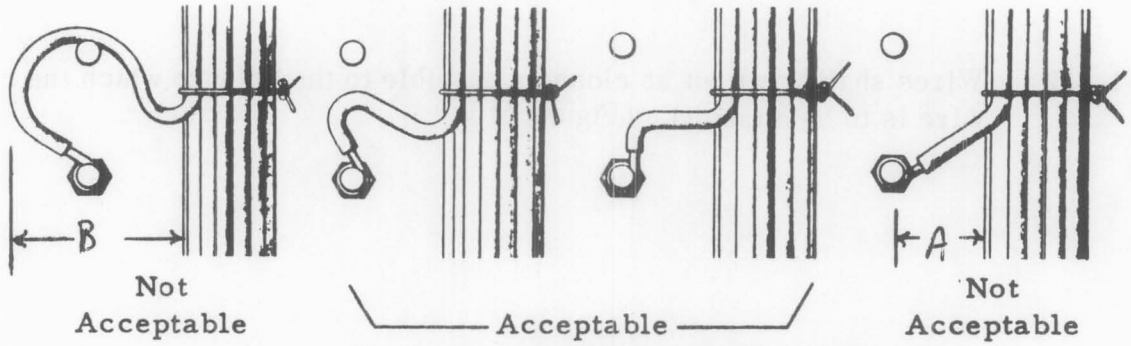


FIGURE 7B

A. Straight Line
B. Wire Service Loop

B - A = 1/2" to 3/4"

3.1.8.4 Wires shall not be taut from the harness to the termination.

3.1.8.5. If space prohibits making a service loop at the termination point, the harness need only be routed to provide adequate stress relief.

3.1.8.6 Wires shall not be spliced in a harness. If a wire is broken it must be removed completely from the harness and replaced.

3.1.8.7 Wires may be run to a common tie point for distribution provided ample space is allowed for multiple connections.

3.1.8.8 All wires shall be wrapped to terminations in the direction opposite the pull of the harness. (Figure 8)

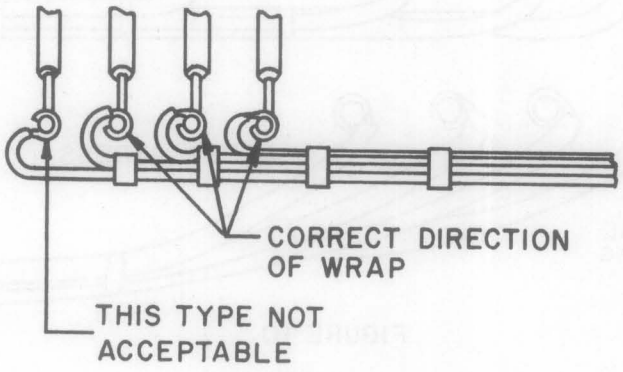


FIGURE 8

3.1.8.9 Shorter wires should be dressed to the top or side of the harness and should break out from the harness without crossing over other wires. (Figure 9)

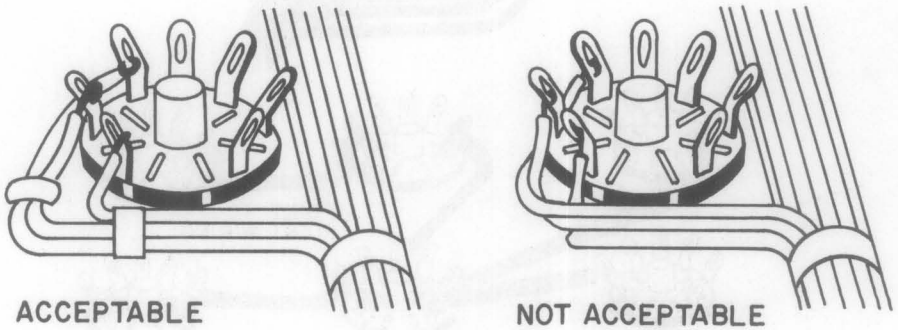


FIGURE 9

3.1.8.10 All wires that break out of a wiring harness must have a service loop equal to all other wires in that harness. (Figure 10)

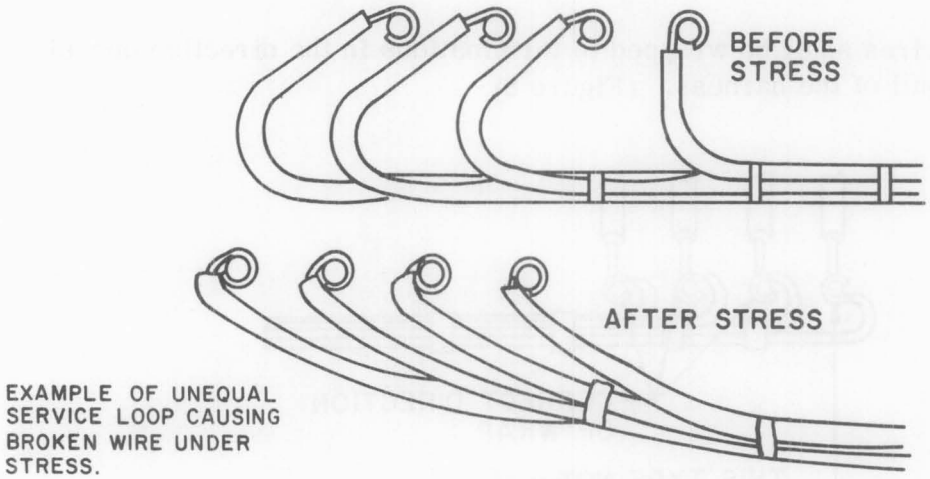


FIGURE 10

3.2 Open Form Wiring

3.2.1 Open form wiring will be color coded as to its specific function and used only when critical RF design dictates.

3.2.2 Types of open form wiring are point-to-point and free running.

3.2.2.1 Point-to-point wiring shall be used only when absolutely necessary, as dictated by the design. This type of wiring requires no service loop. (Figure 11)

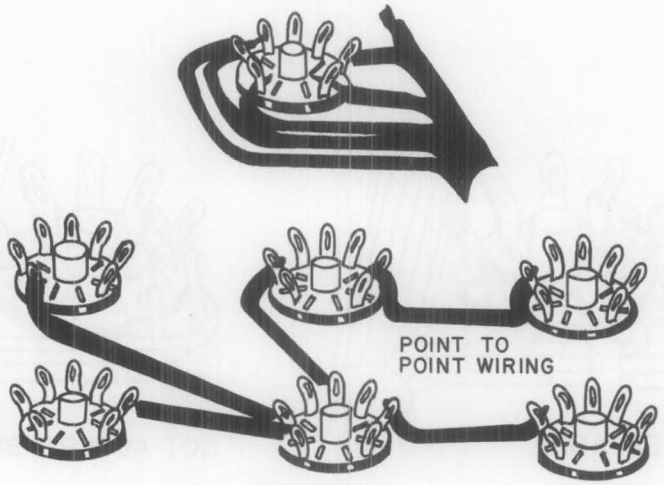


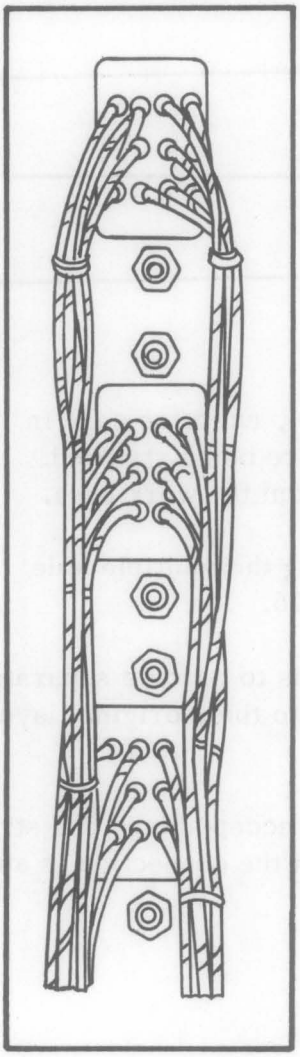
FIGURE 11

3.2.2.2 Free running wires may be routed by the shortest practical path with proper dress and stress relief.

3.2.2.3 Wires should be dressed flatly against an available surface and should not cross over other wires.

3.2.2.4 Sufficient clearance shall be provided for hardware and stenciled data. (Figure 12)

NOT APPROVED



APPROVED

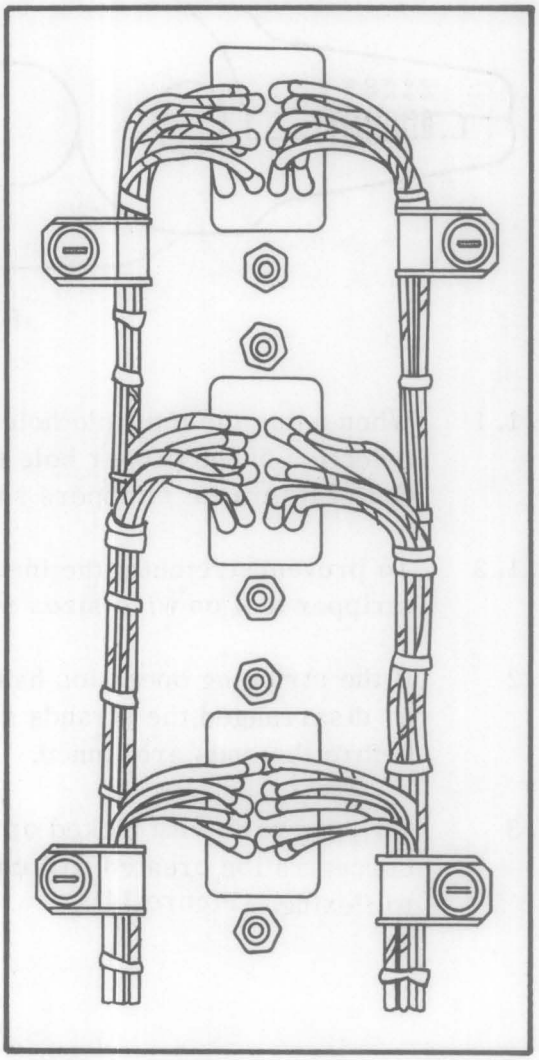


FIGURE 12

4. WIRE PREPARATION

4.1 Insulation Stripping

4.1.1 To strip insulation from the ends of the wire, a non-adjustable (factory set) cutting type stripper should be used. The Ideal Model 45-121 is an example of this type of wire stripper. (Figure 13)

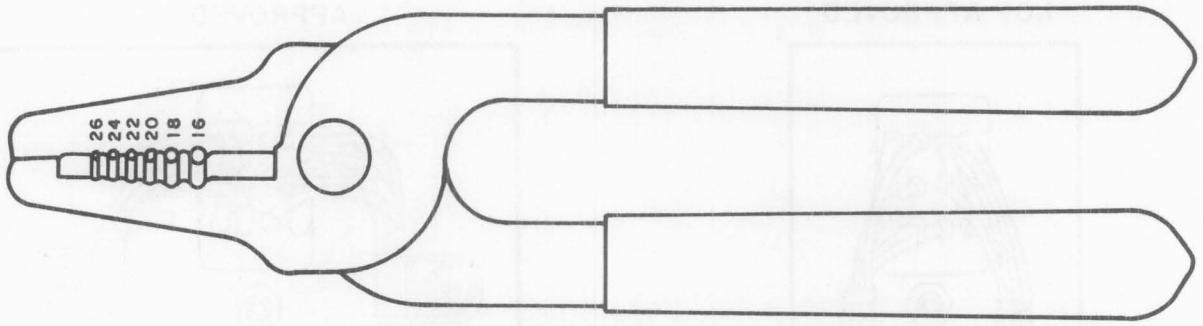


FIGURE 13

4.1.1.1 When using the multiple hole type stripping tool, exercise care in selection of the proper hole for the gauge of wire being stripped. Out of tolerance strippers shall be removed from the work area.

4.1.1.2 To prevent stretching the insulation, avoid using the multiple hole stripper tool on wire sizes smaller than AWG 26.

4.1.2 If the stripping operation has caused the strands to become separated or disarranged, the strands should be restored to their original layout before the ends are tinned.

4.1.3 Stripped wire with nicked or cut strands is not acceptable. The stress concentration created will cause a failure when the connection is subjected to flexing. (Figure 14)

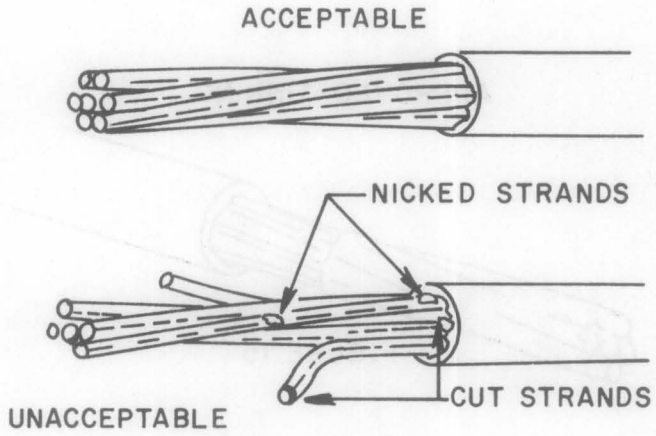


FIGURE 14

4.1.4 Inspection criteria for insulated stranded wire is as follows:

4.1.4.1 Broken strands will not exceed 10% of the total number of strands contained in the wire.

4.1.4.2 If strands are larger than #18, no strands may be broken, and the wire must be re-cut and stripped.

4.1.4.3 Broken strands will be removed back at the termination point of the insulation to prevent shorting to adjacent connections.

4.1.4.4 Under no circumstances will stranded wire be spliced.

4.2 Wire Tinning

4.2.1 Tinning shall penetrate the stripped end of the wire, but shall not obscure the wire contour at the termination point of the insulation. (Figure 15)

APPROVED TINNING

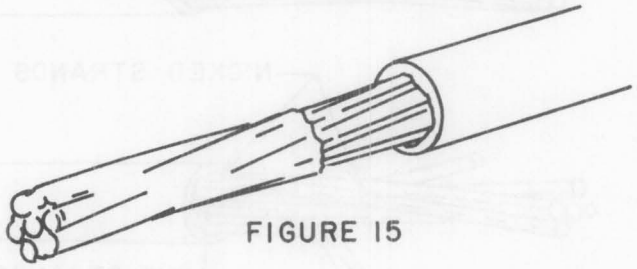


FIGURE 15

4.2.2 During the tinning of a wire with plastic or rubber insulation, the solder shall not be permitted to flow under that insulation. (Figure 16)

Teflon insulated wire is permitted to have all exposed conductor cover with solder during the tinning process.

UNAPPROVED TINNING

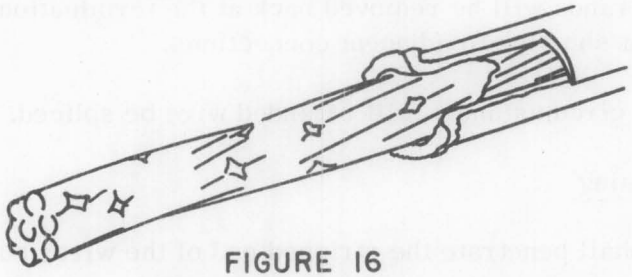


FIGURE 16

4.2.3 After tinning all surfaces must be free of oxide scale, oil, grease, or foreign matter.

4.3 Wire Wrapping

4.3.1 After proper routing and tinning, leads and wires shall be mechanically connected to the termination with a minimum wrap of 180° and a maximum wrap of 360°. An optimum of 270° is preferred. (Figure 17)

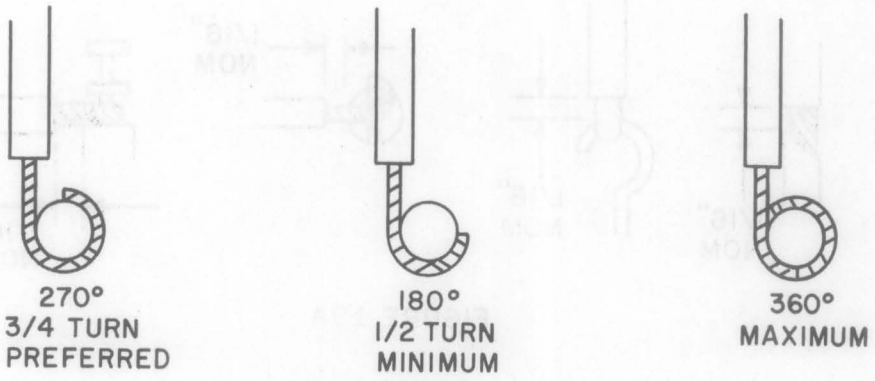


FIGURE 17

4.3.2 No more than four (4) wires or leads shall be connected to a given termination.

4.3.3 Whenever more than four (4) connections are required, (due to design) multiple connecting devices shall be provided. (Figure 18)

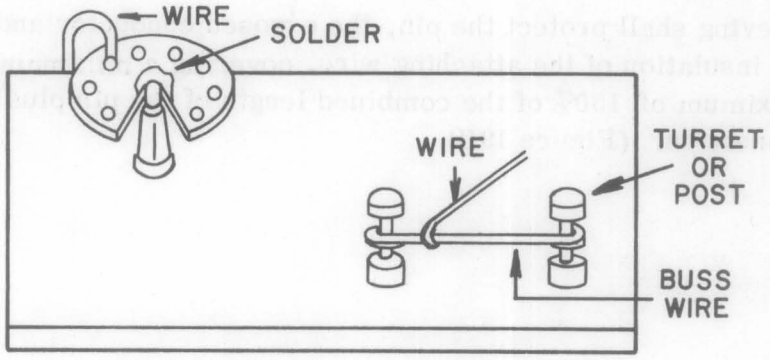


FIGURE 18

4.4 Insulation Clearance

4.4.1 Insulation clearance shall be measured from the point of wire entry to the end of the insulation. (Figure 19A)

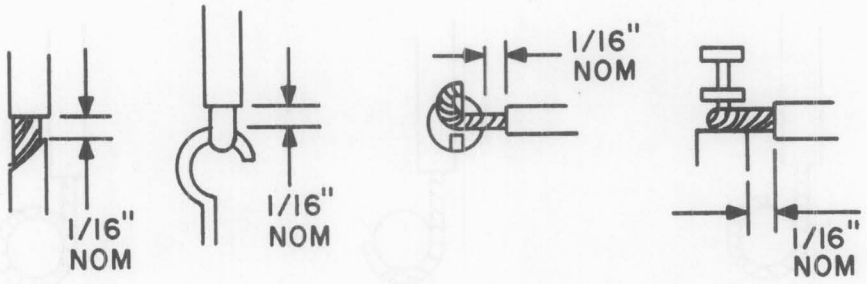


FIGURE 19A

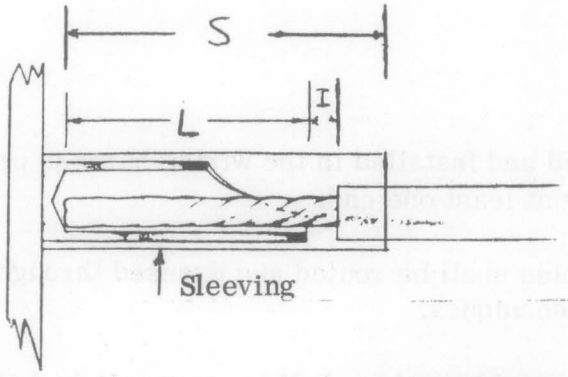
4.4.2 Insulation clearance shall be 1/32 inch minimum and 1/8 inch maximum.

4.4.3 All wires connected to the same termination must have equal insulation clearance.

4.5 Sleeving Requirements for Multi-Pin Connectors

4.5.1 Multi-pin connectors which have solder-cup pins shall require sleeving on all pins to prevent short circuits between adjacent pins.

4.5.2 Sleeving shall protect the pin, the exposed conductor and extend on to the insulation of the attaching wire, covering a minimum of 105% to a maximum of 150% of the combined length of the pin plus the solder connection. (Figure 19B)



$S = L\ (2 \times I)$

FIGURE 19B

4.5.3 Only one wire shall be permitted in each solder cup of a multi-pin connector.

4.5.3.1 Cutting of wire strands to fit a wire into a solder cup shall not be permitted and is forbidden.

4.5.3.2 Wires added to a multi-pin connector shall be avoided where possible, however, if a wire is to be added to a connector pin it shall be wrapped on the pin base observing best workmanship practices for wire wrap, wire insulation, wire routing, wire sleeving and soldering. (Figure 19C)

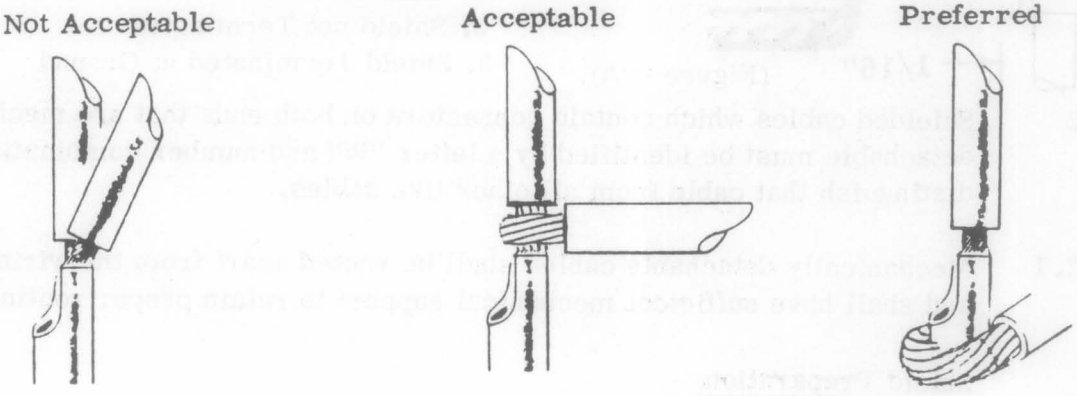


FIGURE 19C

5. SHIELDED CABLES

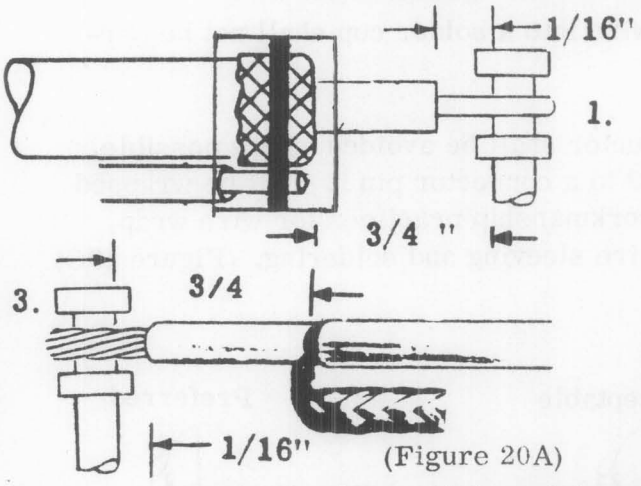
5.1 Cable Installation

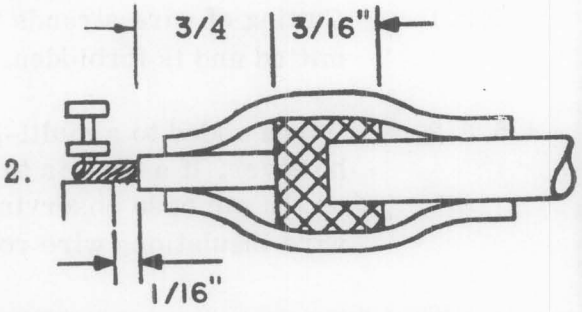
5.1.1 Shielded cables may be routed and installed in the wiring harness provided, such cables are connected by at least one end.

5.1.1.1 Coax cables and shielded cables shall be routed and dressed throughout the unit observing good routing techniques.

5.1.1.2 Terminating a coax cable or shielded cable shall be accomplished allowing a maximum exposed inner cable of 3/4 inch.

5.1.1.3 All such terminated leads shall be kept as short as possible unless mechanical or electrical design prohibits. (Figure 20A)





1. Shield Terminated with a RAYCHEM Solder Sleeve
2. Shield not Terminated
3. Shield Terminated at Ground

(Figure 20A)

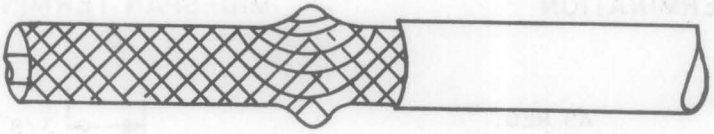
5.1.2 Shielded cables which contain connectors on both ends that are mechanically detachable must be identified by a letter "W" and number combination to distinguish that cable from all other like cables.

5.1.2.1 Mechanically detachable cables shall be routed apart from the wiring harness and shall have sufficient mechanical support to retain proper routing.

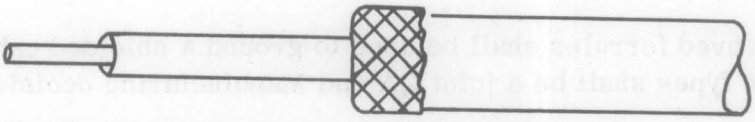
5.2 Shield Preparation

5.2.1 The metal shield in a cable must be terminated to prevent damage to the cable and give short circuit protection to adjacent connections.

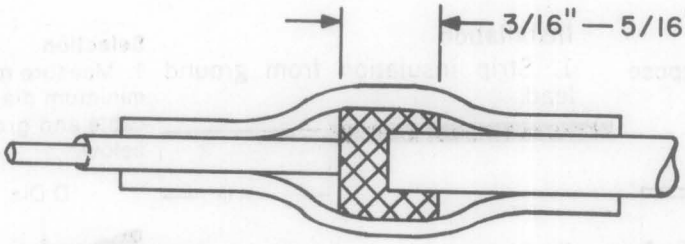
5.2.1.1 The following illustrations demonstrate the proper method of preparing the shields for terminations which will not be grounded. (Figure 20B)



1. STRIP OUTER INSULATION FROM SHIELD. HUMP SHIELD AND CUT OFF.



2. FOLD SHIELD BACK OVER JACKET.



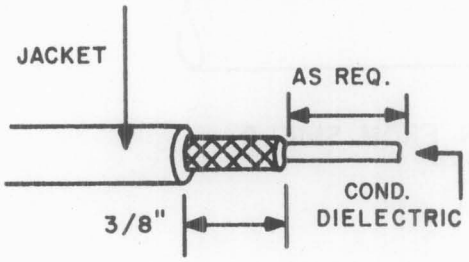
3. SLIP VINYL SLEEVING OVER TERMINATION AFTER SOAKING SLEEVING IN TOLUOI FOR APPROXIMATELY 30 MINUTES.

NOTE: THIS PROCEDURE IS TO BE FOLLOWED ONLY WHEN FERRULES CANNOT BE USED. ALL SHIELDED CONDUCTORS SHALL BE STRIPPED IN ACCORDANCE WITH THE DIMENSIONS GIVEN IN THE APPLICABLE WIRING LIST. WHERE SUCH IS NOT INDICATED, STRIP LENGTH SHALL BE AS SUITABLE FOR THE APPLICATION.

FIGURE 20B

5.2.2 Shielded cables which must be grounded may be done so by two methods, end termination, which is preferred, and mid-span termination. The type of method used depends on the RF design. (Figure 21)

END TERMINATION



MID-SPAN TERMINATION

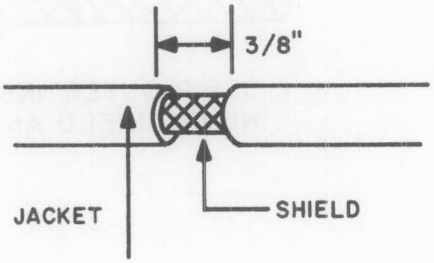


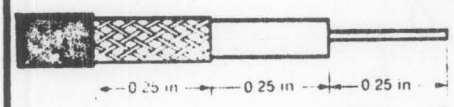
FIGURE 21

5.2.2.1 Only approved ferrules shall be used to ground a shielded cable. Approval of ferrule types shall be a joint QA and Manufacturing decision.

5.2.2.2 The following illustration demonstrates the proper method of preparing the shield and installing the ground wire on a ferrule. (Figure 22)

Strip coaxial cable

Strip the jacket and dielectric to expose the shield and center conductor as shown below.



Stripped coaxial cable.

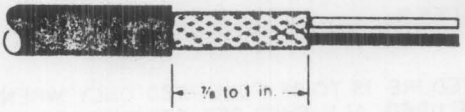
Apply Solder Sleeve Termination

Slide the sleeve termination over stripped coaxial cable. One solder ring should be over cable shield, the other one over the center conductor.

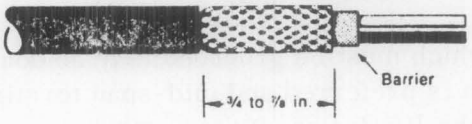
Installation

1. Strip insulation from ground lead.

2. Strip cable jacket to expose shield.

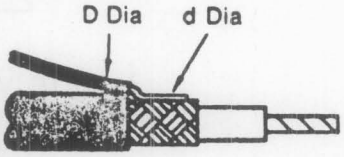


3. Insert dielectric barrier under the shield as shown below (see Raychem installation sheet AS-145 for complete instructions).



Selection

1. Measure maximum diameter (D) and minimum diameter(d) of combined cable and ground lead, as shown below.

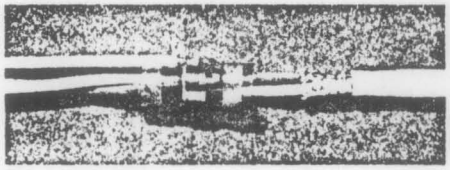


2. Find appropriate size in "Combined Diameter" column of Selection Guide.

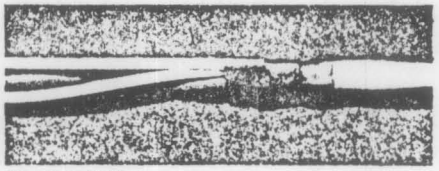
3. Depending on type of conductor, shield plating and method of heating, select proper part number from Selection Guide.

FIGURE 22

Raychem SOLDER SLEEVE® WITH PRE-INSTALLED GROUND LEAD



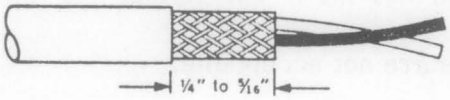
Before termination



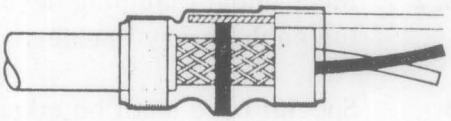
After termination

Installation

Strip shielded cable
Strip the cable jacket to expose the shield as shown below.

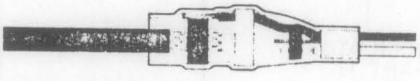


Assemble
Center Solder Sleeve termination over stripped portion of cable.



