CONTRACT NO. NAS9-13955
DRL NO. T-935
LINE ITEM NO. 2
DRD NO. MA-183T
NASA CR-
141575

MODIFIED ELECTRICAL CONNECTOR

FINAL REPORT
DECEMBER 1974

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SANTA ANA, CALIF. 92702

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Final Report

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ABSTRACT

This final report covers a removable interfacial insulator design concept that simplifies electrical connector repairability when damage occurs to male electrical contacts or resilient interfacial seal.

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OBJECTIVE

To modify existing electrical connectors and eliminate many of the problems with bent or broken pins and damaged interfacial seals; to alleviate much of the time, effort and expense associated with replacing these pins and seals in the event they do become damaged.

BACKGROUND

In the Apollo Command and Service Module and Lunar Module Programs, 85% of the reported problems with electrical connectors involved one or more of these three anomalies: recessed or improperly sealed pins, damaged seals, and bent pins.

Damaged Seals

Although there are several seals in a connector, the interfacial seal appears to be the most fragile. It can be damaged when pins are inserted or removed from the connector, or be punctured or torn by the pin in a rear-release connector. In a front-release connector, the seal may be damaged either by the pin or contact extraction tool. Also, foreign objects or contamination could render the seal ineffective. In any of these cases, the entire connector must be replaced.

Recessed Pins

Recessed pin contacts are due primarily to improper seating of the pin contact in its retaining device. To re-seat the contact, the rear accessory hardware must be removed from the shell to gain access to the insert. After properly seating the contact, the accessory hardware must be reassembled to the connector.

Bent or Broken Pins

Pin contacts are most often bent or broken by coming into contact with some foreign object, ie, a tool, hardware, or the mating half of a connector. In the event of pin contact damage, a new pin contact must be installed by first removing the aft accessory hardware from the shell to gain access to the insert, extract the wire with the damaged contact, remove damaged pin contact, re-strip the wire, crimp a new pin contact, re-insert, and finally, reassembling the accessory hardware to the connector.

As indicated above, to repair these anomalies is expensive, time consuming and in same cases, these repairs will cause delays in critical program scheduling.

DESIGN GENERAL

The interfacial insert consists of a rigid dielectric disc with pins molded in place and protruding from both sides. An interfacial seal is bonded to each side of the disc (see Figure 1). One side of the disc mates to female contacts in a modified MS3470, MIL-C-0026482 type connector, the other side will mate to its standard mate, a MS3476 plug connector with female contacts.

The interfacial insert is retained in the modified shell by a metal clip with a series of tines running perpendicular to the strip axis (see Figure 2).

The clip is cut to a prescribed length and fits into an undercut in the modified shell. This clip is retained in the undercut by butting the edges together. The clip is oriented in the shell so that the tines will deflect upward when the interfacial insert is installed or removed. In the locked position, the tine lodges against a shoulder on the interfacial insert (see Figure 3).

The interfacial insert, insert retaining clip is accommodated in a modified female shell. The engaging portion is unchanged and will mate to its standard mating connector (see Figure 4).

DESIGN FEATURES

Interfacial Insert

a. Insert to Shell Polarizing Key - This key assures correct alignment when mated to symmetrical layouts. The key will also preclude incorrect installation into the insertion tool because the key height is greater than the tool I.D. (see Figure 5).

b. Keyways - A normal and three alternate position keyways are provided on the peripheral shoulder. These keyways engage a key on the insertion tool to further assure correct installation. The normal keyway will also always be in line with the insert to shell polarizing key to provide a visual inspection that the interfacial insert is correctly aligned for normal position installation (see Figure 5).

