# SECTION IV. WIRING CHANGES

## 4.1 Introduction

This section discusses various methods for accomplishing wiring changes in FCC interconnecting harness systems.

Harnesses can be reworked temporarily by cutting existing conductors and splicing in new conductor segments or by using special splicing devices. These techniques are explained further in Paragraph 4.2.2. Normally, neither of these methods would be considered acceptable for high-reliability production units.

The transition to RWC and the use of the distribution unit system permits multiple pin-assignment changes.

## 4.2 Wiring-Change Categories

4.2.1 Production. Production change methods can be described as those which would normally be acceptable for end-item use. As such, these change techniques should be economical, be capable of clean documentation, and should have high reliability.

4.2.1.1 Distribution Units. Distribution units will provide the production means for accomplishing the initial interconnection, and for making subsequent pin-assignment changes. These could be either separate units or incorporated into existing interconnecting or distribution electronic packages. Distribution units for use on programs with intricate electronic systems are of such importance that they are covered in detail in Paragraph 4.3.

4.2.1.2 Terminating to Round Connectors. These are two basic methods for terminating FCC into RWC connectors; the first involves terminating the FCC conductors to the connector pins through a solid wire or other device. All terminations can be made in a very limited space; the terminating area is usually potted to provide sealing and strain relief; and there are no provisions for making specific pin-assignment design changes.

The second method (Fig. 4-1) involves making a transition from FCC to RWC in the area dajacent to the round connector, or in the FCC harness run in the vicinity of the round connector. This method will see much general use for the interim period while many electronic units have round-wire connectors. In addition to providing the transition to the RWC connectors, it also provides a production means of accommodating pin-assignment changes in the rear of the round-wire connectors. If removable crimp contacts are used, the harness can be easily reworked; if solder and/or potting are utilized at the RWC connector, then only design revisions can be made for pin-assignment changes in new harness fabrication.

The transition from FCC to RWC for the second method can be made in several ways. NASA/MSFC has completely developed, tooled, and tested a method for lap soldering the stripped RWC to the bared FCC. A prepared assembly, prior to molding, is shown in Figure 4-2. Section VI of this report contains detailed instructions for the manufacturing of this NASA/MSFC transition. Figure 3-83 shows an assembly of many such transitions proposed for use on the ATM program.

Other methods for making this transition, which have been successfully prototyped, include crimping, welding, and soldering. Figure 4-3 shows a crimping technique developed by Picatinny Arsenal. Figure 4-4 shows a miniature, tungsten inert-gas (TIG) weld by the Dynatech Corporation that can be easily tooled for high production. Figure 4-5 shows a ganged soldering technique accomplished with Raytheon solder sleeves. In each method shown, the transition area would be covered with a minimum molded cross section for sealing and strain relief. The transition area could be supported by a connector adapter bracket or be located a distance from the connector and separately supported.

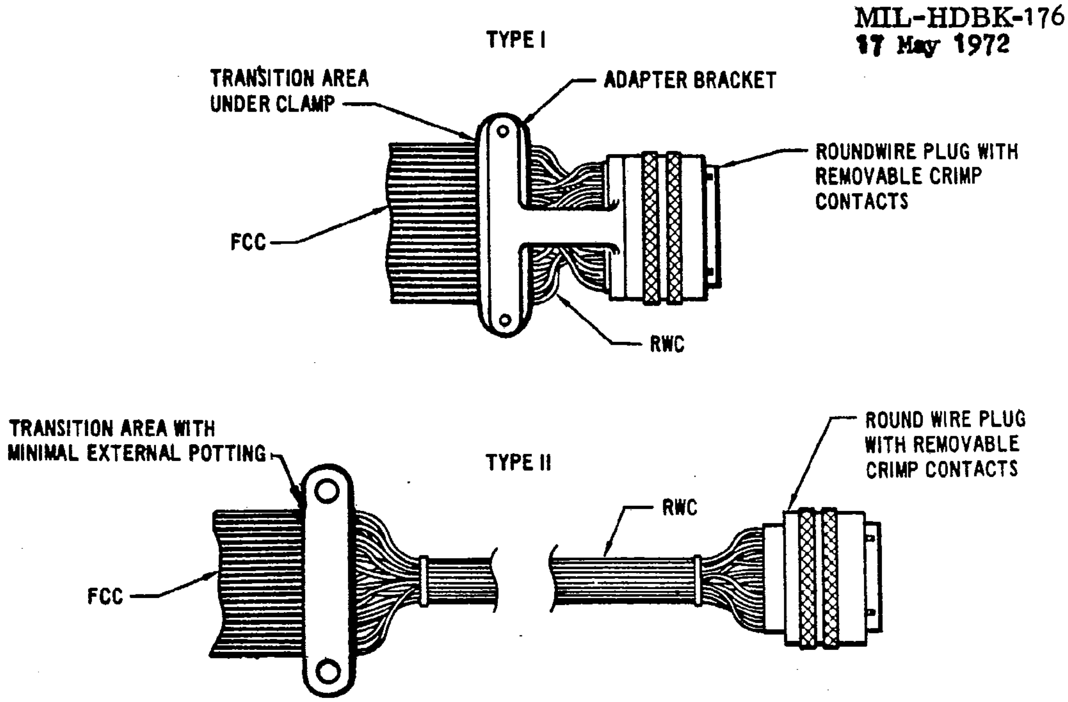


FIGURE 4-1. Transition from round-wire plug termination (NASA/MSFC).