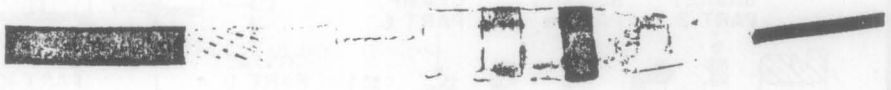
Terminate
Place the assembled unit in an infrared or hot air reflector. Heat until the tubing shrinks and the solder preform melts and flows. Inspect for a noticeable fillet of solder along the lead wire and cable shield.

Raychem COAXIAL SOLDER SLEEVE®



Solder Sleeve Termination correctly positioned on coaxial cable.

Heat the Assembly
Place the Solder Sleeve Assembly in an appropriate Raychem heating tool reflector. Center the small solder ring in the reflector and heat until solder melts and flows. Then center the other solder ring and heat until the solder melts and flows.



Cable correctly prepared for termination.

Completed termination.

5.3 Coaxial Cables

5.3.1 Coaxial cables shall be terminated at both ends by a mechanical connector or terminating device to prevent damage to the cable.

5.3.2 Coaxial cables shall be routed for maximum separation from all heat generating components and moving parts.

5.3.2.1 Coaxial cables shall be protected against tight radius bends. A bend radius of three times greater than the cable diameter must be maintained.

5.3.2.2 Mechanical clamping devices, when used, should never be permitted to deform the cable in any manner.

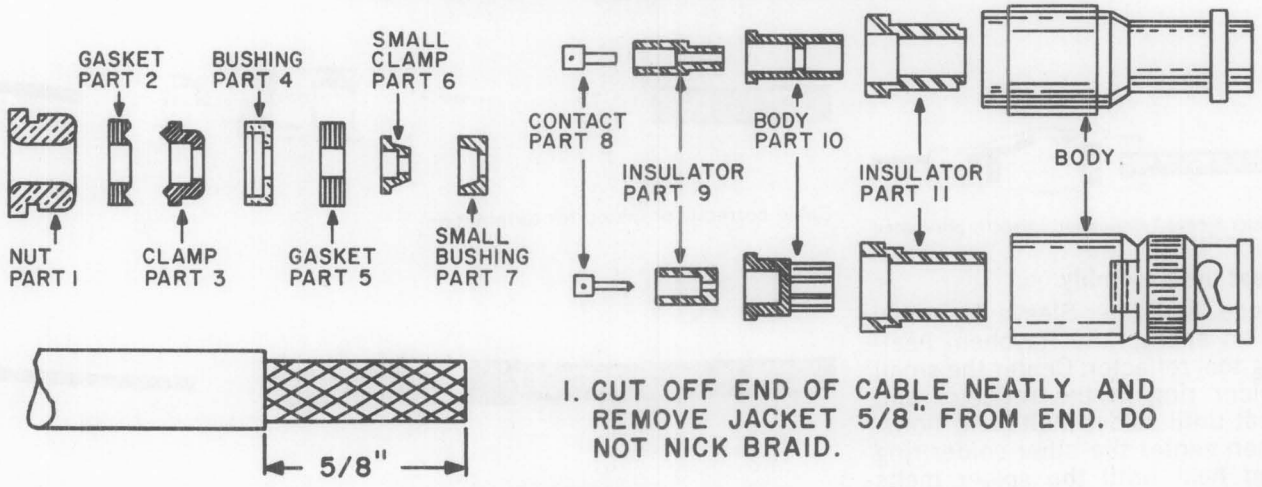
5.3.3 Special care shall be taken when routing and clamping coaxial cables in the main chassis to prevent pinching, chaffing, denting or deforming.

5.3.3.1 Coaxial cables with damaged outer jackets are not acceptable.

5.3.3.2 The metal shield shall not be visible after installation of the terminating connectors.

5.3.4 The following illustrations demonstrate the proper procedure for installing specific connectors on different types of coaxial cables. (Figure 23)

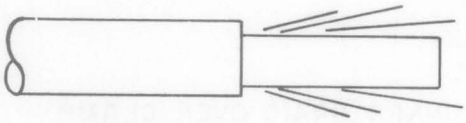
TRIAX CABLE, CONNECTION ASSEMBLY



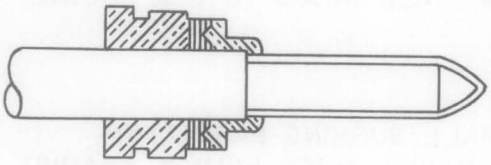
1. CUT OFF END OF CABLE NEATLY AND REMOVE JACKET 5/8" FROM END. DO NOT NICK BRAID.

FIGURE 23A

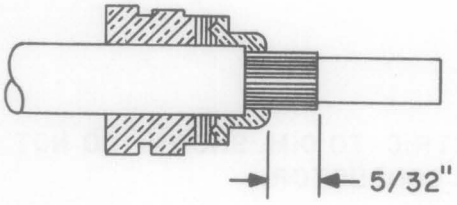
TRIAX CABLE CONTINUED



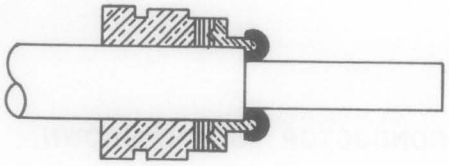
2. COMB OUT BRAID.



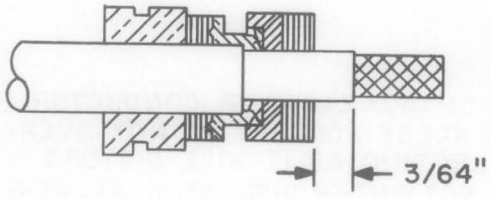
3. TAPER BRAID, SLIDE NUT, GASKET AND CLAMP OVER TAPERED BRAID MAKING SURE INNER SHOULDER OF CLAMP IS POSITIONED TIGHTLY AGAINST END OF JACKET.



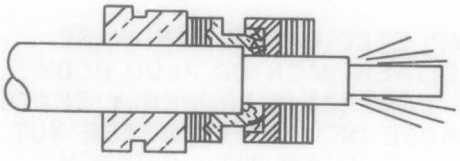
4. TRIM BRAID TO 5/32" AS SHOWN.



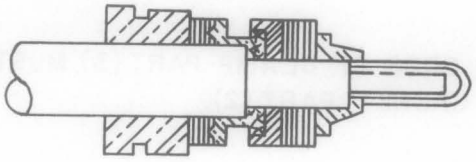
5. FLARE BACK BRAID OVER CLAMP.



6. PLACE PART (4) AND (5) IN POSITION SHOWN. REMOVE INNER JACKET TO DIM. SHOWN.



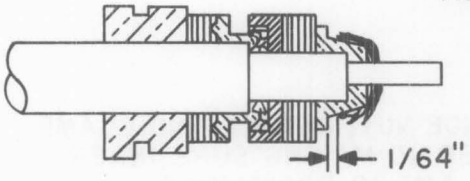
7. COMB OUT INNER BRAID.



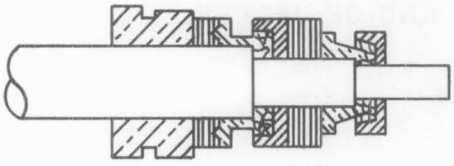
8. TAPER BRAID, SLIDE CLAMP PART (6) OVER TAPERED INNER BRAID MAKING SURE INNER SHOULDER OF CLAMP IS POSITIONED TIGHTLY AGAINST END OF INNER JACKET.

FIGURE 23A CONTINUED

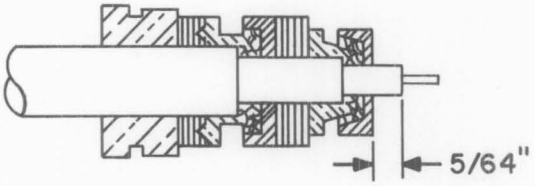
TRIAX CABLE CONTINUED



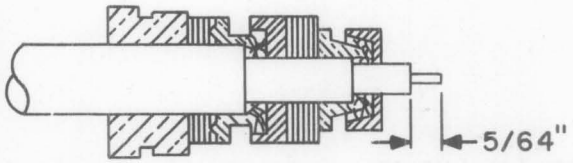
9. FOLD BACK INNER BRAID OVER CLAMP AND TRIM INNER BRAID TO DIM. SHOWN.



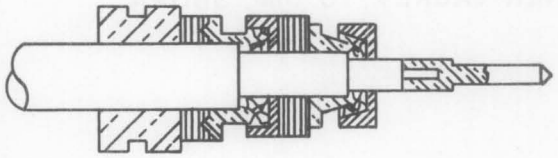
10. PLACE SMALL BUSHING PART(7) IN POSITION SHOWN. PUSH FIRMLY AGAINST BRAID.



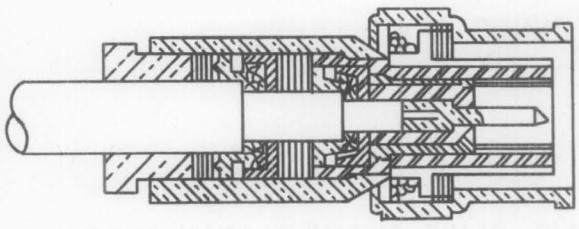
11. TRIM DIELECTRIC TO DIM. SHOWN. DO NOT NICK INNER CONDUCTOR.



12. TRIM INNER CONDUCTOR TO DIM. SHOWN.



13. SOLDER CONTACT ON INNER CONDUCTOR. REMOVE EXCESS SOLDER. DO NOT OVER-HEAT DIELECTRIC AS IT WILL DISTORT AND WILL NOT ENTER INSULATOR PROPERLY.

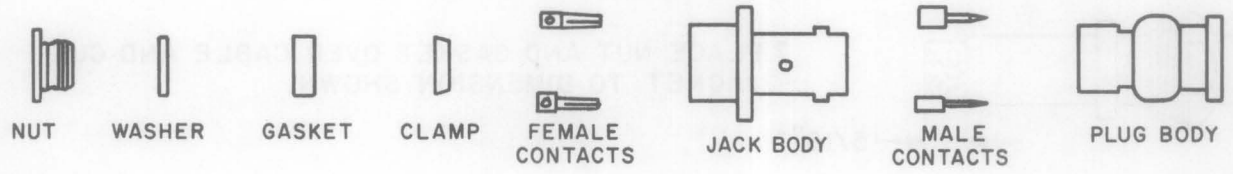


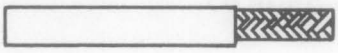
14. INSERT COMPLETED CABLE HARDWARE ASSY INTO EITHER JACK OR PLUG BODY. MAKE SURE PART (2) IS PROPERLY SEATED ON SHARP EDGE OF PART (3) AFTER NUT IS STARTED. TIGHTEN WITH WRENCH.

NOTE: SHARP EDGE OF CLAMP PART(3) MUST SPLIT GASKET PART(2).

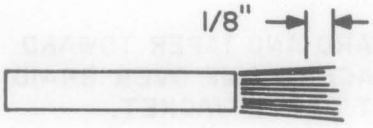
FIGURE 23A CONTINUED

BNC CONNECTOR ASSEMBLY

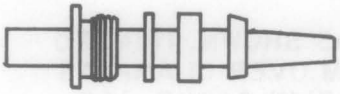




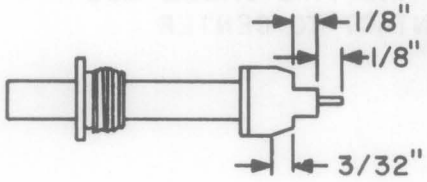
1. TRIM JACKET 19/64" FOR RG-58/U, 5/16" FOR RG-59/U OR 21/64" FOR RG-71/U.



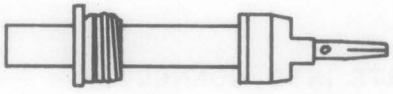
2. FRAY SHIELD AND STRIP INNER DIELECTRIC 1/8". TIN CENTER CONDUCTOR.



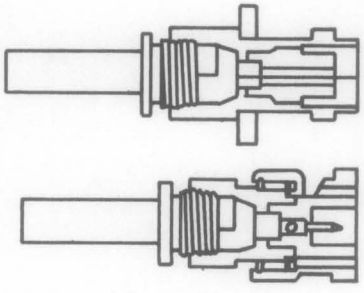
3. TAPER BRAID AND SLIDE NUT, WASHER, GASKET AND CLAMP OVER BRAID. CLAMP IS INSERTED SO THAT ITS INNER SHOULDER FITS SQUARELY AGAINST END OF CABLE JACKET.



4. WITH CLAMP IN PLACE, COMB OUT BRAID, FOLD BACK SMOOTH AS SHOWN AND TRIM 3/32" FROM END.



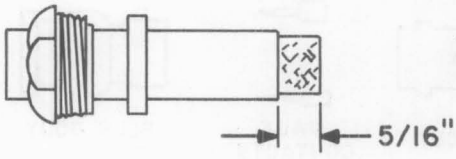
5. SLIP CONTACT IN PLACE, BUTT AGAINST DIELECTRIC AND SOLDER. REMOVE EXCESS SOLDER FROM OUTSIDE OF CONTACT. BE SURE CABLE DIELECTRIC IS NOT HEATED EXCESSIVELY AND SWOLLEN SO AS TO PREVENT DIELECTRIC FROM ENTERING INTO CONNECTOR BODY.



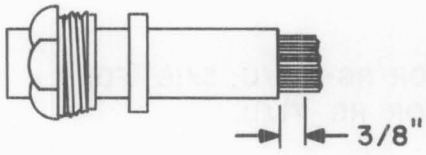
6. PUSH ASSEMBLY INTO BODY AS FAR AS IT WILL GO. SLIDE NUT INTO BODY AND SCREW IN PLACE WITH WRENCH UNTIL TIGHT. FOR THIS OPERATION, HOLD CABLE AND SHELL RIGID AND ROTATE NUT.

FIGURE 23A CONTINUED

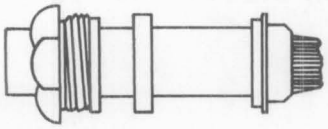
BNC CONNECTOR CONTINUED



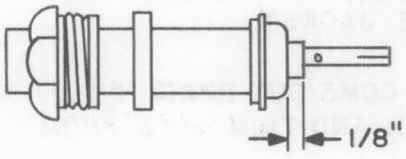
7. PLACE NUT AND GASKET OVER CABLE AND CUT JACKET TO DIMENSION SHOWN.



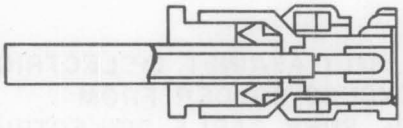
8. COMB OUT BRAID AND FOLD OUT. CUT CABLE DIELECTRIC TO DIMENSION SHOWN.

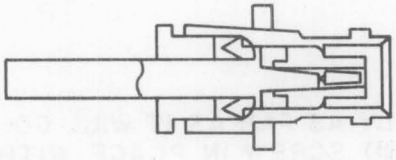


9. PULL BRAID WIRES FORWARD AND TAPER TOWARD CENTER CONDUCTOR. PLACE CLAMP OVER BRAID AND PUSH BACK AGAINST CABLE JACKET.



10. FOLD BACK BRAID WIRES AS SHOWN, TRIM TO PROPER LENGTH AND FORM OVER CLAMP AS SHOWN. FOR RG-62 AND 71/U CABLE ADD BUSHING. SOLDER CONTACT TO CENTER CONDUCTOR.





11. INSERT CABLE AND PARTS INTO CONNECTOR BODY. MAKE SURE SHARP EDGE OF CLAMP SEATS PROPERLY IN GASKET. TIGHTEN NUT.

FIGURE 23A CONTINUED

5.4 Pull Test Methods

5.4.1 Crimped or swaged terminals shall be tested for proper assembly by referring to the applicable sections of MIL-STD-202B, "Test Methods for Electronic and Electrical Component Parts."

5.4.2 The quantity of terminals to be tested and the acceptable number of failed components shall be determined by referring to MIL-STD-105, "Sampling Procedures and Tables for Inspection by Attributes." Results of test shall be entered in the "Pull Test Methods Log".

5.4.3 Unless otherwise specified, Test Condition "A" shall be used as outlined in MIL-STD-202B Method 211.

5.4.3.1 Method of Holding. - The method of holding or clamping shall be accomplished as specified in the individual specification for the specific connector.

EXAMPLE: Connector PIN P/N PBM20-1 shall be inserted into the connector body and clamped in a vise with a 6 inch length of wire supporting the test load.

5.4.3.2 Applied Force. - The force applied to the terminal shall be 1/2, 1, 2, 3, 5, 10, or 20 pounds, as specified by the individual manufacturers' specifications.

EXAMPLE: Connector PIN P/N PBM20-1 shall be capable of supporting 3-1/2 pounds or 56 ounces.

5.4.3.3 Direction of Applied Force. - The point of application of the force and the force applied shall be in the direction of the axes of the terminations, as shown in Figure 23B.

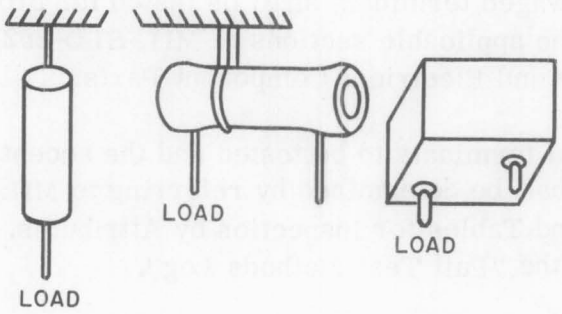


FIGURE 23B

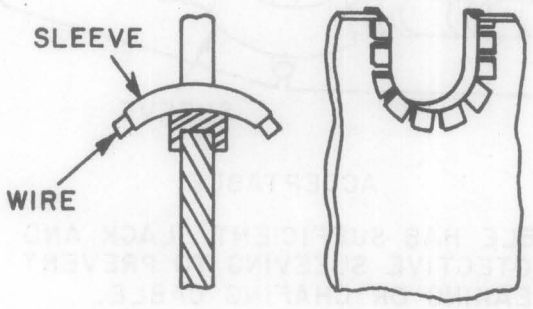
5.4.3.4 Duration of Applied Force. - The force shall be applied gradually to the terminal and then maintained for a period of 5 to 10 seconds.

6. ABRASION PROTECTION

6.1 Insulation Protection

6.1.1 Insulated wire, shielded wire, or coaxial cable shall not be bent around or over sharp corners or edges without proper abrasion protection.

6.1.1.1 When wires and cables must be routed across a sharp edge, suitable protective material shall be used. (Figure 24)

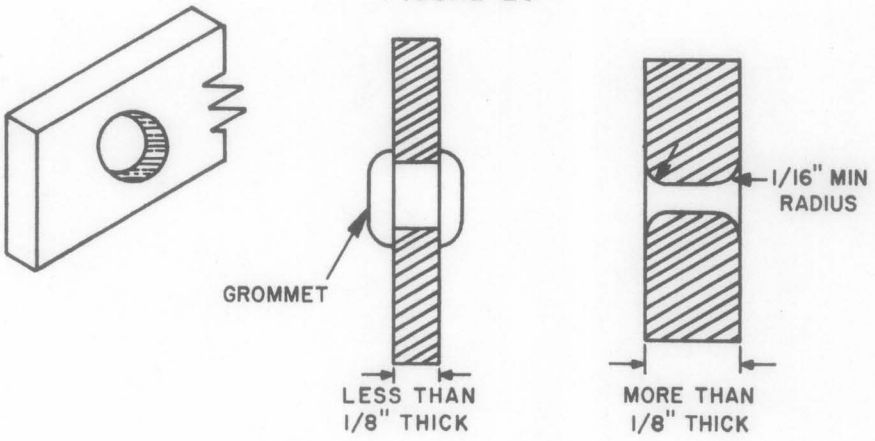


NOTCH OR CUTOUT SHOWING CATERPILLAF GROMMET MATERIAL.

FIGURE 24

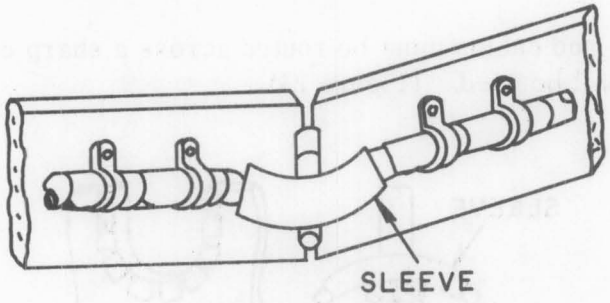
6.1.1.2 Wires passing through the chassis shall be protected by means of a grommet, sleeving or chamferred edges. (Figure 25)

FIGURE 25



6.1.1.3 Wires and cables routed over a hinged area shall be protected by sleeving. (Figure 26)

FIGURE 26



ACCEPTABLE

CABLE HAS SUFFICIENT SLACK AND PROTECTIVE SLEEVING TO PREVENT BREAKING OR CHAFING CABLE.

7. CABLE TYING AND CLAMPING

7.1 Tie Wraps

7.1.1 Wires and cables grouped into a harness shall be retained by a MIL approved tie wrap, such as Thomas & Betts Model 23M and 24M.

7.1.1.1 Tie wraps shall be installed tightly enough to prevent slipping, but shall not cut into or deform the insulation of any conductor. (Figure 27)

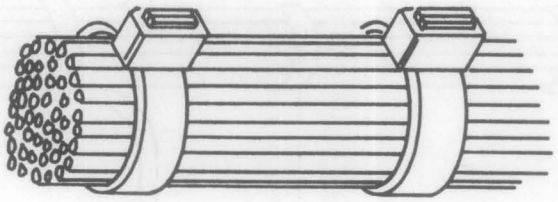


FIGURE 27

7.1.1.2 Tie wraps shall be oriented such that after installation the locking devices lie to one side or the other in the harness.

7.1.1.3 An approved hand operated wrapping tool, which automatically cuts and applies the proper tension, shall be used to install all tie wraps.

7.1.2 Criteria for tie wrap spacing:

7.1.2.1 When a single conductor breakout occurs, a tie wrap must be placed just prior to that breakout. (Figure 28)

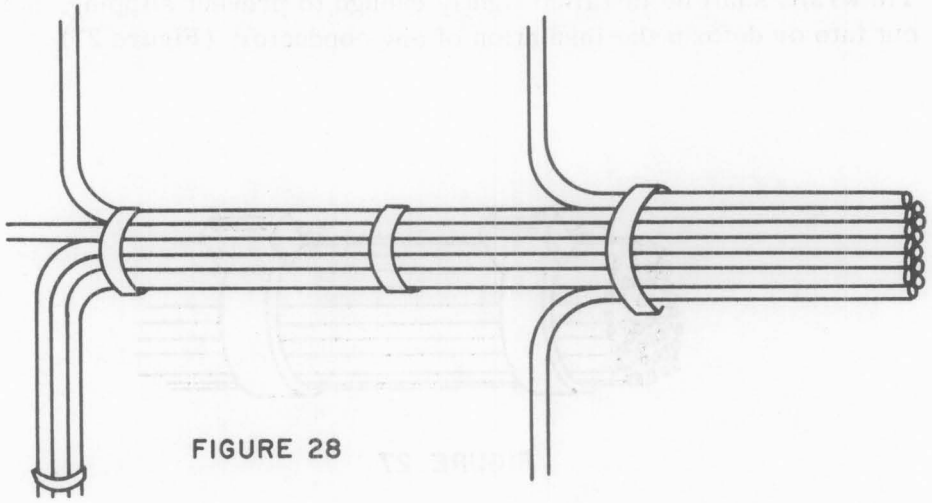


FIGURE 28

7.1.2.2 When a major branch or breakout occurs, a tie wrap must be placed just prior to and directly after that branch or breakout.

7.1.2.3 Along a straight run of harness, tie wraps shall be equally spaced with a maximum of three inches between wraps.

7.1.2.4 A tie wrap shall be placed just before and directly after all bends in the wiring harness. (Figure 29)

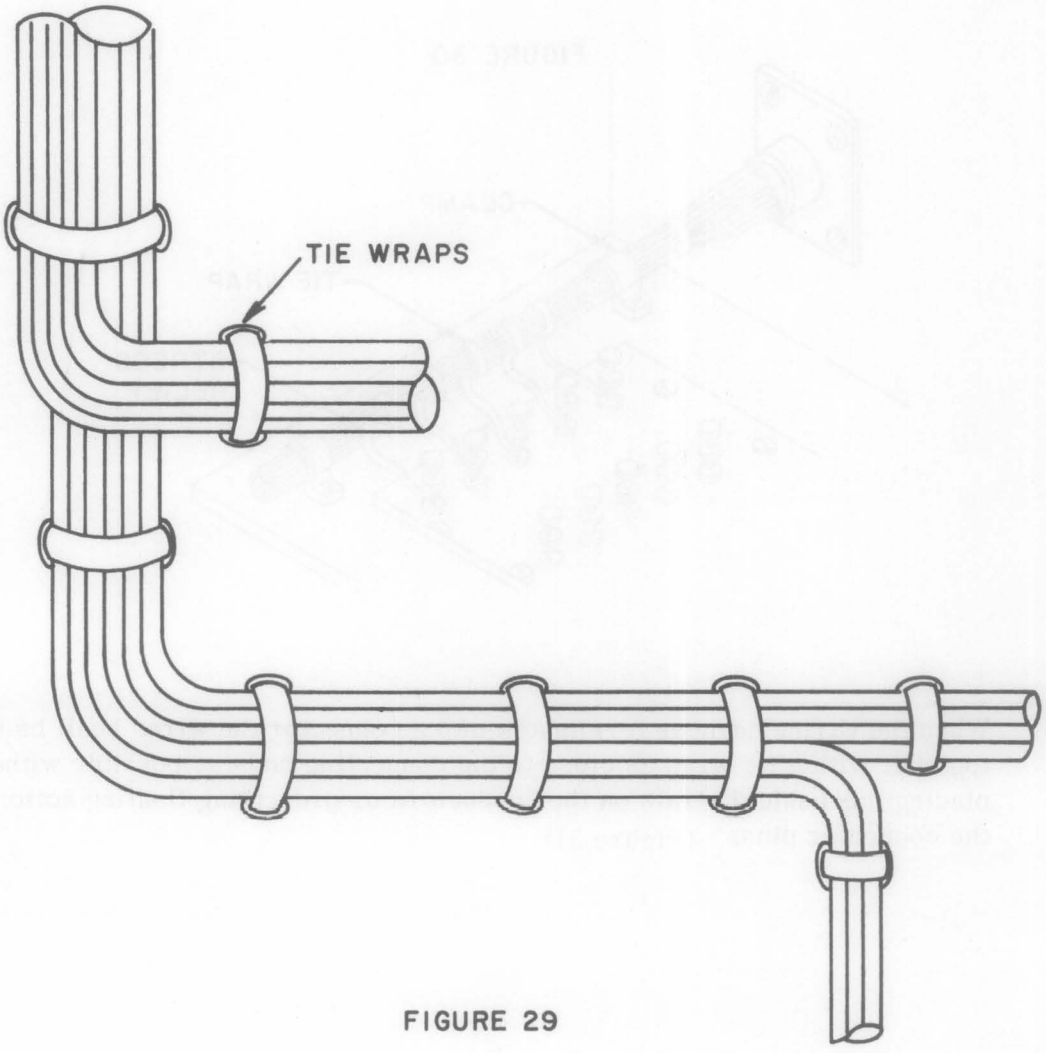
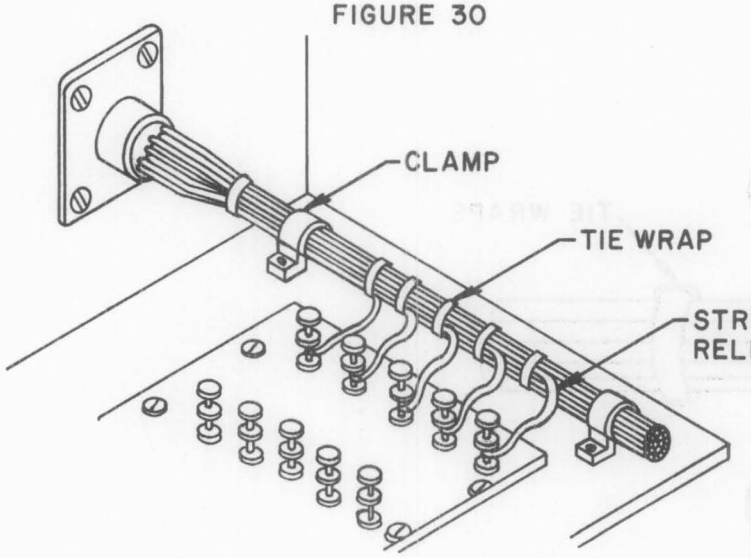


FIGURE 29

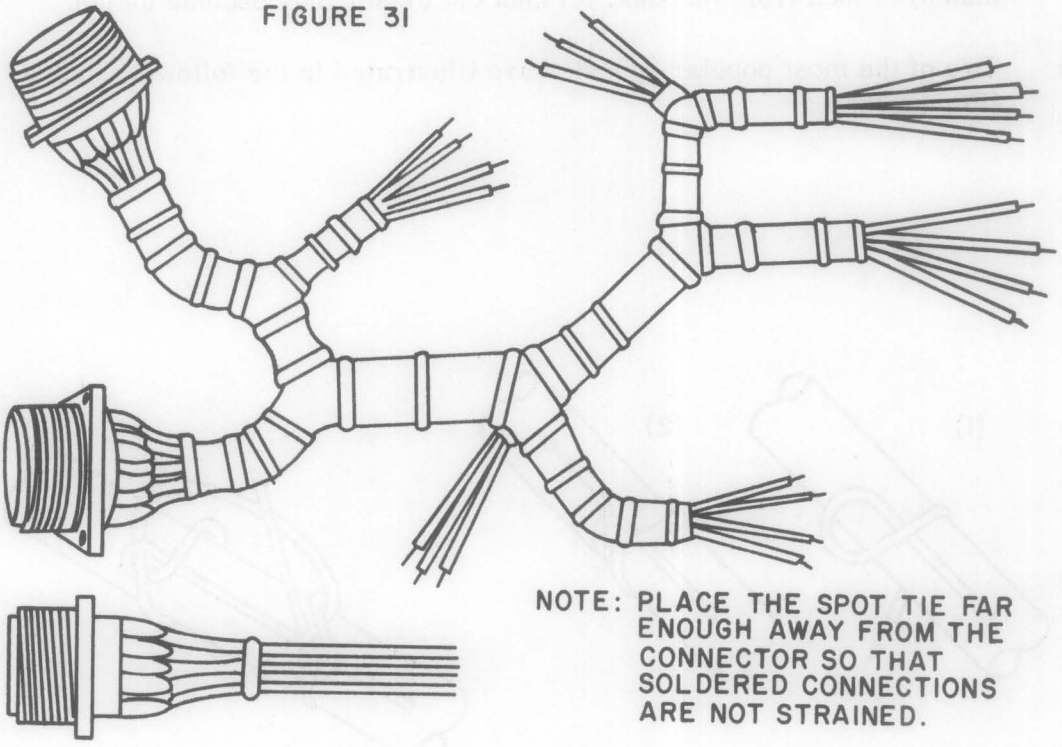
7.1.2.5 When multiple breakouts occur along a short area, such as connections to a terminal board, a tie wrap shall be placed just prior to the first breakout and along equal intervals allowing no more than one inch of unwrapped conductor to be loose from the harness. (Figure 30)

FIGURE 30



7.1.2.6 When the wiring harness terminates into a connector the wires shall be bound together with a tie wrap as close to the connecting ends as possible without placing mechanical strain on the conductors or preventing floating action of the connector pins. (Figure 31)

FIGURE 31



NOTE: PLACE THE SPOT TIE FAR ENOUGH AWAY FROM THE CONNECTOR SO THAT SOLDERED CONNECTIONS ARE NOT STRAINED.

