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TECHNOLOGY UTILIZATION

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CABLES AND CONNECTORS

A COMPILATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# Foreword

The National Aeronautics and Space Administration and Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace research and development programs.

This document is one of a series intended to furnish such information. The compilation is divided into three sections that reflect the uses, adaptations, and maintenance plus service, that are innovations deriving from problem solutions in the space research and development programs, both in house and by NASA and AEC contractors.

The first section covers technology relevant to the employment of flat conductor cables (FCC) and their adaptation to and within conventional systems. Section two is concerned with connectors and covers a variety of adaptations. The last section is devoted to maintenance and service technology and includes a variety of shop hints useful in the installation and care of cables and connectors.

The latest patent information available at the final preparation of this Compilation indicates that NASA and AEC have decided not to apply for patents on the items herein. However, potential users of items described should consult the cognizant organization for updated patent information at that time.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this Compilation.

Jeffrey T. Hamilton, *Director*  
*Technology Utilization Office*  
*National Aeronautics and Space Administration*

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# Section 1. Flat Conductor Cable (FCC) Technology

## TECHNIQUES FOR ATTACHING FLAT CONDUCTOR CABLE DIRECTLY TO ROUND CONNECTORS: I

Several methods have been conceived for attaching flat conductor cable (FCC) directly to the existing contact points of conventional round connectors. In each of these concepts, the connection is sealed from the environment and is repairable if damaged.

The connectors all employ a two-transition termination: The FCC is connected to the round wire, and the round wire is crimped to the existing contacts, which are then installed in conventional round connectors. This concept can be applied to several sizes and types of connectors.

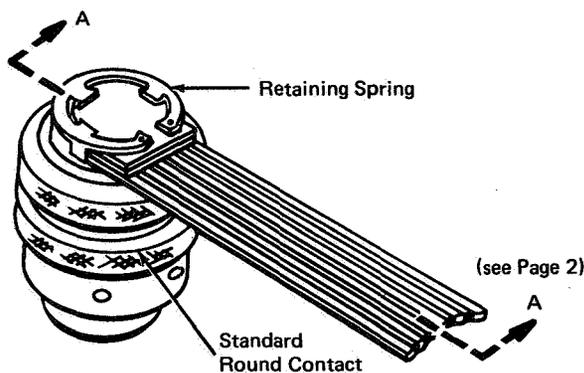


Figure 1. FCC Termination to Standard Round Contact (Retaining Spring)

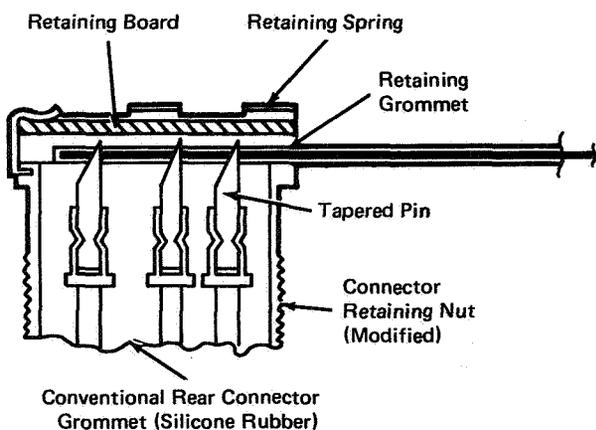
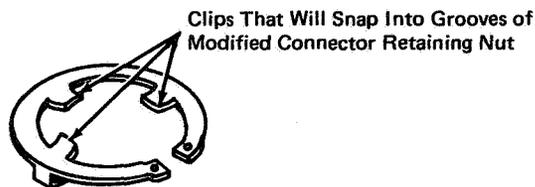


Figure 2. Section A-A



3a. Taper Pin



3b. FCC Retaining Spring

Figure 3. Modified Parts

Figure 1 shows the FCC and a standard round connector; Figure 2 is a cutaway view of the same assembly. Existing pin or socket contacts are used, but with a newly designed tapered pin (Figure 3a). Other new parts include: an FCC retaining grommet that insures contact between the tapered pin and the FCC, protects the contact from damages, and keeps moisture out; a circular retaining board that serves to position and secure the retaining grommet; and an FCC retaining spring (Figure 3b). The retaining spring is a heavy spring-loaded clip that secures both the retaining grommet and the retaining board. This spring is similar to a snapping, but it has fingers on top to apply force to, and to secure, the retaining board, the grommet, and the FCC. Small slots must be cut in the outside of the retaining nut to allow the three fingers of the spring to snap into the nut. Two versions of this design are available, one for a five-contact connector and one for a thirteen-contact connector.

Source: J. O. Doyle and E. J. Stringer of Rockwell International Corp. under contract to Marshall Space Flight Center (MFS-24152, 24153)

Circle 1 on Reader Service Card.

## TECHNIQUES FOR ATTACHING FLAT CONDUCTOR CABLE DIRECTLY TO ROUND CONNECTORS: II

In the preceding article a method was described by which flat conductor cable (FCC) may be directly attached to conventional round connectors. An alternative method has been prepared, using the

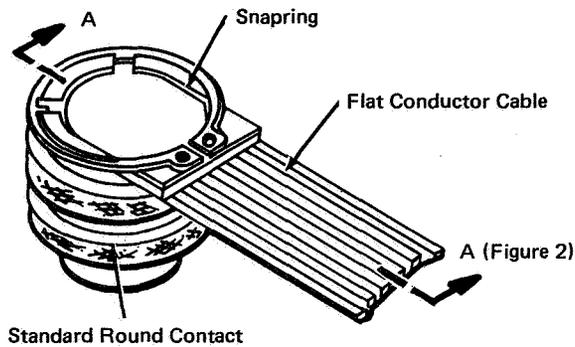


Figure 1. FCC Termination to Standard Round Contact (Snapping)

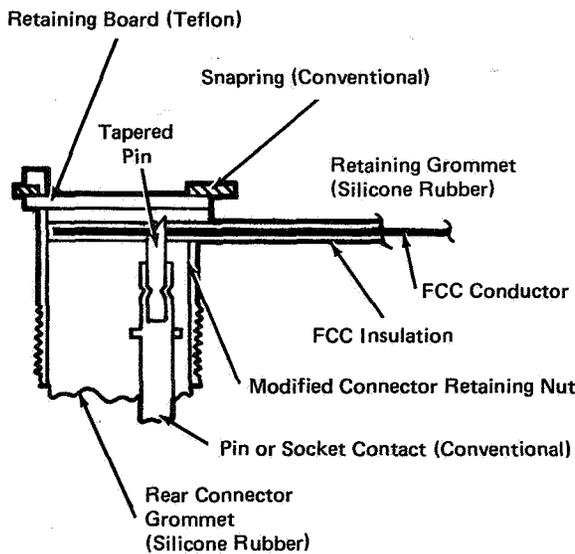
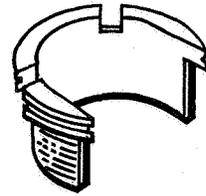
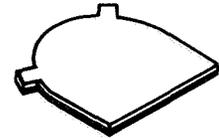


Figure 2. Section A-A



3a. Modified Connector Retaining Nut



3b. FCC Retaining Board (Nylon)



3c. Tapered Piercing Pin

Figure 3. Modified Parts

standard snapping that comes with the connectors rather than the modified retaining spring. Like the preceding assembly, this connection is sealed against moisture, is damage resistant, and is repairable.

The connector, as shown in Figures 1 and 2, is similar to the system employing the retaining spring. However, the retaining nut, the retaining board, and the tapered piercing pin are modified as shown in Figure 3. The modified retaining nut is larger than the standard nut and has been milled to allow the snapping to fit into place.

This assembly can also be made in several sizes, and designs have been proposed for five- and thirteen-contact connectors.

Source: J. D. Doyle and E. J. Stringer of Rockwell International Corp. under contract to Marshall Space Flight Center (MFS-24155, 24156)

Circle 2 on Reader Service Card.

**TECHNIQUES FOR ATTACHING FLAT CONDUCTOR CABLE DIRECTLY TO ROUND CONNECTORS: III**

A third method for connecting flat and round conductor cables differs from the techniques described in Parts I and II in that the FCC is connected to a pad of flat conductor by a series of tapered pins. The flat conductor pad is in turn firmly seated against tapered contact pins that are connected to the round cable.