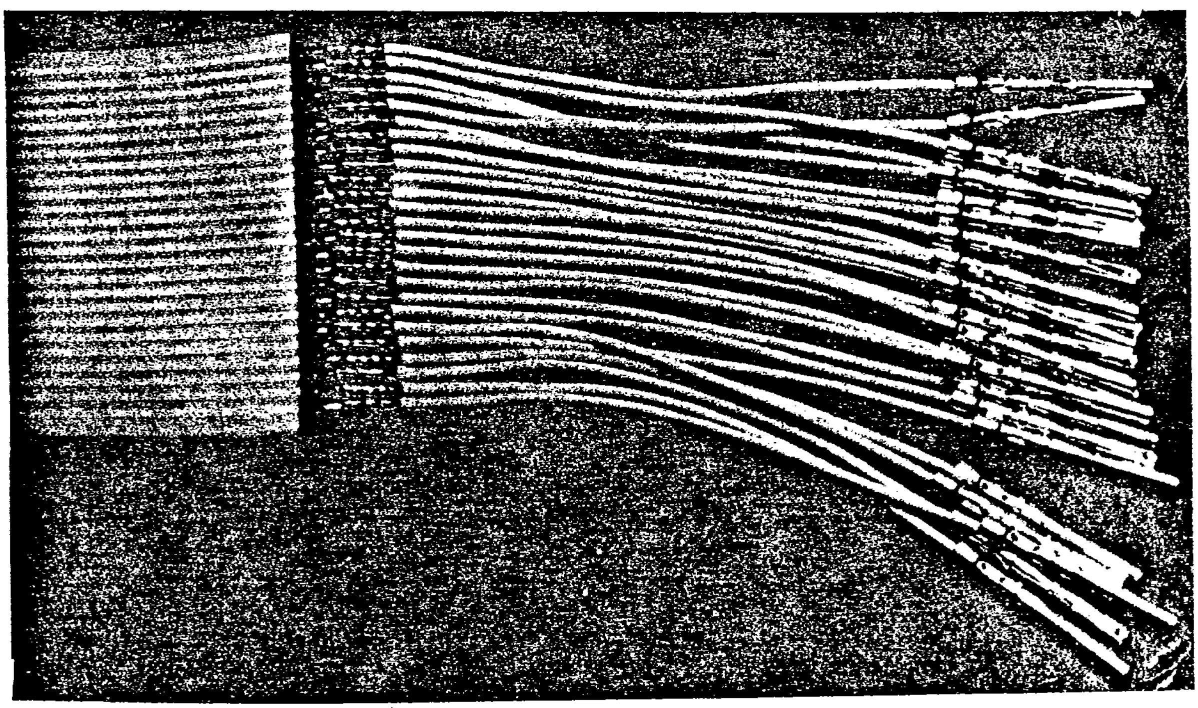

FIGURE 4-2. NASA/MSFC transition - FCC to RWC (potting omitted for clarity).

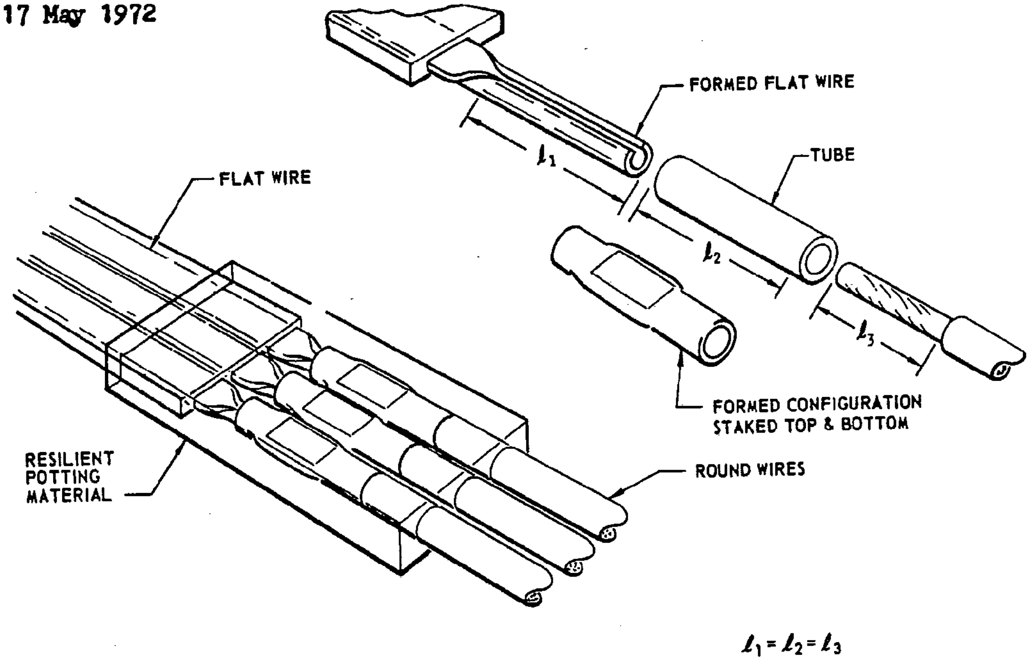


FIGURE 4-3. Crimp transition - FCC to RWC (Picatinny Arsenal).