7.2 Cable Lacing and Spot Tying

7.2.1 The use of individual spot-ties in electronic equipment is preferred over the running stitch method as field servicing can be expedited by the removal and replacement of spot-ties only in the affected area.

7.2.1.1 Black nylon lacing cord (ribbon type) shall be used in preference to round cord. This will reduce the possibility of cutting into the wire insulation or having the spot-ties become loose in handling.

7.2.1.2 All spot-ties shall be on the under side of the harness where possible.

7.2.1.3 Spot-ties shall be evenly spaced and tight in order to prevent movement of the individual wires. The spot-tie shall not compress the wires.

7.2.1.4 Spot-tie surplus shall not be cut closer than 1/8 inch from the knot or longer than 3/16 inch from the knot. A knot cut closer may become untied.

7.2.1.5 Two of the most popular spot-ties are illustrated in the following figure. (Figure 32)

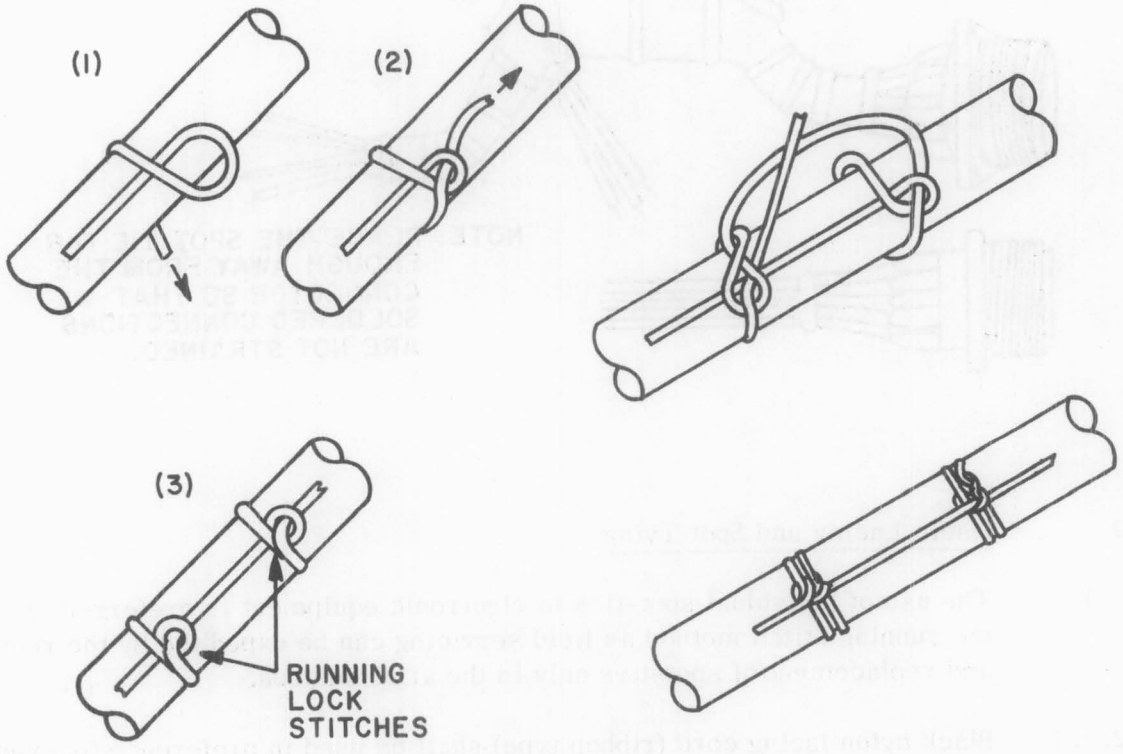


FIGURE 32

7.2.1.6 Spacing of spot-ties shall be in accordance with the same established criteria as set for tie wraps, as outlined in paragraph 7.1.2.

7.3 Cable Clamps

7.3.1 Wires and cable harnesses shall be securely retained in their respective position under normal service conditions of shock and vibration by a positive holding device which is capable of being easily released or removed to allow for repair.

7.3.1.1 The size of a cable clamp shall be determined by its application with regard to width and length required.

7.3.1.2 Only an approved type of cable clamp such as T&B Ty-TXXX, Tyg-34M or a preformed plastic loop type, shall be used.

7.3.1.3 A cable clamp shall not compress or deform wires or cables in any manner.

7.3.1.4 Cable clamps shall not be placed directly over an existing cable tie wrap as extensive damage to the wires may result.

7.3.1.5 Location of cable clamps shall be as outlined in the following procedures and diagrams:
Place a cable clamp directly before any 90^{o} bend of the harness. (Figure 33)

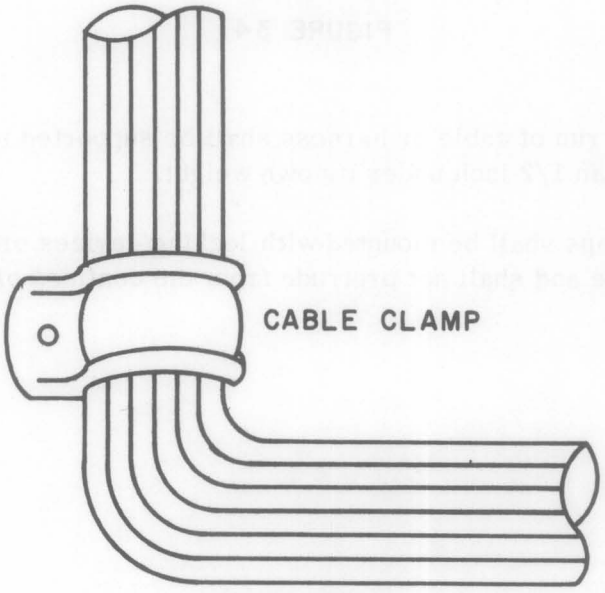


FIGURE 33

When a cable harness separates into two major branches, a cable clamp must be placed just prior to the separation and on each individual branch after any bend. (Figure 34)

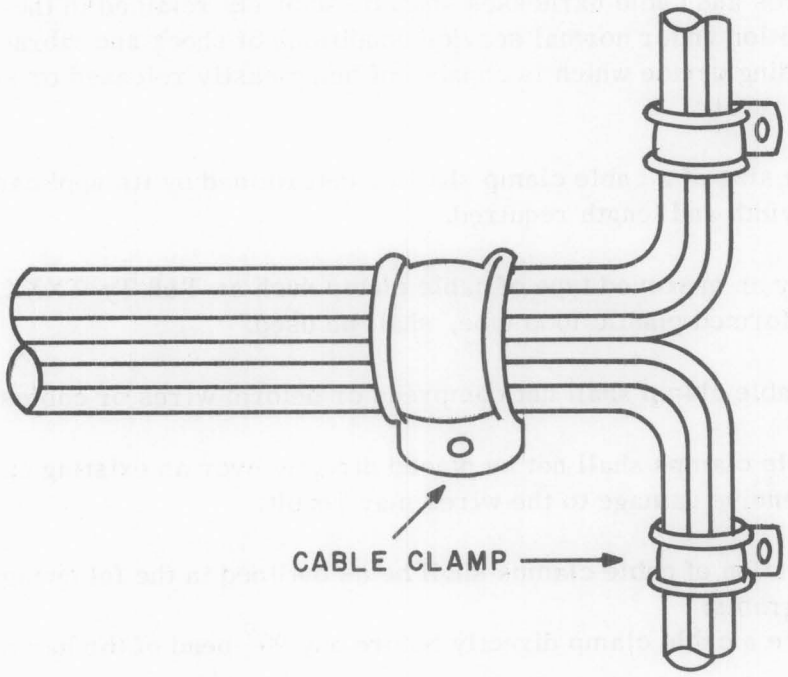


FIGURE 34

A straight run of cable or harness shall be supported to prevent sagging of more than 1/2 inch under its own weight.

Cable clamps shall be mounted with locking devices oriented to the side of the cable and shall not protrude from the confines of the unit.

8. SOLDERLESS TERMINALS

8.1 Swage or Crimp

8.1.1 Solderless terminals which are swaged or crimped are designed to accommodate wires that have been stripped but not tinned. Wires must be cut to the desired length prior to swaging or crimping.

8.1.1.1 Solderless terminals used shall be in accordance with MS25036 standards and shall be UL, CSA certified.

8.1.1.2 The use of a terminal with an insulator grip is preferred wherever practical.

8.1.1.3 Terminals with uninsulated grips shall be protected with sleeving which fits tightly over the terminals. A tie wrap may be used to prevent slippage.

8.1.1.4 Only the proper crimping tools specified by the terminal manufacturer shall be used.

8.1.1.5 The swage or crimp shall be made entirely on the barrel or grip of the terminal with proper tension to secure and retain the wire(s). (Figure 35)

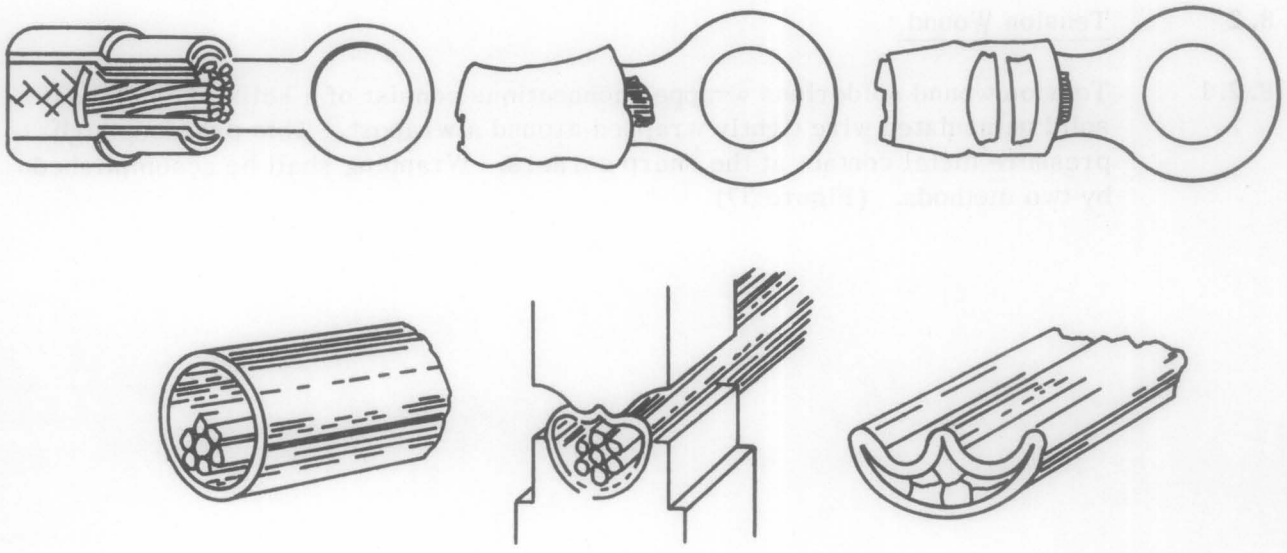


FIGURE 35

8.1.1.6 The bare conductor shall be flush with the sight (inspection) hole or shall extend 1/16 inch maximum into the tongue.

8.1.1.7 The wire insulation shall extend into the insulated grip with no bare wire visible after swaging.

8.1.1.8 The gap between the wire insulation and the end of the barrel shall not exceed 1/16 inch on uninsulated terminals. (Figure 36)

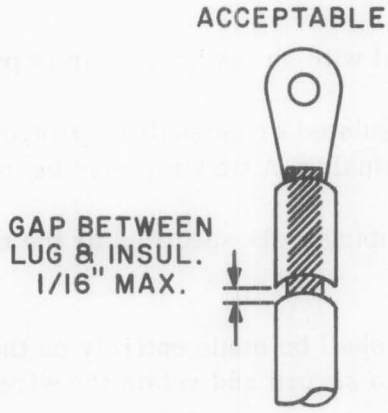
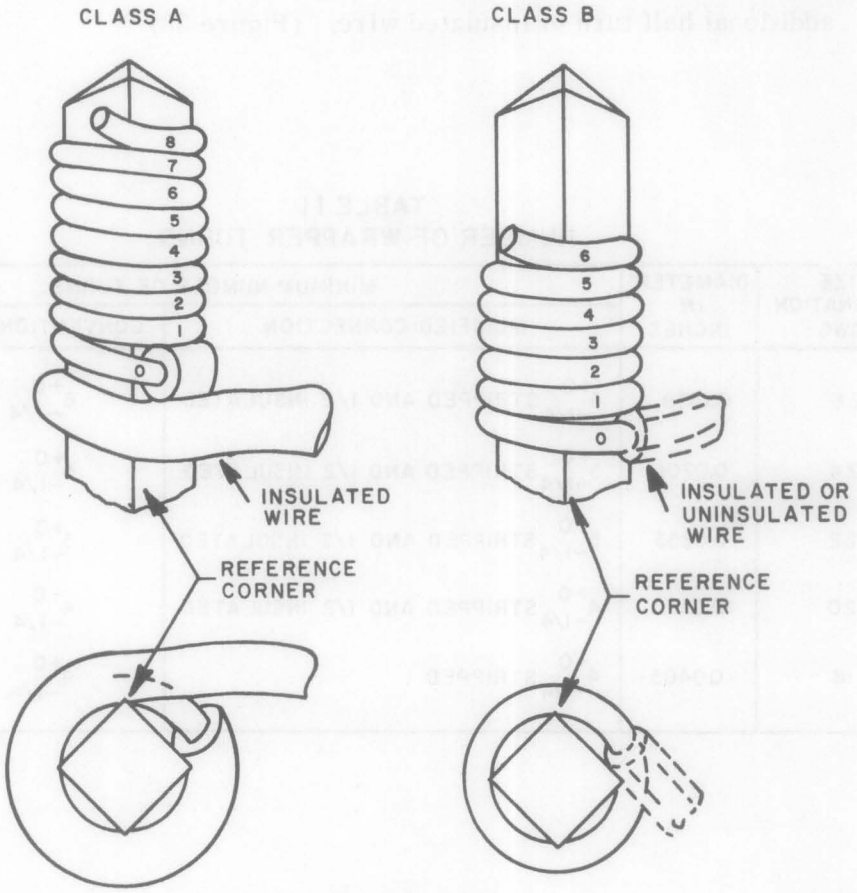


FIGURE 36

8.2 Tension Wound

8.2.1 Tension wound solderless wrapped connections consist of a helix of continuous solid uninsulated wire tightly wrapped around a wrapost. This produces high pressure metal contact at the sharp corners. Wrapping shall be accomplished by two methods. (Figure 37)



SOLDERLESS WRAPPED CONNECTIONS ON A SQUARE WRAP POST.

FIGURE 37

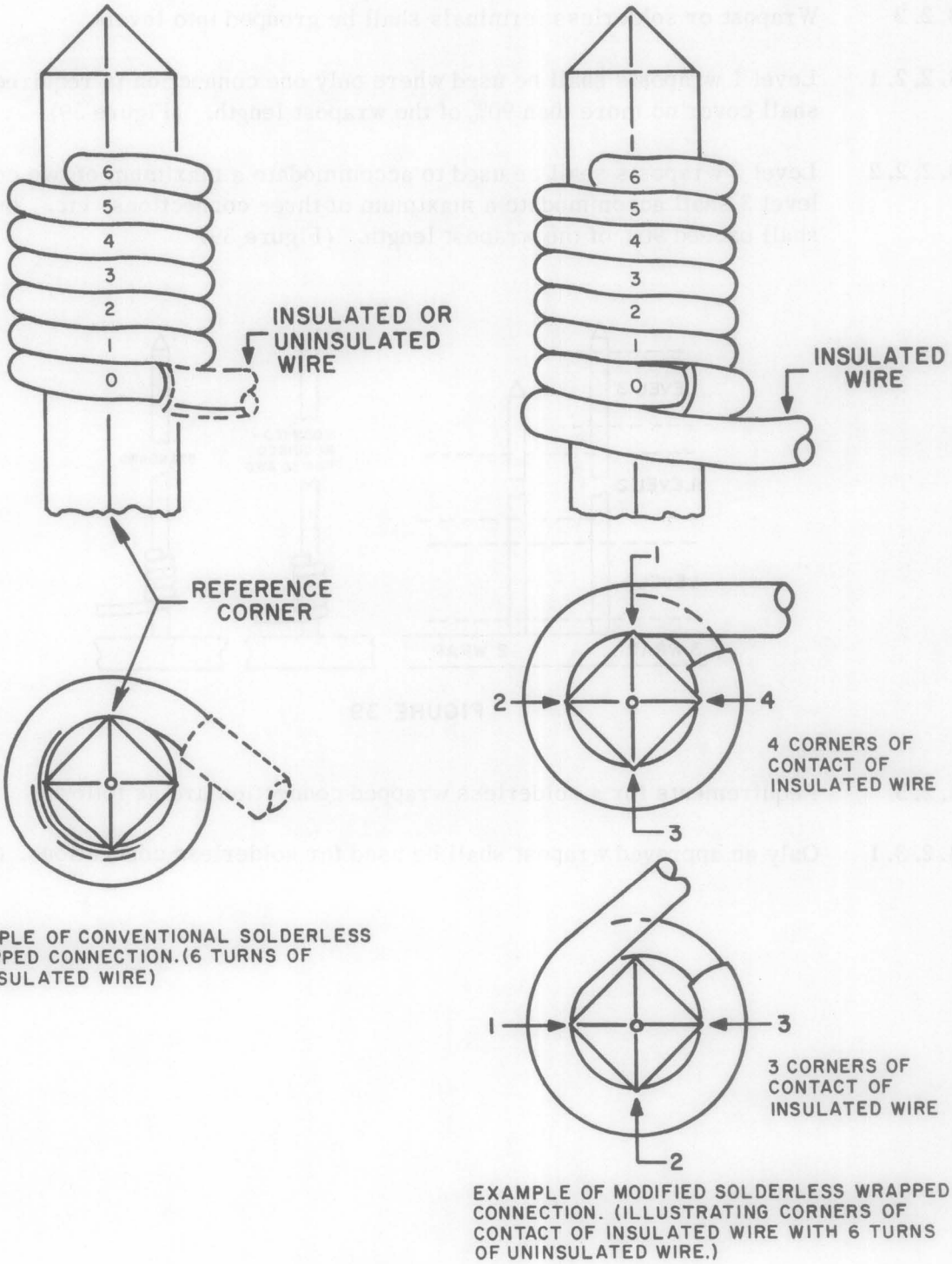
8.2.1.1 Class A (modified solderless wrapped connection). This wrap shall consist of the number of turns as specified by Table II, with an additional, minimum, half turn of insulated wire to be wrapped around the wrapost to insure better vibration characteristics. A half turn shall contact at least three corners of the wrapost. (Figure 38)

8.2.1.2 Class B (conventional solderless wrapped connection). This wrap shall also consist of the number of turns as specified by Table II, but without the additional half turn of insulated wire. (Figure 38)

TABLE II
NUMBER OF WRAPPER TURNS

SIZE DESIGNATION AWG	DIAMETER IN INCHES	MINIMUM NUMBER OF TURNS	
		MODIFIED CONNECTION	CONVENTIONAL CONNECTION
26	0.0159	$6^{+0}_{-1/4}$ STRIPPED AND 1/2 INSULATED	$6^{+0}_{-1/4}$ STRIPPED
24	0.0201	$5^{+0}_{-1/4}$ STRIPPED AND 1/2 INSULATED	$5^{+0}_{-1/4}$ STRIPPED
22	0.0253	$5^{+0}_{-1/4}$ STRIPPED AND 1/2 INSULATED	$5^{+0}_{-1/4}$ STRIPPED
20	0.0320	$4^{+0}_{-1/4}$ STRIPPED AND 1/2 INSULATED	$4^{+0}_{-1/4}$ STRIPPED
18	0.0403	$4^{+0}_{-1/4}$ STRIPPED	$4^{+0}_{-1/4}$ STRIPPED

TITLE: Main Chassis Assembly and Wiring



EXAMPLE OF CONVENTIONAL SOLDERLESS WRAPPED CONNECTION. (6 TURNS OF UNINSULATED WIRE)

EXAMPLE OF MODIFIED SOLDERLESS WRAPPED CONNECTION. (ILLUSTRATING CORNERS OF CONTACT OF INSULATED WIRE WITH 6 TURNS OF UNINSULATED WIRE.)

FIGURE 38

8.2.2 Wrapost or solderless terminals shall be grouped into levels.

8.2.2.1 Level 1 wraposts shall be used where only one connection is required and shall cover no more than 90% of the wrapost length. (Figure 39)

8.2.2.2 Level 2 wraposts shall be used to accommodate a maximum of two connections, level 3 shall accommodate a maximum of three connections, etc., but none shall exceed 90% of the wrapost length. (Figure 39)

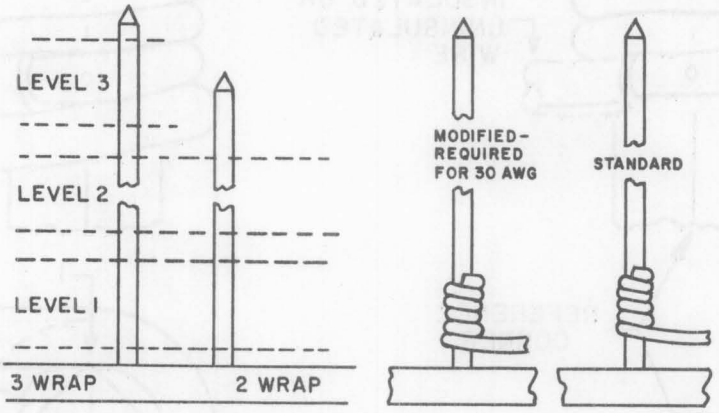
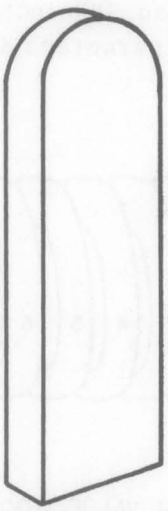


FIGURE 39

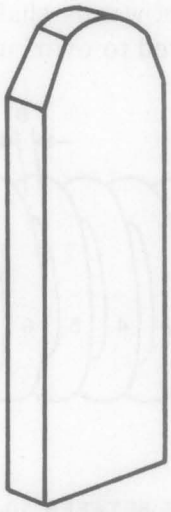
8.2.3 Requirements for a solderless wrapped connection are as follows:

8.2.3.1 Only an approved wrapost shall be used for solderless connections. (Figure 40)

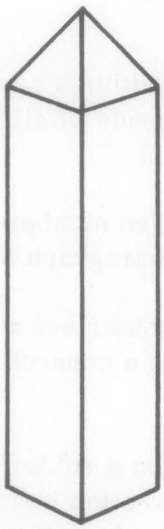
COMMON TIP CONFIGURATIONS



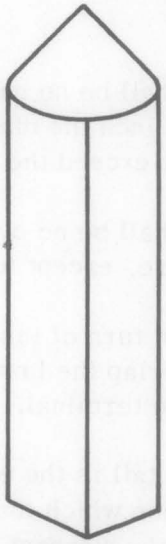
RADIUS



SEMI-RADIUS



PYRAMID

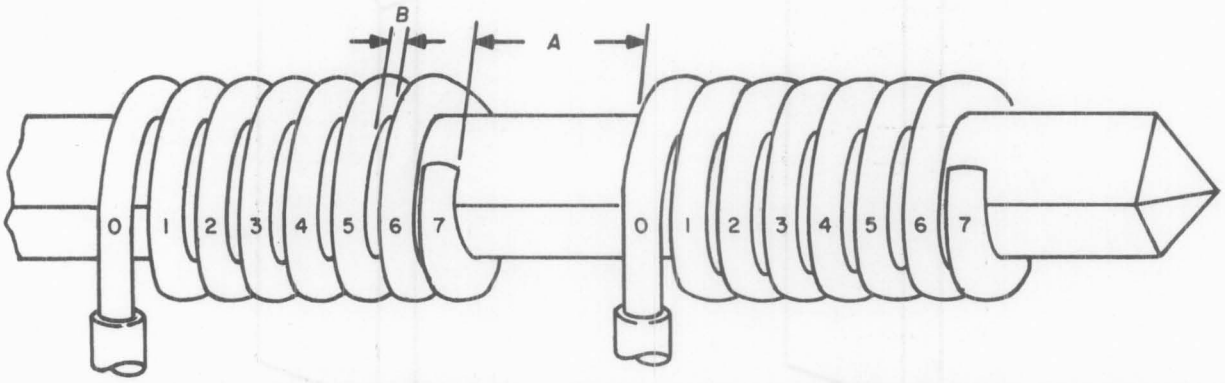


CONICAL

FIGURE 40

8.2.3.2 . The use of a round wrapost is permitted, but all wraps must be soldered.

8.2.3.3 Solderless wraps shall be distributed by placing the first wrap at the base of the wrapost and each successive wrap placed in a stacking configuration. Adjacent wraps shall not be spaced greater than .005 inch and may be permitted to overlap by conditions outlined in paragraph 8.2.3.6. (Figure 41)



A. SPACE ALLOWANCE BETWEEN ADJACENT CONNECTIONS. (TYPICAL VALUE, 0.005 IN.; ALLOWANCE MAY BE REDUCED TO ACCOUNT FOR STATISTICAL VARIATION IF NECESSARY. IF THE OVERLAP PERMITTED IN PARAGRAPH 8.2.3.6 IS THE PRACTICE IN A GIVEN APPLICATION, THIS BECOMES A NEGATIVE ALLOWANCE.)

B. SPACE ALLOWANCE BETWEEN ADJACENT TURNS WITHIN A CONNECTION. (TYPICAL VALUE, 1/2 THE WIRE DIAMETER MAXIMUM.)

FIGURE 41

8.2.3.4 There shall be no gaps between adjacent turns within a connection greater than 1/2 inch the diameter of the wire, and the sum of all gaps on any side shall not exceed the wire diameter. (Figure 41)

8.2.3.5 There shall be no overlapping within the specified number of turns of uninsulated wire, except for the conditions stated in paragraph 8.2.3.6, below.

8.2.3.6 The first turn of insulated wire in a modified solderless wrapped connection may overlap the last turn of uninsulated wire in a connection below it on the same terminal.

8.2.3.7 The end tail is the end of the last turn of wire on a solderless wrapped connection which may extend in a tangential direction instead of resting against the wrapost and shall not extend greater than the wire diameter. (Figure 42)

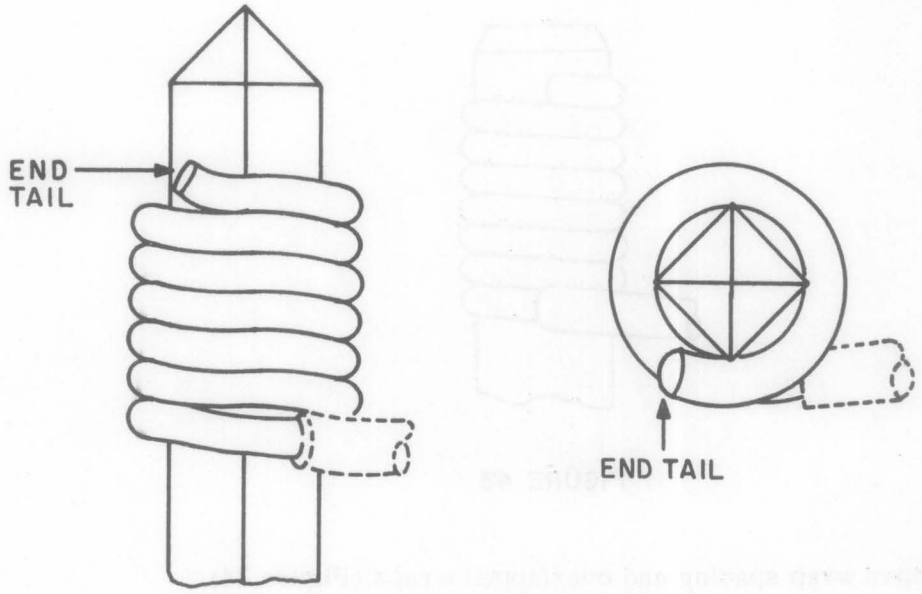


FIGURE 42

8.2.3.8 Rewrapping that portion of the wire that has been previously wrapped on a wrapost is not permitted.

8.2.3.9 Wraps can be made on the same portion of a wrapost from which a previously made solderless wrapped connection has been unwrapped. This may be done provided the wrapost is undamaged.

8.2.4 Visual inspection of solderless wrapped connections shall be made for the following reject criteria.

8.2.4.1 No insulation or insufficient insulation wrap for modified wraps. (Figure 43)

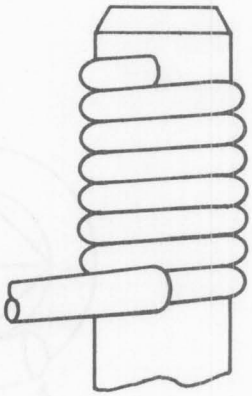


FIGURE 43

8.2.4.2 Improper wrap spacing and overlapped wraps (Figure 44).

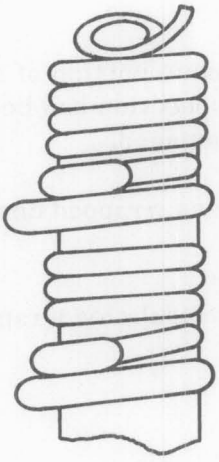


FIGURE 44

8.2.4.3 Insufficient number of wrap turns as specified by Table II (Figure 45).

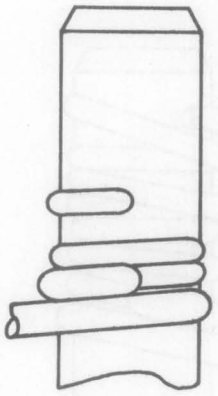


FIGURE 45

8.2.4.4 End tail not conforming to the requirements of paragraph 8.2.3.7 (Figure 46).

FIGURE 46

8.2.4.5 Overlapped turns within the specified minimum (Figure 47).

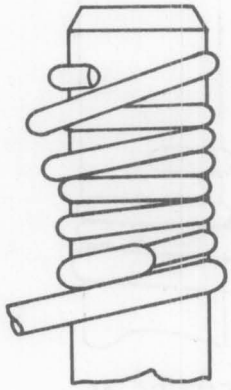


FIGURE 47

8.2.4.6 Spacing between adjacent turns within the connection (Figure 48).

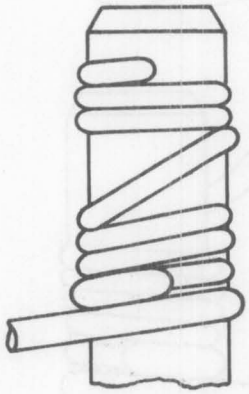


FIGURE 48

9. SPECIFIC WIRING TECHNIQUES

9.1 Buss Wiring

9.1.1 Buss wiring within the main chassis shall be accomplished by following the wiring criteria outlined in "Sub Chassis Assembly and Wiring," paragraph 4.4, pages 21 through 23.