The assembled connection is shown in Figure 1; Figures 2 and 3 show details of the construction. The FCC conductor pad is standard flat conductor

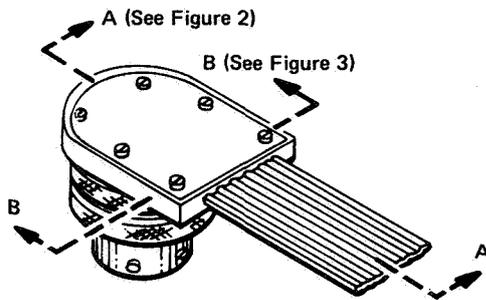


Figure 1. Termination to Standard Round Contact

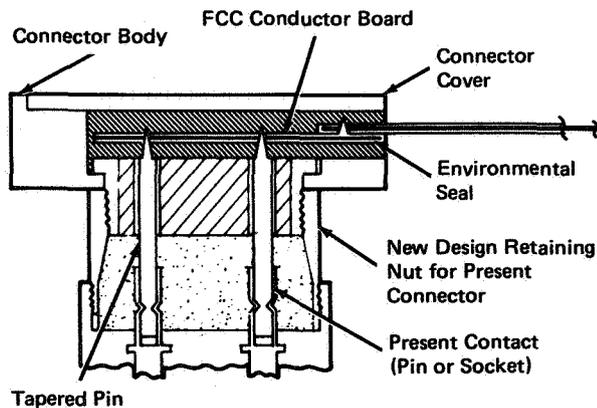


Figure 2. Section A-A

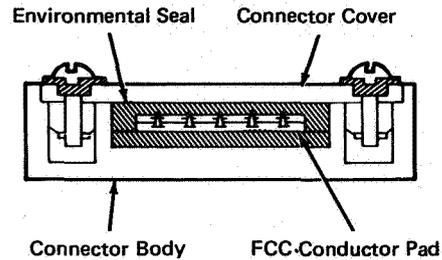


Figure 3. Section B-B

cable that has been cut to fit the connector shell, fitted with tapered pins to contact the FCC, and sealed environmentally. The connector cover is screwed into the connector body to press against the silicone-rubber environmental seals and form a moisture-proof assembly. In a second version of the connector, camloc fasteners are substituted for the screws to allow quick disassembly during repairs or changes.

The connector body is fabricated to fit the shell-and-connector configuration; the connector-body retaining nut screws into a modification of the conventional-connector retaining nut. It is this arrangement that permits the use of a standard round connector. The modified retaining nut is threaded at the bottom to fit a conventional round connector, and at the top to fit the connector-body retaining nut.

Source: R. C. Brennan, J. D. Doyle,  
and E. J. Stringer of  
Rockwell International Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-24161, 24164)

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### TECHNIQUES FOR ATTACHING FLAT CONDUCTOR CABLE DIRECTLY TO ROUND CONNECTORS: IV

This connector concept offers an "in-line" connection between the flat conductor cable (FCC) and the round cable, as opposed to the right-angle connection described in Parts I, II, and III. Like the other techniques, this one protects the connection against moisture and damage and provides the accessibility necessary for repairs.

The assembly is shown in Figures 1 and 2. The cover secures the retaining pad and the grommets to form an environmental seal. A coupling nut holds the cover in a fixed position; it screws on a retaining nut that is modified to fit conventional round connectors.

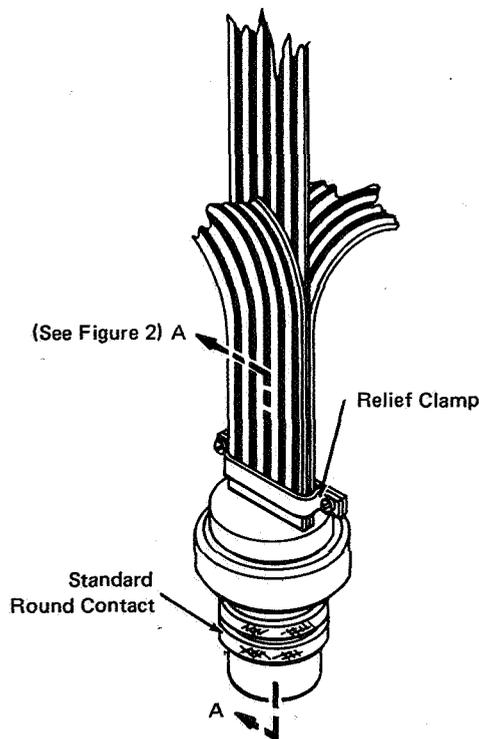


Figure 1. Termination to Standard Round Contact (In-Line)

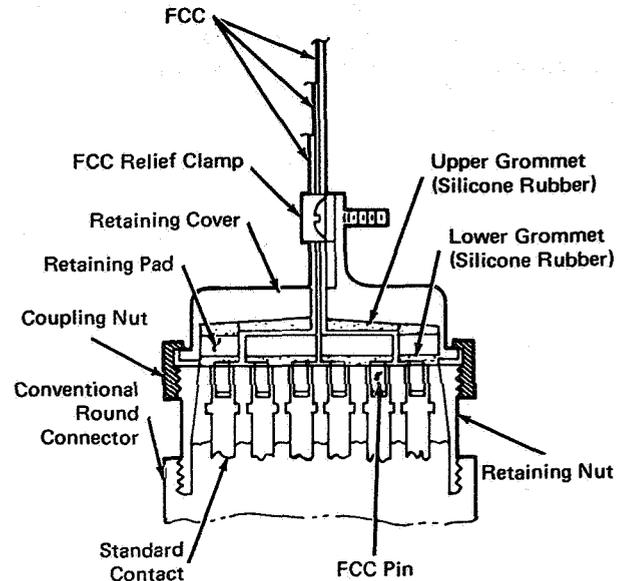


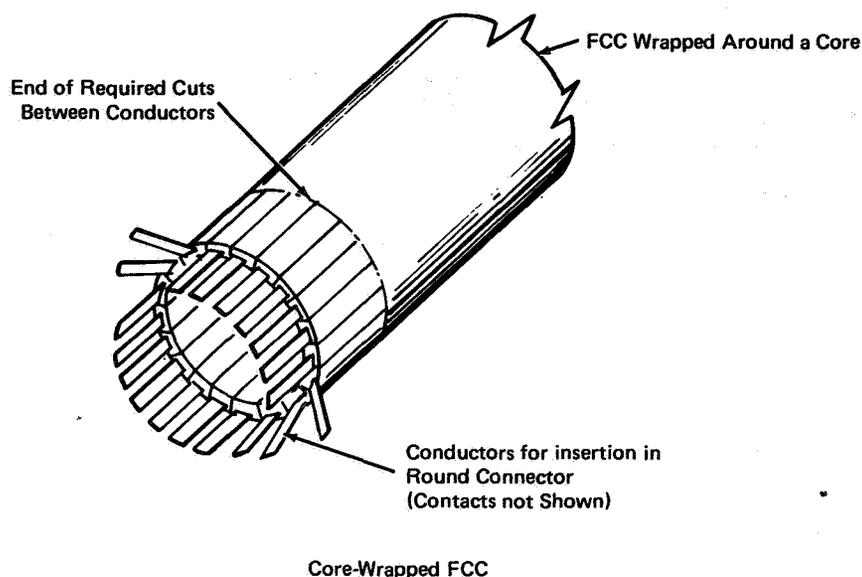
Figure 2. Section A-A

The example shown can accommodate three FCC's. The upper grommet has a single slit, and the lower grommet has three slits to separate the cables. A variety of contact configurations may be used with this system, as well as most sizes of connectors.

Source: T. O. Doyle and  
E. J. Stringer of  
Rockwell International Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-24181)

Circle 4 on Reader Service Card.

### TECHNIQUE FOR ATTACHING FLAT CONDUCTOR CABLE DIRECTLY TO ROUND CONNECTORS: V



This is another method for assembling flat conductor cable (FCC) and existing contacts and installing them into existing round connectors. At the end of the conductor the insulation between each strand is cut for easy insertion into the contact and for flexible installation of the contact into the connector.