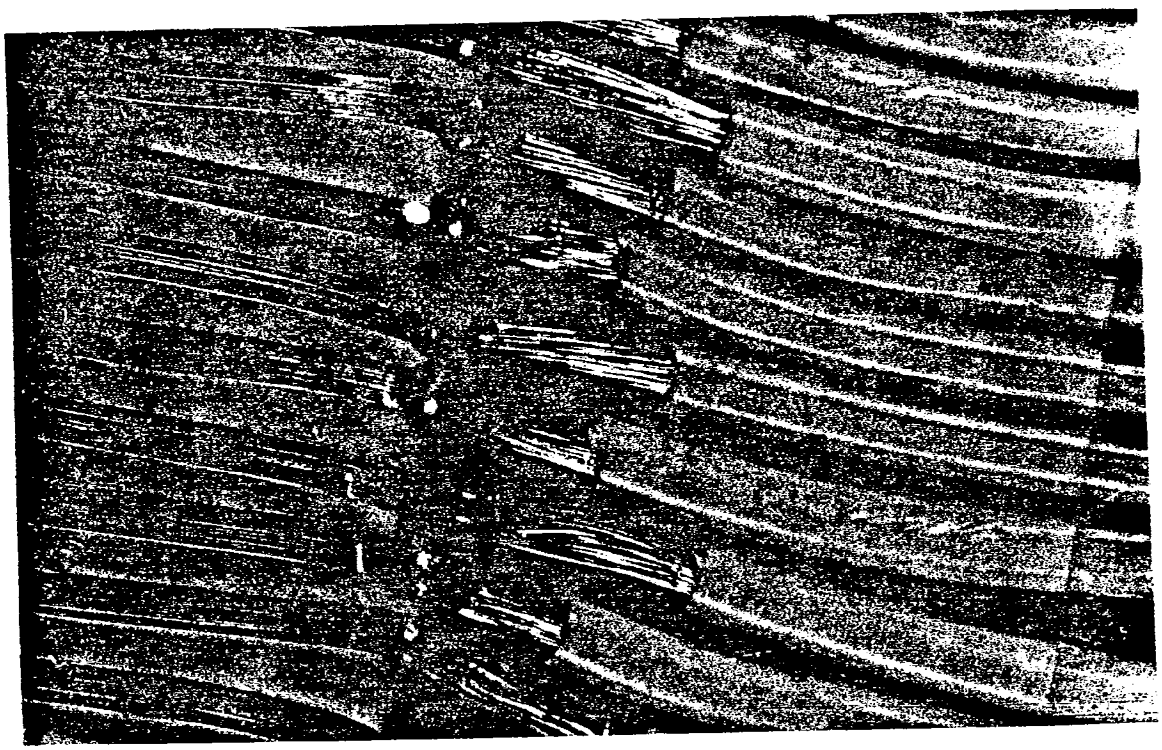

FIGURE 4-4. TIG welding transition - FCC to RWC (Dynatech Corp.).

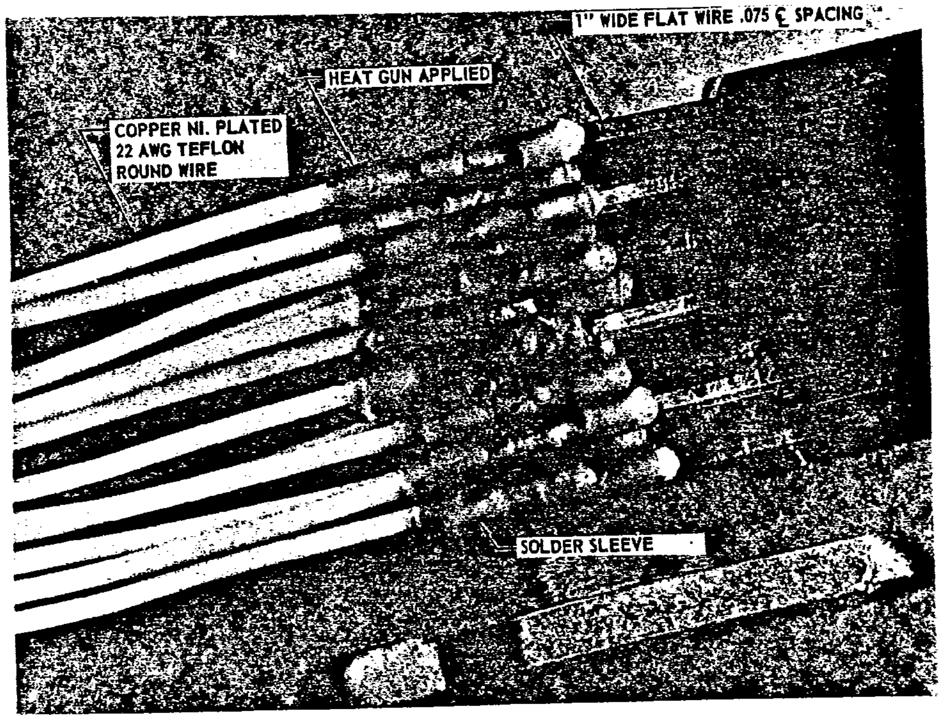


FIGURE 4-5. Ganged solder transition - FCC to RWC (Raytheon).

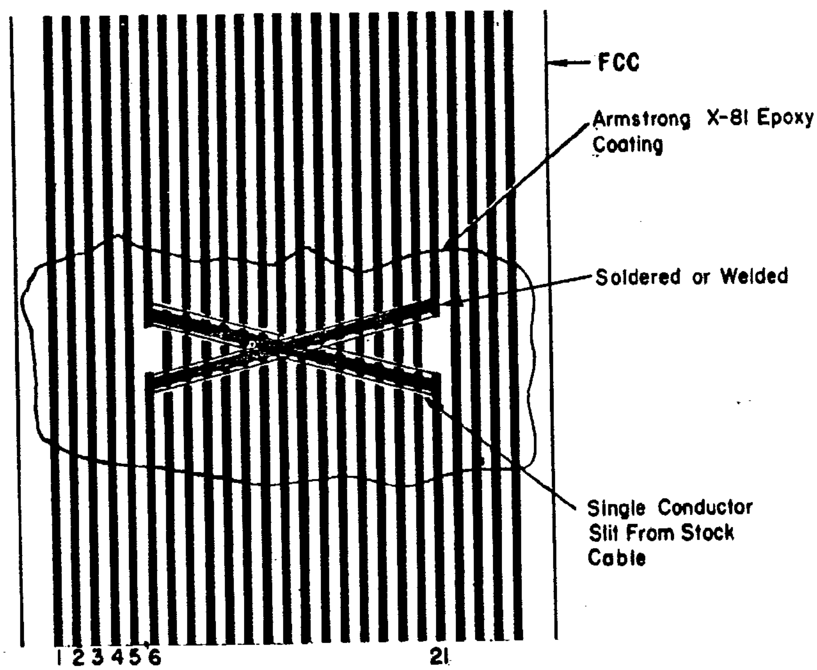


FIGURE 4-6. Rerouting conductors within an FCC.

In general, the transition to round-wire plugs provides an efficient termination system, with RWC pin-assignment change capability; however, part of the harness-fabrication cost saving is sacrificed, and additional termination junctions are imposed in the harness system.

4.2.2 Temporary. The following FCC wiring-change techniques can generally be considered as temporary or nonproduction. For many testing and development programs for system evaluation, and other limited applications, these methods could be used; however, for production efficiency and reliability, they would not normally be acceptable.

4.2.2.1 Rerouting Within a Cable. Simple wiring-circuit changes can be accomplished by a crossing or switching of two or more conductors of an interconnecting FCC without the use of external hardware. The two conductors are interrupted, and single conductors are soldered or welded to the ends of the interrupted conductors to restore the desired continuity (Fig. 4-6). This exchange should be made at a point in the interconnecting hardware where the cable is anchored or properly supported to eliminate subsequent cable flexing in the cable joint area.