9.2 Rotary Switches

9.2.1 Rotary switches shall be constructed in sections called wafers or decks and shall be labeled alphabetically, starting with wafer "A" nearest the mounting end. (Figure 49)

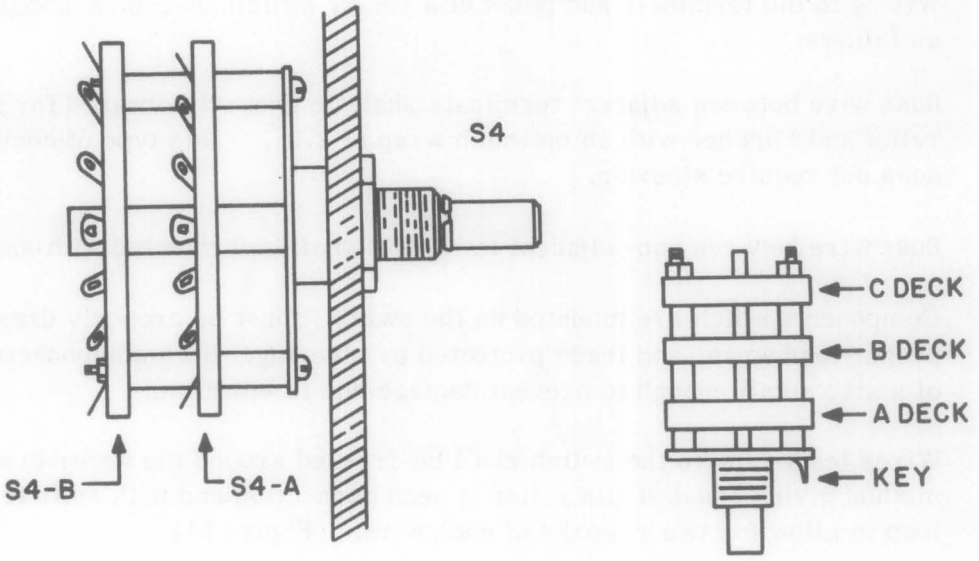


FIGURE 49

9.2.2 Each wafer shall be divided into sections and shall contain terminals and poles. Terminals shall be labeled with numbers starting with No. 1 and continuing around the wafer in a counterclockwise direction, as viewed from the rear of the switch. (Figure 50)

WAFER SWITCHES

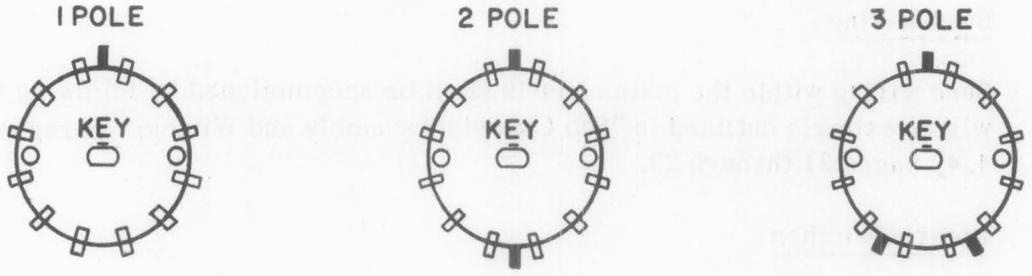


FIGURE 50

9.2.3 Wiring to the terminals and poles of a rotary switch shall be accomplished as follows:

9.2.3.1 Buss wire between adjacent terminals shall be properly dressed for stress relief and clinched with an optimum wrap of 270°. This type of connection does not require sleeving.

9.2.3.2 Buss wire between non-adjacent terminals shall be protected with sleeving.

9.2.3.3 Components which are mounted on the switch must be properly dressed with proper lead wrap, and leads protected by sleeving. Such components shall be of a size small enough to prevent damage due to vibration.

9.2.3.4 Wires leading up to the switch shall be dressed around the wafer in a spiral method giving equal strain relief to each connection and with sufficient service loop to allow for two reworks of each wire. (Figure 51)

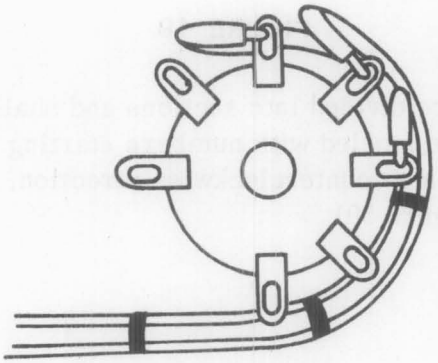


FIGURE 51

9.2.3.5 When shielded cables are used on a wafer switch, a common tie point shall be used for grounding or terminating the shields.

9.3 Slide Switch

9.3.1 Equipment designed to operate from multi-power sources shall be provided with a slide switch for rapid change of power requirements.

9.3.2 Slide switches shall be constructed in a manner to prevent accidental changing of voltage and shall be mounted in an area accessible without removing any equipment covers.

9.3.3 Wires to a slide switch shall be routed and dressed with a sufficient amount of service loop to allow for two reworks of each wire and shall be clinched with an optimum 270^{o} wrap.

9.3.4 Terminals of a slide switch shall be protected with sleeving to prevent short circuit conditions.

9.4 Potentiometers

9.4.1 Potentiometers shall be mechanically secured to prevent movement during adjustment.

9.4.2 Wiring to the terminals of a potentiometer shall be accomplished with respect to the manufacturer's terminal designations. (Figure 52)

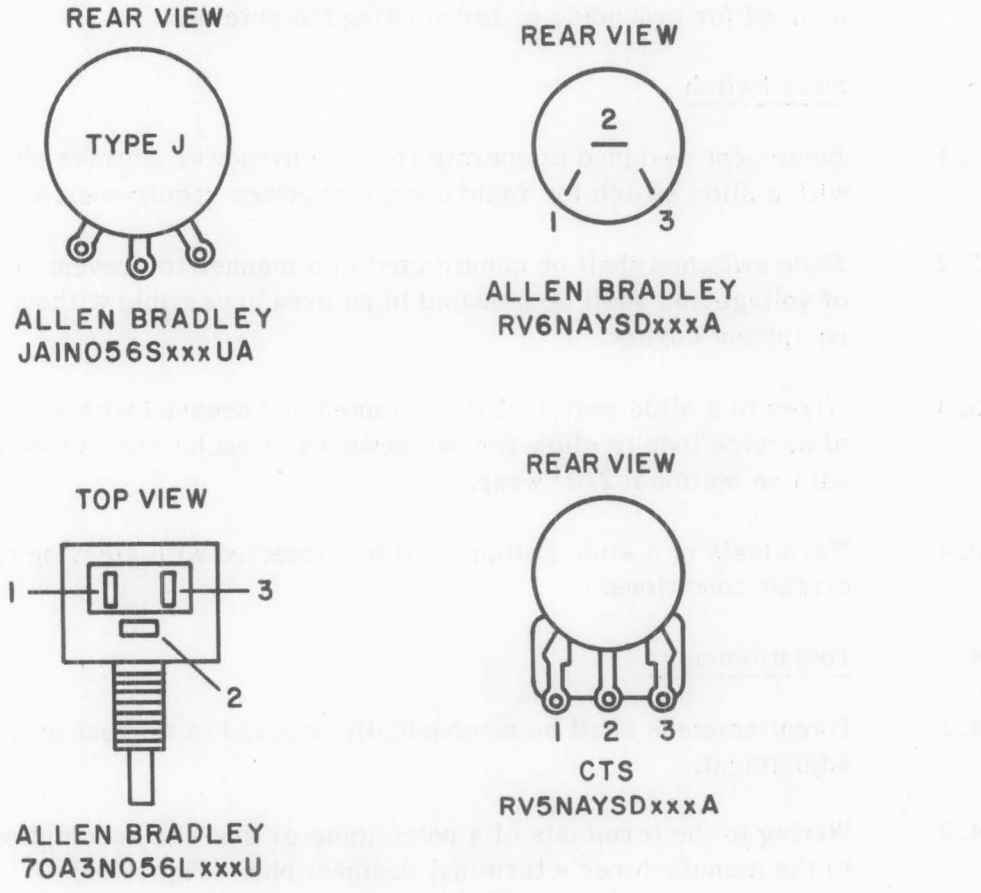


FIGURE 52

9.4.3 Wires shall be dressed to the terminals of a potentiometer with sufficient service loop to allow for two reworks of each wire and shall be clinched with an optimum 270° wrap.

9.5 Fuseholder

9.5.1 Each piece of equipment which operates from an ac line voltage source shall be equipped with a safety fuse constructed to handle replacement cartridge type fuses. The fuseholder shall be located in an accessible area on the unit.

9.5.2 Wiring to the fuse terminals shall be routed and dressed with sufficient service loop to facilitate two reworks per wire and give equal stress relief from the cable harness.

9.5.3 The fuseholder shall be mechanically secured to prevent movement and shall be identified on the chassis with a letter and number combination and value of the replacement fuse. Fuseholders used to house spare fuses shall be identified as a spare.

9.5.4 After wiring, cartridge type fuseholder assemblies shall be protected with sleeving secured in place with a tie wrap. This sleeving shall encompass the entire fuseholder assembly.

9.6 Power Switch

9.6.1 Power switches shall be mechanically mounted on the front panel using dress hardware and shall be actuated mechanically outside the unit by means of a rotary, toggle, slide or pushbutton mechanism.

9.6.2 Wires to the power switch shall be routed and dressed to allow for two reworks per connection.

9.6.3 Terminals of a power switch shall be insulated with sleeving to prevent shorting.

9.7 Hinged Assemblies

9.7.1 Hinged assemblies shall be mechanically retained in the normal operating position by approved mechanical locking devices, such as push-locks or camlocks.

9.7.2 When a printed circuit board is an integral part of a hinged assembly, the PC board shall be mounted to the assembly by means of an edge board connector.

9.7.3 Hinged PC boards shall be mechanically retained in the operating position by means of mounting hardware or quick-release lock devices and shall not be deformed in any manner by the retaining device.

9.7.4 Wires and cables shall be dressed and routed in such a manner as to allow the hinged assembly to be extended to its extreme position, and shall be secured with cable clamps to prevent strain on the cable harness.

9.7.5 When the cable harness terminates into a hinged assembly, the cable shall be routed parallel with the hinge and clamped prior to the first breakout of the cable.

9.7.6 In a straight run of cable harness the wires may break out to a hinged assembly, provided such wires are properly dressed with adequate strain relief. (Figure 53)

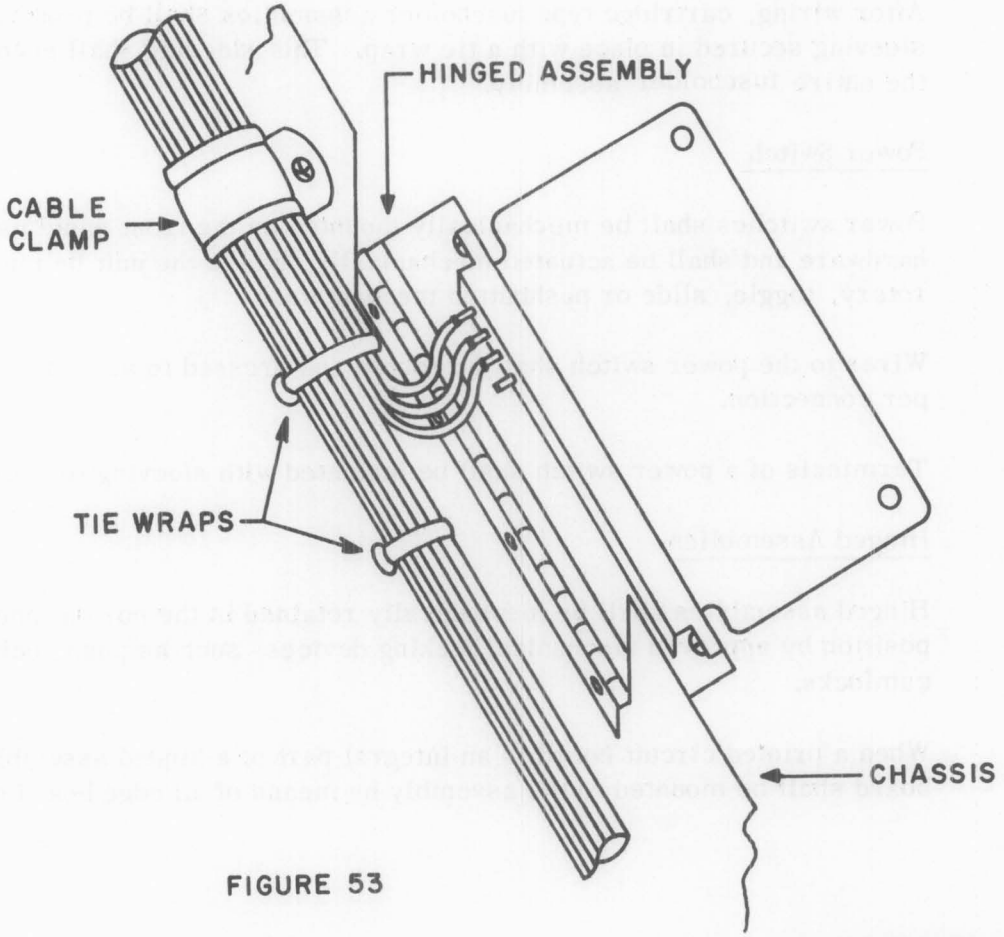
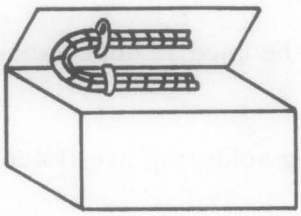
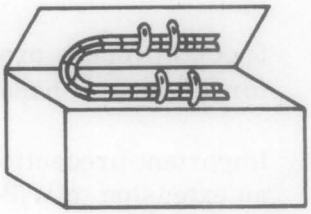


FIGURE 53

9.7.7 Cables which make a 180° bend on a hinged assembly shall be secured at both sides of the bend with a service loop between clamps equal to ten times the cable diameter. (Figure 54)



1. SHORT BEND ON HINGED DOOR.
2. ONE CLAMP EACH SIDE.



1. LONG LOOP (10 x CABLE DIA.) ON HINGED DOOR.
2. TWO CLAMPS EACH SIDE WITH HEAVY CABLE.

FIGURE 54

10. MAIN CHASSIS SOLDERING, GENERAL

10.1 Solder Connections

10.1.1 A good solder connection will provide a positive electrical and a strong mechanical bond of parts and will be accomplished per the following procedures:

10.1.1.1 Special process procedure WJP-1010 shall be used as acceptance criteria for all general hand soldering.

10.1.1.2 Important precautions to be followed during soldering are listed here as an extension to WJP-1010.

Wires or leads must be properly wrapped and clipped before soldering, and will not be reclipped after soldering.

After wrapping of the wires or leads, rigid support must be maintained to prevent movement of parts during the soldering process.

10.2 Inspection Criteria

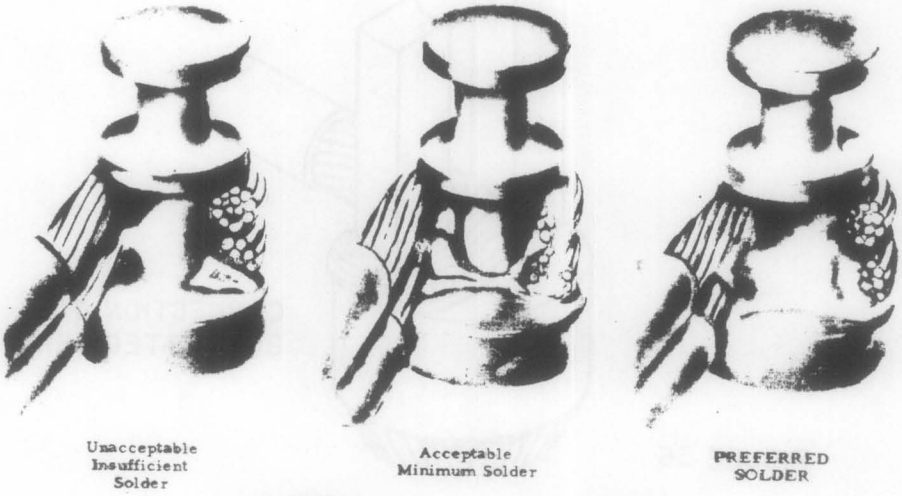
10.2.1 All solder connections will be inspected 100% for quality characteristics.

10.2.1.1 The use of soldering aids or other tools to exert force on wires or leads to inspect the connection will not be permitted.

10.2.1.2 Bending or pulling of wires or components to determine the security of a connection can cause a serious reliability hazard. Visual inspection in most cases will be adequate.

10.2.2 The quality and reliability of a solder connection can be determined by the following visual characteristics:

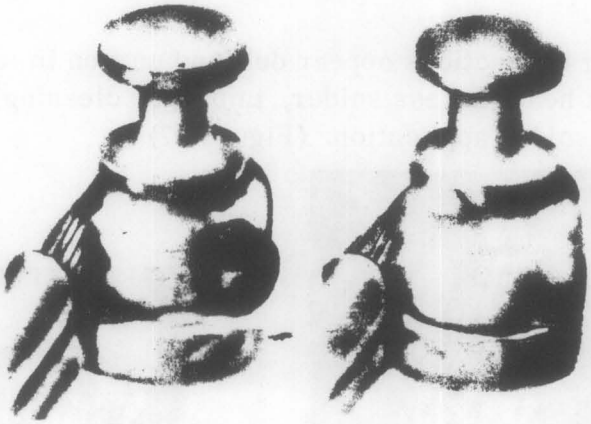
10.2.2.1 Good solder connections will appear shiny and smooth with a fillet from the lead to the terminal. (Figure 55)



Unacceptable Insufficient Solder

Acceptable Minimum Solder

PREFERRED SOLDER



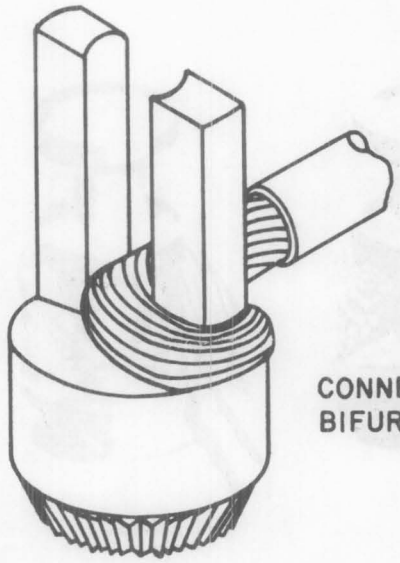
Acceptable Maximum Solder

Unacceptable Excessive Solder

FIGURE 55

10. 2. 2. 2 A minimum quantity of solder should be used to cover the lead and should allow the lead contour to be visible.

10. 2. 2. 3 A solder connection shall not rely on solder alone, a good mechanical wrap must be incorporated. (Figure 56)



CONNECTION TO BIFURCATED TERMINAL

FIGURE 56

10. 2. 2. 4 Cold solder connections appear dull and uneven in texture, caused by insufficient heat, excess solder, improper cleaning, or movement during the solder application. (Figure 57)

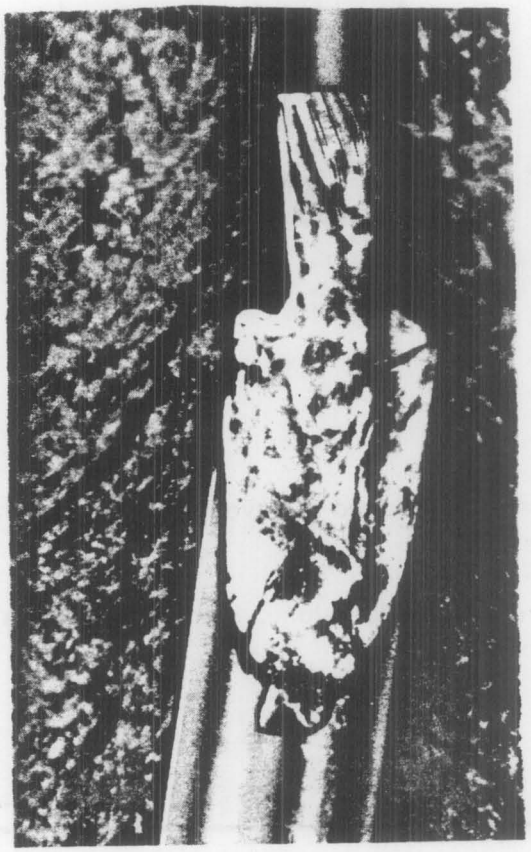


FIGURE 57

10.2.3 Ground soldering of component leads to the chassis shall be accomplished using a large wattage iron placing the majority of the heat to the chassis and sufficient heat to the component lead to insure uniform flow of solder to form a smooth even fillet. (Figure 58)

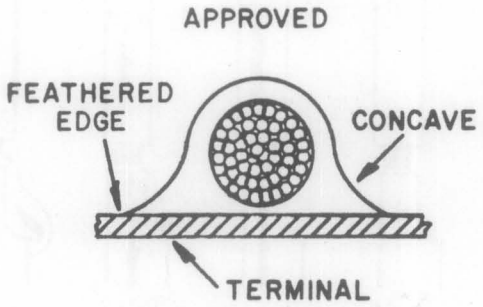
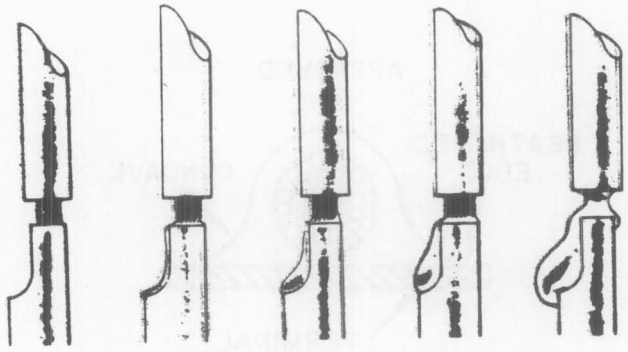


FIGURE 58

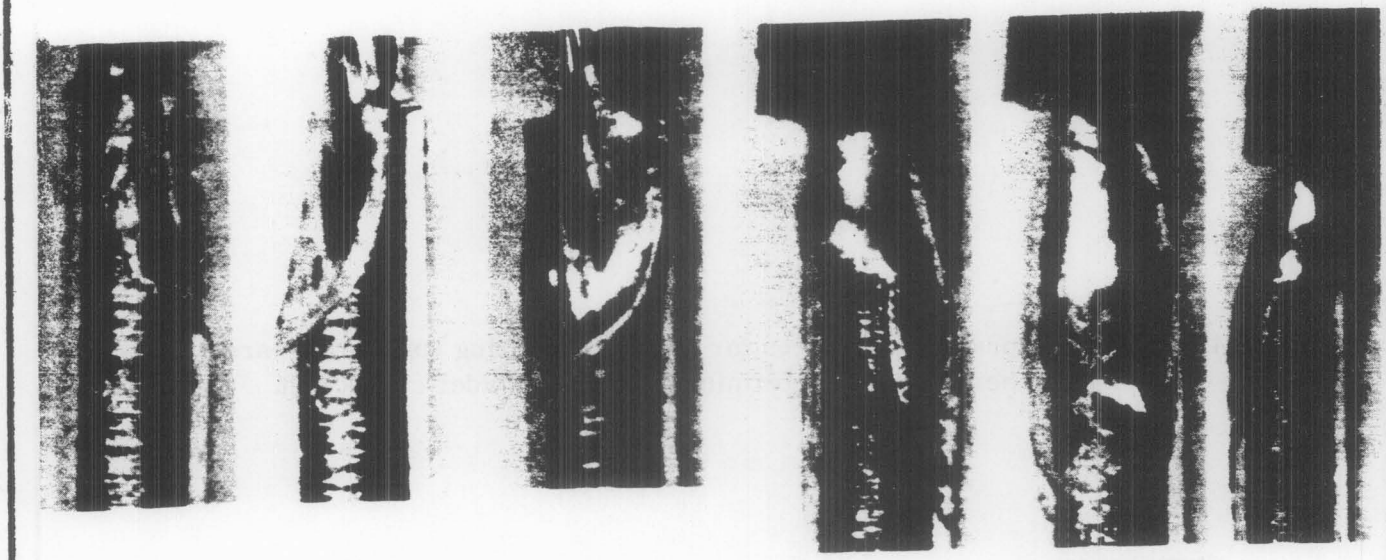
10.2.4 Illustrations and techniques for specific soldering applications are included here to aid in determining a proper solder connection.

TITLE: Main Chassis Assembly and Wiring

Minimum and maximum solder build up.



Min Standard Max



MINIMUM MAXIMUM

WATKINS – JOHNSON CO.

WJ

WORKMANSHIP STANDARDS

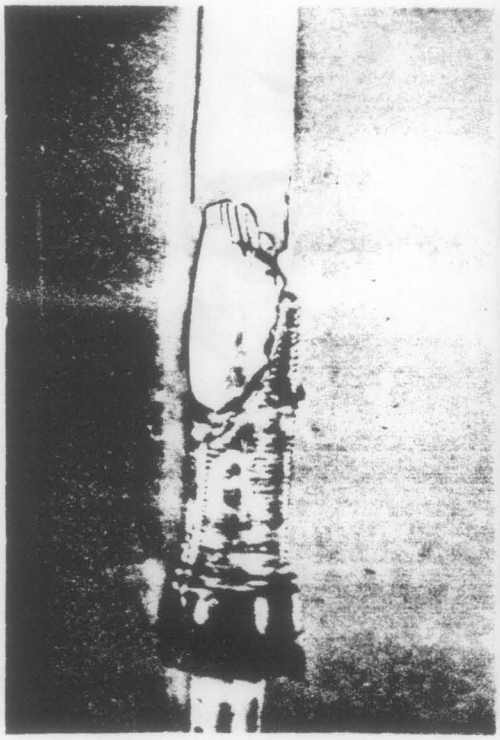
ISSUE DATE 11/1/73 REVISION NO. _____

ORIGINATED BY D Smith AND R Stelter

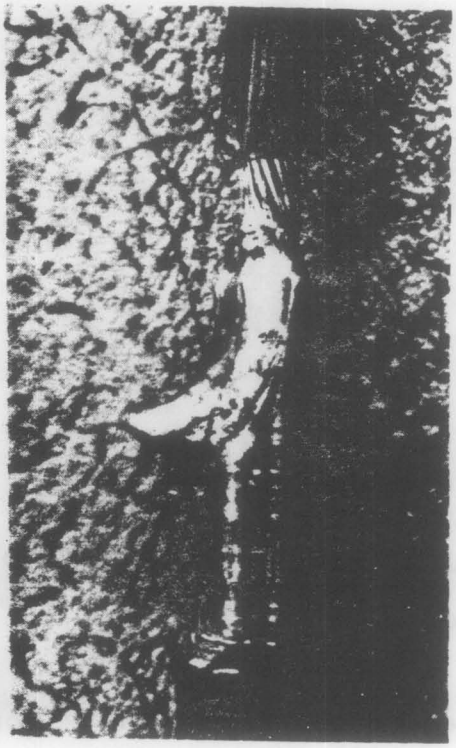
APPROVED BY B Wright

TITLE: Main Chassis Assembly and Wiring

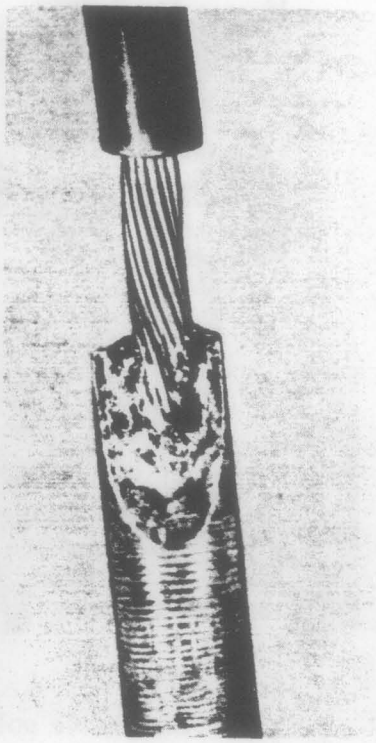
UNACCEPTABLE JOINTS



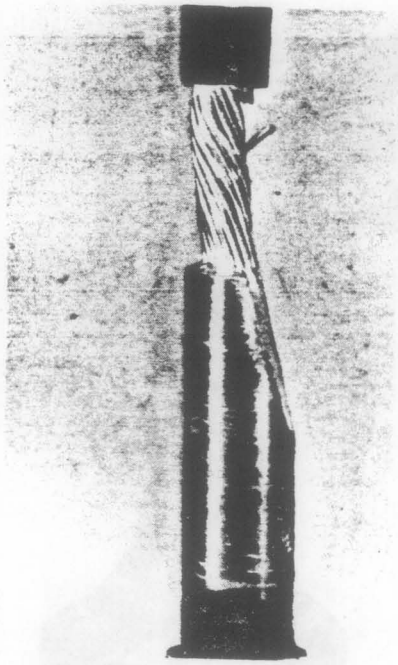
ROSIN JOINT



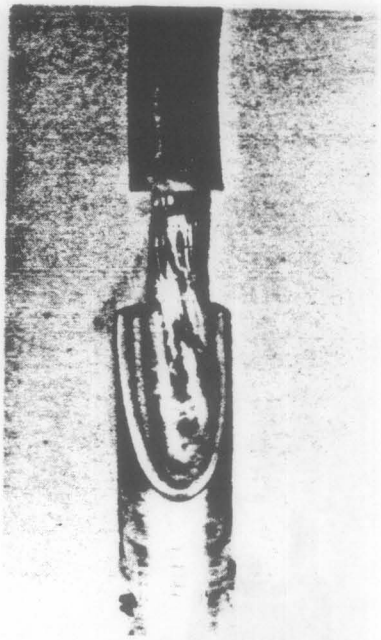
SOLDER PROJECTION



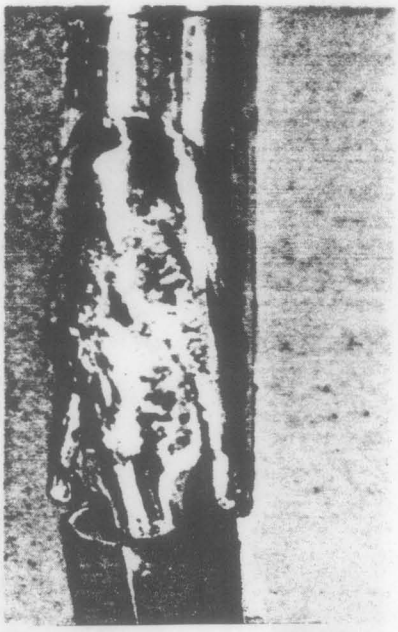
DISTURBED JOINT



BROKEN STRAND



1 NICKED CONDUCTOR



EMBEDDED INSULATION

WATKINS – JOHNSON CO.