Once cut, the FCC (back side of the slices) is wrapped around a core (see figure). If the FCC is 5 cm (2 in.) in width, then the core should be approximately 3 cm (1 1/4 in.) in diameter, so that the sides of the FCC will meet and all of the conductors will be utilized. The core may be made of a rubberized material (e.g., silicone) or a hard flexible polymeric material. Spot tying or other methods may be used to hold the FCC in place around the core. A heat-shrinkable sleeve may then be applied to secure the FCC more firmly and to seal against moisture.

The ends of the conductors are now stripped of insulation and slipped into the barrel of the contact. The crimp pin is pushed in to hold the conductors in place and then are crimped for a permanent hold.

The contacts are existing pin or socket contacts, normally used in round connectors. The crimp pin

is made from a copper alloy, soft enough to allow two crimps to penetrate from the contact into the crimp pin and to allow the other two crimps from the contact into the conductor and crimp pin. A conventional crimping tool may be used.

The rear socket insulator of the connector identifies each contact cavity with a letter. The insulation on each FCC conductor can be similarly labeled. It is possible to plan where each FCC conductor will go into the connector, as the conductors are flexible enough to bend or turn. With careful planning, extreme bending or turning can be eliminated. After all FCC conductors have been inserted into their respective connector cavities, a heat-shrinkable tube may be installed around the connector and the FCC/core, as a moisture seal and protection for the conductors.

Source: E. J. Stringer and J. A. Walling of  
Rockwell International Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-24131)

Circle 5 on Reader Service Card.

## REPAIRABLE FCC CONNECTOR

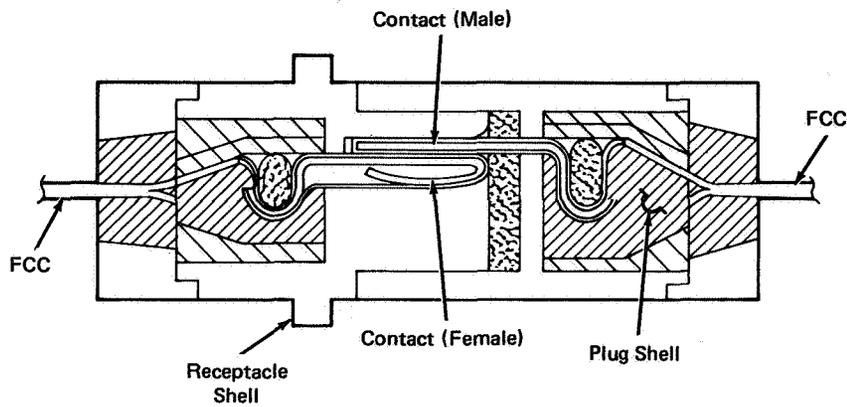


Figure 1. Cutaway View

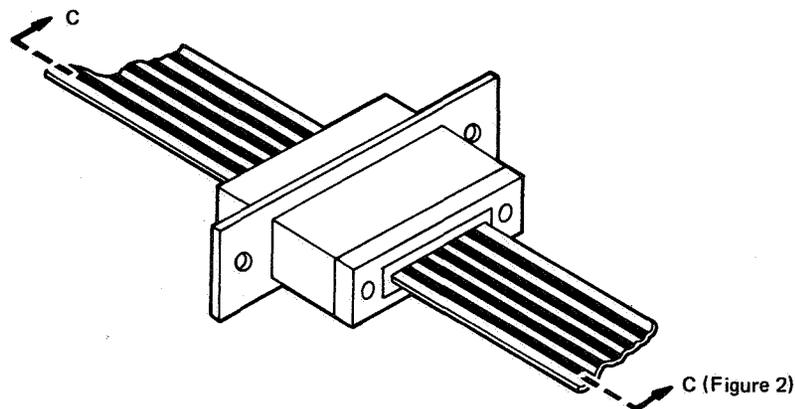


Figure 2. Nontransitional Connector

This design permits a repairable assembly of a flat conductor cable (FCC) and contact. The only transition, that between the FCC in the plug connector and the FCC in the receptacle connector, occurs when both connectors are mated (see Figure 1). The connector is shown in use in Figure 2.

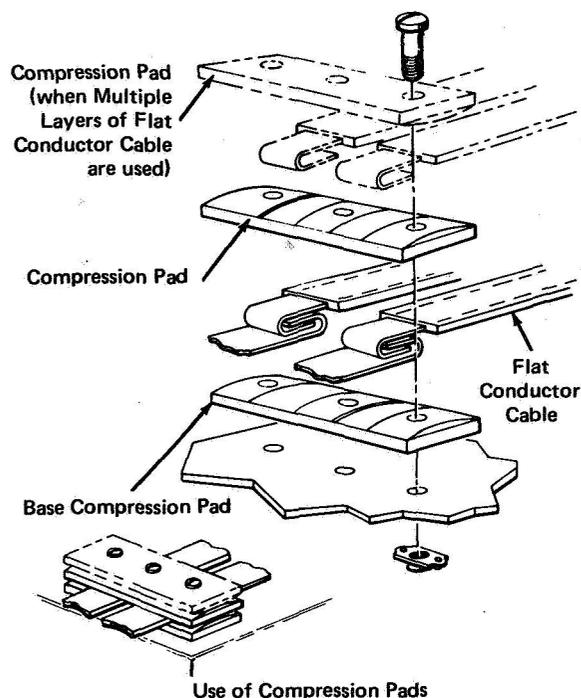
There are many materials to choose from for the conductors and contacts. However, the materials should be polymeric and offer good impact strength, vibration tolerance, insulation, and moisture resistance. The contact material should be a copper alloy that will not allow galvanic action to occur when the

dissimilar metals of the contact and conductor touch. The grommet should be made of silicone rubber.

Source: E. J. Stringer  
Rockwell International Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-24136)

Circle 6 on Reader Service Card.

**COMPRESSION PAD CABLE SPLICE: A CONCEPT**



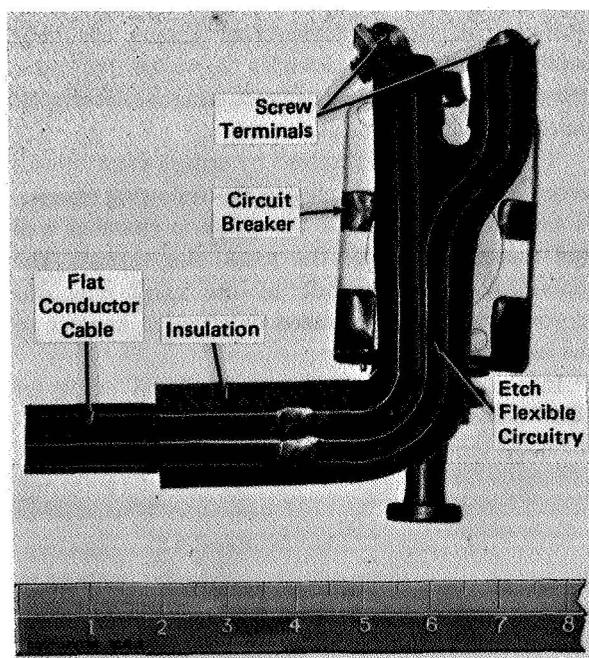
Compression pads provide a positive mechanical splice for joining two pieces of flat conductor cable directly. The compression pads are placed above and below the cable end pieces which are aligned end-to-end. Screws clamp the compression pads into place as shown in the illustration.

Where no severe thermal or mechanical stresses exist, this splice provides an easy method of joining cables in situations where it is desirable to separate and rejoin the cables at will.

Source: P. J. Rossi and R. W. Gibb, Jr., of Rockwell International Corp. under contract to Johnson Space Center (MSC-17530)

*No further documentation is available.*

**HIGH RELIABILITY FLAT CONDUCTOR CABLE CONNECTOR**



EFC Connection

Etch flexible circuitry (EFC) can be used with high reliability to connect flat conductor cable (FCC) to conventional circuit breakers. In addition, EFC may serve as a connector for computer cables and automobile wiring.

To make the connection, a piece of EFC with a suitable mechanical shape (see figure) is fabricated. It fits two screw terminals and has a right-angle bend for proper lead dress. Then, the insulation is stripped from the ends of the FCC and the EFC. The exposed copper wires are cleaned and resistance-welded together; the exposed areas are covered with insulation. Diffusion-bonded polyamide insulation was used in this case, but other insulation, such as heat-shrinkable tubing, may also be used.