4.2.2.2 Rerouting Within the FCC Plug Area. By properly preparing the cable, simple pin-assignment changes can be made in the plug-termination area. No additional junctions are required.

An example of this method for the NASA/MSFC conductor-contact plug assembly is explained as follows: Assuming conductor Nos. 2 and 10 are to be interchanged, the cable is stripped, slit, and folded as shown in Figure 4-7. Then conductor plating and plug assembly, as explained in Section VI, can be accomplished for either the premolded or molded-on plug versions.

4.2.2.3 Cable Matrix Joints. It is possible to accomplish pin-assignment changes and parallel circuit paths in an FCC harness through the use of the matrix joint system. Figure 4-8 shows the principles involved in such a joint. Interconnections can be made by welding, either of bare conductors or through insulation. The completed joint would be coated or encapsulated for sealing and mechanical strength. The Ralph Thacker Company of Los Angeles, California, has an automated X-Y coordinate-sensitive drilling machine for removing the insulation from preselected circular areas. Although the method adds one additional joint in the harness, complete pin-assignment-change capability is provided. The matrix system has been used by Ansley West on the carrier landing equipment for Bell Aerosystems.

4.2.2.4 Auxiliary Terminating Devices. Various auxiliary terminating or splicing devices are available for connecting FCC conductors to terminals, wires, pins, and to other FCC conductors. Figure 4-9 shows a line of tape terms available from Ansley West. The FCC is slit between conductors, and the terminals crimp on and pierce the insulation to make contact. This system is not applicable where vibration, frequent bending, extreme temperature cycling, or high reliability are required.

## 4.3 Distribution Units

4.3.1 System Advantages. The design application of distribution units was covered in detail in Section III. The important system advantages achieved are:

a. Cable assemblies are two-ended and can be terminated in a "by layer," predetermined configuration for all program connectors.

b. The electronic unit pin assignments can be selected for optimum circuit zoning that will automatically provide optimum zoning in the FCC harnesses.

c. All circuit or pin-assignment changes can be made in the distribution units without affecting FCC harnesses or electronic units.

d. The FCC harnesses between the distributors can be designed and installed prior to the circuit-design freeze of the electrical systems. The optimum cable and connector widths and sizes can be used on these harnesses.

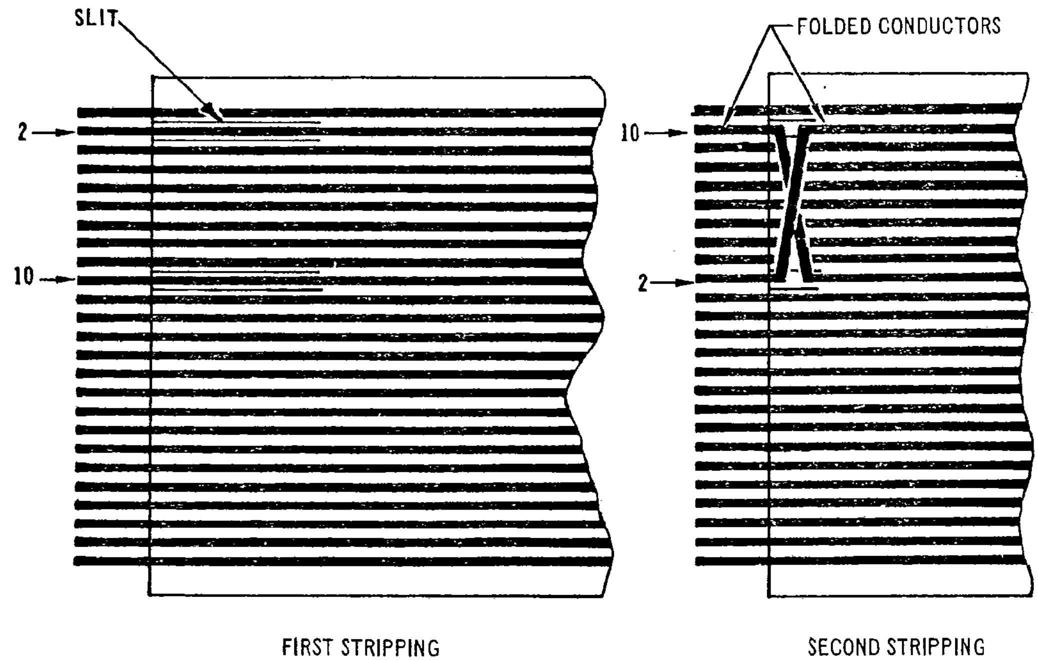


FIGURE 4-7. FCC preparation for plug rerouting.

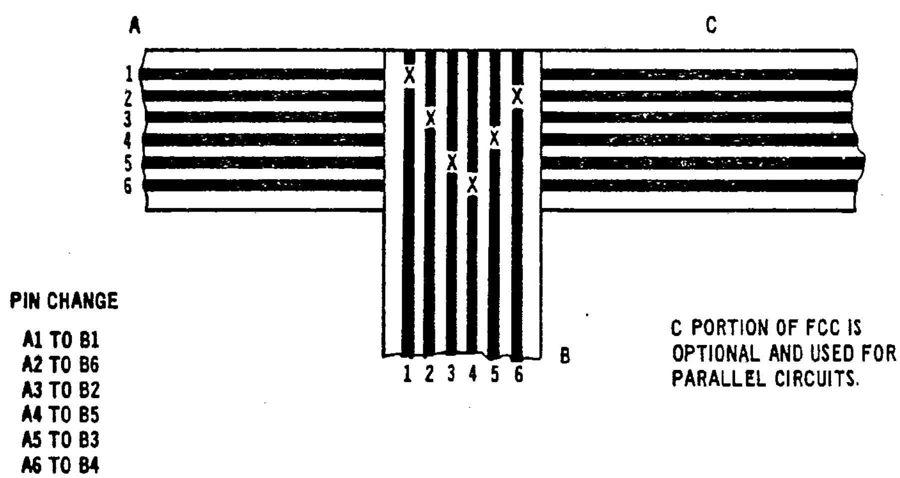


FIGURE 4-8. Cable matrix joint (Ansley West).