WJ

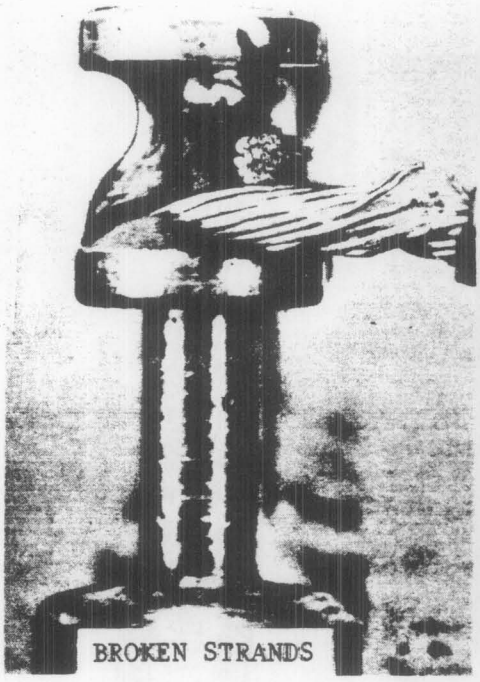
WORKMANSHIP STANDARDS

ISSUE DATE 11/1/73 REVISION NO. ____

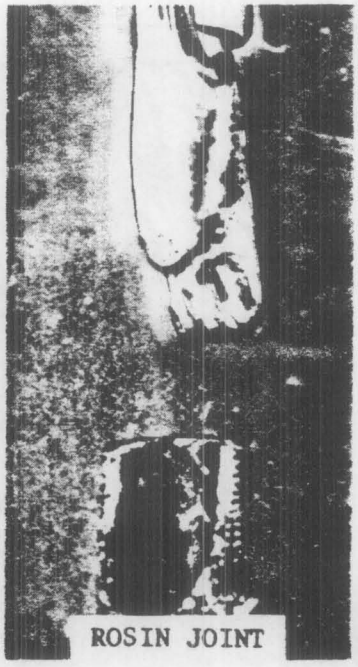
ORIGINATED BY D Smith AND R Steiber

APPROVED BY B N Wright

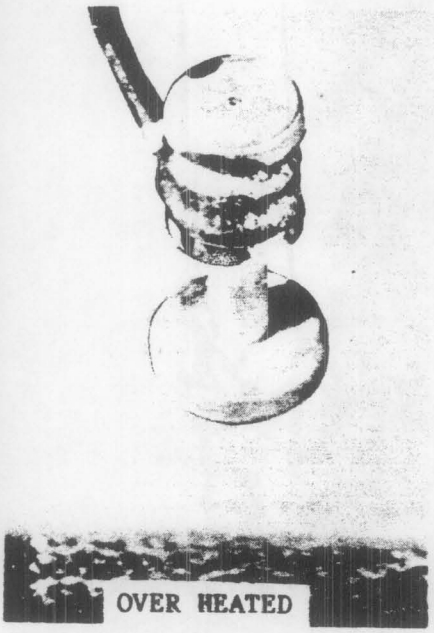
TITLE: Main Chassis Assembly and Wiring



BROKEN STRANDS

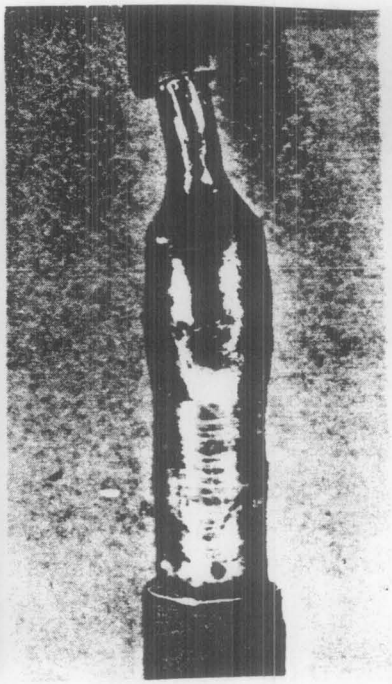


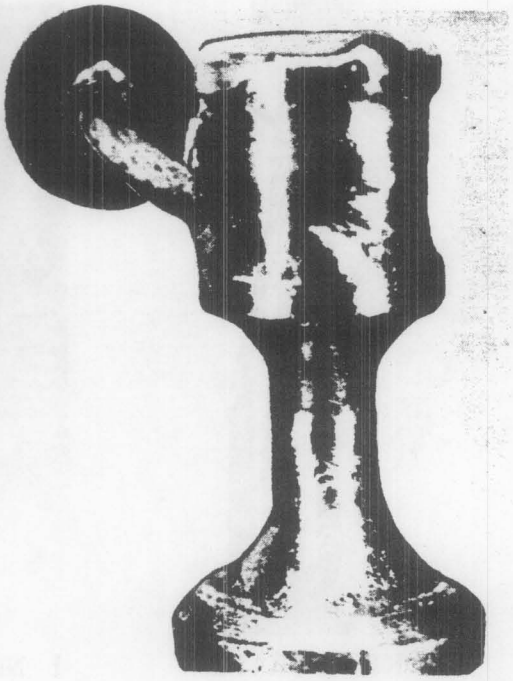
ROSIN JOINT



OVER HEATED

Excessive solder can be detected by peaks, domes or an overflow of solder. Not acceptable. When a sufficient amount of solder is used, the joint should be covered and the contour of the wire should be visible.





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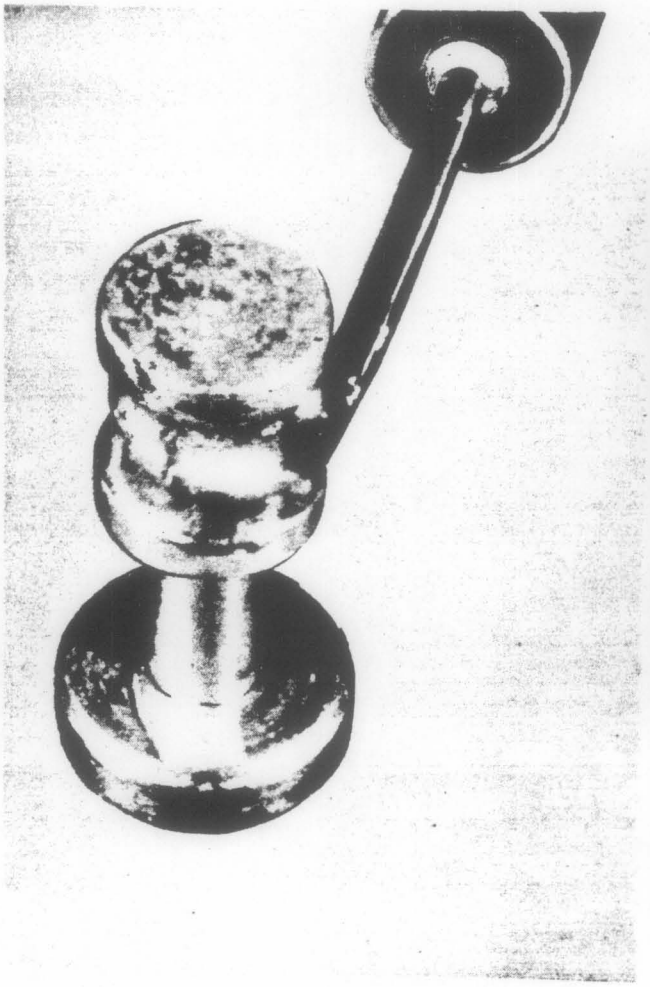
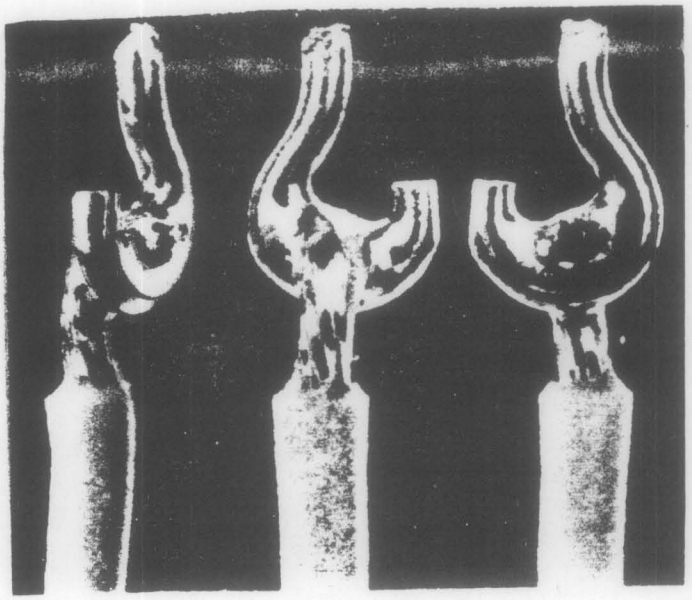
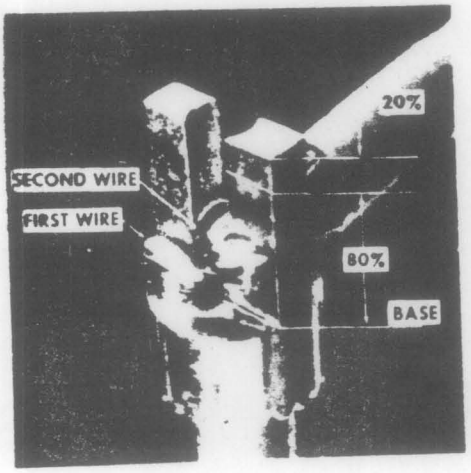
WORKMANSHIP STANDARDS	
ISSUE DATE 11/1/73 REVISION NO.	
ORIGINATED BY D Smits AND R Steiber	
APPROVED BY B A Wright	

TITLE: Main Chassis Assembly and Wiring

ACCEPTABLE SOLDER CONNECTIONS







MANUAL REVISION RECORD

Mechanical Assembly

PAGE	Original Issue Date	Latest Revision	Approved	Date
1	2/9/77	2/9/77		2/9/77
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MECHANICAL ASSEMBLY

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MECHANICAL ASSEMBLY

WATKINS-JOHNSON CO.

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WORKMANSHIP STANDARDS

ISSUE DATE 2/9/77 REVISION NO. ____

ORIGINATED BY D Smith AND R Steiber

APPROVED BY Bud Wright

TITLE: Mechanical Assembly

1. PURPOSE

1.1 This standard shall be used to establish general guidelines and assembly techniques in order to maintain mechanical reliability in the equipment under varying vibration and handling conditions.

2. APPLICABLE DOCUMENTS

2.1 The documents listed below were used to aid in the preparation of this standard. In the event of a conflict arising between this standard and any reference document, this standard shall take precedence.

Specifications

Federal

QQ-P-416	Plating Cadmium (Electro Deposited)
QQ-S-571	Solder; tin alloy; lead-tin alloy; and lead alloy

Military

MIL-STD-454	Requirements #9 Standard general requirements for electronic equipment.
MIL-E-5400	Electronic equipment, airborne, general specifications for.
MIL-T-55155A	Terminal, Feed thru (insulated) and Terminal, Stud (insulated and non-insulated)
MS-35333	Washer, lock, flat-internal tooth.

TITLE: Mechanical Assembly

3. SCREW, NUTS AND WASHERS APPLICATIONS

3.1 Screws

3.1.1 Screws secured by nuts, or other retaining devices which permit projection beyond the retaining device, shall be of such length to permit a minimum projection of 1 thread and a maximum projection of 3 threads, with an optimum of 1 1/2 threads desirable. Screws 1 inch and longer shall be permitted to have a maximum of 1/8 inch plus 1 1/2 threads projecting from the retaining device (Figure #1)

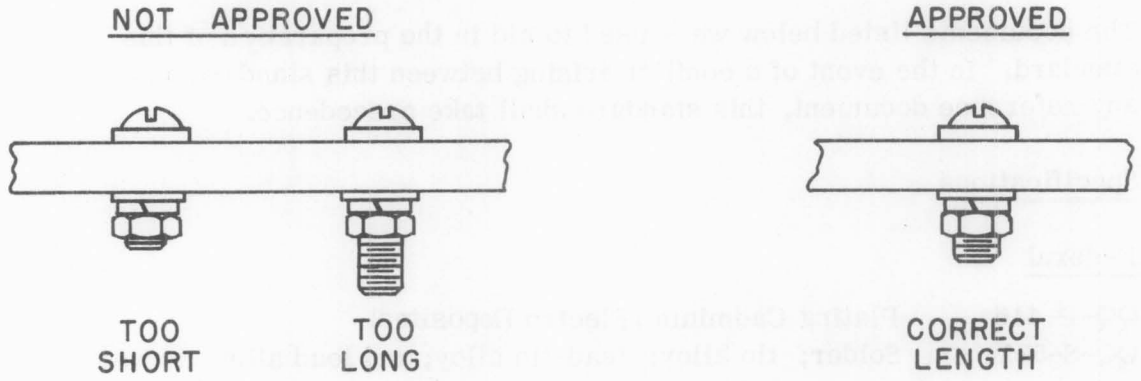


FIGURE 1

3.1.2 The ends of screws shall not be clipped, machined or filed to secure the above conditions.

3.1.3 The maximum length of a screw or bolts will be limited by the next larger standard length and shall be permitted to extend beyond the retaining device under those circumstances. Exceptions are, purchased parts such as meters, switches, and relays, etc., and when design requirements cannot be met.

3.1.4 Sheet metal and self-tapping screws are not acceptable for mechanical assembly, and require prior approval for contractual obligations.

3.1.5 The use of odd-size or special threads, or a non-standard type of head is prohibited and require special approval prior to installation.

3.1.6 Screws with damaged or burred heads or slots are not acceptable. A screw head that does not afford a good mechanical bond with the appropriate screwdriver shall be replaced. (Figure #2)

TITLE: Mechanical Assembly

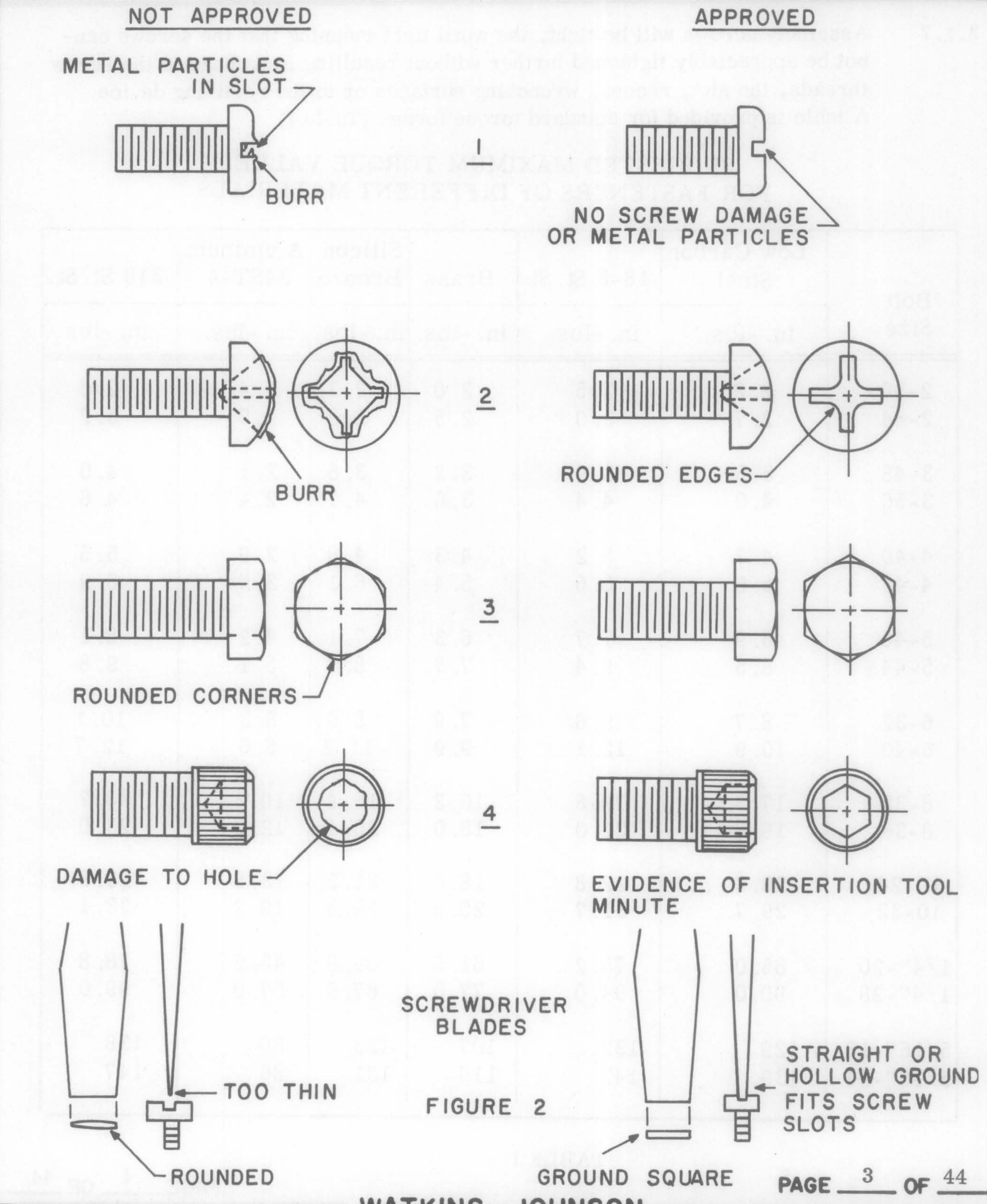


FIGURE 2

3.1.7 Assembly screws will be tight, the word tight meaning that the screws cannot be appreciably tightened further without resulting in damage to the screw threads, the slot, recess, wrenching surfaces or to the retaining device. A table is provided for standard torque forces (Table I)

SUGGESTED MAXIMUM TORQUE VALUES FOR FASTENERS OF DIFFERENT MATERIALS

Bolt Size	Low Carbon Steel	18-8 St. St.	Brass	Silicon Bronze	Aluminum 24ST-4	316 St. St.
	in. -lbs.	in. -lbs.	in. -lbs.	in. -lbs.	in. -lbs.	in. -lbs.
2-56	2.2	2.5	2.0	2.3	1.4	2.6
2-64	2.7	3.0	2.5	2.8	1.7	3.2
3-48	3.5	3.9	3.2	3.6	2.1	4.0
3-56	4.0	4.4	3.6	4.1	2.4	4.6
4-40	4.7	5.2	4.3	4.8	2.9	5.5
4-48	5.9	6.6	5.4	6.1	3.6	6.9
5-40	6.9	7.7	6.3	7.1	4.2	8.1
5-44	8.5	9.4	7.7	8.7	5.1	9.8
6-32	8.7	9.6	7.9	8.9	5.3	10.1
6-40	10.9	12.1	9.9	11.2	6.6	12.7
8-32	17.8	19.8	16.2	18.4	10.8	20.7
8-36	19.8	22.0	18.0	20.4	12.0	23.0
10-24	20.8	22.8	18.6	21.2	13.8	23.8
10-32	29.7	31.7	25.9	29.3	19.2	33.1
1/4"-20	65.0	75.2	61.5	68.8	45.6	78.8
1/4"-28	90.0	94.0	77.0	87.0	57.0	99.0
5/16"-18	129	132	107	123	80	138
5/16"-24	139	142	116	131	86	147

TABLE I

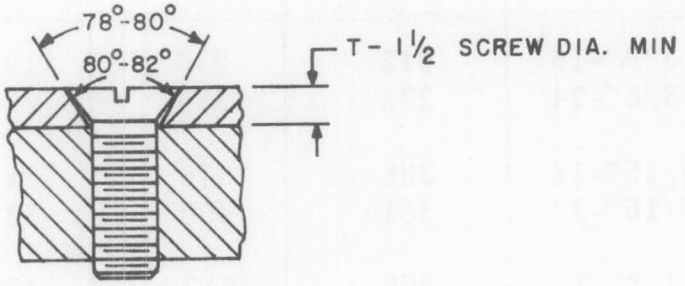
SUGGESTED MAXIMUM TORQUE VALUES FOR FASTENERS OF DIFFERENT MATERIALS

Bolt Size	Low Carbon Steel	18-8 St. St.	Brass	Silicon Bronze	Aluminum 24ST-4	316 St. St.
	in. -lbs.	in. -lbs.	in. -lbs.	in. -lbs.	in. -lbs.	in. -lbs.
3/8"-16	212	236	192	219	143	247
3/8"-24	232	259	212	240	157	271
7/16"-14	338	376	317	349	228	393
7/16"-20	361	400	327	371	242	418
1/2"-13	465	517	422	480	313	542
1/2"-20	487	541	443	502	328	565
9/16"-12	613	682	558	632	413	713
9/16"-18	668	752	615	697	456	787
5/8"-11	1000	1110	907	1030	715	1160
5/8"-18	1140	1244	1016	1154	798	1301
3/4"-10	1259	1530	1249	1416	980	1582
3/4"-16	1230	1490	1220	1382	958	1558
7/8"-9	1919	2328	1905	2140	1495	2430
7/8"-14	1911	2318	1895	2130	1490	2420
1"-8	2832	3440	2815	3185	2205	3595
1"-14	2562	3110	2545	2885	1995	3250
	ft. -lbs.	ft. -lbs.	ft. -lbs.	ft. -lbs.	ft. -lbs.	ft. -lbs.
1-1/8"-7	340	413	337	383	265	432
1-1/8"-12	322	390	318	361	251	408
1-1/4"-7	432	523	428	485	336	546
1-1/4"-12	396	480	394	447	308	504
1-1/2"-6	732	888	727	822	570	930
1-1/2"-12	579	703	575	651	450	732

TABLE I CONTINUED

3.1.8 Unless otherwise specified, no lubricant shall be used on the screw or the retaining device to facilitate installation.

3.1.9 Flat head screws must be the correct degree to properly fit the mating countersink for which it was designed, and shall be of a standard degree cut. (Figure #3)



CORRECT USE OF FLAT-HEAD SCREW

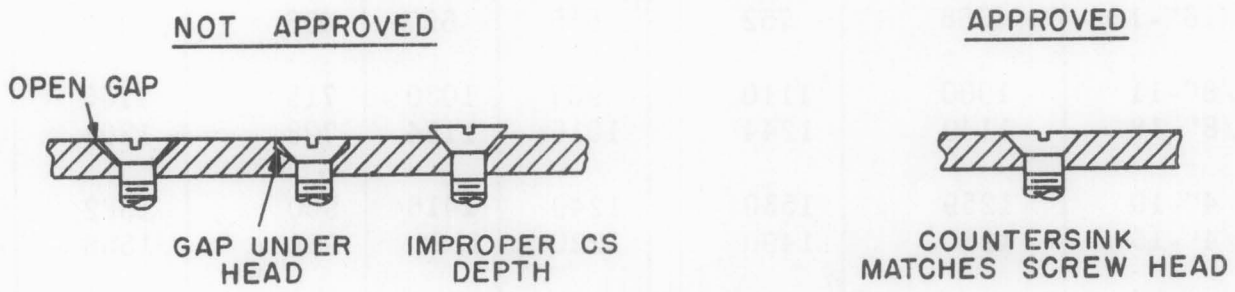


FIGURE 3

3.1.9.1 The gap between the head of the screw and the countersink or dimple shall not exceed .003 inch nor extend for more than 1/3 of the circumference.

3.1.9.2 All flat head screws shall be flush to the surface and properly seated when adequately tightened. (Figure #4)

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WORKMANSHIP STANDARDS

ISSUE DATE 2/9/77 REVISION NO. ____

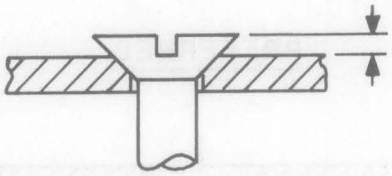
ORIGINATED BY D Smith AND R Steiber

APPROVED BY Bud Wright

TITLE: Mechanical Assembly

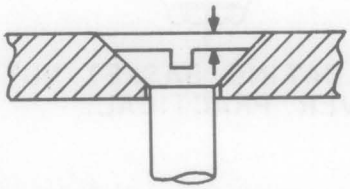
NOT APPROVED

100° FLAT HEAD



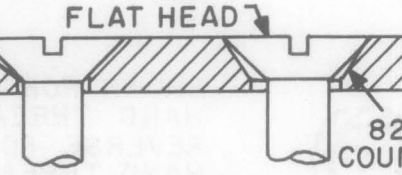
1

1. HEAD PROTRUSION EXCEEDS .005" IN COUNTERSUNK OR DIMPLED SHEETS.



2

1. TOO LARGE COUNTERSINK DIAMETER.

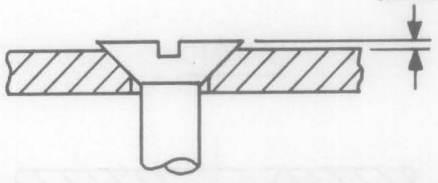


3

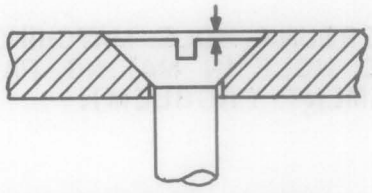
1. GAP UNDER HEAD WILL ALLOW INSERTION TO SHANK OF .005" FEELER GAGE.
   GAP UNDER HEAD WILL ALLOW INSERTION OF .004" OR LESS FEELER GAGE FOR MORE THAN 40% OF CIRCUMFERENCE.
2. ANGLE OF SCREW HEAD AND COUNTERSINK DO NOT AGREE.

APPROVED

.005 MAX



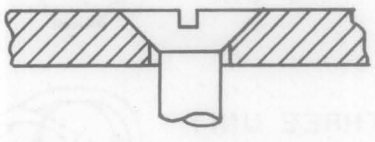
1. MAXIMUM HEAD PROTRUSION OF .005" NO SHAVING ALLOWED.



1. HEAD DEPRESSION WITHIN LIMITS LISTED BELOW:

THREAD SIZE	4	6	8	10	.250
MAX. DEPRESSION	.008	.009	.010	.011	.013

COUNTERSINK ANGLES



1. MAXIMUM GAP WILL ALLOW INSERTION TO SHANK OF .003" FEELER GAGE FOR LESS THAN 33% OF CIRCUMFERENCE.
2. COUNTERSINK ANGLE AND INCLUDE ANGLE OF SCREW HEAD ARE THE SAME.

FIGURE 4

3.1.9.3 Flat head screws may be retained by a self-locking nut, and should be avoided in a tapped hole configuration. (Figure #5)

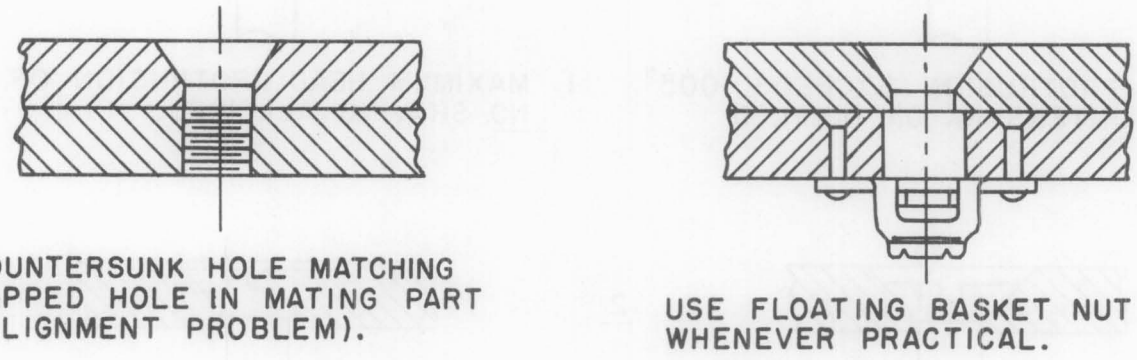


FIGURE 5
ALIGNMENT OF COUNTERSUNK HOLES

3.1.10 When drilled Phillister head screws are used, safety wiring will be required to assure that tightness will remain under varying vibration conditions. (Figure #6)

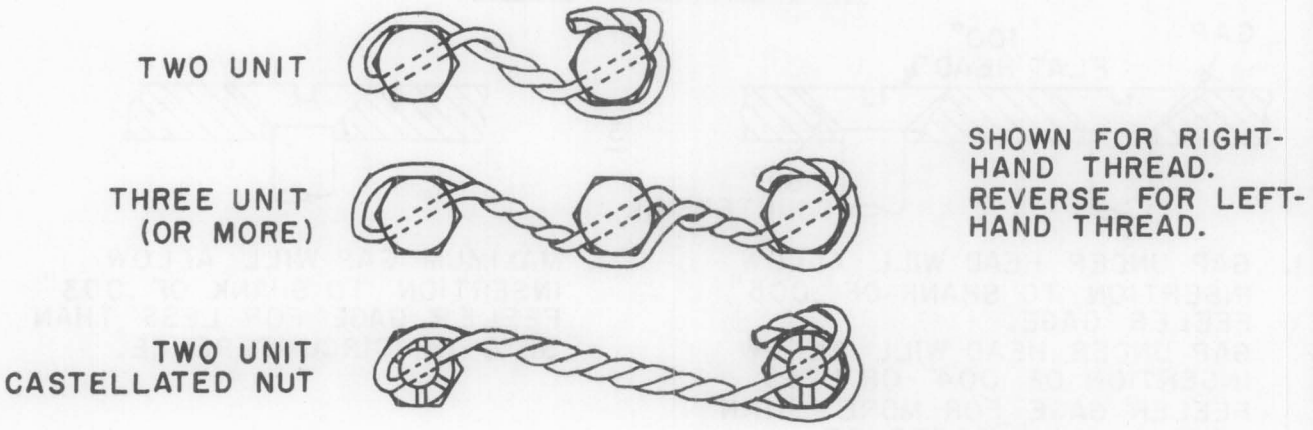


FIGURE 6

3.1.10.1 Safety wires must never be reused, as wrapping and rewrapping causes structural failure of the wire.

3.1.11 Set screws used to secure parts, shall be installed so the point of the set screw bears on the flattened section of the shaft and shall be of the cup-pointed variety when only one is used.

3.1.11.1 When set screws are used against a round shaft, two set screws must be used and shall be spaced at 90° and 120° increments.

3.1.11.2 If practical, all set screws of the same size used in the equipment will have one type of head.

3.2 Nuts

3.2.1 Hexagonal nuts are preferred for general mechanical assembly. Square nuts may be used only when they are captive or floating as part of a fastening device.

3.2.1.1 Nuts should be sufficiently thick and strong not to fail before the bolt or screw fails.

3.2.1.2 Nuts shall be tightly seated against the bearing surface, but shall not deform the wrenching surfaces or cause damage to other parts of the assembly.

3.2.2 Sheet-spring nuts for general mechanical assembly will be used only when specifically requested or prior approval given, except for rack mounting of equipment.

3.2.3 Self-locking nuts that contain a non-metal locking material, such as Nylock or Rosan shall not be used for grounding applications (Figure #7)

The following illustrations demonstrate the proper grounding techniques.