Source: H. C. Peregrin, R. J. Tillis, and W. F. Iceland of Rockwell International Corp. under contract to Johnson Space Center (MSC-17372)

*No further documentation is available.*

## Section 2. Connector Technology

### ADAPTER CONVERTS MALE N CONNECTOR TO FEMALE N CONNECTOR

A simple adapter can be screwed into a male N connector to convert it into a female N connector. The adapter is of three-piece construction and can be fabricated on a lathe.

The adapter, shown in cross section, consists of a barrel which is threaded on both ends, a Teflon bushing, and a contact pin. The Teflon bushing electrically insulates the contact pin from the walls of the adapter and holds the pin in place.

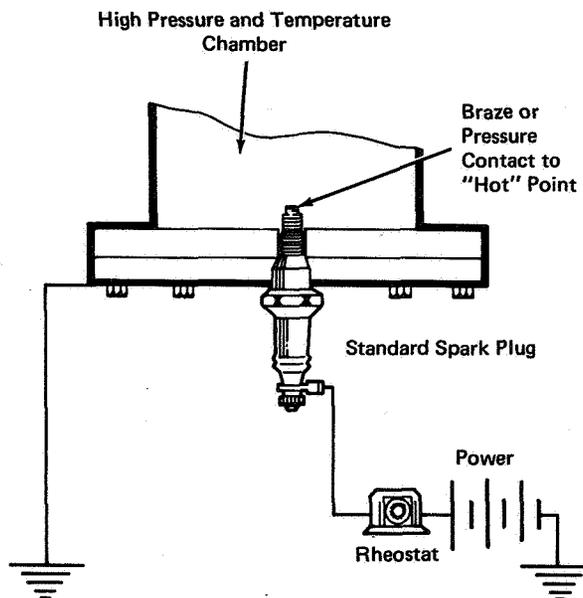
The adapter was designed to provide a female connection on a tee connector used in calibrating

radio frequency voltmeters. It may be useful in converting any male N connector to a female N connector.

Source: C. M. Fowler of  
Philco Ford Corp.  
under contract to  
Johnson Space Center  
(MSC-11082)

*Circle 7 on Reader Service Card.*

### SPARK PLUG IS LOW COST ELECTRICAL FEED-THROUGH INTO HIGH PRESSURE CHAMBER



Transmission of electrical energy into a high pressure steam chamber required an adequate insulator which, because of the nature of tests to be conducted, had to be inexpensive. Among candidate insulation materials, ceramics appeared the most attractive. However, cost of fabricating special ceramic insulators was prohibitive.

The problem was resolved by using a conventional automotive type spark plug in the following manner. A hole was drilled into the pressure chamber wall and tapped to receive the spark plug threads. The grounded outer electrode of the spark plug was removed to permit a brazed or clamped contact to the inner "hot" electrode.

Insulation resistances are generally in excess of 100k ohms. Additionally, the spark plug can withstand gas temperatures in excess of 1922 K (3000° F) and pressures in excess of  $690 \times 10^4 \text{ N/m}^2$  (1000 psi).

Source: C. E. Maskell of  
Aerojet-General Corp.  
under contract to

AEC-NASA Space Nuclear Systems Office  
(NUC-00032)

*No further documentation is available.*

## PIN CONTACT AND WIRE ASSEMBLY

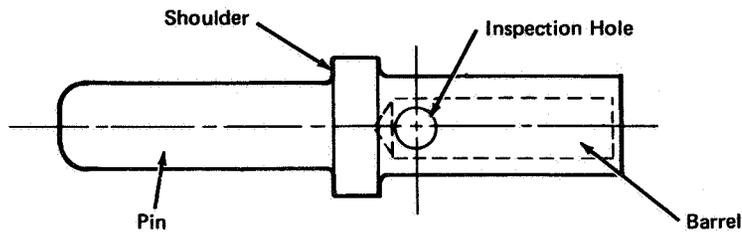


Figure 1. Present Design

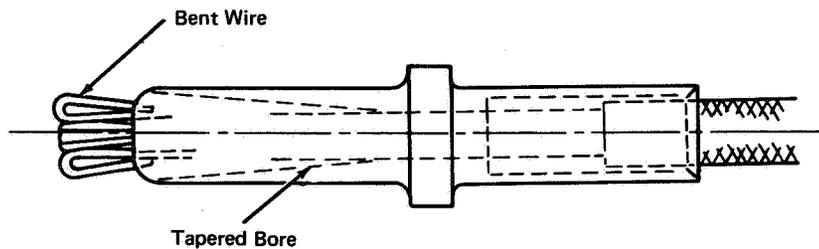


Figure 2. New Method

This crimpless, solderless connection concept may significantly improve the connection of stranded wire to specific terminals.

The contact design presently in use is shown in Figure 1. It consists of a solid portion, a shoulder, a barrel portion, and an inspection hole. The solid portion is inserted into the stationary contact; the shoulder serves as a seat for the pin insertion/removal tool; the barrel receives the stranded wire end; and the inspection hole permits final verification of the operation. An expensive crimping tool is required to crimp the wire within the barrel. Improper crimping combined with excessive tension on the wire will result in failure.

The new method is shown in Figure 2. The solid portion of the pin now has a tapered-through bore, and the inspection hole is no longer required. The bare wire strand is inserted into and through the contact to extend beyond the pin. Using simple

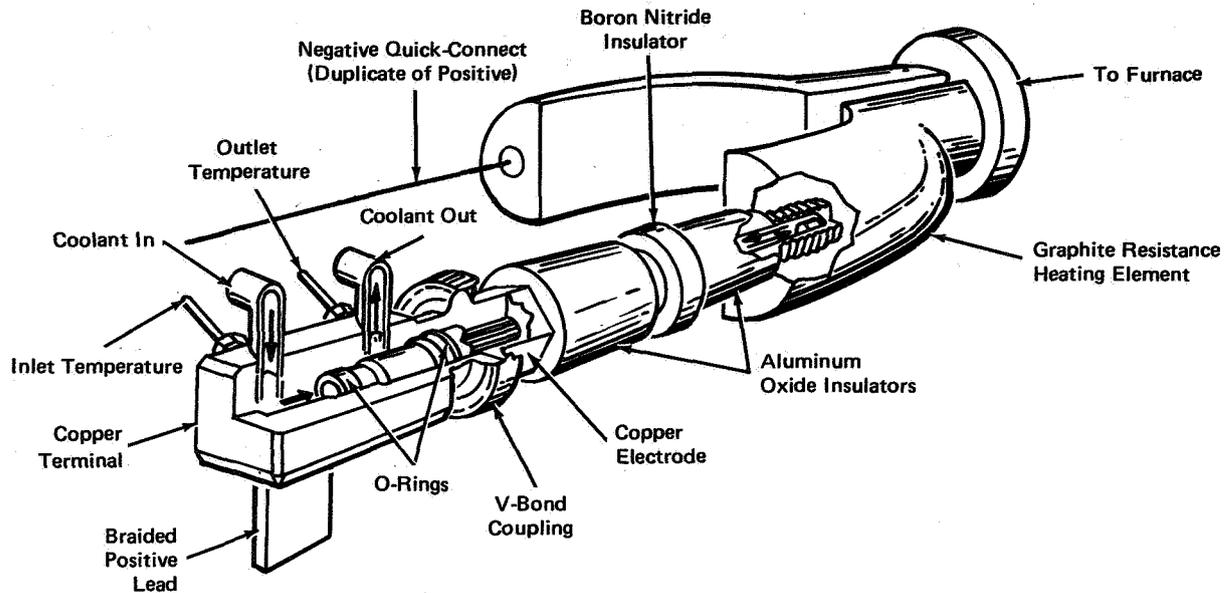
flat-nosed pliers, 3 or 4 strands are bent over and back. The entire wire is then pulled back into the tapered port where it is arrested through wedge action. Increased tension on the installed wire only increases the reliability of the electrical and mechanical connection.

This wire connection principle can be extended to numerous other terminal and lug types eliminating complex and expensive assembly tools. As such, it should be of wide interest to the manufacturing industry in general.