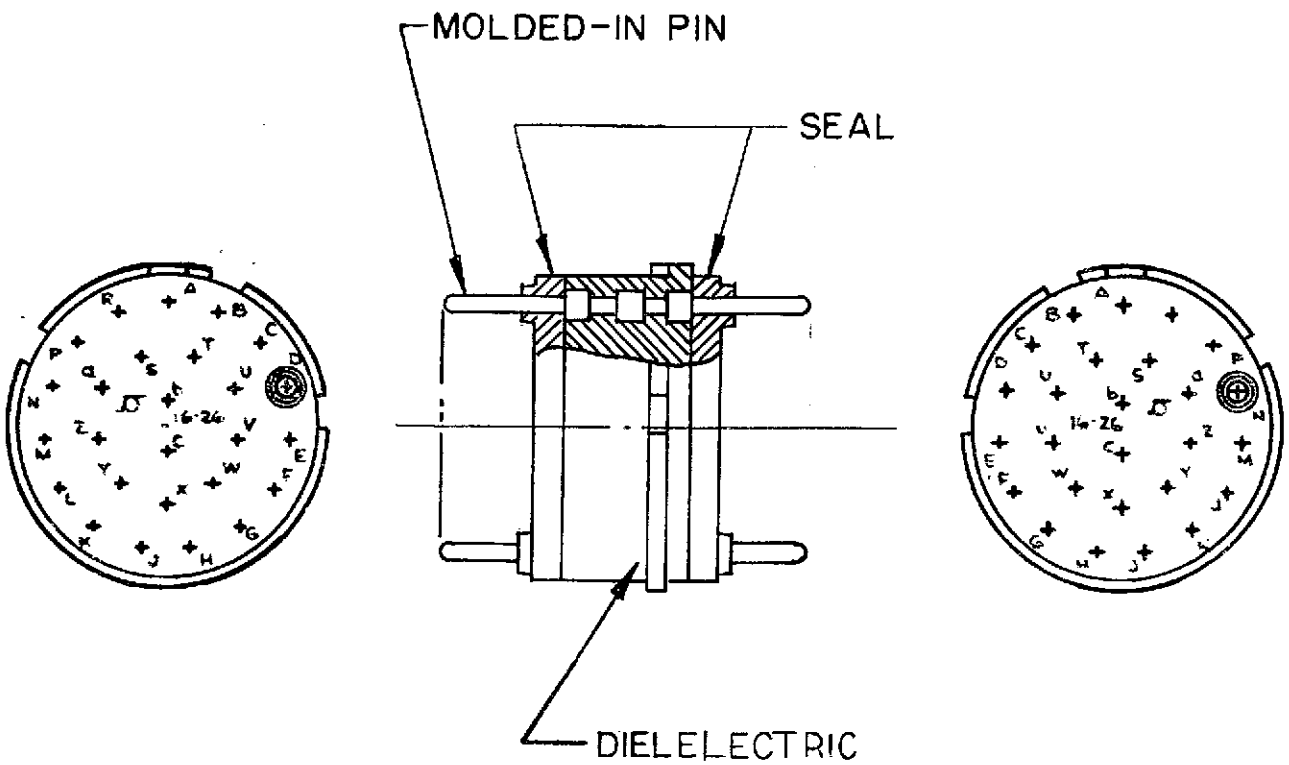
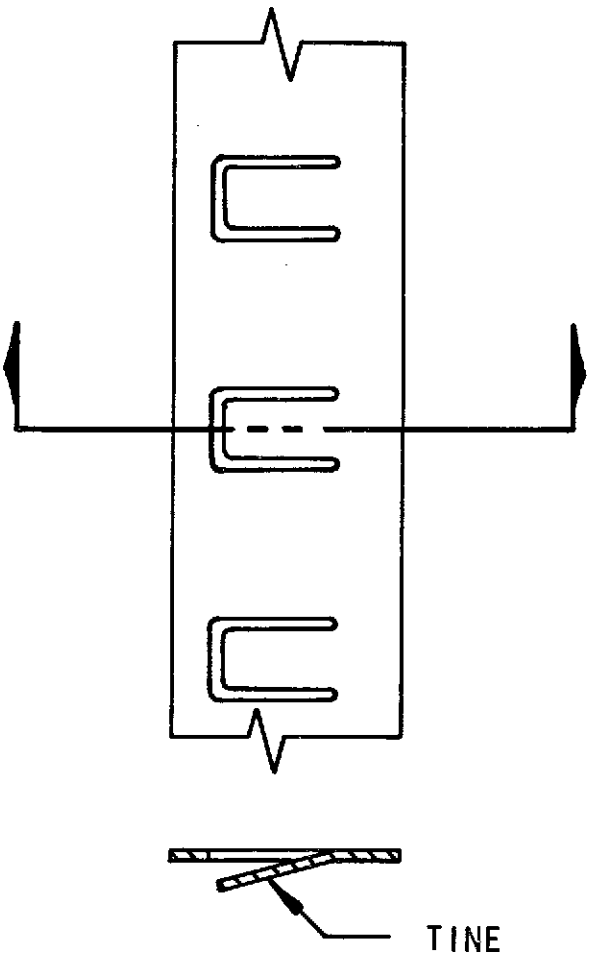