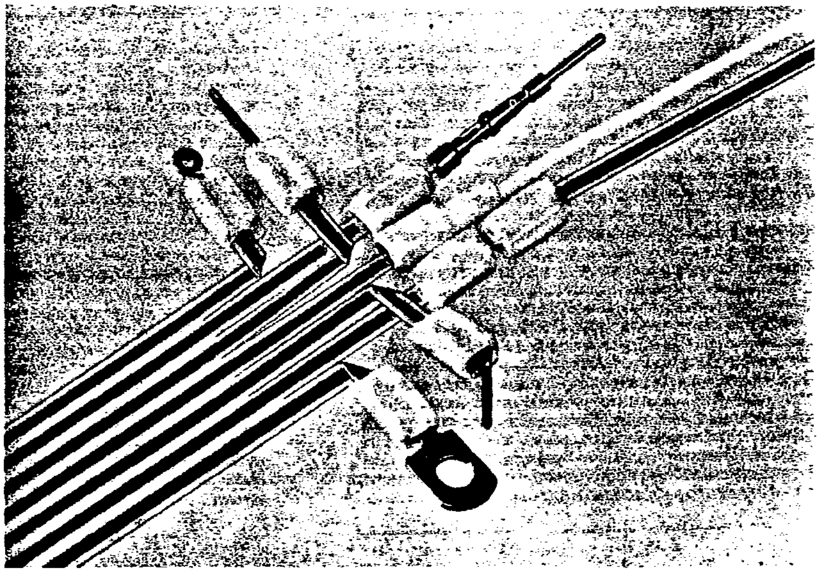

FIGURE 4-9. Tape - terms (Ansley West).

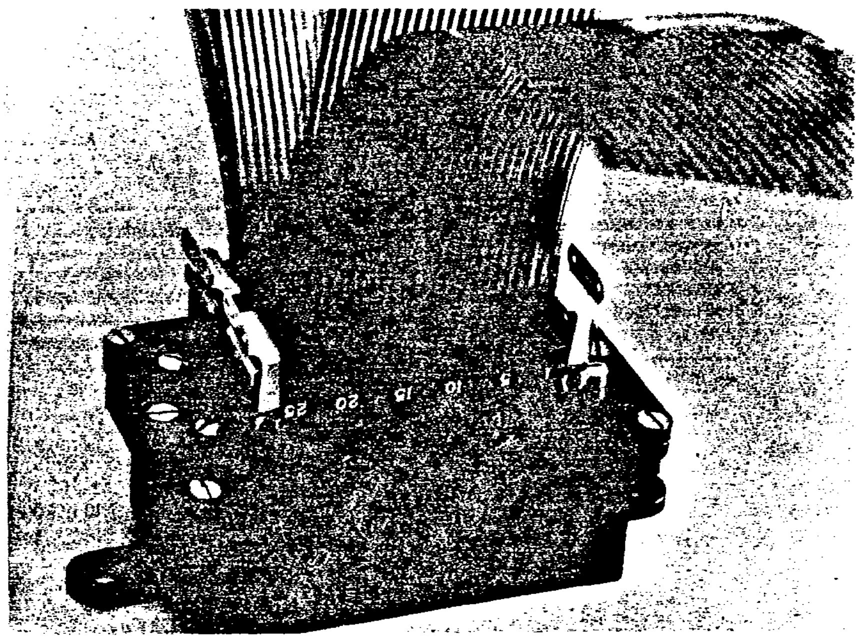

FIGURE 4-10. MSFC jumper wire distribution unit.

e. The minimum-number and smallest-size connectors can be used on each electronic unit.

f. The electronic unit pin-assignment designed for one program will automatically provide the optimum design for all other programs.

g. The number of wire-harness changes will be reduced to a minimum. It is estimated that this would be up to 95 percent reduction, depending on the complexity of the system.

4.3.2 Design Objectives. The design objectives are as follows:

a. Minimum number of circuit joints.

b. Minimum size and weight.

c. Capability of being wired or interconnected automatically for production and manufally for prototype.

d. Capability of being reworked manually with connectors mated.

e. Installation or replacement with minimum disturbance to adjacent installations and interconnecting harness system.

f. Random, nonparallel interconnections to reduce internal field interferences to a minimum.

g. Capability of accommodating various input-ouptut connectors, including both the FCC and RWC type.

h. Accommodate various conductor sizes required by the interconnecting network.

i. Provide bussing and parallel circuit paths as required.

4.3.3 Configurations. Various configurations of distribution units, suitable for use with FCC, have been proposed and a number have been developed. In general, these fall into two categories or configurations: those with a few connectors (usually two identical connectors) and those with many connectors of various types and sizes. The former would generally be used in a single-harness run to provide the pin-assignment change capability. These units could be included in initial design, but could also be added easily to harness runs requiring circuit changes after initial design. The many connector distribution units would generally be incorporated in the initial design to provide the many advantages listed above.

4.3.3.1 Distributors With Few Connectors. NASA/MSFC has developed several distribution units. They are relatively lightweight, simple, easy to install, and provide the means for unlimited pin-assignment changes. Two of these units are further discussed in the following paragraphs.

Figure 4-10 shows a simple, sealed box with two MSFC solder-type receptacles, and molded-on FCC plugs installed. The interconnections are made by soldering insulated round-wire jumpers between the receptacle solder pots that are inside the housing.

Figure 4-11 shows a disassembled view of a distributor that uses a PC board to accomplish the required pin-assignment changes. By cutting circuit conductors and adding jumper wires, all pin-assignment combinations can be accomplished. Small terminals to facilitate soldering can be easily added to the modified PC board if desired.

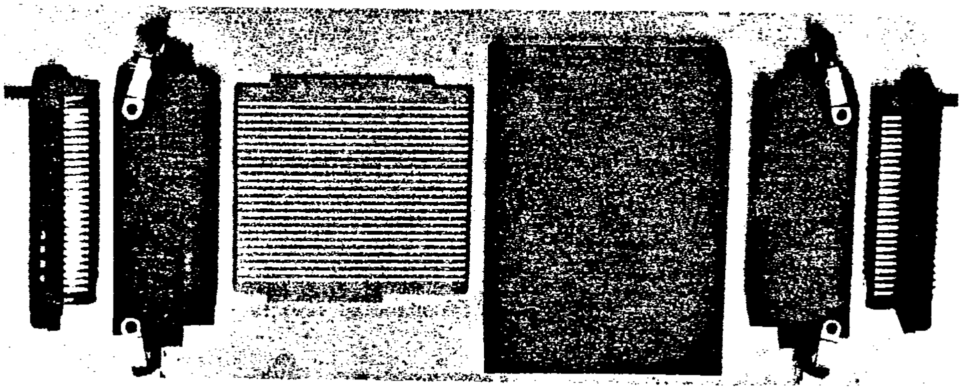

FIGURE 4-11. MSFC PC board distribution unit.