Source: R. Steiner of  
Rockwell International Corp.  
under contract to  
Johnson Space Center  
(MSC-17355)

*No further documentation is available.*

**“QUICK CONNECT” PROVIDES SIMULTANEOUS CONNECTION OF POWER  
ELECTRODE, COOLING WATER, AND INSTRUMENTATION**



Electric Furnace Connector

This device is an electric furnace connector used to connect the electrode power, the coolant, and the thermocouple for monitoring coolant temperature. Since the electrodes used in electric furnaces require large electrical currents, e.g., 2000 amperes at 40 volts dc, a flow of cooling water must be supplied to the electrodes, and thermocouples are necessary to monitor the coolant temperature. This normally requires extra connectors.

The new connector consists of two main parts: The copper terminal and the copper electrode (see figure). A V-bond coupling holds the two together. The mating surfaces of the terminal and electrode are silver plated to reduce electrical resistance. The electrode has aluminum oxide and boron nitride insulators; a braided copper lead brazed to the copper terminal

provides the electrical current from the power supply. Thermocouples in the connector measure the inlet and outlet temperature of the coolant water. O-rings are used to provide water-tight seals in the connector. Two connectors, one positive and one negative, are required for each graphite resistance heating element in a furnace installation. Each connector is rapidly and easily screwed into its mating element.

Source: R. J. Steffen of  
Westinghouse Corp.

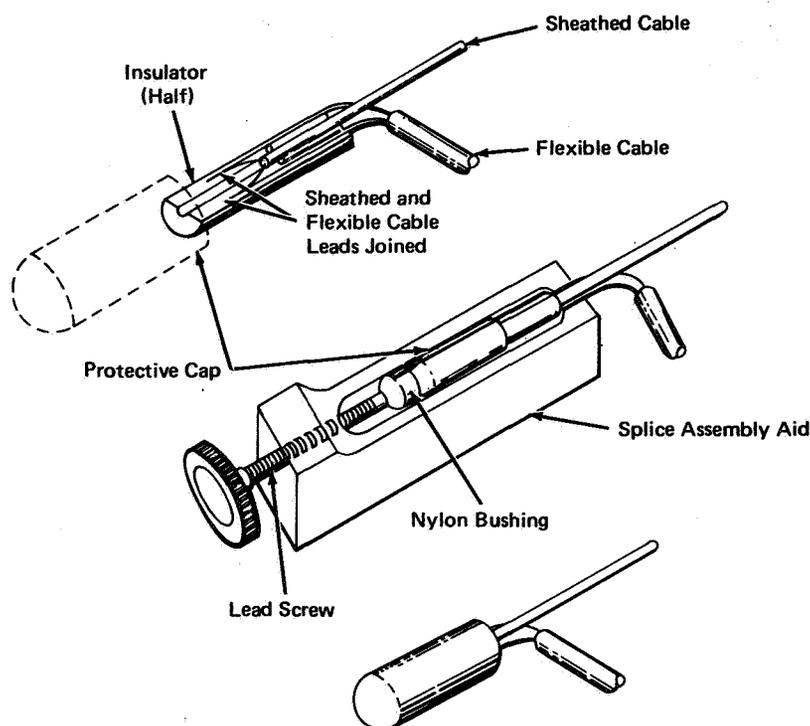
under contract to  
AEC-NASA Space Nuclear Systems Office  
(NUC-10040)

*No further documentation is available.*

## Section 3.

# Cable and Connector Maintenance Technology

### SPLICE ASSEMBLY AID FOR SHEATHED CABLE TO FLEX CABLE TRANSITION



Electrical Splice Assembly  
for Sheathed-to-Flexible Cable Transition

The procedure for splicing the leads of sheathed cables used for transducers to the leads of flexible cables used for instrumentation has been slow and difficult and frequently has resulted in insulator breakage.

This assembly aid (see figure) was designed to form a protective cap over the insulator around the transition junction of the cable leads. After the sheathed-to-flexible cable transition junction has been achieved, the cables are placed in the assembly aid and the protective cap is forced over the insulator and cable junction assembly by turning the lead screw. The nylon bushing prevents slipping, cracking, or scratching of the insulator cap by providing a

smooth, uniformly distributed axial load over the end of the cap.

This fixture permits rapid assembly of the cable transition device, and eliminates breakage and marring of the insulator surface. It is portable and simple to use in the field.

Source: R. A. Pearce of  
Aerojet-General Corp.  
under contract to  
AEC-NASA Space Nuclear Systems Office  
(NUC-10307)

*No further documentation is available.*

TEFLON GUIDES SIMPLIFY INSULATION TESTING

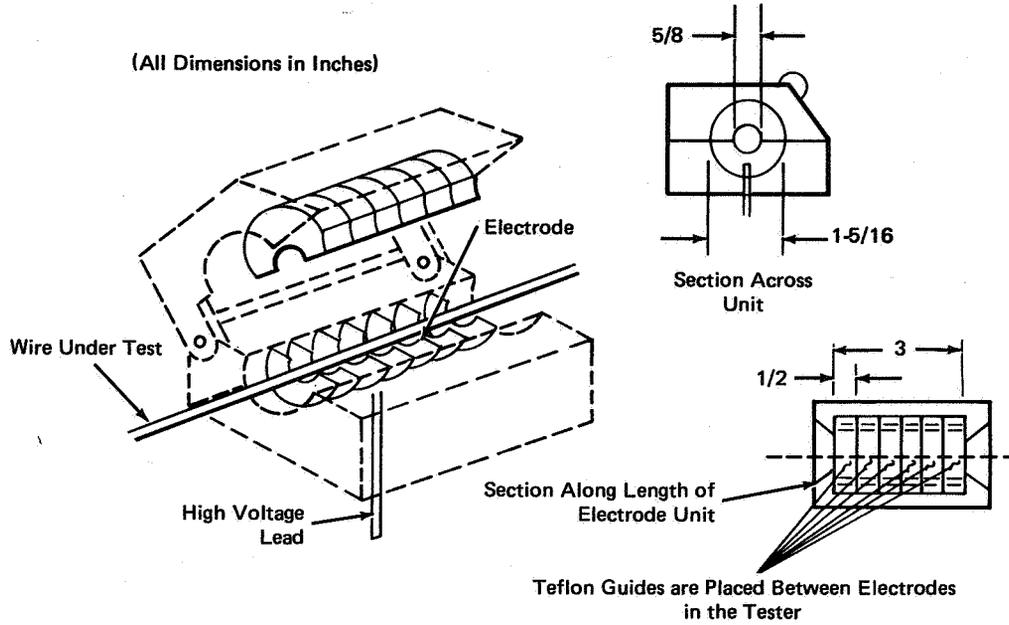
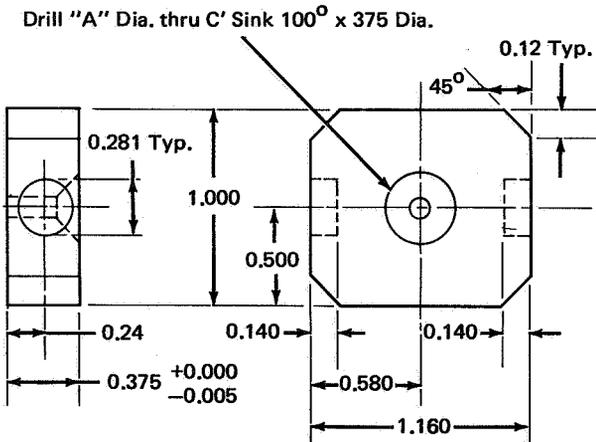


Figure 1. Slaughter Impulse Tester



PART NO.	NO. REQD	"A" DIA.
-IA	6	.059
-IB	6	.098
-IC	6	.209
-ID	6	.323

(All Dimensions in Inches)

Figure 2. Teflon Wire Guide

The testing of electrical wire insulation with a Slaughter impulse tester can be speeded by inserting a set of Teflon wire guides between the electrodes of the tester.

The Slaughter impulse tester is shown in Figure 1. When the wire under test is passed over the electrodes, a certain amount of flexing is induced. The spacing between the wire and the electrodes changes due to the flexing, and erratic voltage readings are generated. By inserting guides that reduce the opening for the wire, the flexing is prevented and stable readings are obtained.