FIG 1 BASIC
INSERT CONSTRUCTION



-4-

FIG 2
METAL INSERT RETENTION CLIP

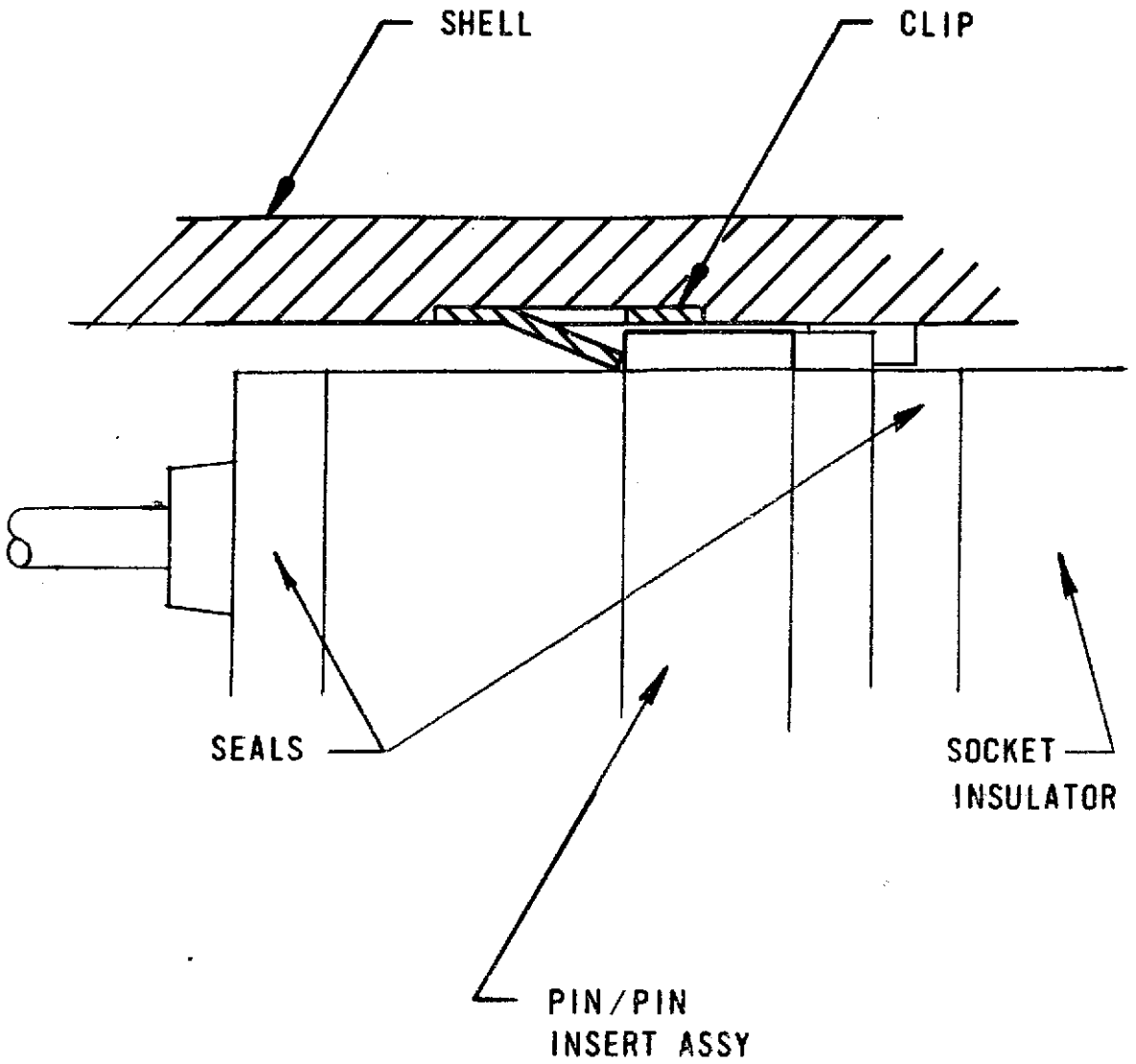