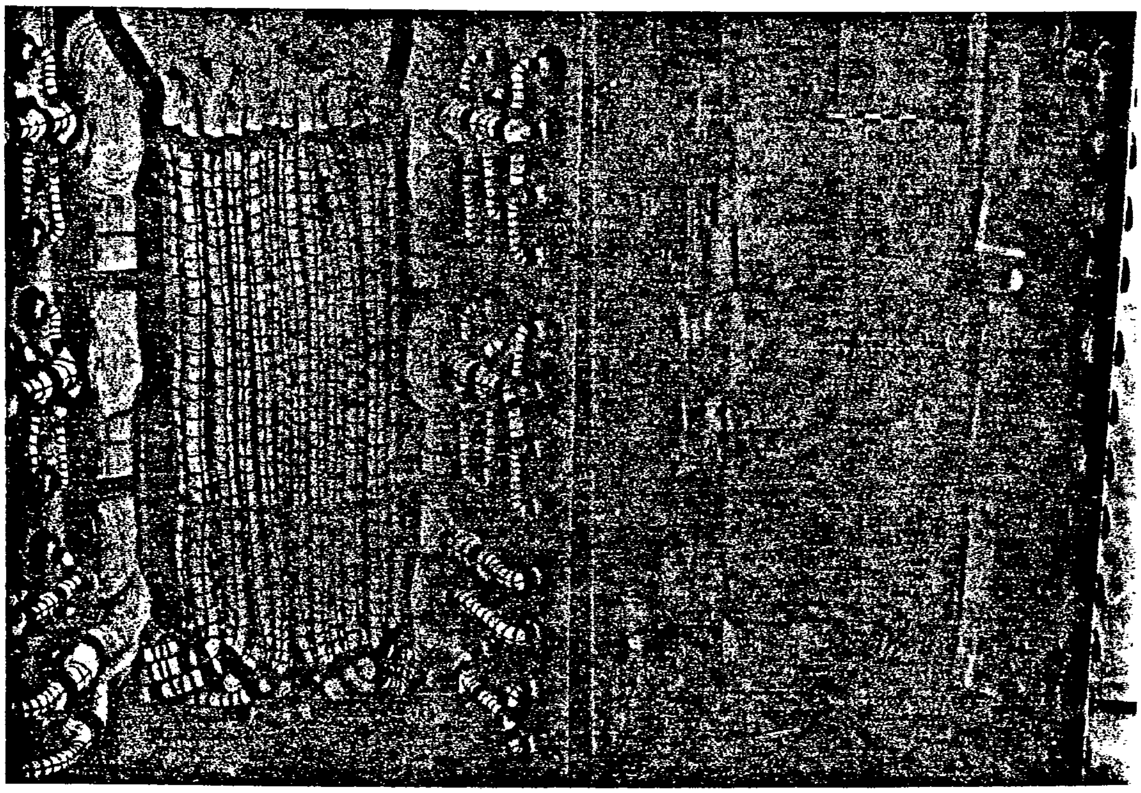

FIGURE 4-12. Saturn GSE patch-panel distributor (NASA/MSFC).

4.3.3.2 Distributors With Many Connectors. Various types of central distribution units with many input-output connectors have been considered and/or prototyped. These are described as follows:

a. GSE patch-panel distributor - Figure 4-12 shows the rear-view wiring comparison between FCC and RWC patch-panel distributor designs used by NASA/MSFC on the Saturn program. These distributors have forty 61-pin RWC input-output connectors and test points for each circuit. To avoid costly design changes, initial RWC terminations and pin assignments were retained. The use of the printed-circuit, flexible harnesses provided major cost savings, 50-percent reduction in cabinet volume, and 30-percent reduction in weight. Continuous FCC can also be incorporated into this type design through the use of the matrix interconnection described in Paragraph 4.2.2.3.

b. Wire-wrap distributor - Figure 4-13 shows a programmable distributor unit (by Ansley West) used on a research space vehicle program to provide maximum circuit change flexibility and rework capability in the instrumentation circuits. RWC input-output connectors are interconnected with a wire-wrap plane by continuous FCC. This design permits programmed, automatic production interwiring and simple hand rework for circuit changes to the instrumentation circuits after initial fabrication.

c. Termi-point distributor - A distribution unit using the Termi-Point termination system was developed and a prototype built by MDC. Figure 4-14 shows the design concept and typical installation. All interconnection wiring can be accomplished by programmed automatic equipment. Multilayer wiring will permit bussing of circuits. Rework can be accomplished with simple hand tools. Upper terminations can be moved to lower positions on the post terminals to simplify rework. The use of stranded, interconnecting wire, with the post clip securely gripping the insulation, gives added resistance to vibration and shock. This system provides the minimum number of circuit junctions by making all interconnections directly to the connector rear post. The use of this concept would require the development of connectors with Termi-Point rear posts located on a modular grid to accommodate the automatic wiring systems. In addition, the interconnecting wire sizes would be limited by the connector post sizes and centerline spacings.

d. Multiconnector distributor using PC boards and plug-in jumpers - Figure 4-15 shows the NASA/MSFC basic design and jumper-wire arrangement. The PC board is double-sided to accommodate the usual NASA/MSFC double-cable connectors. This design is very convenient for making wiring changes and the plug-in jumper concept facilitates almost unlimited rechange cycles or capability. Figure 4-15 shows a design accommodating six 1-inch, 24-pin FCC connectors. The dimensions of this particular distributor are 19 by 10 by 2.2 centimeters (7.5 by 4.5 by 0.85 inches). The bushings in the PC board are a standard type (Cambion 3704-1-03) manufactured by Cambridge Thermionic Corporation, Cambridge, Massachusetts. The pins are modified (shortened) to save space. Depending upon circuit quantity requirements, other sizes of this type distributor are feasible, practical, and manufacturable.