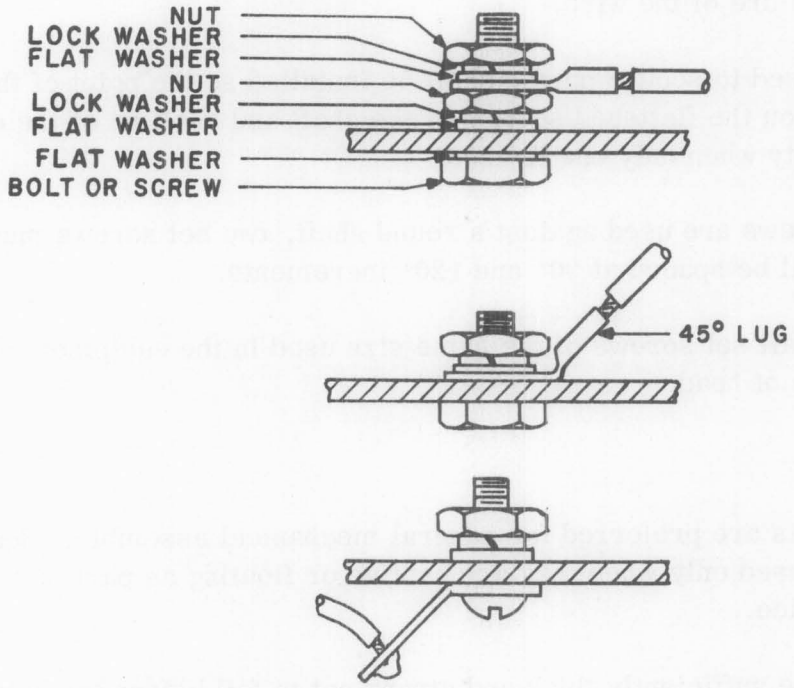
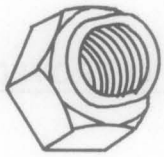
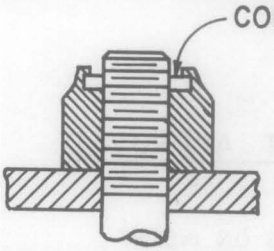


FIGURE 7
ACCEPTABLE
CHASSIS GROUND CONNECTIONS

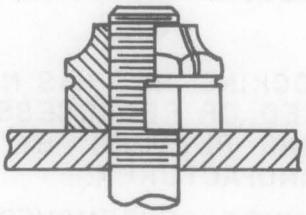
3.2.3.1 A self-locking nut is a nut which has a self-contained locking feature for gripping a threaded member so that relative rotation between the nut and the threaded companion member is impeded or prevented. Four basic types of self-locking nuts known as the prevailing torque type with performance requirements specified by MIL-N-25027 are generally used on military electronic equipment. These four types are shown below. (Figure 8, 9, 10)



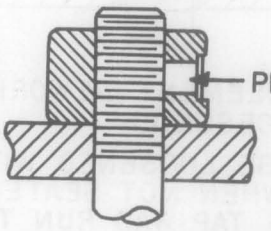
1. OUT-OF-ROUND THREADED COLLAR ABOVE LOAD-BEARING THREADS GRIPS THE BOLT AND RESISTS LOOSENING.



2. A NON-METALLIC COLLAR SECURELY CLAMPED IN THE TOP OF THIS TYPE PRODUCES THE LOCKING ACTION.

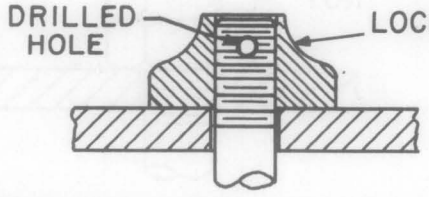


3. THE SLOTTED SECTION OF THIS TYPE FORMS BEAMS WHICH ARE DEFLECTED INWARD AND GRIP THE BOLT.



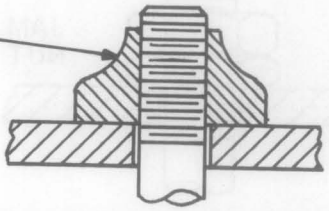
4. IN THIS TYPE, A NON-METALLIC "PLUG" INSERT GRIPS THE THREADS AND CAUSES A WEDGING ACTION BETWEEN BOLT AND NUT.

NOT APPROVED



1. SCREW, BOLT, OR STUD THAT HAS BEEN USED FOR COTTER PINS.
2. THREADS DO NOT PROJECT PAST LOCKING FEATURE.

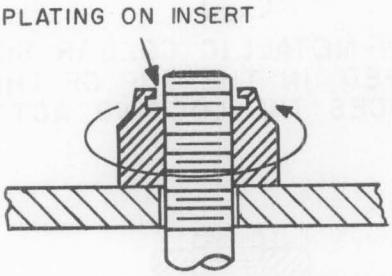
APPROVED



1. NO DRILLED HOLE IN SCREW, BOLT, OR STUD.
2. SCREW, BOLT, OR STUD SHALL ALWAYS EXTEND PAST LOCKING FEATURE A MINIMUM OF:
   a) ROUND OR CHAMFERED-END SCREWS AT LEAST THE FULL ROUND OR CHAMFER.
   b) FLAT-END SCREWS AT LEAST 1/32 INCH.

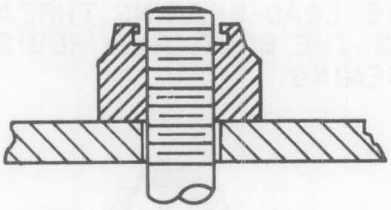
FIGURE 8

NOT APPROVED



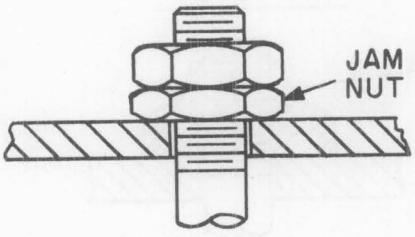
1. LOCKING ELEMENT REWORKED OR REPROCESSED.
2. NUT CAN BE LOOSENED WITH FINGERS WHEN NOT SEATED, INDICATING TAP WAS RUN THROUGH NUT PRIOR TO ASSEMBLY.

APPROVED

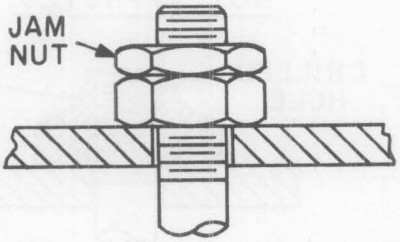


1. SELF-LOCKING NUT HAS NOT BEEN REWORKED OR REPROCESSED (INCLUDING PLATING) BY OTHER THAN NUT MANUFACTURER.
2. NUT CANNOT BE REMOVED FROM STUD OR SCREW WITHOUT USE OF TOOLS (WRENCH, ETC.).

JAM NUTS



1. LOAD IS ON JAM NUT.



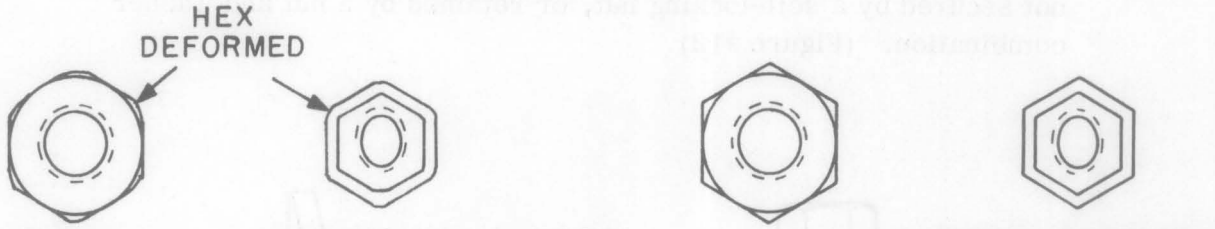
1. JAM NUT IS AWAY FROM WORK SURFACE SO THAT LOAD IS ON REGULAR NUT

FIGURE 9

NOT APPROVED

APPROVED

HEX NUTS
(PLAIN AND SELF-LOCKING)



1. SHARP CORNERS ROUNDED OR DAMAGED IN WRENCHING.

1. HEX IS NOT DEFORMED. NUTS MAY BE READILY WRENCH-TIGHTENED OR REMOVED.

FIGURE 10

3.2.4 Clinch, anchor, weld, and other types of securing nuts shall be installed to rest squarely on the material surface. The capturing mechanism of the assembly shall be on the side of the panel which affords a deeping into the material as tension is applied by the screw. Installation of these types of nuts shall be made after plating or other chemical processes. (Figure #11)

CLINCH, ANCHOR, WELD, AND OTHER TYPES OF SECURED NUTS SHOULD NOT LOOSEN WHEN PROPERLY SET. MORE INTENSIVE INSPECTION OF THESE TYPES IS REQUIRED. (SEE FIGURE 11.)

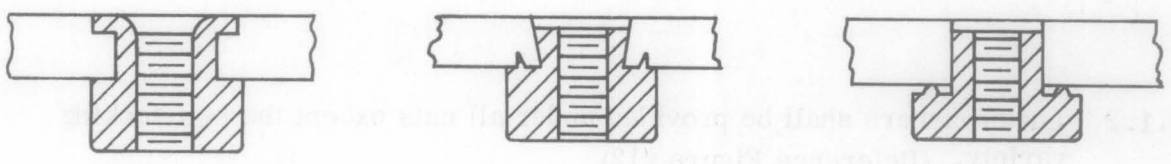


FIGURE 11

3.3 Washers

3.3.1 All screw and nut, or bolt and nut assemblies shall be made vibration proof by means of a lock washer or self-locking nut.

3.3.1.1 Lock-washers shall be provided under the heads of all round head screws not secured by a self-locking nut, or retained by a nut and washer combination. (Figure #12)

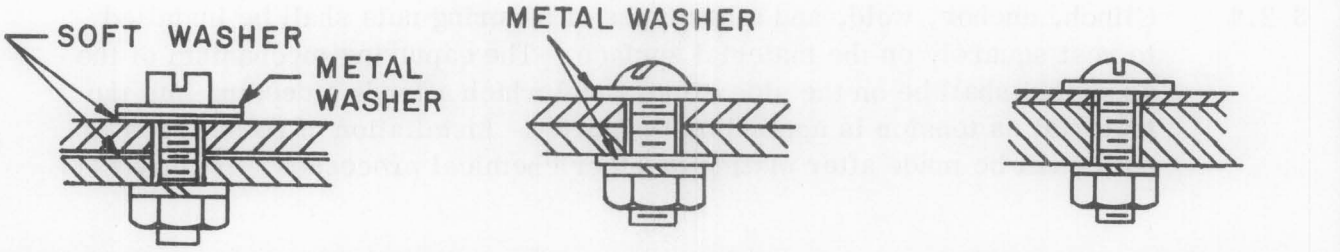


FIGURE 12

3.3.1.2 Lock-washers shall be provided under all nuts except the self-locking variety. (Reference Figure #12)

3.3.1.3 Internal tooth, external tooth, or spring type lock-washers are recommended for general mechanical applications.

3.3.1.4 Lock-washers with external teeth are preferred for making electrical bonds, noise suppression, and external grounding. (Figure #13)

FIGURE 13

3.3.2 Flat washers for general mechanical use shall be bronze-plated, cadmium plated, zinc-plated steel or stainless steel for corrosion resistance.

3.3.2.1 A flat washer shall be used as an intervening metal surface for protection of component parts and to prevent crushing by equally distributing the screw pressure.

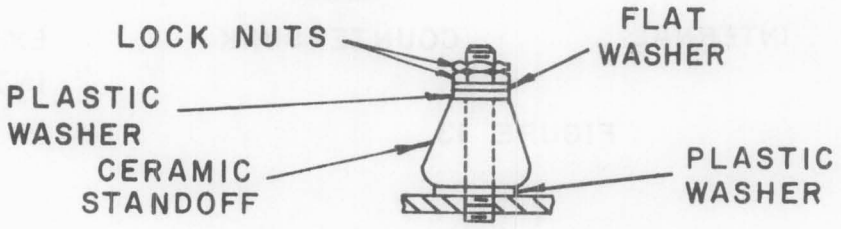
3.3.2.2 When a nut or screw head bears on a painted surface, a flat washer shall be placed between the nut and/or the head of the screw and the painted area. (Figure #14)

WASHERS FOR PAINTED SURFACES

FIGURE 14

3.3.2.3 A flat washer shall be required between a split-lock washer and a part made of magnesium, soft aluminum or other soft metals to minimize damage from the lock washer.

3.3.2.4 Component parts made of ceramic, plastic, phenolic or other non-metals shall be protected by installing a flat washer between the component body and any locking device. (Figure #15)



WASHERS FOR CERAMIC MATERIAL

MOUNTING OF PRECISION RESISTOR ON CHASSIS

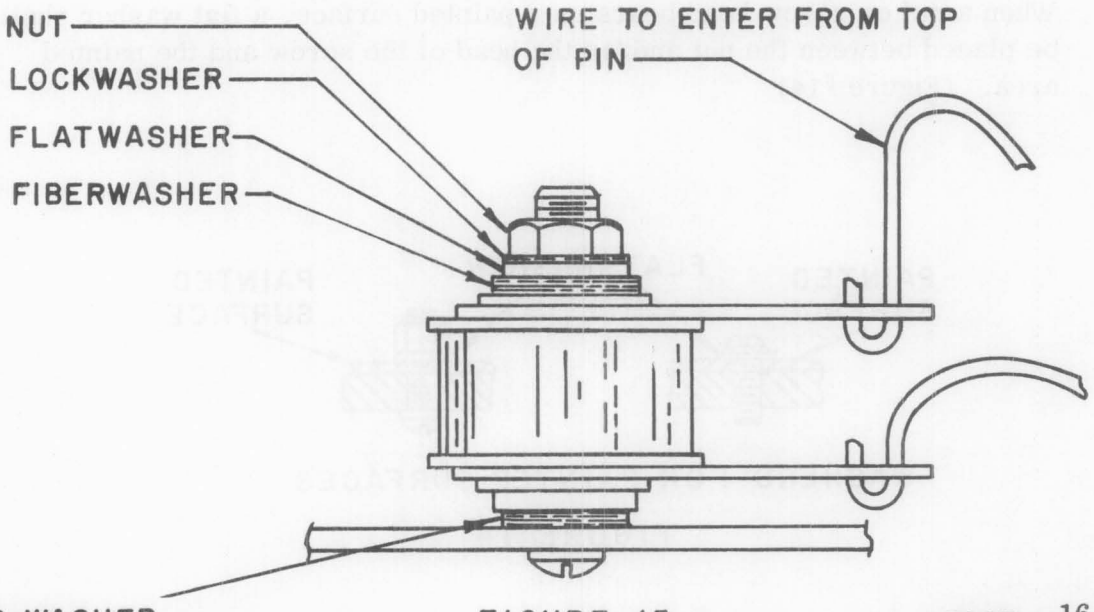
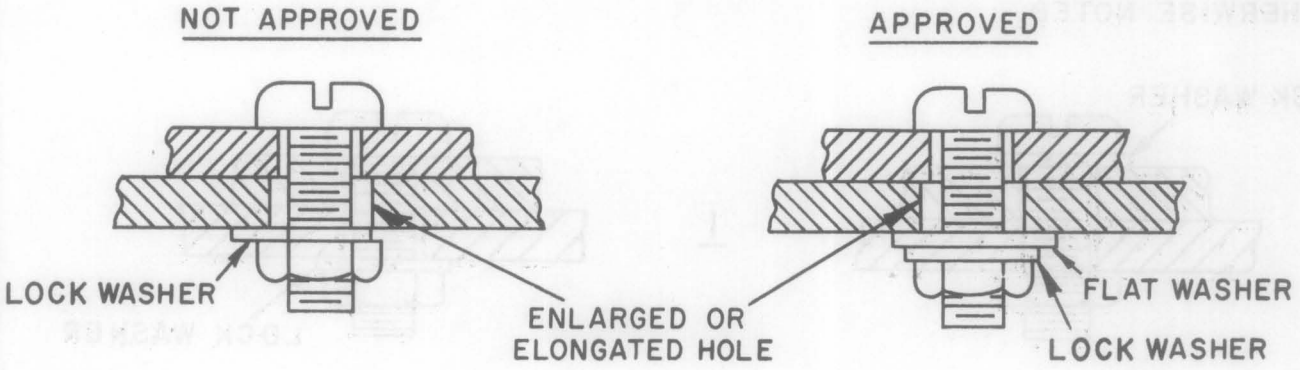


FIGURE 15

3.3.2.5 A flat washer shall be required over a slotted or oversized hole to protect the mounting screw head and support the lock washer. (Figure #16)



1. LOCK WASHER DOES NOT BEAR ON PANEL.
2. LOCK WASHER DOES NOT BEAR ON PANEL FOR ITS FULL CIRCUMFERENCE.

1. FLAT WASHER USED WHEN LOCK WASHER DOES NOT BEAR ON PANEL FOR ITS FULL CIRCUMFERENCE.

FIGURE 16

3.3.2.6 Plastic or other compressible materials mechanically joined shall be adequately protected by flat washers installed under all mounting screw heads, lock washers and nuts. (Figure #17)

TITLE: Mechanical Assembly

NOT APPROVED APPROVED

FOR ALL APPLICATIONS SHOWN BELOW A SELF LOCKING NUT MAY BE SUBSTITUTED FOR NUT-LOCKWASHER COMBINATIONS. ALL PANELS ARE METALLIC UNLESS OTHERWISE NOTED.

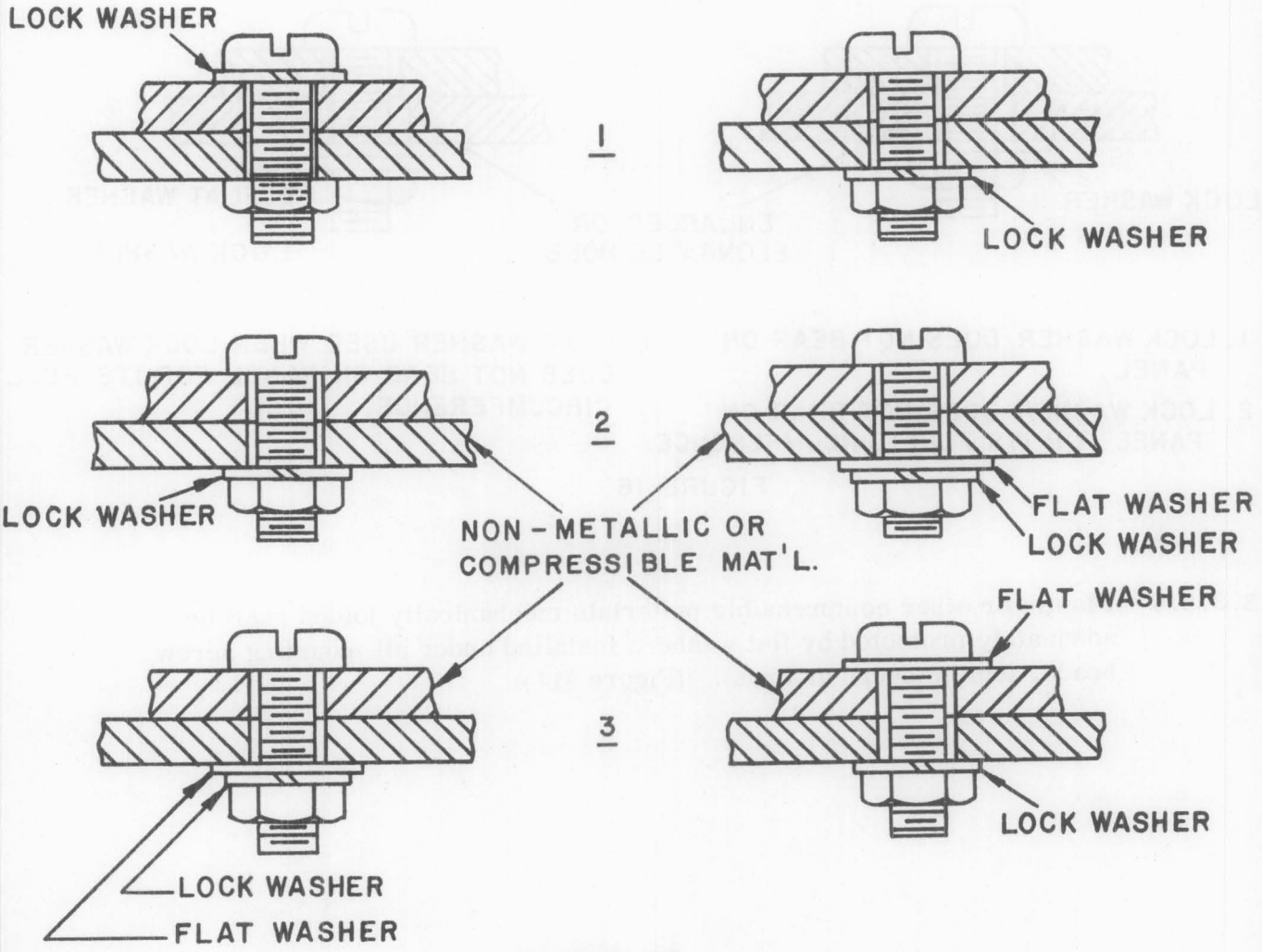


FIGURE 17

4. FASTENERS AND MECHANICAL ASSEMBLIES

4.1 Tapped Holes

4.1.1 Tapped holes shall be drilled to such a depth as to allow the use of a standard taper tap and shall be in a material capable of retaining threads under normal torque applications.

4.1.1.1 Screws and bolts shall provide a minimum engagement length, equal to one diameter into any tapped hole. (Figure #18) (Table II)

TABLE II

DEPTH OF TAPPED HOLES

MATERIAL	ENTRANCE LENGTH FOR "SCREWS, BOLTS, A .	THREAD CLEARANCE AT BOTTOM OF HOLE B	THREAD LENGTH C	UNTHREADED PORTION OF E	DEPTH OF DRILLED HOLE F
ALUMINUM	2D	4/N	2D+4/N	4/N	C+E
CAST IRON	1 1/2D	4/N	1 1/2D+4/N	4/N	C+E
BRASS	1 1/2D	4/N	1 1/2D+4/N	4/N	C+E
BRONZE	1 1/2D	4/N	1 1/2D+4/N	4/N	C+E
STEEL	D	4/N	D+4/N	4/N	C+E

D = DIAMETER OF FASTENER
A = ENTRANCE LENGTH
B = THREAD CLEARANCE AT BOTTOM OF HOLE
C = TOTAL THREAD LENGTH IN HOLE
E = UNTHREADED PORTION OF HOLE
N = THREADS PER INCH
F = DEPTH OF TAP-DRILL HOLE

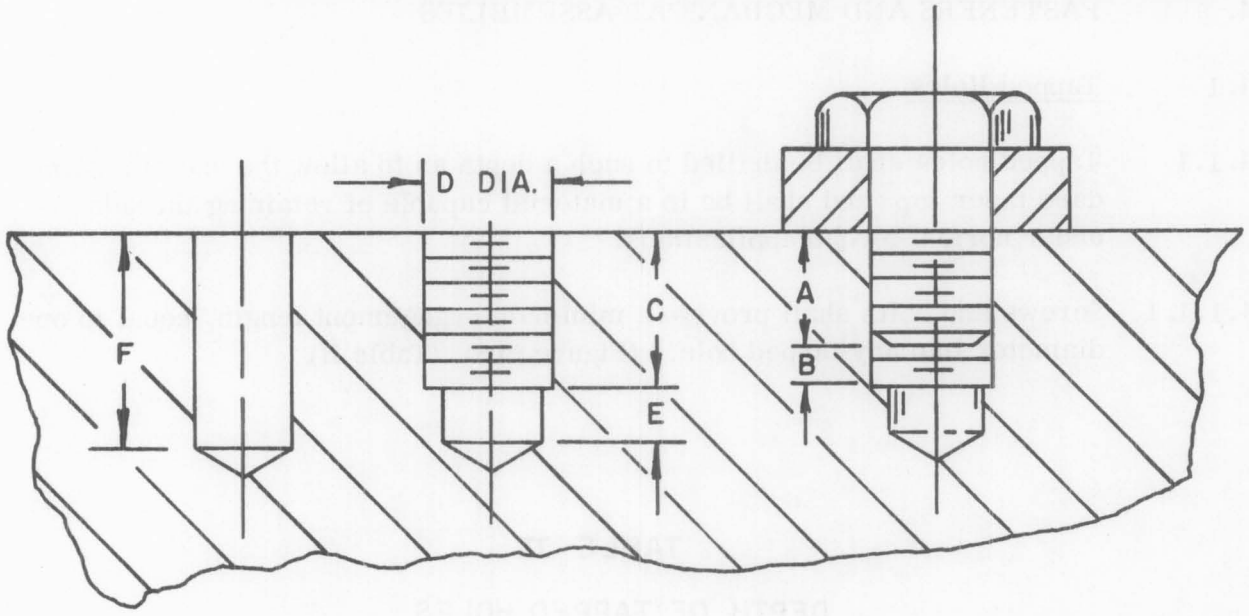


FIGURE 18

4.1.1.2 Screws and bolts shall be mechanically secured by a locking device when used in a tapped hole. (Figure #19)

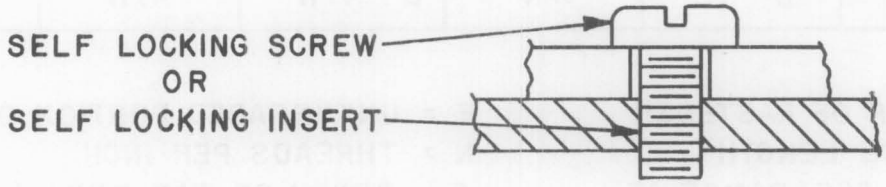


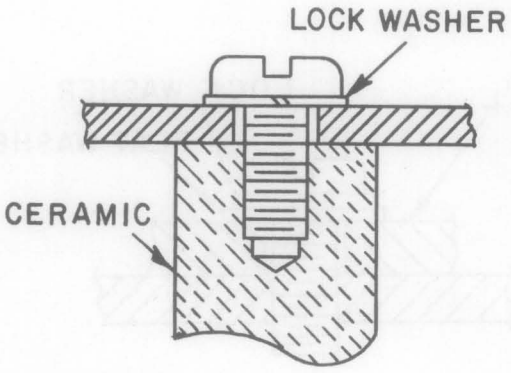
FIGURE # 19

NOTE:

ILLUSTRATION TO SHOW USE OF LOCK WASHER WHEREVER USED WITH FLAT WASHER, WHETHER UNDER HEAD OF BOLT OR NUT.