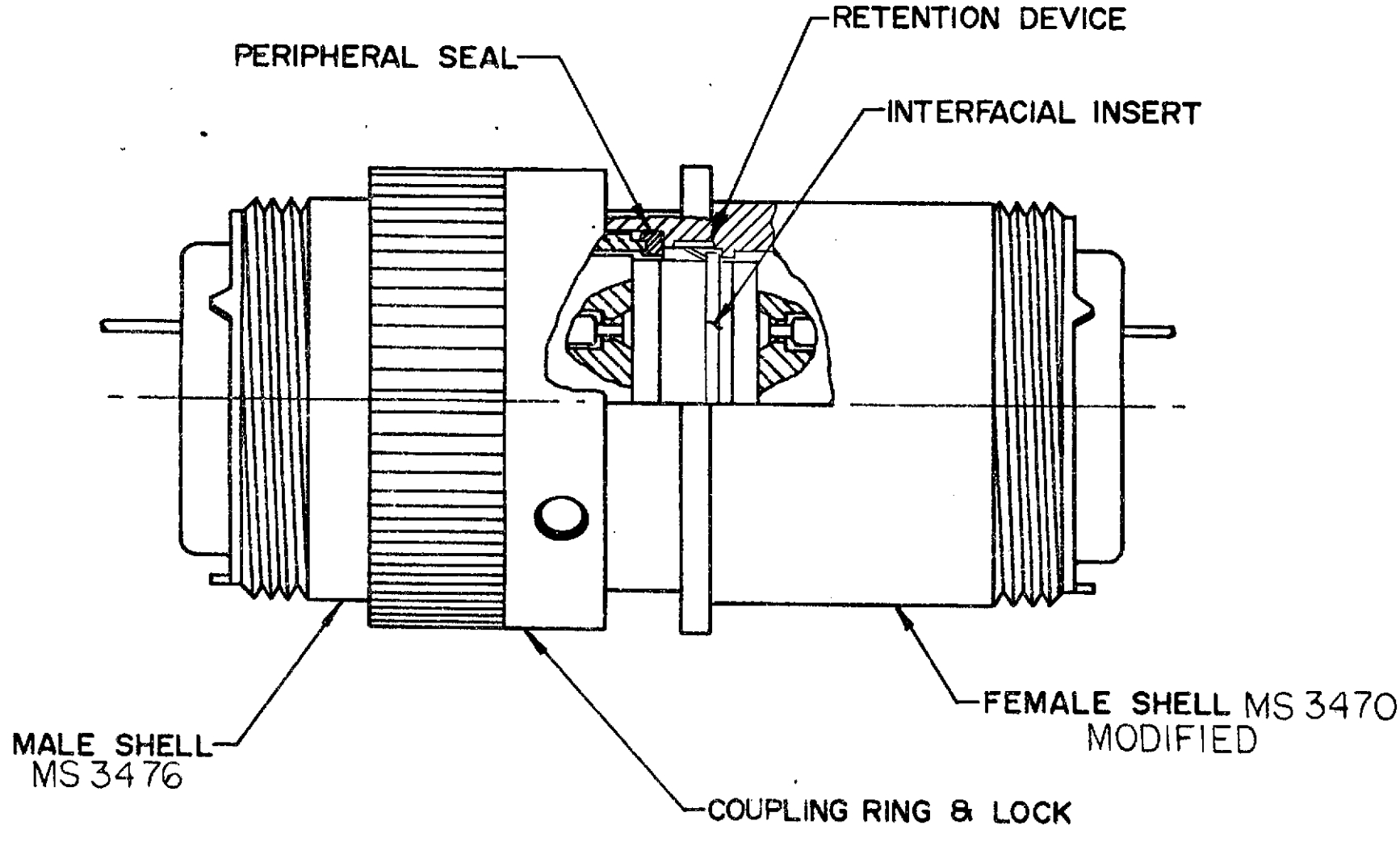
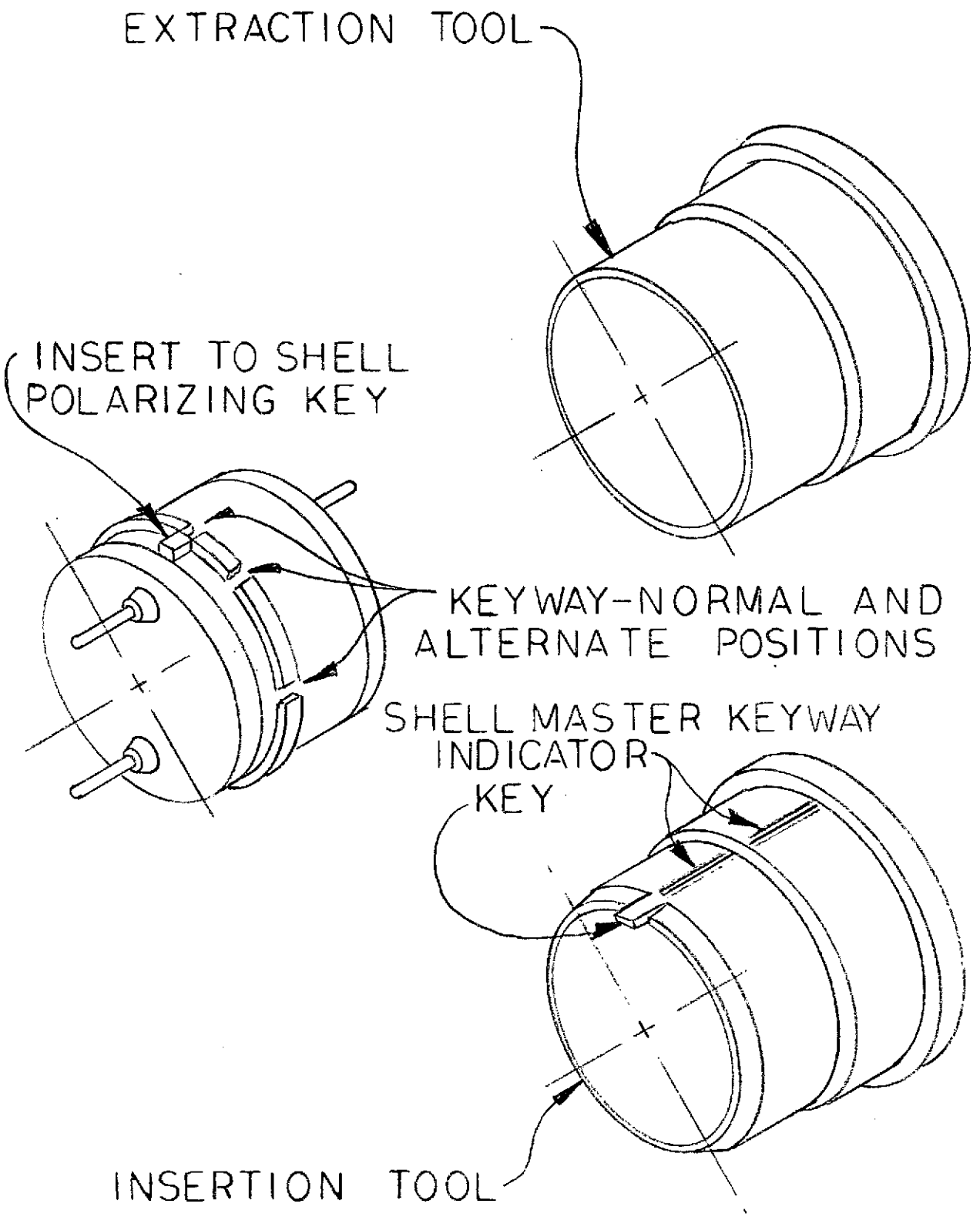