## 4.4 Conclusion

The various wiring-change methods described can be used, as applicable, to accommodate pin-assignment changes in FCC interconnecting harness systems. It is important to give proper consideration to the anticipated pin-assignment change requirements early in the program, and design the system accordingly. The addition of change devices or the use of "temporary" rerouting schemes done on an "as required" basis will result in a less-than-optimum final design.

The use of distribution units will provide system circuit changeability, permit use of simple interconnecting harnesses designed and fabricated early in the program, and will efficiently accommodate kit additions and various configuration changes between production units.

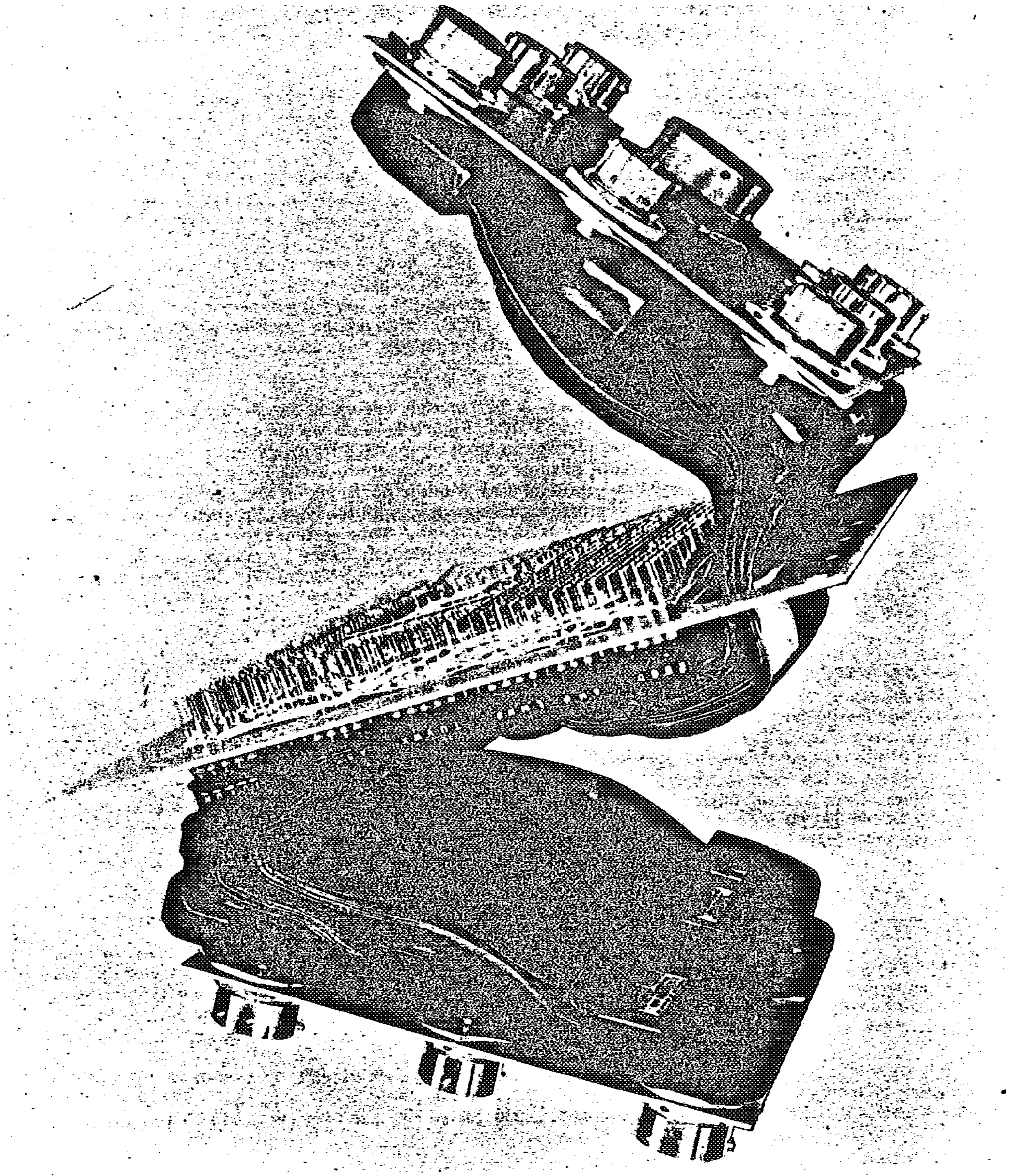

FIGURE 4-13. Wire-wrap distributor (Ansley West).