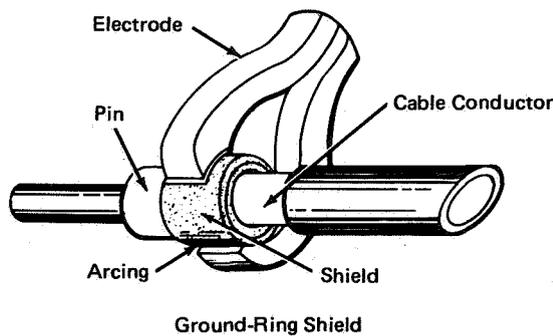
Figure 2 provides the information needed to fabricate the wire guide. Dimension "A" is varied to accommodate several wire sizes. The guides are inserted between the electrodes of the Slaughter impulse tester as shown in Figure 1.

Source: D. J. Ensing and L. E. Twist of Rockwell International Corp. under contract to Johnson Space Center (MSC-13019)

No further documentation is available.

### ARCING SHIELDS FOR CONNECTING PINS

Gold-plated and silver-plated connector pins are used for power cables where low resistance is important and protection from corrosion is critical. The usual method for soldering cable conductors into the pins is by passing an electric current through the solder cup part of the pin to provide the necessary heat. The carbon tipped electrodes used in the process sometimes do not provide adequate surface contact, and arcing between the two components results, damaging the pins sufficiently to render them useless.



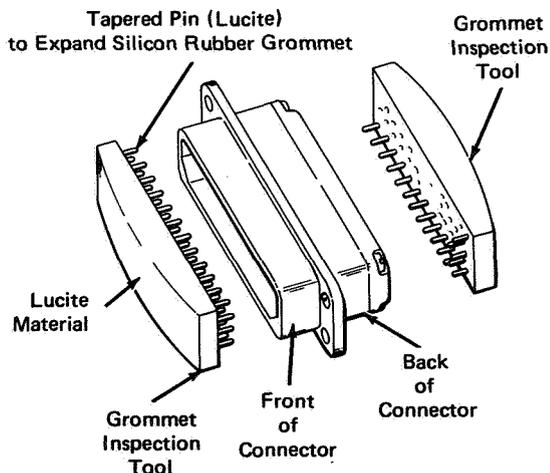
Cable termination ground rings (Hy-Rings), that are excellent heat and electrical conductors, can be fitted snugly over the connector pins to prevent arcing. These shields absorb any arcing and heat is more evenly distributed throughout the portion of the pins being soldered. Positioning of the Hy-Ring shield is illustrated in the drawing and accomplished in the following manner:

Strip large gauge wire to accommodate large pin barrel assembly and insert wire into pin. Place tight fitting Hy-Ring over barrel assembly and apply heat for soldering purposes. All arcing and surface burning will then occur at the Hy-Ring rather than the plated pin surface. After soldering, the Hy-Ring is removed and discarded.

Source: I. H. Trail of  
Bendix Corp.  
under contract to  
Kennedy Space Center  
(KSC-10672)

*No further documentation is available.*

### INSPECTION TOOL DETECTS CRACKS IN ELECTRICAL CONNECTOR GROMMETS



A new inspection tool detects cracks in miniature connector grommets. The tool, made of clear plastic, simulates oversize connector pins and has a lens-shaped surface to magnify the inspected part. When the tool is mated with the connector, the tapered pins expand the holes in the rubber grommet. In this position, the built-in magnifying lens enlarges the field of view so that defects are more easily seen.

Source: R. D. Deskin and A. Z. Campoy of  
Rockwell International Corp.  
under contract to  
Johnson Space Center  
(MSC-15434)

*Circle 8 on Reader Service Card.*

## SHRINKABLE TUBING SPEEDS ASSEMBLY OF CONTACT PINS TO LEAD WIRES

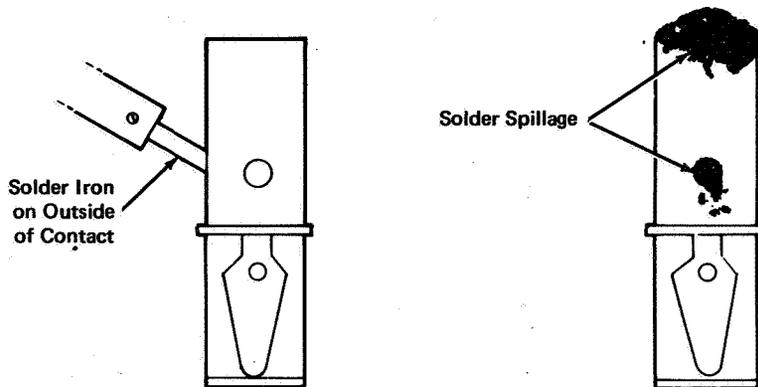


Figure 1. Prior Method

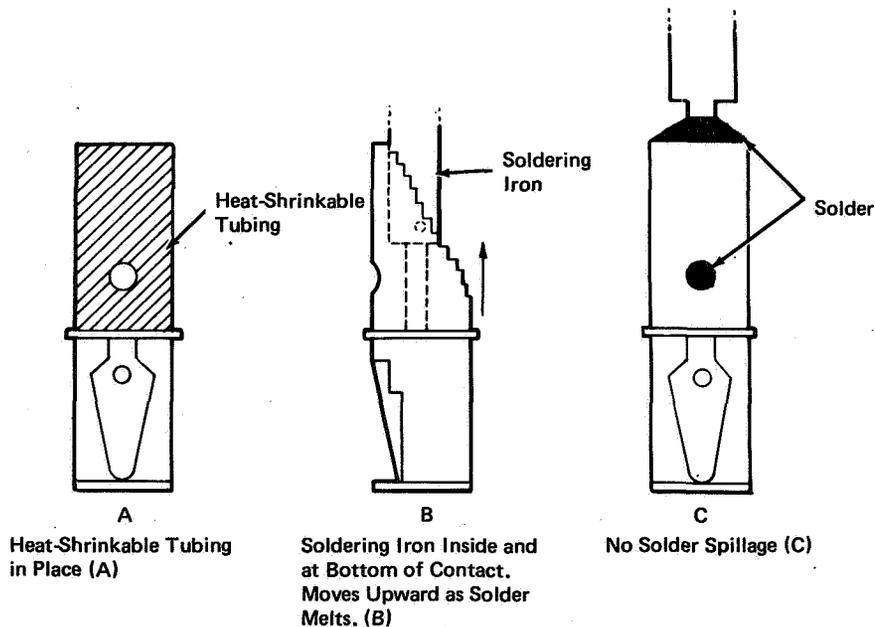


Figure 2. New Method

When soldering a wire and contact pin, solder spillage on the external surface of the contact pin makes insertion of the pin into a connector difficult (see Figure 1). The spillage can be eliminated using a piece of heat-shrinkable tubing.

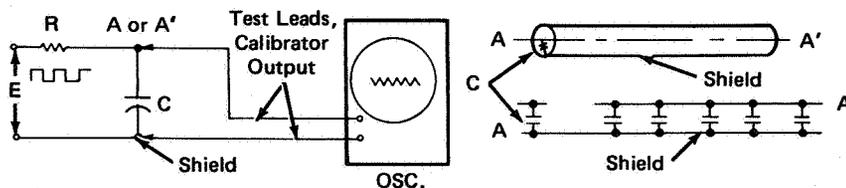
The new technique is shown in Figure 2. A short piece of heat-shrinkable tubing is placed over the contact pin and heated. The soldering iron is then inserted into the contact pin and solder is allowed to fill the contact. The wire is quickly inserted into the molten solder and the joint allowed to cool. The

heat-shrinkable tubing is then removed and the pin is cleaned with alcohol. A neat joint, free of solder spillage, results.

Source: G. W. Cleveland of  
Rockwell International Corp.  
under contract to  
Johnson Space Center  
(MSC-15065)

*No further documentation is available.*

**OSCILLOSCOPE FACILITATES DISCOVERY OF CABLE-END DISCONTINUITIES**



Oscilloscope Square Wave Calibration Voltage  
10 to 20 Megohms  
Cable Capacitance

Oscilloscope Connector

The majority of cable discontinuities occur at the connector ends. Physical inspection gives a 50 per cent success probability in determining which connector contains a discontinuity. An incorrect determination necessitates disassembly of both connectors to locate and correct the fault.

A simple test now accurately identifies the faulty end. Using an oscilloscope calibration signal as a voltage source, comparative observations of the cable capacitance at the connector ends can be made.