TITLE: Mechanical Assembly

NOT APPROVED



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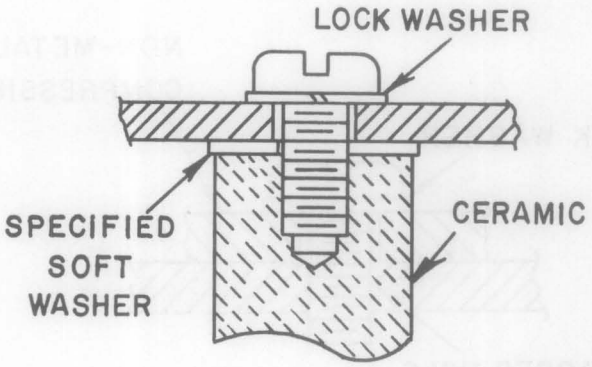
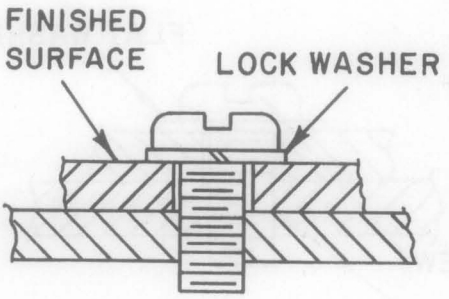
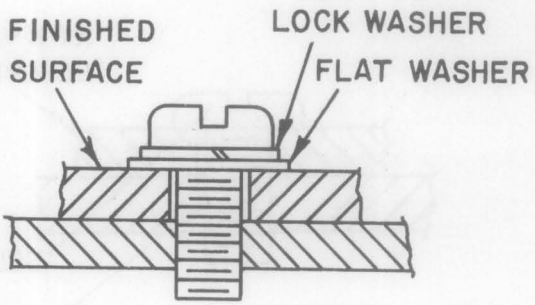
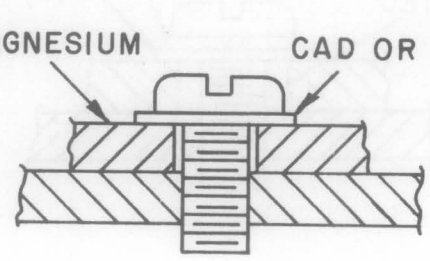
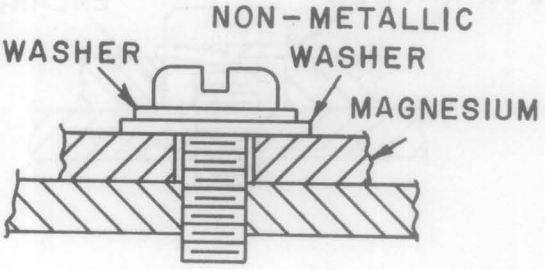




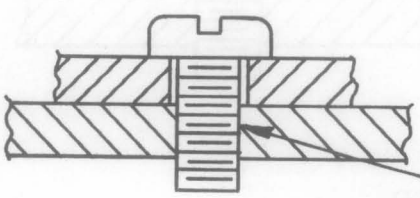


1. FINISHED SURFACE APPLIES TO EXTERIOR PAINTED SURFACES, PANELS, ETC ONLY.





NOT APPROVED



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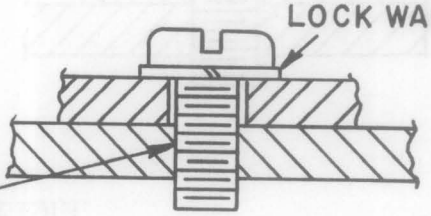

FIGURE 19

NOT APPROVED

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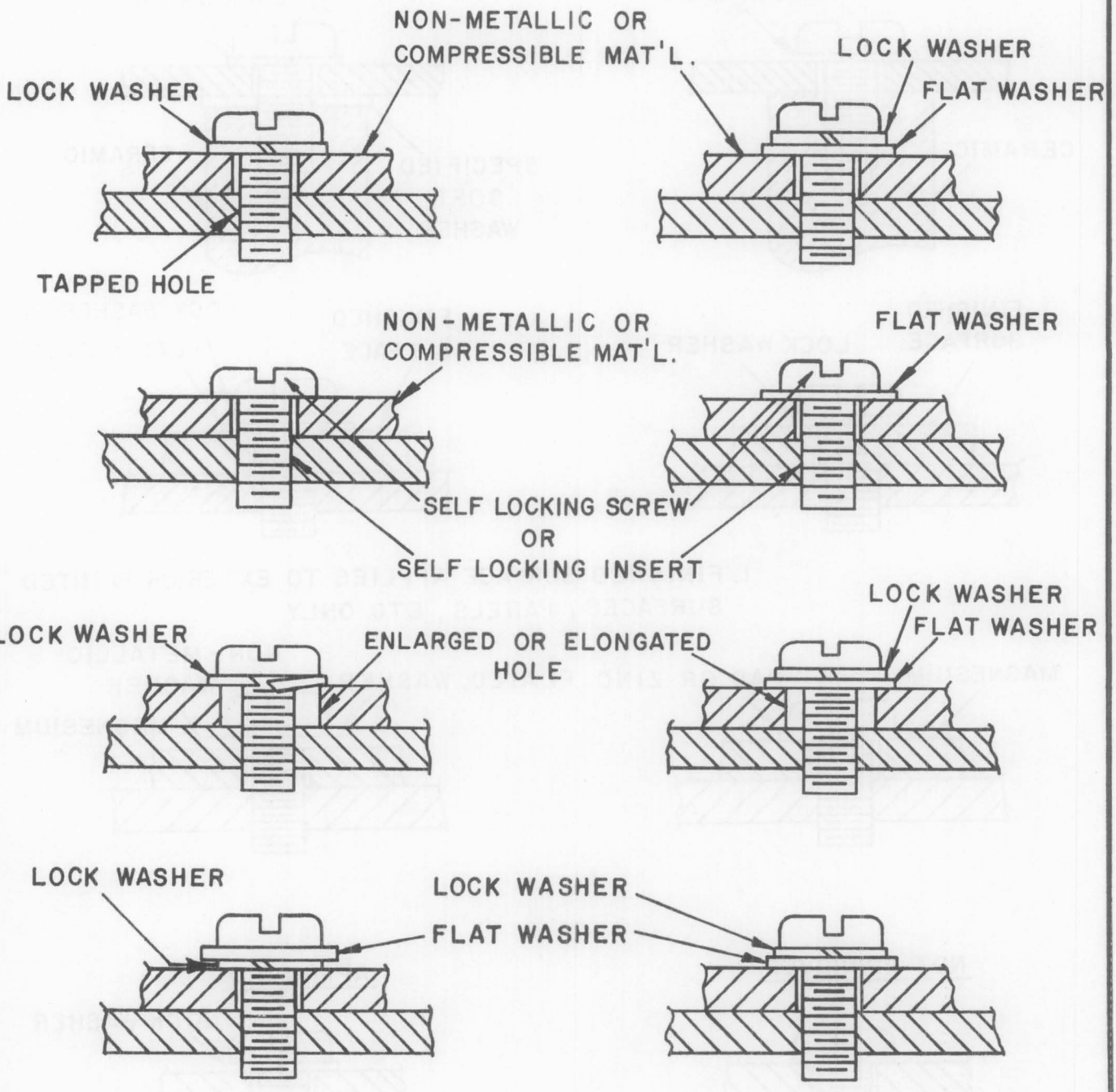


FIGURE # 19 CONTINUED

4.1.1.3 Countersunk holes shall not be permitted to interface with a tapped hole. (Reference Figure #5)

4.1.1.4 Rework of a tapped hole may be accomplished by using a threaded insert or a Heli-coil, provided this application returns the threaded hole back to the original size. (Figure #20)

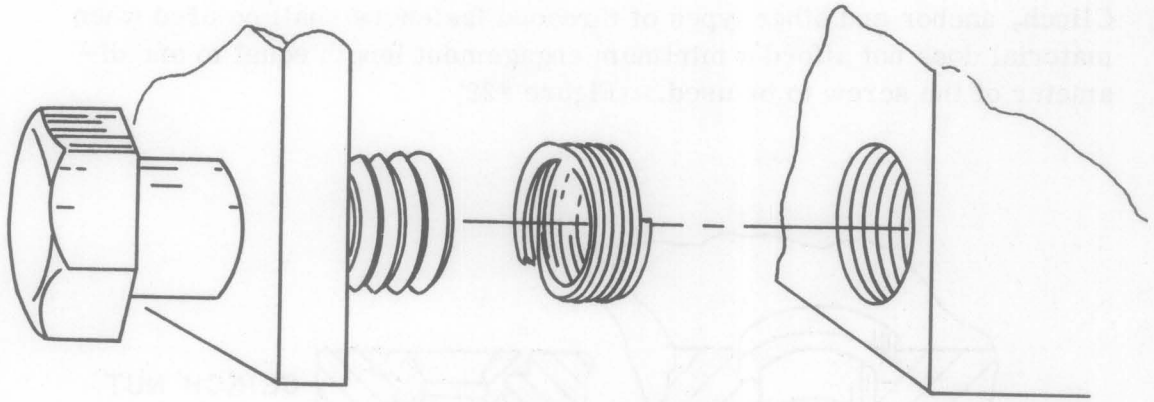


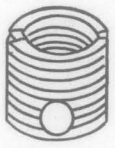
FIGURE 20- HELI-COIL INSERT

4.1.2 Threaded inserts shall be installed to form permanent threads in soft material such as plastics, phenolics or aluminum.

4.1.2.1 Threaded inserts shall be vibration proof to insure installation and secured by a self-locking mechanism, such as Heli-coil action, Rosan or a Nylock insert. (Figure #21)

HELI-COIL INSERT

ROSAN INSERT



NYLOCK INSERT

FIGURE 21

4.1.2.2 Threaded inserts, especially those retained by Rosan or Nylock shall not be used for grounding applications.

4.2 Threaded Fasteners

4.2.1 Where screw protrusion may occur through a tapped hole, the use of a threaded fastener is preferred over the tapped hole.

4.2.1.1 Clinch, anchor and other types of threaded fasteners shall be used when material does not afford a minimum engagement length equal to one diameter of the screw to be used. (Figure #22)

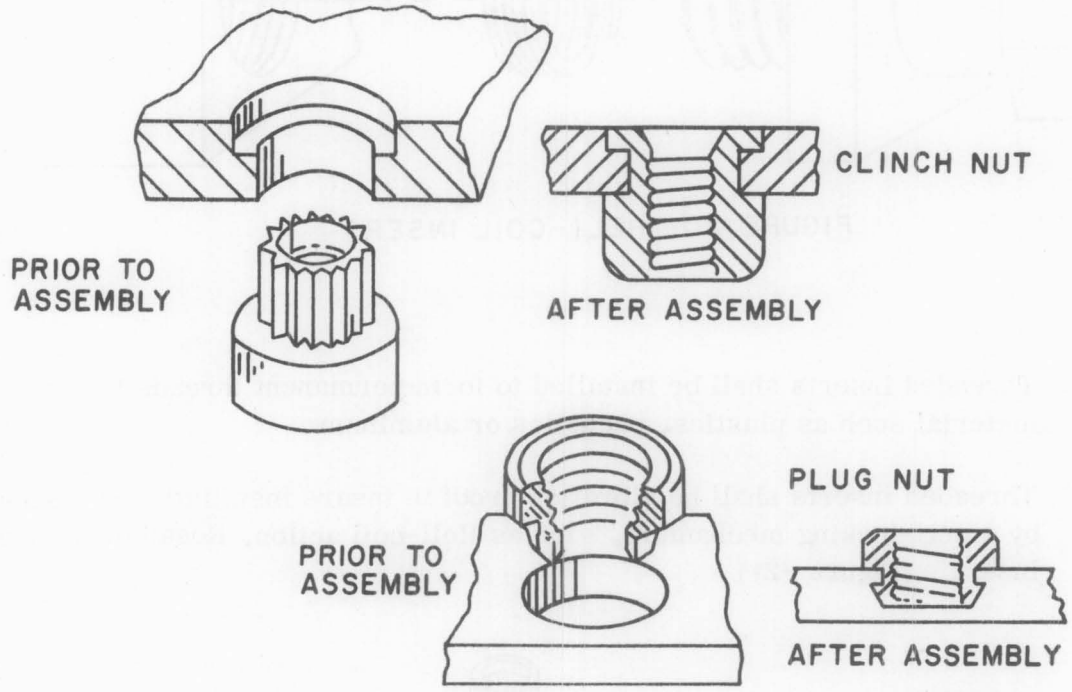


FIGURE 22

4.2.1.2 The head or flanged portion of the threaded fastener shall be securely seated to the part it is installed on, with a maximum gap of .003 inch for no more than 1/3 of the circumference.

4.2.1.3 Threaded fasteners shall remain seated when normal screw torque is exerted to the device.

4.2.1.4 Lock washers shall be required under the screw head when installed into a non-locking threaded fastener.

4.2.1.5 Plastic, ceramic or compressible materials shall be protected by a flat washer when mounted between a lock washer and a threaded fastener.

4.2.1.6 Threaded fasteners shall not be used for electrical grounding with special emphasis on fasteners using nylon.

4.2.1.7 A maximum of 5% imperfect threads shall be permitted within a specified thread length in any threaded fastener.

4.2.1.8 Self-locking threaded fasteners using nylon shall not be reused.

4.2.1.9 Threaded fasteners that have become cross-threaded shall be removed and discarded.

4.3 Floating Basket Nuts

4.3.1 Floating nuts shall be used for dust cover application and shall not be used to form structural portions of an assembly.

4.3.1.1 Installation of a floating nut assembly shall be such, that the anchor portion shall rest squarely on the mounting surface and shall be secured by mechanical means which offers no interference with the mating parts. (Figure #23)

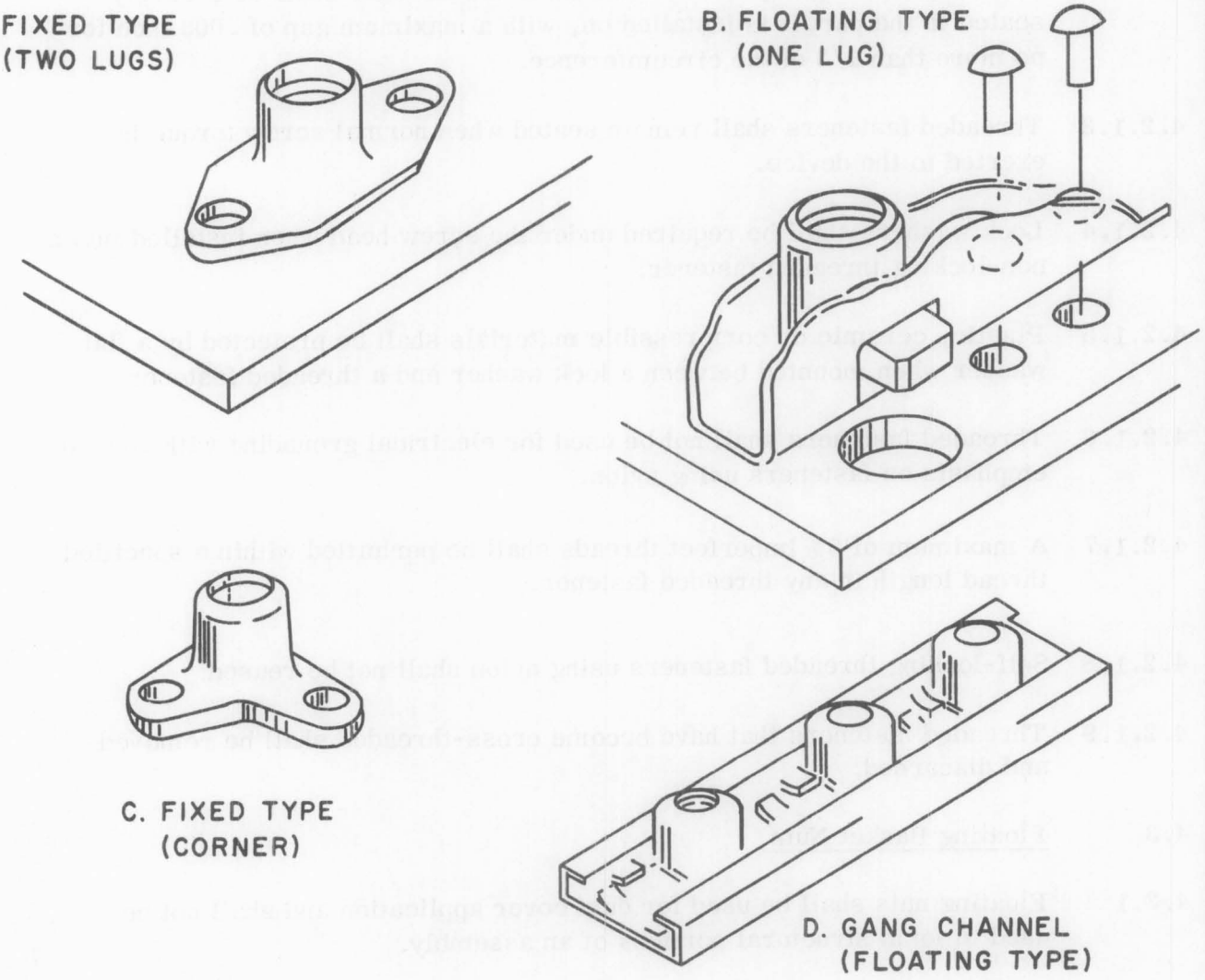


FIGURE 23

4.3.1.2 When required due to location, through holes to accommodate floating nuts, shall be large enough in diameter to permit full utilization of the floating action possible with that device. (Refer to Figure #5)

4.3.1.3 Floating nuts shall not be used for electrical grounding applications.

4.3.1.4 A maximum of 5% imperfect threads shall be permitted within a specified thread length in any floating nut.

4.3.1.5 Floating nuts that have become cross-threaded shall be removed and discarded.

4.3.1.6 Floating nuts with a cracked housing or retaining tang shall be discarded.

4.3.1.7 Floating nuts removed from an assembly to accomplish another operation, shall not be reused and must be discarded.

4.4 Quick Release Fasteners

4.4.1 Quick release fasteners shall be used primarily for dust covers, access doors and panels or lids but shall not be used for structural applications.

4.4.1.1 Camloc 1/4 turn Fasteners shall be used for material thickness with variations up to .030" inch in thickness. (Figure #24)

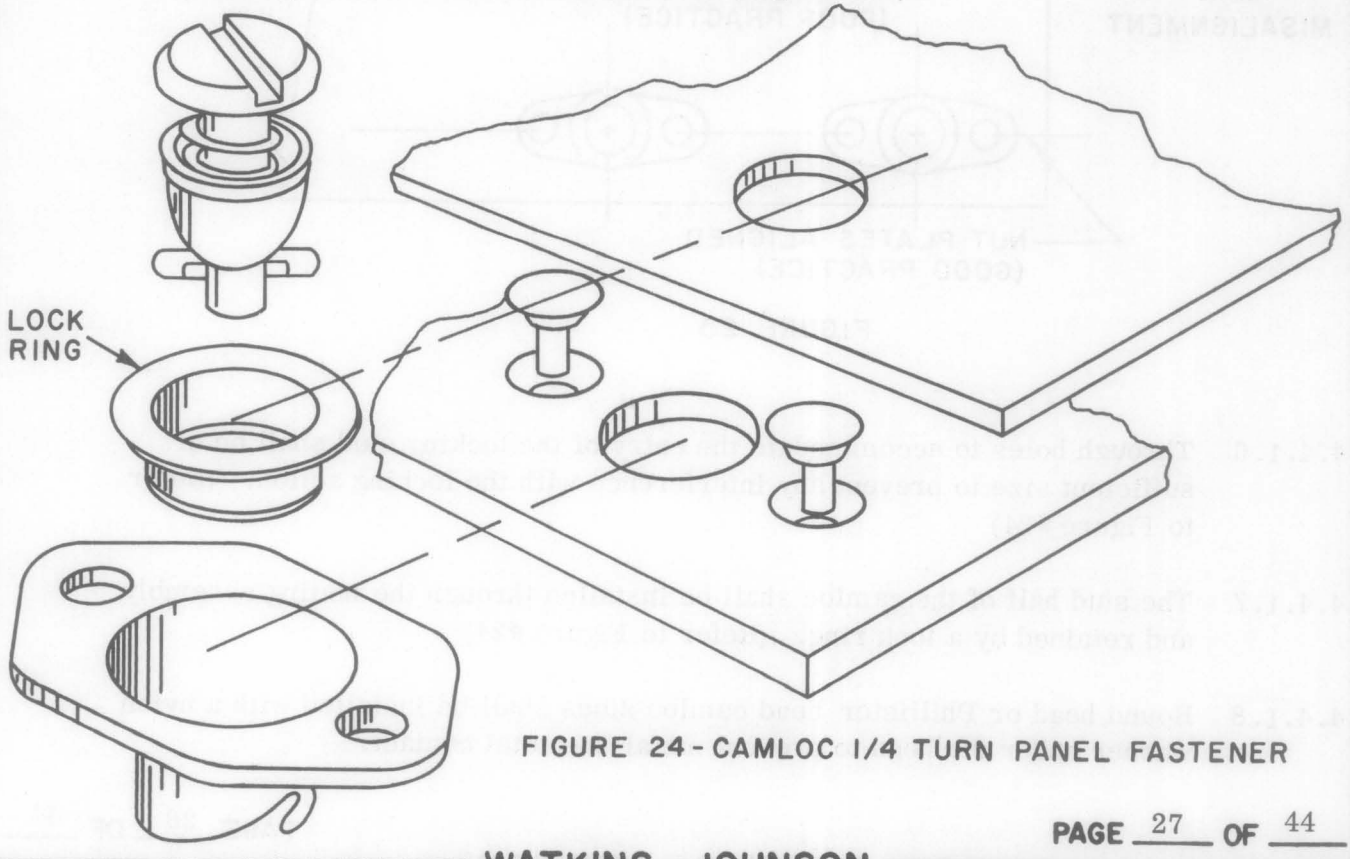


FIGURE 24 - CAMLOC 1/4 TURN PANEL FASTENER

4.4.1.2 The fastener assembly shall rest squarely on the mounting surface with a maximum of .030 inch gap between fastener and surface with no more than 1/3 of the fastener area offset from the mounting surface.

4.4.1.3 Cracks in the mounting flanges or the retaining portion of the fastener assembly shall be the criteria for rejection.

4.4.1.4 Camloc fasteners shall be installed parallel with respect to the nearest straight edge of the attaching area.

4.4.1.5 All Camloc assemblies on a common mounting surface shall be aligned to give a good workmanship apperance. (Figure #25)

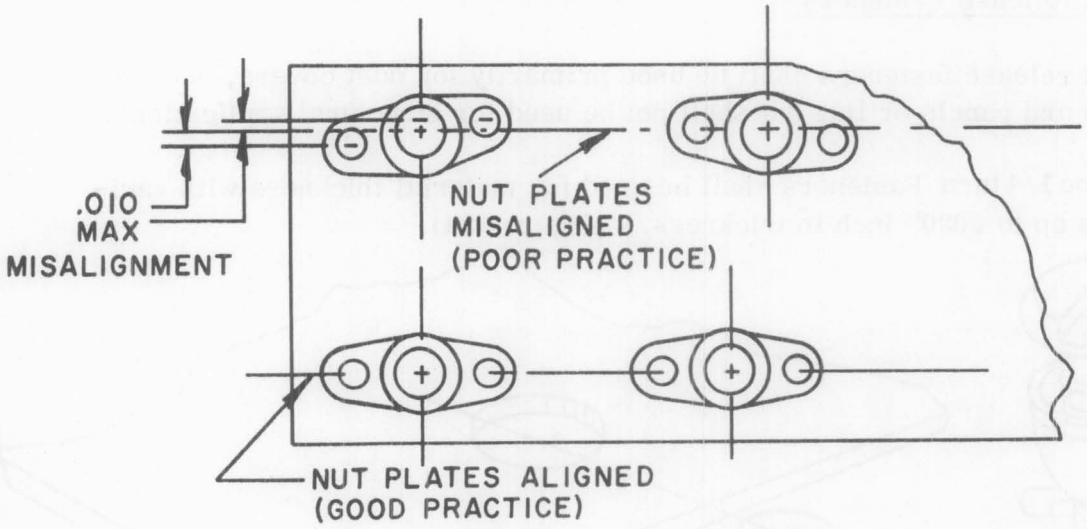


FIGURE 25

4.4.1.6 Through holes to accommodate the entry of the locking stud shall be of sufficient size to prevent any interference with the locking action. (Refer to Figure #24)

4.4.1.7 The stud half of the camloc shall be installed through the mating assembly and retained by a lock ring. (Refer to Figure #24)

4.4.1.8 Round head or Phillister head camloc studs shall be installed with a nylon washer under the head to prevent metal-to-metal contact.

4.5 Rivets

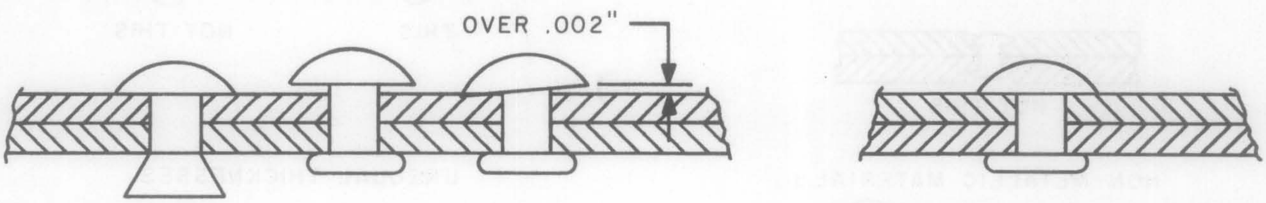
4.5.1 Proper selection of the correct type and size rivet shall be contingent on the intended application.

4.5.1.1 Pop (Chobert) Rivets only shall be used for non-structual applications. Installation of mechanical fasteners, Camlocs, floating basket nuts, internal brackets, and P. C. Board connectors for example shall be acceptable.

4.5.1.2 Solid Rivets only shall be used for structual applications such as main deck to side panel attachment to increase the mechanical support, and shall be specified on the applicable drawing.

4.5.1.3 Where the drawing calls out for the installation of solid rivets in a non-structural application, such as a mechanical fastener, the use of Pop (Chobert) Rivets shall be acceptable unless otherwise specified by contractual obligations.

4.5.1.4 The head of any type rivet shall be properly formed and squarely seated to provide a tight bond, and shall be acceptable within the following specified limits. (Figure #26)



1. BELL HEAD.
2. OPEN HEAD.
3. TILTED HEAD.

1. DRIVEN HEAD COMPLETELY DRIVEN.
2. MANUFACTURED HEAD TIGHT AGAINST RIVETED SURFACE.
3. MANUFACTURED HEAD PERPENDICULAR TO RIVET BODY.

FIGURE 26

FIGURE 26 ILLUSTRATES SOME OF THE ACCEPTABLE AND REJECTABLE APPLICATIONS OF THE USE OF RIVETS FOR METAL FASTENING.

TITLE: Mechanical Assembly

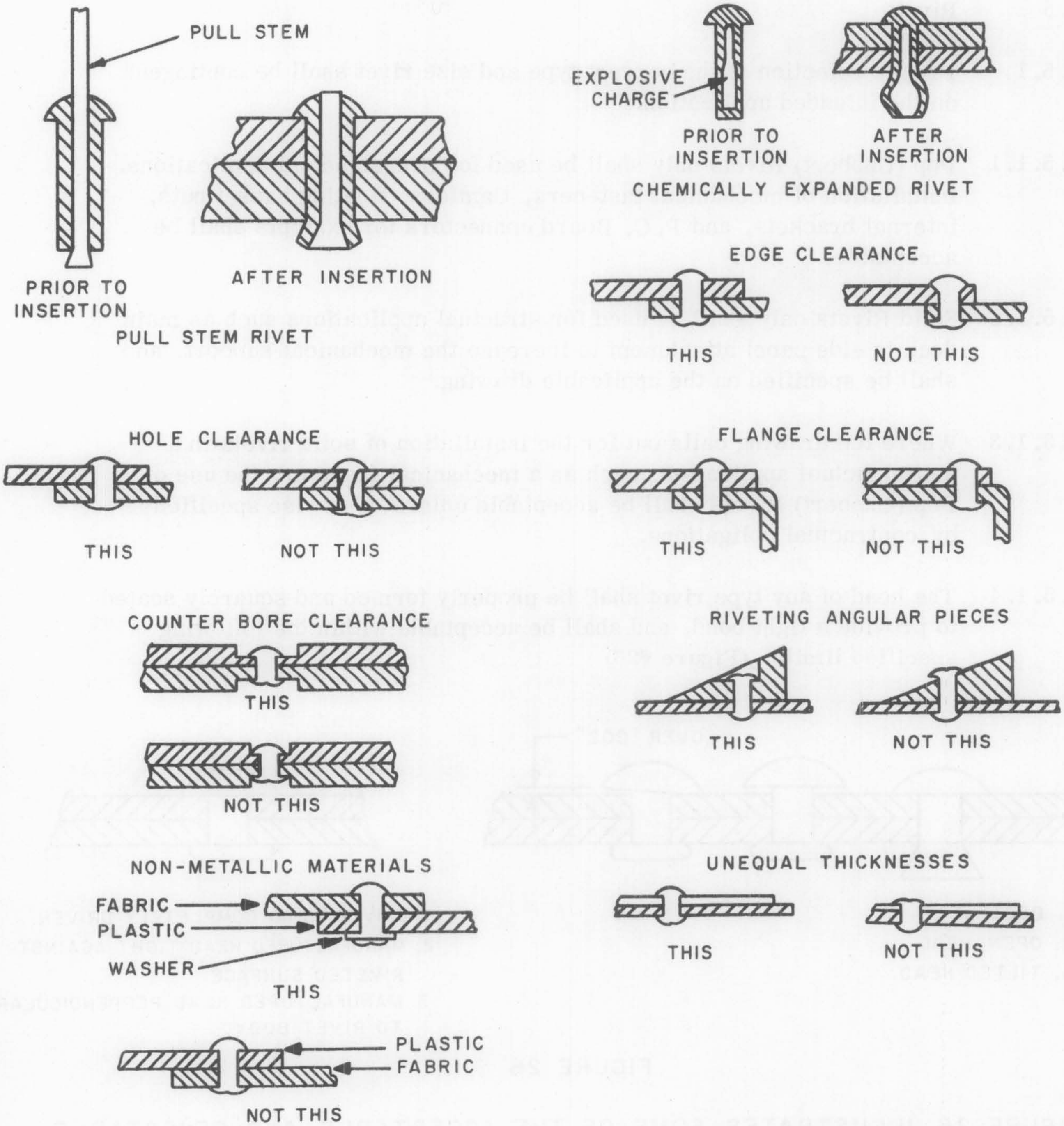
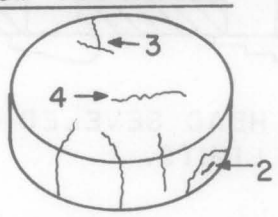

PULL STEM
PRIOR TO INSERTION
AFTER INSERTION
PULL STEM RIVET
EXPLOSIVE CHARGE
PRIOR TO INSERTION
AFTER INSERTION
CHEMICALLY EXPANDED RIVET
EDGE CLEARANCE
THIS
NOT THIS
HOLE CLEARANCE
THIS
NOT THIS
FLANGE CLEARANCE
THIS
NOT THIS
COUNTER BORE CLEARANCE
THIS
NOT THIS
RIVETING ANGULAR PIECES
THIS
NOT THIS
NON-METALLIC MATERIALS
FABRIC
PLASTIC
WASHER
THIS
PLASTIC
FABRIC
NOT THIS
UNEQUAL THICKNESSES
THIS
NOT THIS

FIGURE # 26 CONTINUED

4.5.1.5 The staking or rolling operation shall be uniform in appearance and shall not produce cracks or splits in the rolled or flared portion of the rivet in excess of the following acceptable limits. (Figure #27)

(a) No single part shall have more than two cracks or split per end
(b) No cracks or splits shall extend into the shank

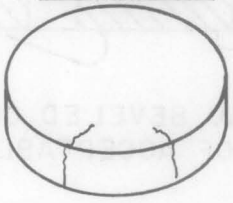
NOT APPROVED



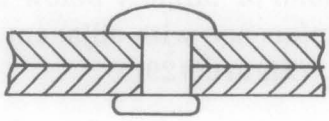
1

1. THREE OR MORE CRACKS OF ANY TYPE.
2. CRACK RESEMBLING A WEDGE-SHAPED OPENING OR MORE THAN TWO CRACKS ON THE PERIPHERY.
3. TWO OR MORE INTERSECTING CRACKS.
4. CRACK ON TOP SURFACE.

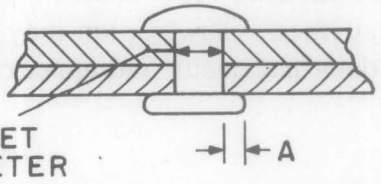
APPROVED



1. TWO OR FEWER FINE LINE RADIAL CRACKS AROUND THE PERIPHERY AND APPROXIMATELY RADIAL.
2. NO OPENING OR CRACKS WHICH MIGHT PERMIT A CHIP TO FALL OUT.
3. NO INTERSECTING CRACKS.
4. NO CRACKS IN ANY LOCATION OTHER THAN ON AND AROUND THE PERIPHERY OF DRIVEN HEAD.

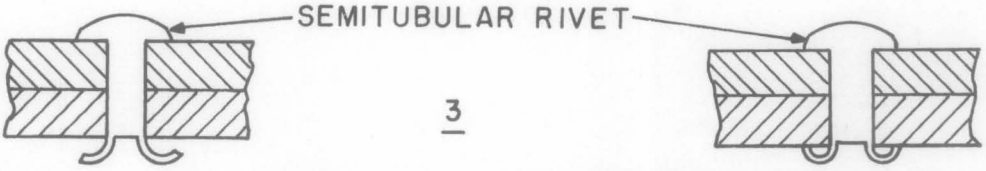


2



1. DRIVEN HEAD OFFSET BEYOND ACCEPTABLE LIMITS.

1. DRIVEN HEAD OFFSET BUT WITHIN THE FOLLOWING LIMITS:
   A MIN = .13 x RIVET DIAMETER
   A MAX= .38 x RIVET DIAMETER



3

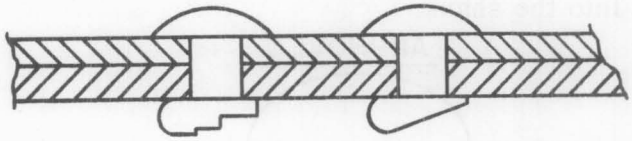
1. INCOMPLETELY ROLLED HEAD.