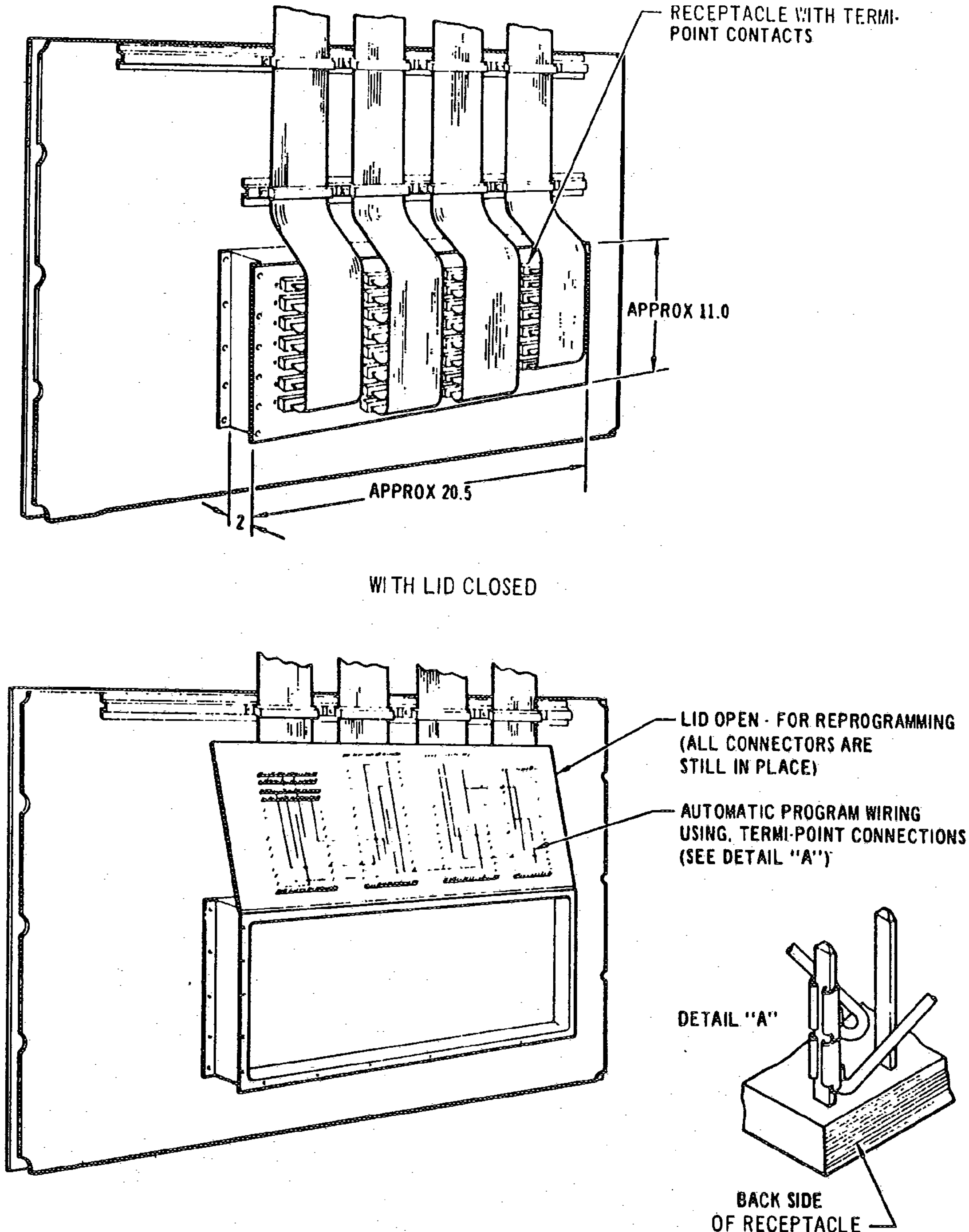


FIGURE 4-14. Termi-Point distributor.

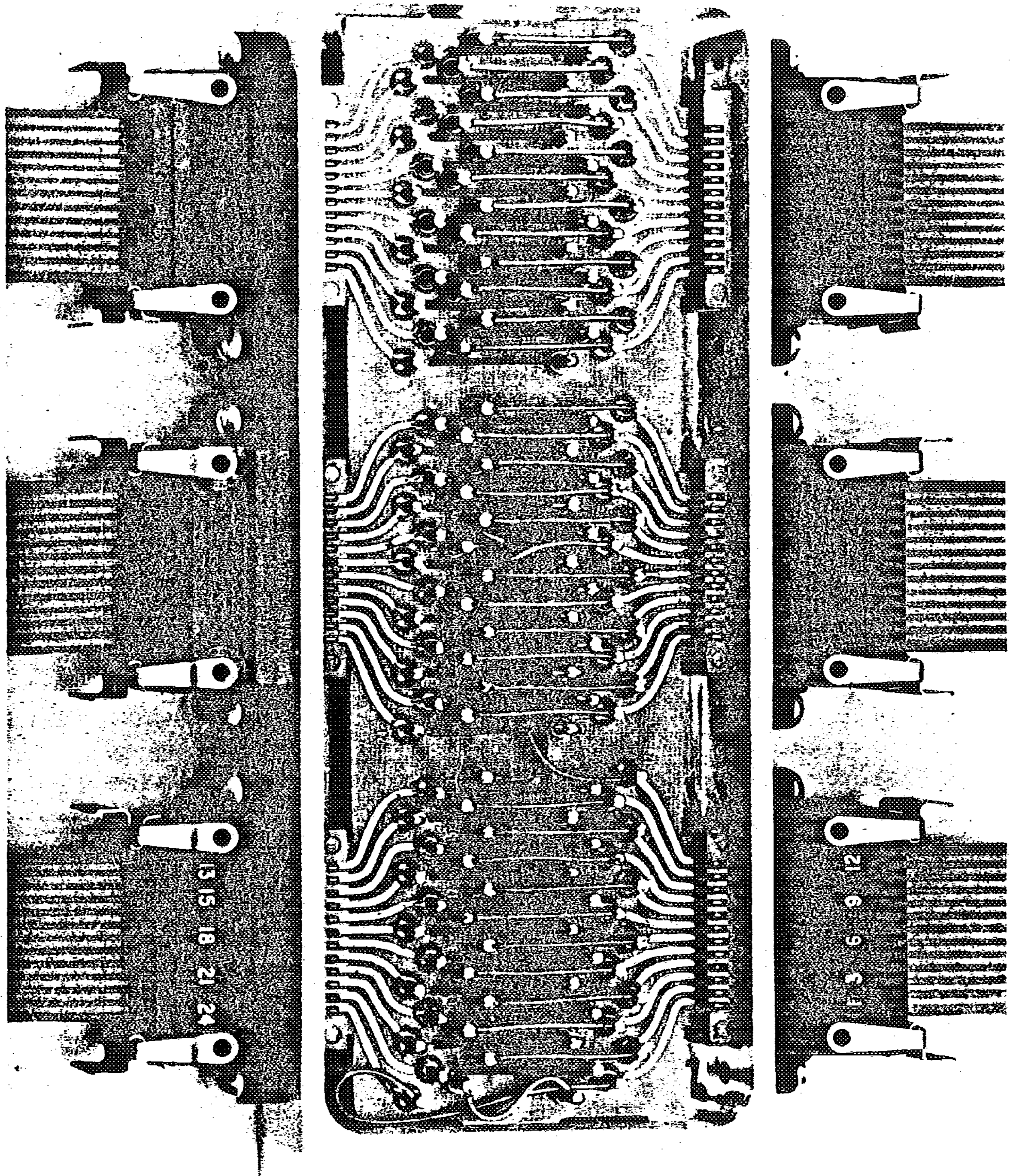

FIGURE 4-15. Multiconnector distributor with plug-in jumper pins (NASA/MSFC).