FIG 3
INSTALLED INSERT ASSY



MODIFIED MIL-C-83723 MATING ELECTRICAL CONNECTOR
WITH INTERFACIAL INSERT

FIGURE 4



DESIGN FEATURES

FIG 5

DESIGN FEATURES , Continued

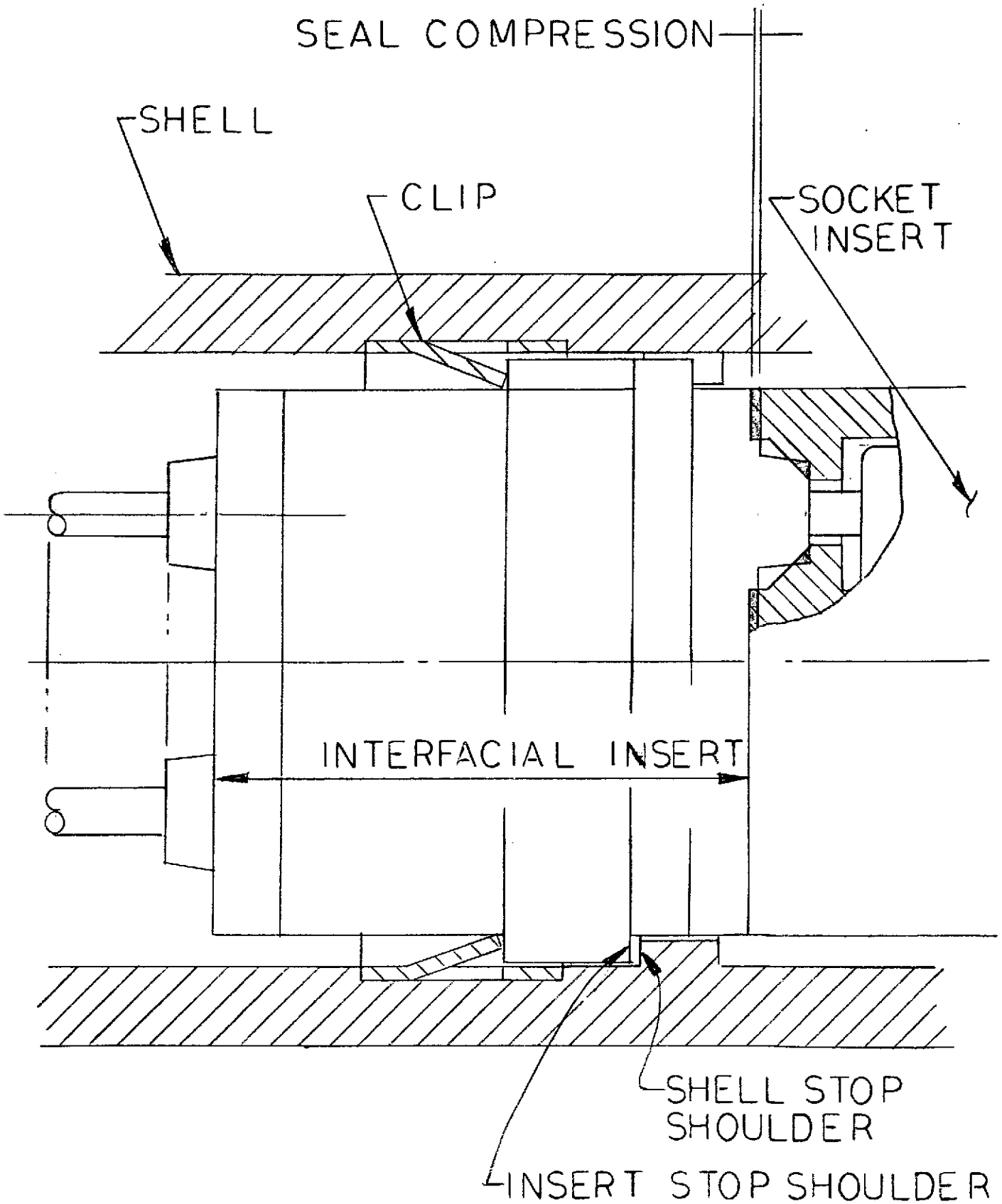
Interfacial Insert

c. Raised Shoulder - The raised shoulder on the interfacial insert performs two functions. First it precludes over insertion by stopping against a shoulder in the shell; second, it is the holding surface for the metal clip tines (see Figure 6).

d. Seals - Seal compression in the area indicated in Figure 6 will provide a constant preload on the interfacial insert. This preload is transfered to the metal clip tines so that the interfacial insert is rigidly affixed to the modified shell (see Figure 6).