1. PROPERLY ROLLED HEAD.

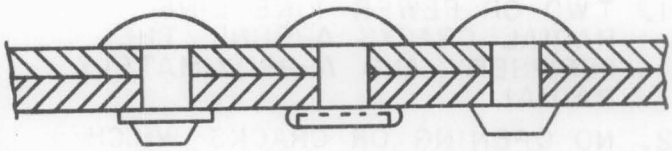
FIGURE 27

4.5.1.6 Tooling marks should not be evident on the joined materials after the staking or rolling process and shall be the basis for rejection. (Figure #28)

NOT APPROVED

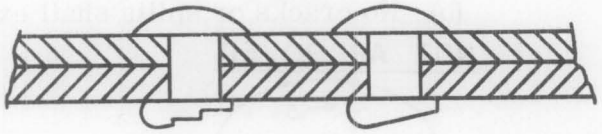


1. DRIVEN HEAD BEVELED OR STEPPED IN EXCESS OF ACCEPTABLE LIMITS.

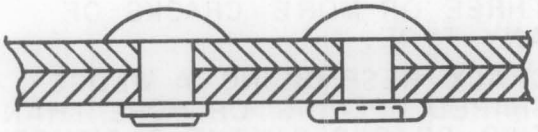


1. DRIVEN HEAD DEFORMED IN EXCESS OF ACCEPTABLE LIMITS.

APPROVED



1. DRIVEN HEAD BEVELED OR STEPPED WITHIN LIMITS.

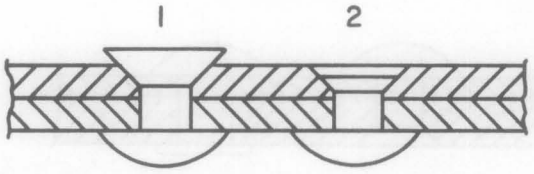


1. DRIVEN HEAD DEFORMED WITH PUNCH RINGS BUT WITHIN LIMITS.

FIGURE 28

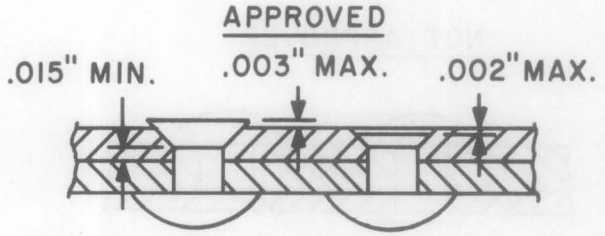
4.5.1.7 A flat head rivet shall be properly countersunk flush or slightly below the surface. Protrusion may be permissible if interference with adjacent parts does not occur and appearance is not degraded. (Figure #29)

NOT APPROVED

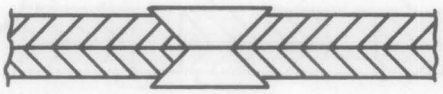


1. DRIVEN HEAD ABOVE PANEL CAUSED BY LONG RIVET OR FAILURE TO TRIM HEAD AFTER DRIVING.
2. DRIVEN HEAD BELOW PANEL SURFACE DUE TO SHORT RIVET BEING USED.

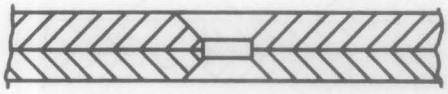
APPROVED



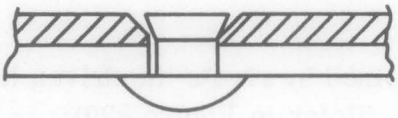
1. DRIVEN COUNTERSUNK HEAD IS FLUSH WITHIN $^{+.003}_{-.002}$



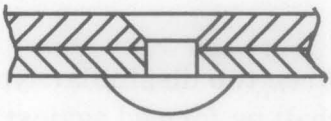
1. DOUBLE COUNTERSINK WITH NO CYLINDRICAL PORTION DUE TO COUNTERSINK TOO DEEP.
2. DRIVEN HEAD NOT FINISHED AFTER TRIMMING.



1. CYLINDRICAL PORTION IS AT LEAST .015" ON AT LEAST ONE OF THE PANELS.
2. HEAD OF RIVET REFINISHED AFTER TRIMMING.



1. RIVET SHANK DOES NOT FILL HOLE IN SHEET MATERIAL.
2. CONICAL PORTION OF DRIVEN HEAD DOES NOT FILL SPACE PROVIDED.

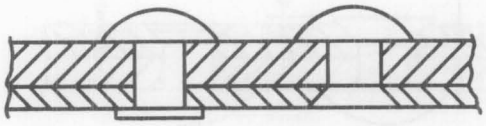


1. RIVET SHANK COMPLETELY FILLS HOLE.
2. CONICAL PORTION OF DRIVEN HEAD FILLS COUNTERSINK OR DIMPLE PROVIDED.

FIGURE 29

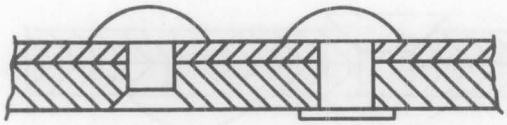
4.5.1.8 When materials of different thickness are joined by rivets the driven head shall be formed against the thicker material whenever possible. (Figure #30)

NOT APPROVED

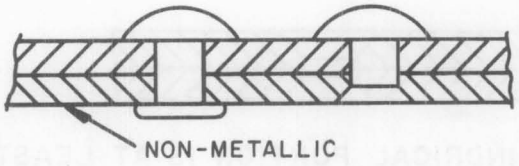


1. DRIVEN HEAD FORMED AGAINST THINNER PANEL.

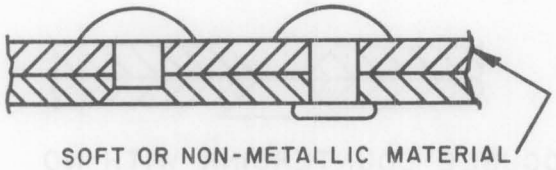
APPROVED



1. DRIVEN HEAD FORMED AGAINST THE THICKER PANEL WHENEVER POSSIBLE.



1. DRIVEN HEAD FORMED AGAINST SOFT OR NON-METALLIC PANEL.



1. DRIVEN HEAD FORMED AGAINST THE HARDER MATERIAL OF THE SHEETS BEING JOINED WHEREVER POSSIBLE.

FIGURE 30

4.5.1.9 When two dissimilar types of materials are joined by rivets the driven head shall be formed against the harder material. (Refer to Figure #30)

4.5.1.10 Assemblies shall not be joined unless the rivet head and the up-setting surfaces are parallel. (Figure #31)

SURFACES NOT PARALLEL SURFACES PARALLEL

UNACCEPTABLE ACCEPTABLE OPTIMUM

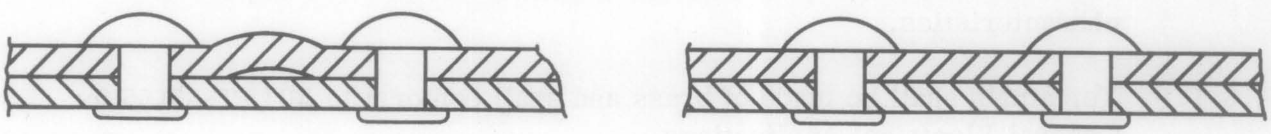
RIVETING INSTALLATION

RIVET HOLES SHALL BE ALIGNED TO PREVENT BUCKLING OF THE RIVET OR OTHER INSTALLATION DEFECT.

FIGURE 31

4.5.1.11 Rivets or riveted assemblies shall not be used for an electrical circuit or for grounding purposes.

4.5.1.12 Hole alignment shall be maintained within drawing tolerances to prevent buckling and separation between joined materials. (Figure #32)



1. SHEET SEPARATION OR BUCKLING DUE TO INCORRECT OR OUT OF LINE HOLES OR CUMLATIVE TOLERANCE OF THE SHEETS.

1. MULTIPLE RIVETS INSTALLED SO AS TO KEEP SHEETS STRAIGHT AND PARALLEL.

FIGURE 32

4.5.1.13 Hole clearance shall be maintained by using the manufacturers drill size chart. (Table III)

Rivet Hole and
Countersink Dimensions

1. Rivet Diameter	2. HOLE SIZE (Drill Size Ref)	3. Countersink	4. Permissible Hole Size for Rework
1/16	.064 - .068 (#52)	$100^\circ \times .115 \begin{smallmatrix} + .015 \\ - .000 \end{smallmatrix}$	.064 - .071
3/32	.097 - .102 (#40)	$100^\circ \times .180 \begin{smallmatrix} + .015 \\ - .001 \end{smallmatrix}$	.097 - .106
1/8	.127 - .135 (#30)	$100^\circ \times .225 \begin{smallmatrix} + .015 \\ - .000 \end{smallmatrix}$	.127 - .140
5/32	.156 - .168 (#21)	$100^\circ \times .286 \begin{smallmatrix} + .015 \\ - .000 \end{smallmatrix}$	.158 - .174
3/16	.189 - .202 (#11)	$100^\circ \times .353 \begin{smallmatrix} + .015 \\ - .000 \end{smallmatrix}$	.189 - .209
1/4	.252 - .266 (F)	$100^\circ \times .476 \begin{smallmatrix} + .015 \\ - .000 \end{smallmatrix}$	.252 - .276

TABLE III

4.5.2 Rework of a faulty rivet shall require the hole diameter to be drilled for the next standard size rivet and for that size to be installed.

4.6 Terminals

4.6.1 Terminals for PC Board installation shall conform to the following characteristics.

4.6.1.1 Terminals shall be made of brass and shall conform to MIL-T-55155 for General Electrical Applications.

4.6.1.2 Terminals shall be solder coated, tin-lead plated, gold plated, silver plated, or hot tin dipped to insure good solderability.

4.6.1.3 A minimum of .010 inch of pad material shall extend around terminal when mounted onto a PC Board. (Figure #33)

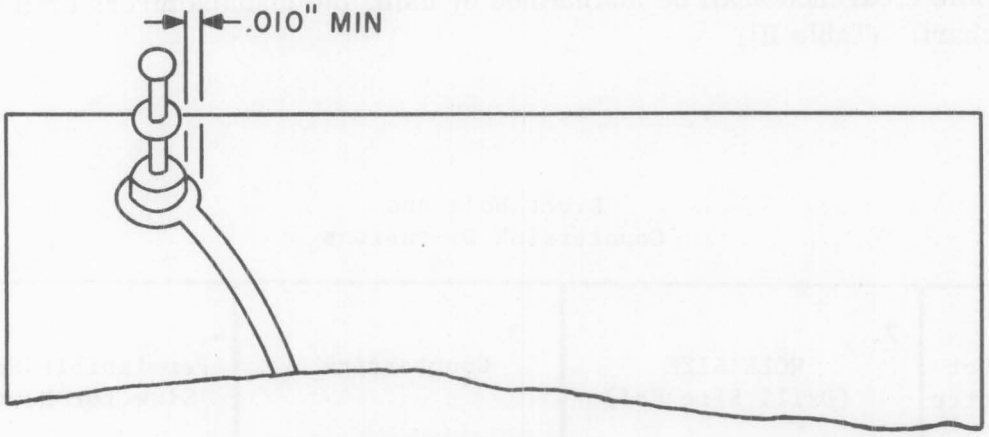


FIGURE 33

4.6.1.4 Terminals shall be installed perpendicular with the mounting surface, and concentric with the mounting hole.

4.6.1.5 The base of a terminal shall be flatly resting against the Epoxy or Glass material and shall be staked or swagged against the circuit side only. (Figure #34)

TITLE: Mechanical Assembly

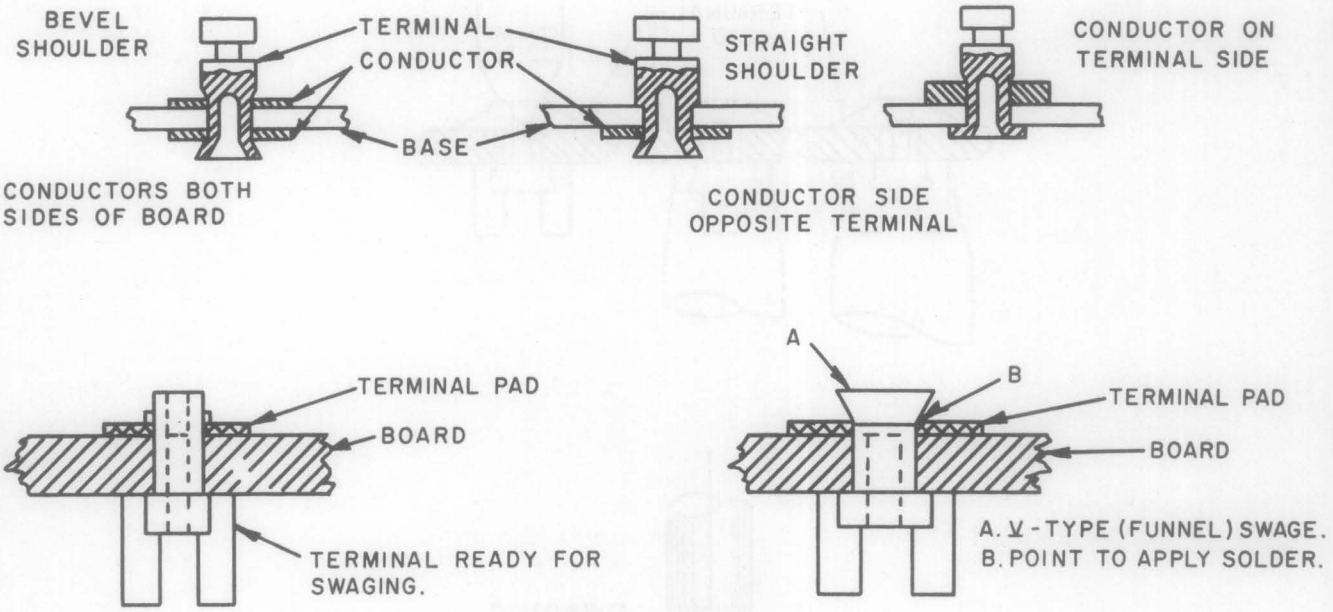
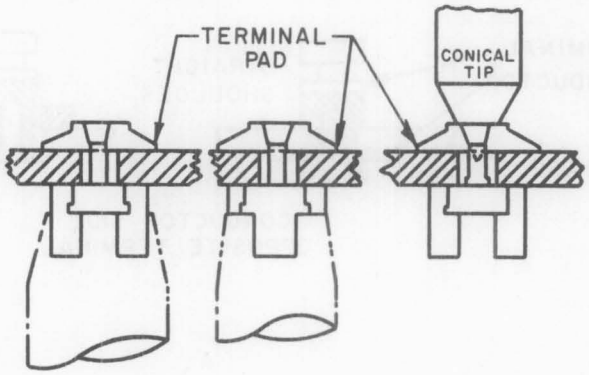


FIGURE 34

4.6.1.6 Funnel flanged type terminals shall be preferred for general applications, and shall be installed with a swagging operation that yields an included angle of between 55 and 120 degrees. (Figure #35)

Roll flange type terminals are not preferred, but when specified for a particular application shall be subject to the same inspection/rejection criteria as outlined for the installation of roll flanged eyelets. (Refer to Figures #36 and #37)



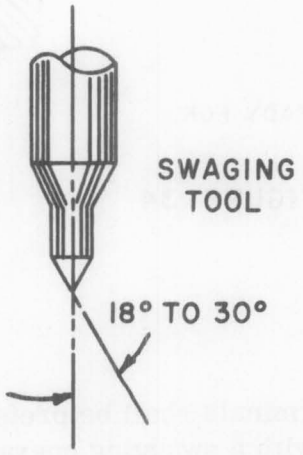


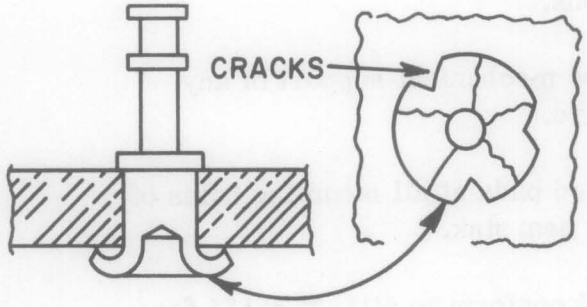
FIGURE 35

4.6.1.7 A terminal shall be sufficiently tight, such that no movement can be evident by normal finger pressure.

4.6.1.8 After swagging the flange shall be seated continuously around the circumference with a gap not to exceed 1/3 of that circumference.

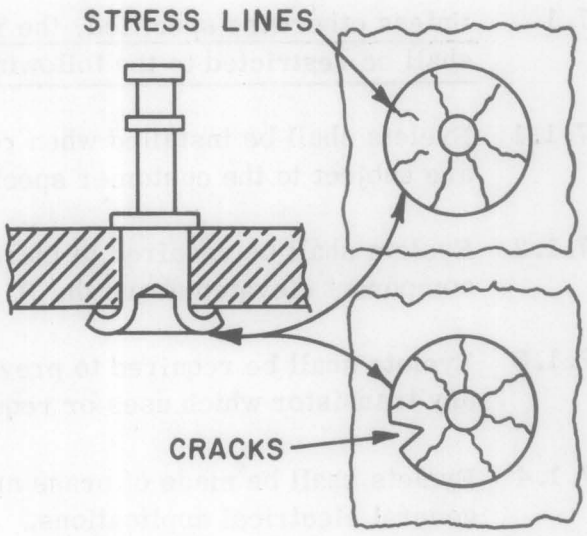
4.6.1.9 Splits in the flange shall be permitted with a maximum of 5 total, provided such splits do not extend into the barrel. (Figure #36)

NOT APPROVED

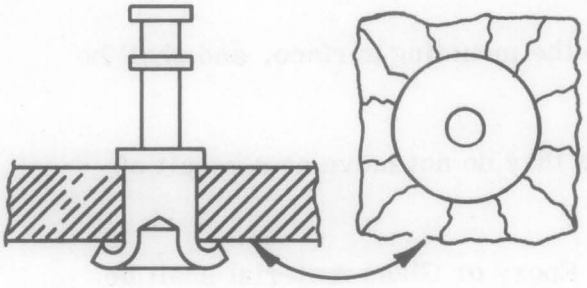


1. STACKING CRACKS IN EXCESS OF 10 PERCENT OF ASSEMBLED TERMINALS IN EACH BOARD.

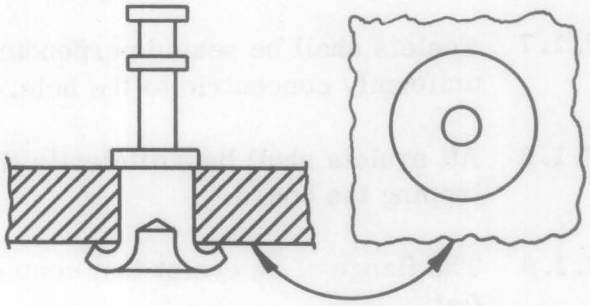
APPROVED



1. STACKING CRACKS IN LESS THAN 10 PERCENT OF ASSEMBLED TERMINALS. STRESS LINES RADIATING OUTWARD FROM CENTER HOLE TO OUTER EDGE.



1. TERMINAL BOARD DAMAGED DUE TO EXCESSIVE PRESSURE, WRONG TOOLING OR COMBINATION OF BOTH.



1. NO CRACKS OR DAMAGE TO BOARD.
2. MINOR CRAZING, NOT OVER 1/32" BEYOND TERMINAL PERMISSABLE.

FIGURE 36

4.6.1.10 Solder shall cover not less than 80% of the flange periphery and a minimum of 75% of the flange height.

4.7 Eyelets

4.7.1 Unless otherwise specified, the requirements and use of eyelets shall be restricted to the following criteria.

4.7.1.1 Eyelets shall be installed when required by contractual obligations and are subject to the customer specifications.

4.7.1.2 Eyelets shall be required to increase the mechanical support of any component elevated above the P.C. Board.

4.7.1.3 Eyelets shall be required to prevent lifted pads at all mounting holes of any transistor which uses or requires a heat sink.

4.7.1.4 Eyelets shall be made of brass and shall conform to MIL-T-55155 for general electrical applications.

4.7.1.5 Eyelets shall be solder coated, tin-lead plated, gold plated, or hot tin dipped to insure good solderability.

4.7.1.6 The inside diameter of an eyelet shall be no more than 0.035 inch greater than the diameter of the lead or terminal to be inserted.

4.7.1.7 Eyelets shall be seated perpendicular to the mounting surface, and shall be uniformly concentric to the hole.

4.7.1.8 All eyelets shall be sufficiently tight that thay do not move as a result of tapping the board.

4.7.1.9 The flange of an eyelet that contacts the Epoxy or Glass material shall be flat.

4.7.1.10 All rolling, staking or swagging operations shall be performed against the circuit or pad area only. (Figure #37)

TITLE: Mechanical Assembly

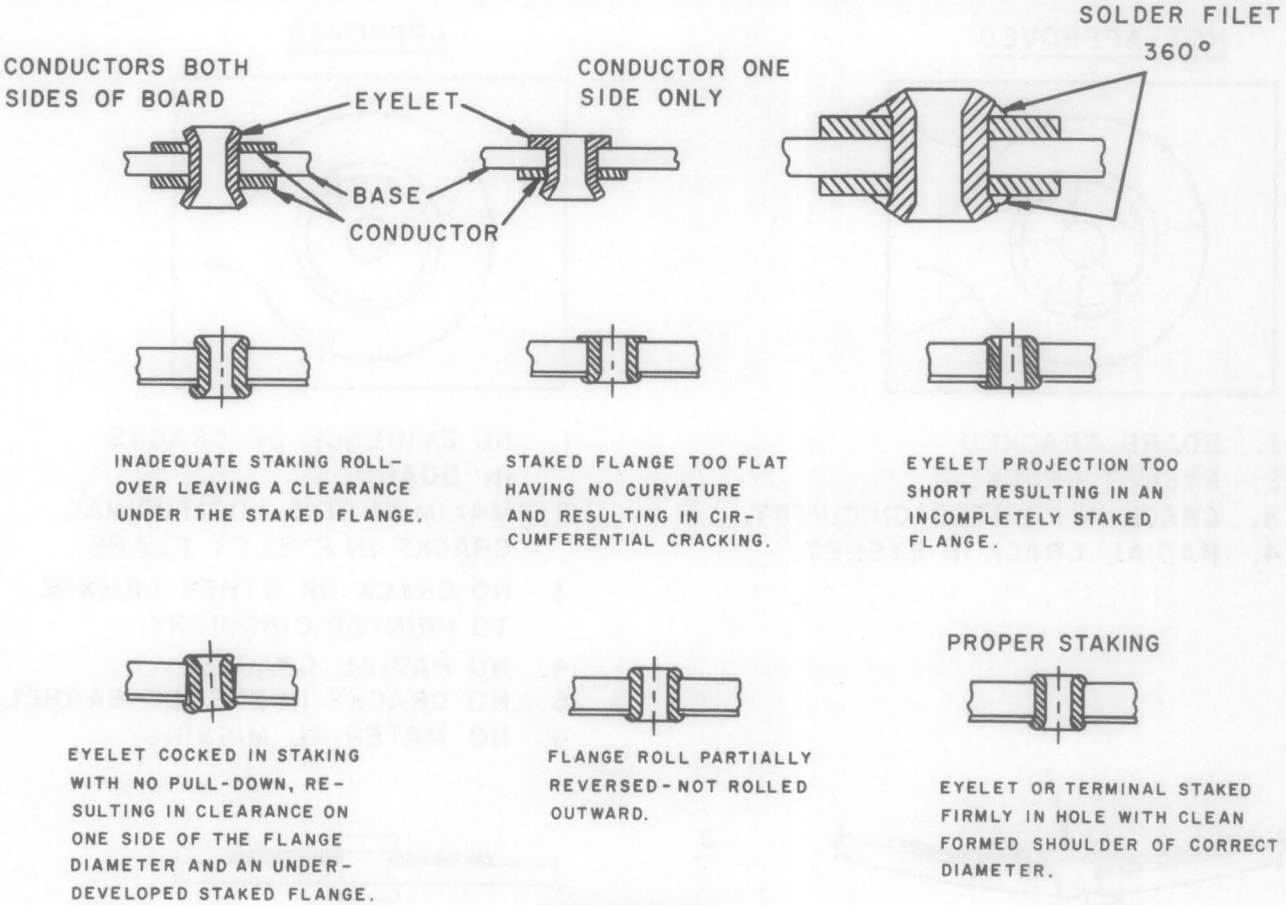


FIGURE 37

4.7.2 Roll-over type rivets shall conform to characteristics as outlined in paragraphs 4.7.1.4 thru 4.7.1.10 and in conjunction with the following unique requirements.

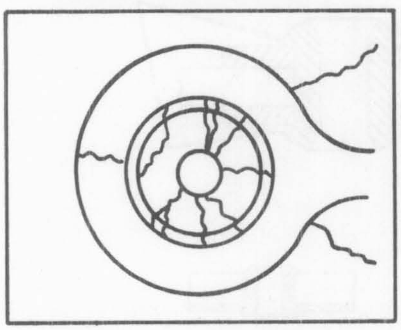
4.7.2.1 Forming should produce a smooth roll-over that touches the terminal area continuously around the circumference with a gap no more than 1/3 of the eyelet circumference.

4.7.2.2 Splits shall be permitted in the flange provided such splits do not extend into the barrel or body with maximum of 5 total splits in the flange. (Figure #38)

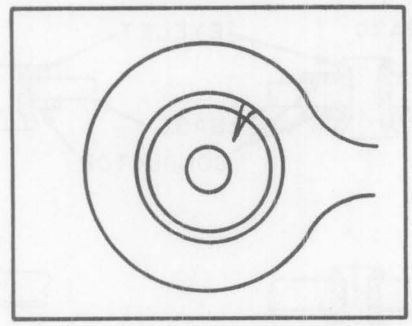
TITLE: Mechanical Assembly

NOT APPROVED | APPROVED

1

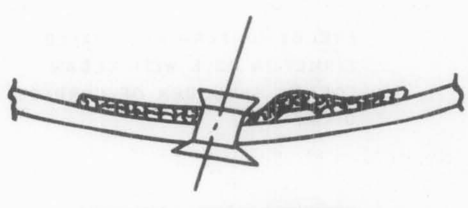


1. BOARD CRACKED.
2. EYELET CRACKED.
3. CRACK IN PRINTED CIRCUITRY.
4. RADIAL CRACK IN EYELET.

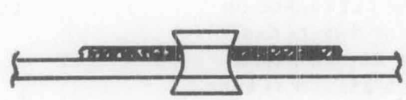


1. NO EVIDENCE OF CRACKS IN BOARD.
2. MAXIMUM OF 5 LOGITUDINAL CRACKS IN EYELET FLARE.
3. NO CRACK OR OTHER DAMAGE TO PRINTED CIRCUITRY.
4. NO RADIAL CRACKS.
5. NO CRACKS IN EYELET BARREL.
6. NO MATERIAL MISSING.

2



1. BOARD DEFORMED.
2. EYELET NOT SET SYMETRICALLY.
3. CIRCUITRY DAMAGED.
4. EYELET TOO TIGHT.
   OR
5. EYELET TOO LOOSE.



1. BOARD NOT DEFORMED.
2. EYELET SET SYMETRICALLY.
3. CIRCUITRY UNDAMAGED.
4. EYELET CAPABLE OF BEING TURNED WHEN REASONABLE TORQUE IS APPLIED.
5. EYELET WILL NOT RATTLE IN BOARD.

FIGURE 38

4.7.2.3 Deforming of the PC Board or the eyelet flange shall not be permitted.

TITLE: Mechanical Assembly

4.7.3 Funnel flange and flat flange eyelets shall conform to characteristics as outlined in paragraphs 4.7.1.4 thru 4.7.1.10 and in conjunction with the following unique requirements.

4.7.3.1 Swagging shall result in a funnel periphery even and unjagged with placement uniformly concentric to the hole.

4.7.3.2 Splits shall be permitted in the flange but shall not extend into the barrel.

4.7.3.3 A good solder fillet around the flange of a flat flange type, shall cover not less than 80% of the flange periphery.

4.7.3.4 Solder shall cover a minimum of 75% of the flange height.

4.7.3.5 Cracks shall not be permitted in the solder fillet between the flange and the terminal area.

4.8. <u>Solder Lugs</u>

4.8.1 Solder lugs shall be installed to provide a point to which ground wires can be soldered in area not easily accesible or on a material to which wires can not be soldered.

4.8.1.1 Solder lugs which contain internal teeth in the mounting hole shall be preferred for installation onto metal surfaces.

4.8.1.2 Solder lugs with no locking provisions shall be preferred for installation onto non-metal and/or compressible materials.

4.8.1.3 No more than two (2) wires per hole shall be acceptable on any ground solder lug.

4.8.2 Proper application of solder lugs shall be accomplished in conjunction with the installation of flat washers and lock washers to give good mechanical retention and a reliable electrical connection.

4.8.2.1 The following illustrations demonstrate the proper installation of solder lugs. (Figure #39)

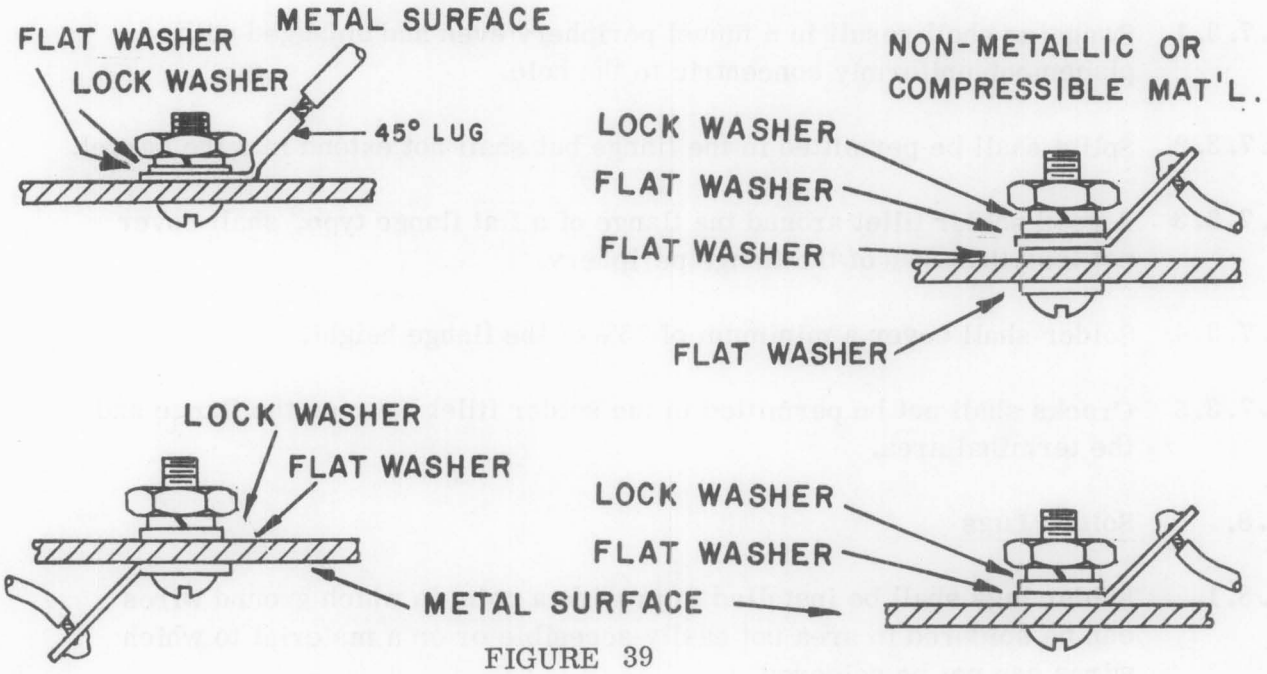


FIGURE 39

4.8.2.2 Cadmium plated chassis shall be protected from corrosion by using only stainless steel hardware at all points of contact between the hardware and the plating.