Shielded wire exhibits a constant capacitance per unit length. A broken conductor decreases the capacitance to almost zero. Observation of the wave form on an oscilloscope, connected as shown in the illustration, indicates the faulty end. A proper configuration

degrades the wave form in relationship to the RC time constant, whereas a broken connection causes a very small change in wave shape.

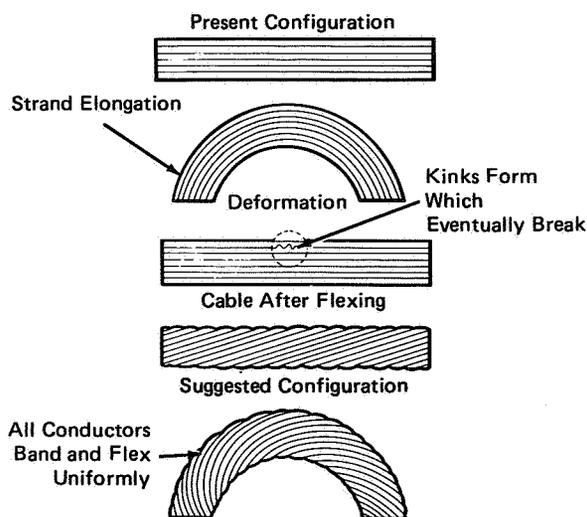
This test selects the faulty end accurately, thus eliminating the extra work of disassembling a good connector. Possible connector damage from unnecessary handling is also avoided.

Source: C. F. Schott of  
Rockwell International Corp.  
under contract to  
Johnson Space Center  
(MSC-17479)

*No further documentation is available.*

**MULTI-CABLE HARNESS PREVENTS CABLE BREAKAGE**

A new harness construction permits individual cables to flex and bend without breaking. The conventional method of harnessing cable and the new method are shown in the figure. The conventional



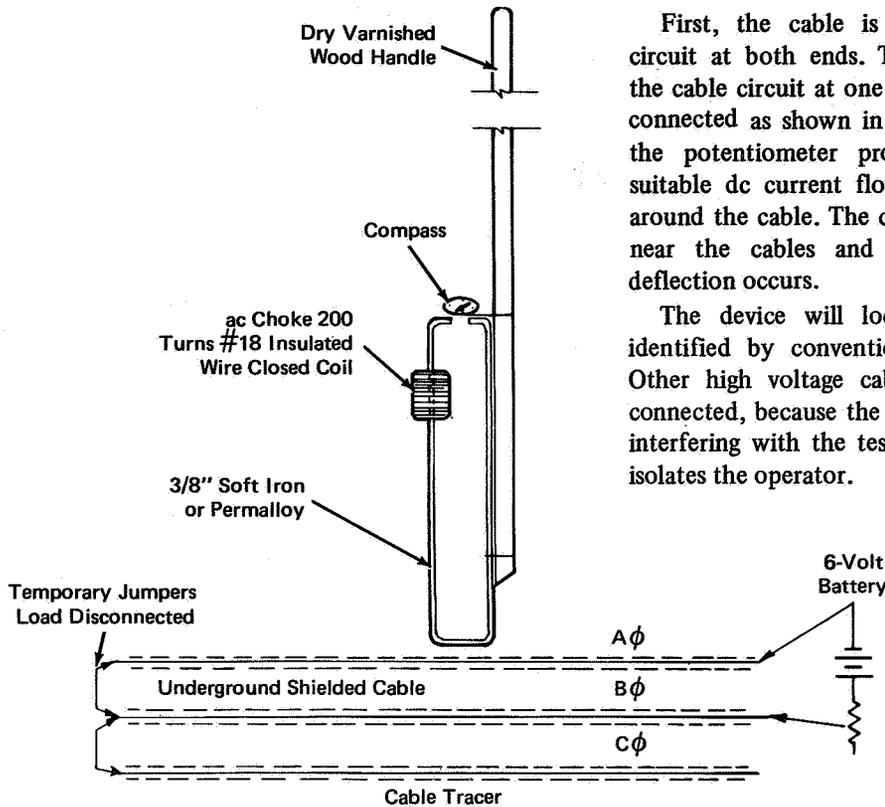
harness is subject to failure, because the cables do not flex uniformly. Some cables are elongated causing kinks in the metallic strands and, after repeated flexing, breakage.

In the new harness all the conductors are twisted in a common direction with a uniform pitch. A helical or rope type bundle is thus formed in which every cable flexes uniformly; no cable is subjected to unnecessary stress or elongation. The twisted cables can be covered with heat-shrinkable tubing, or they can be wrapped with vinyl tape having a 50% overlap to provide additional flexibility by allowing the conductors to slide under the outer jacket.

Source: W. L. Knoth of  
Rockwell International Corp.  
under contract to  
Johnson Space Center  
(MSC-15086)

*No further documentation is available.*

### COMPASS TRACES UNDERGROUND CABLES: A CONCEPT



First, the cable is disconnected from its high circuit at both ends. The temporary jumpers close the cable circuit at one end. Then the accessories are connected as shown in the figure. The battery, with the potentiometer properly adjusted, provides a suitable dc current flow, inducing a magnetic field around the cable. The cable tracer is then positioned near the cables and is moved until a compass deflection occurs.

The device will locate cables that cannot be identified by conventional high frequency tracers. Other high voltage cables do not have to be disconnected, because the ac choke prevents them from interfering with the test. The wooden handle safely isolates the operator.

This new device traces and identifies individual high-voltage underground shielded cables. It locates cables that are close together and multigrounded cables.

A soft iron loop is mounted on a wooden handle. A compass is placed above the air gap in the loop and an ac choke is wound around it (see figure). A six-volt battery, a potentiometer, and several jumpers are also required.

*No further documentation is available.*

Source: R. R. Peck of  
Rockwell International Corp.  
under contract to  
Johnson Space Center  
(MSC-15667)

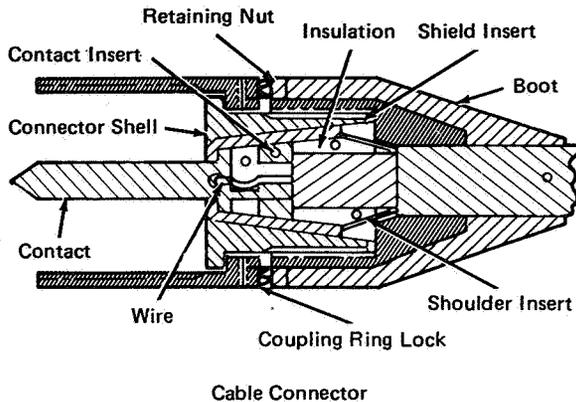
### REPAIRABLE, SELF-LOCKING MINIATURE COAXIAL CABLE CONNECTOR

This repairable, self-locking miniature coaxial connector can replace conventional connectors, which cannot be repaired but must be replaced if not working properly.

After the wiring and shield insulation is stripped per standard specification, the wire conductor is inserted into the specially designed contact. A hole in the contact allows the wire to be seen. A shoulder insert is used to hold the wire insulation relative to

the wire; a contact insert retains the wire and insulation (or housing) insert in their respective places. After thus securing the wiring, the connector shell is slipped over the assembly, and a shield insert is pressed into it. A retaining nut, threaded over the shell, presses in the inside assembly against the connector shell. Slots within the shell hold a ring lock in place; this is part of the self-locking feature. A tension spring, positioned between retaining nut and

ring lock, forces the ratchet side of the ring lock against the ratchet side of the coupling ring. A boot is then placed over the retaining nut and coaxial cable area for a moisture seal.



When the plug is mated to its respective receptacle, the ratchet side of the coupling locks itself against the ratchet side of the ring lock, thus providing a mechanical lock. When the plug is to be removed, the ring lock is pulled back, releasing the ratchet, and the coupling ring is unscrewed from the receptacle. If the connector is to be repaired, the boot is removed, repairs made, and the connector reassembled. The design can be applied to any type of threaded connector.