e. Insertion Tool - The insertion tool has a key on the engaging end which engages the applicable keyway on the interfacial insert. In line with the key on the tool is an indicator which is aligned with the master keyway of the shell. The combination of the indicator, key and keyway on the interfacial insert are features to assure correct installation. The chamfer on the leading O.D. edge allows the tine to drop down and retain the interfacial insert when the tool is extracted. To further assure correct installation, the tool body diameter is the same as the mating male plug connector. This feature eliminates excessive tool side play in the receptacle engaging I.D. (see Figure 6).

f. Extraction Tool - This tool has the same basic features of the insertion tool except it has no key and no chamfer. The O.D. of this tool deflects the metal clip tines away from the shoulder when inserted in the engaging I.D. of the shell. On the assumption that the extraction tool is only used to remove a damaged interfacial insert, a needle nosed pliers or any other similar tool is used to pull the damaged insert and tool from the connector.



DESIGN FEATURES

FIG 6

DESIGN PROBLEM AREAS

In anticipation of implementing the interfacial insert in production type MIL-Spec connectors, the problem areas listed below must be considered.

1. A 66% increase in receptacle connector weight.

2. A 57% increase in receptacle connector length.

3. Increased equipment penetration or front of panel extension depending on where the receptacle mounting flange is located.

4. Increased connector costs, due to special non-MIL-type shell.

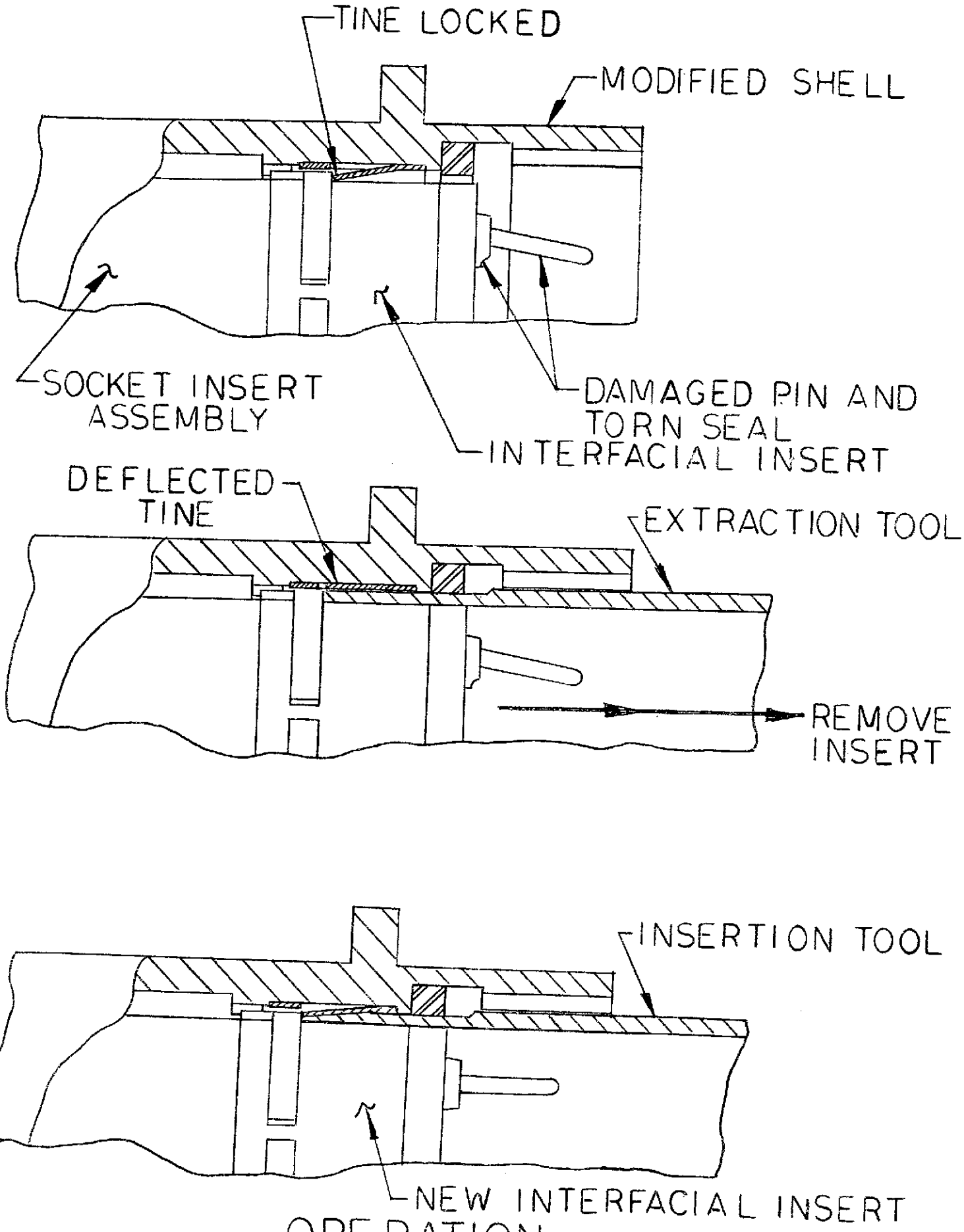
5. New socket insulator is required for contact arrangements which are not symmetrical about the vertical axis. This non-symmetry only occurs in a few contact arrangements covered by MIL-C-5015. Both MIL-C-38999 and MIL-C-0026482 contact arrangements are all symmetrical about the vertical axis.