Source: J. A. Walling and E. J. Stringer of  
Rockwell International Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-24110)

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## REPLACING LOCKING INSERTS IN ELECTRICAL CABLE CONNECTORS

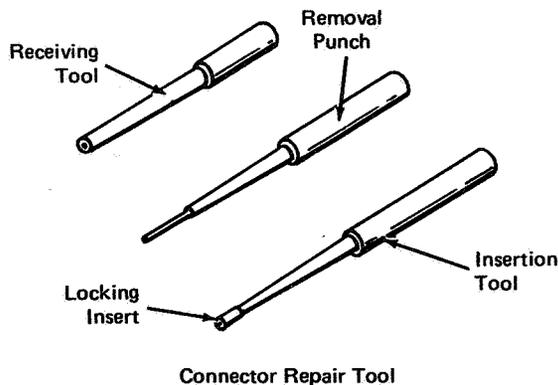
In replacing defective locking inserts in electrical cable connectors, a removal punch and receiving tool (see figure) are used to remove the defective part, while an insertion tool (holder) is used to install the replacement part. The locking insert is removed in the following manner:

1. Select the proper tools according to pin size. Carefully insert the receiving tool through the rubber grommet from the cable side of the connector, being careful not to damage the rubber. Lubricate the punch with alcohol as required. Twist and push the receiving tool down until it is firmly against the hard plastic insert retainer. Release the receiving tool; the rubber grommet will hold it in place.

2. Now, from the opposite side, carefully insert the removal punch (on pin-type connectors be careful not to damage the rubber). Lubricate with alcohol as required and carefully lean the punch slightly to one side to engage the locking insert. Tap the punch lightly to press the insert out of the plastic retainer and into the hollow of the receiving tool.
3. Tilt the connector so that the receiving tool hangs down assuring that the removed insert will stay in the hollow of the tool. Slowly remove the receiving tool. Check the removed insert to assure that all pieces are accounted for.

The replacement locking insert is installed as follows:

Install a new locking insert on the insertion tool with the locking prongs directed at the point of the tool. Carefully push the new insert through the rubber grommet from the cable or wire side of the connector. Make sure that you are lined up with the hole in the hard plastic retainer and press the new insert all the way in until it is locked in place.



Source: B. A. Bienvenu of  
IBM Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-21876)

Circle 10 on Reader Service Card.

## INEXPENSIVE PIN ALIGNMENT GAUGE FOR ELECTRICAL CONNECTORS

Simple inexpensive gauges can be easily fabricated for checking the alignment of pins in multipin electrical connectors where small pin size and close spacing inhibit visual inspection and accessibility.

Gauges of this design successfully solved the problem of quickly, easily, and positively checking recessed pin connectors in aerospace electrical systems, for bent or misaligned pins. Such connectors may include various numbers of pins, in several sizes and lengths, arranged in various patterns. The maximum pin misalignment allowable to insure proper mating of the connectors is 0.0254 cm (0.010 in.) out-of-perpendicular at the pin tip.

Individual gauges are made for each pin size, i.e., 8-, 12-, 16-, and 20-gauge pins. Each gauge consists of a flat acrylic plastic plate through which is inserted a headless bushing and a probe. The flat plates are cut from 1.27-cm (1/2-in.) thick clear plastic sheets. A hole is drilled in each plate perpendicular to the bottom surface to accept a headless bushing installed with a press fit. For 8- and 12-gauge pins, the bushing ID is 0.4762 cm (0.1875 in.) to accept probes made from 0.4762-cm (3/16-in.) drill rod; for 16- and 20-gauge pins, the bushing ID is 0.3175 cm (1/8 in.)

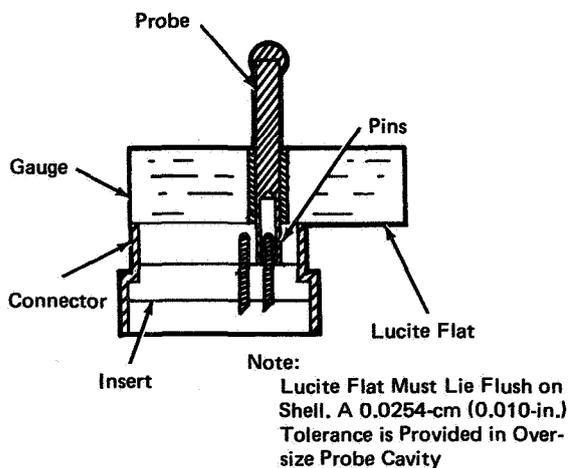


Figure 1. Acceptable Condition

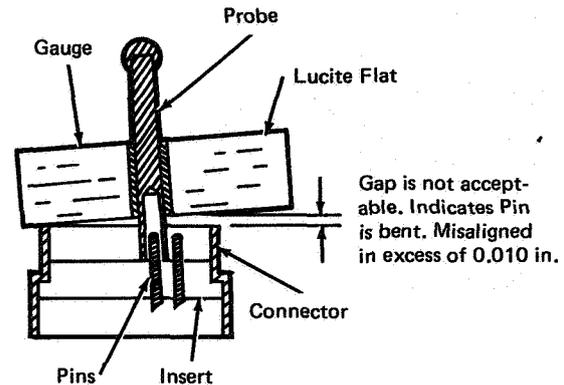


Figure 2. Defective Condition

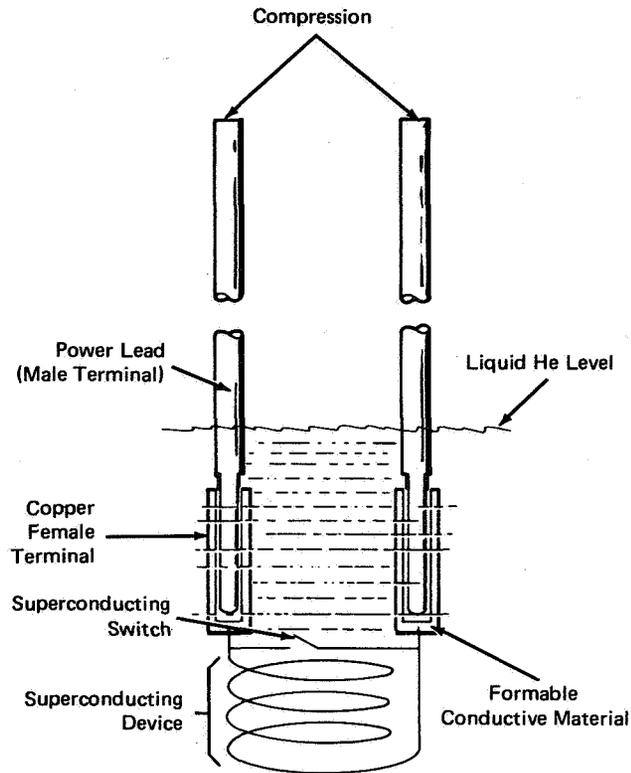
to accept probes made from 0.3175-cm (1/8-in.) drill rod. A longitudinal hole is drilled in the end of each probe, 0.0254 cm (0.010 in.) larger in diameter than the selected pin size. Each flat plastic plate is marked with the pin gauge for identification.

In use, the proper pin gauge is slipped, in turn, over each pin to be checked so that the flat plastic plate contacts the edge of the connector shell. Contact between the flat plastic plate and the full circumference of the connector shell indicates that pin misalignment, if any, is within the allowable tolerance (Figure 1). A gap between the flat plastic plate and the connector shell indicates that the pin is misaligned beyond the acceptable limits (Figure 2). The use of these gauges reduces the otherwise difficult task of inspecting electrical connectors for bent or misaligned pins to a simple "go - no go" operation.

Source: W. T. Hollar of  
General Dynamics Corp.  
under contract to  
Lewis Research Center  
(LEW-11618)

*No further documentation is available.*

## REMOVABLE CRYOGENIC CURRENT LEADS



Schematic of Demountable Leads

A pair of removable cryogenic current leads and low-resistance terminals can be used to power a superconducting device. Prior technology has employed soldered or bolted connections that do not permit removal of the leads after the superconducting device is charged. This results in a constant heat flow into the system through the leads, when power is no longer required.

As the figure shows, a compressive force holds the terminals in intimate contact during the charge cycle. The female terminal, coated internally with a formable conductive material such as indium or soft silver, forms a low-resistance connection. After the

superconducting device is charged to the desired current level, the compressive force is removed, and the male terminals are pulled from the system by vertical force alone, thus avoiding unnecessary tension loading of the superconducting device.

Source: E. J. Lucas and R. J. Powers of  
Avco-Everett Research Laboratory  
under contract to  
Goddard Space Flight Center  
(XGS-11368)

*No further documentation is available.*

**Notes:**

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