OPERATION AS A UNIT

(See Figure 7)

The top figure depicts a connector with a damaged seal and contact. To replace the interfacial insert, simply insert the extraction tool and remove the damaged insert, gripping the pin contacts with a needle nose plier.

Place the new interfacial insert into the insertion tool, install as shown in the lower figure, remove the tool and connector is now repaired and ready for service.



OPERATION

FIG. 7

TEST AUTHORIZATION

RS

ITT CANNON ELECTRIC
3208 HUMBOLDT ST., LOS ANGELES, CALIF
A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
CANNON PLUGS

NO	DAY	YEAR		
11	11	74	S. Yamamoto	203-74

NEEDED ON OR BY MO.	DAY	YEAR	SUPERVISORY AUTHORITY BELOW 8 HRS. OR $25. OVER THAT AMOUNT DEPT. HEAD APPROVAL REQUIRED	REPORT ISSUED MO.	DAY	YR.	DIV
11	25	74					

DEPARTMENT	AUTHORIZED BY	TEST AUTH. NO.
2031		0187-5010A

DIVISION	ORIGINATOR'S PROJECT NO	ESTIMATED COMPLETION MO.	DAY	YR	HRS
Central Eng.	0187-501				

PURPOSE (TO DETERMINE WHAT AND WHY)

To determine the design feasibility of NASA's Interfacial Insert System as a connector saver.

TEST SAMPLES

QUAN.	ITEM	DRAWING NUMBER WITH CHANGE LETTER	LINE CODE	PART NUMBER / DESCRIPTION	HOW MADE, SOURCE, MATERIALS CO
1	1	HQ0187-500-110		Shell, Test Aid	Eng. Model Shop
1	2	HQ0187-500-113		Tool, Insert Removal	Eng. Model Shop
1	3	HQ0187-500-115		Tool, Insert Insertion	Eng. Model Shop
1	4	HQ0187-500-107		Interfacial Ins. Assy.	Production
1	5	HQ0187-500-112		Clip, Interfacial Ins. Ret.	Production
1	6	029-0000-002		Clip, Ins. Ret. PV 16	Production
2	7	144-1842-000		Insulator Assy PV 16-26S	Production

DISPOSITION OF SAMPLES AFTER TEST (1) ☐ RETURN TO ORIGINATOR; (2) ☐ SCRAP ☐ OTHER, (SPECIFY

CANNON JOB NO	CUSTOMER	CUSTOMER P O NO	MILITARY CONTRACT NO	LAB QUOTE NO
316820	NASA LBJ SC Houston, Texas	NAS-9-13935	N/A	N/A

TESTS REQUIRED AND/OR SPECIAL INSTRUCTIONS (LIST EACH TEST AND APPLICABLE SPECIFICATION)

1. Interfacial Insert Retention. 32 Lbs. Max.
2. Interfacial Insert Insertion Force
3. Socket Contact Insertion Force
4. Pin Contact Retention @20 lbs.
5. Contact Resistance - Set up: REF. MIL-C-39029
6. Durability - 500 cycles.
7. Interfacial Insert Removal Force.

NOTE: Will the test lab please make comments on the operation of the design concept.

GOVT INSPECTION REQUIRED ☐ YES ☐

REPORT/ABSTRACT QUANTITY OF REPORTS REQUIRED_____ FORMAL PRODUCT EVALUATION REPORT REQUIRED ☒ YES ☐ N

Test	Results
Interfacial Insert Retention	No dislodgement @ 32 Lbf.-Max deflection .014 inch.
Interfacial Insertion Force	Max. measured force for five insertions was 24.0 lbs.
Socket Contact Insertion Force	Max. measured force for 26 socket was 7.3 lb
Pin Contact Retention	No dislodgement @ 20 Lbf.-Max.deflection .015 inch.
Contact Resistance(Set up per MIL-C-39029)	Max.measured voltage drop was 38.8mV @ 7.5Ad
Durability (500 cycles).	No damage to insert assembly.
Interfacial Insert Removal Force.	Max. measured force for five removals was 13.0 lbs.

Abstract: The interfacial insert met all requirements listed above and exhibited no operational problems.

J. Woolweaver
Sr. Lab Technician

R. J. Sherrard
Supvr.-Test Laboratory

CONCLUSIONS

As indicated on the enclosed test report, the interfacial insert met all the requirements and exhibited no operational problems.

Listed below are the conclusions made based on the test results.

1. Test - Interfacial Insert Retention.

   Reason - To determine the capability of the metal clip retention.

   Criteria - MIL-C-0026482, Paragraph 3.6.30, 32 lbs. max. for shell size #16.

   Results - Passed 32 lbs. max. with .014 inch deflection.

   Conclusion - Metal clip retention meets insert retention requirements as applicable.

2. Test - Interfacial Insert Insertion Force

   Reason - To determine axial force required to install interfacial insert as in service.

   Criteria - None

   Conclusion - The insertion force of 24 pounds is including the engaging force of 26 #20 socket contacts, the compression of the inner interfacial seal and the metal clip tine deflection. This force of 24 pounds will have to be considered when higher density contact arrangements and larger shell sizes are evaluated.

3. Test - Socket Contact Insertion Force

   Reason - To determine if socket contact insertion force is affected when a male pin contact must be engaged during the insertion process.

   Criteria - MIL-C-0026482, paragraph 3.6.10, 20 lbs. max. for size #20 contacts.

   Conclusion - Engaging a male pin contact does not affect the contact insertion process.

CONCLUSIONS, Continued

4. Test - Pin Contact Retention

   Reason - To determine the effects of interfacial seal compression during the contact retention test.

   Criteria - MIL-C-0026482, Paragraph 3.6.32, 20 lbs. load with .012 max. deflection.

   Conclusion - With a 20 lb. load, the interfacial seal is adding .003 to the .012 max. requirement. This .003 additional deflection should be considered if this test becomes a requirement for the modified connector. Also, during the test, it was discovered that the mating half of the connector would also serve as a good insertion device.

5. Test - Contact Resistance

   Reason - To determine if contact resistance is affected by the interfacial insert pin/pin contacts.

   Criteria - MIL-C-0026482, Paragraph 3.6.5.1, Size #20 contacts = 55 millivolts max.

   Conclusion - The additional pin length does not affect the electrical performance.

6. Test - Durability

   Reason - To determine if repeated mating/unmating would affect the interfacial insert molded in pin contacts.

   Criteria - MIL-C-0026482, Paragraph 3.6.18, 500 cycles of mating/unmating.

   Conclusion - Repeated mating/unmating does not affect the function of the interfacial insert. If base metal exposure on the pin contacts is objectionable in service, this design concept provides a simple solution where many cycles of durability are anticipated.

7. Test - Interfacial Removal Force

   Reason - To determine the amount of force required to remove the interfacial insert.

   Criteria - None

   Conclusion - The removal force of 13 lbs. includes the separation force of 26 #20 socket contacts, again the contact arrangement density and the shell size will influence this force.

SUMMARY

As evidenced by the test report, the objective of simplified connector repairability was successfully met with the interfacial insert design concept.

The design concept of the metal clip method of insert retention and the molded in pin/pin insulator system functioned as intended.

The separate metal clip insert retention design selection over the molded integral plastic tine on the periphery of the insert is necessary so that a functional peripheral seal in the receptacle can be designed in as required by all high performance electrical connectors.

The metal interfacial insert insertion/extraction tools, a set for each shell size, could be made from a thermal plastic material to reduce cost of the tools. To further reduce cost, the tool could be a double ended tool similar to the conventional contact insertion/extraction tools.

The interfacial insert did not present problems in any areas of manufacture and assembly: subsequently, no new technology is required to produce or assemble the insert.

RECOMMENDATIONS

Based on the success of the design evaluation study, ITTCE highly recommends that the follow-on contract to modify a MIL-type male shell, be considered.

Ref: NASA RFP #9-BC721-4-4-164P
ITTCE Proposal G-19580

The design study concluded under this contract was limited to insert assemblies without shell hardware. Without hardware, only a limited number of mechanical and electrical tests are feasible, also no hardware precluded any environmental testing.

Environmental testing, ie, Vibration, Shock, Thermal Shock, Humidity, etc, would confirm the interfacial inserts design capabilities in a MIL-type connector configuration. Subsequently, it behooves NASA to issue the follow-up contract for further development immediately so that no lead time will be lost when an interfacial insert system becomes a real connector requirement.

APPENDIX A

To comply with Item 3.2.1 of the Statement of Work as modified by the Amendment 15, dated 12-9-74, to Contract No. NAS 9-13955, the following Reliability Assessment is submitted as an Appendix to the Final Report entitled "Modified Electrical Connector" which was submitted on December 13, 1974.

Submitted by:

Bruce Arnold

Bruce Arnold, Manager
Military/Aerospace Products

Stephen Yamamoto

Stephen Yamamoto
Senior Design Specialist

RELIABILITY ASSESSMENT

The introduction of the interfacial insert will add the equivalent of an additional connector into the system when determining reliability. That is, a pin and socket insulator and interfacial seal are added by the use of the interfacial insert and these elements approach a total connector.

The numerical reliability of the series addition can be determined by the following equation:

$$R_T = R_1 \times R_2$$

Where R_T = Total Modified Connector Reliability

R_1 & R_2 = Standard Connector Reliability

Using this equation, the reliability at specified levels can be determined as shown in the table below:

Standard Connector Reliability	Modified Connector Reliability	% Change
.99	.98	- 2
.999	.998	- 0.2
.9999	.9998	- 0.02

At a very low reliability level of .99, the reduction in reliability is 2% by the use of the interfacial insert. However, the interfacial insert has the potential of eliminating 85% of connector problems (which can cause failure) and will therefore increase connector reliability by one order of magnitude.