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DEVELOPMENT OF FLAT CONDUCTOR CABLE FOR COMMERCIAL AND RESIDENTIAL WIRING - FINAL REPORT

James R. Carden

George C. Marshall Space Flight Center
Marshall Space Flight Center, Ala. 35812

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16. ABSTRACT

The overall spectrum of the George C. Marshall Space Flight Center's (MSFC) total effort in a space technology spin-off development project, Development of Flat Conductor Cable (FCC) for Commercial and Residential Wiring, is presented in this report. A discussion of the background, program milestones, industry participants, system outgrowth, hardware availability, cost estimates, and overall status of the program is presented for the 1970-to-present time period. Although the artwork presents detailed information, it is intended that the reader obtain more detailed information from the reports presented in Sections III and IV, B.

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I. INTRODUCTION

This report covers the overall spectrum of the George C. Marshall Space Flight Center's (MSFC) total effort in a space technology spin-off development project, covering the period 1970-to-present. This project, Development of Flat Conductor Cable (FCC) for Commercial and Residential Wiring, covers the background, program milestones (Fig. 1), industry participants, system outgrowth, hardware availability, cost estimates, and overall status of the program. Although the artwork presents detailed information, it is intended that the reader obtain more detailed information from the reports presented in Sections III and IV, B. From a development viewpoint, this project is identified as the Surface Mounted Flat Conductor Cable System, but due to separate areas of activity set forth by industry, Underwriters Laboratory (UL), and the National Electric Code (NEC) people, tasks were divided into the under-carpet system and the baseboard system. As a result, the contents of this report will be defined as separate tasks or systems.

II. BACKGROUND

The project, Development of Flat Conductor Cable for Commercial and Residential Wiring, is the outgrowth of a more general project to apply aerospace technology to problems in the building industry. This project, known first as the Urban Development Applications Project and later as the Urban Construction and Safety Project, has been active since 1970 under NASA'S Office of Technology Utilization.

One of the earliest problem areas identified was electrical wiring for commercial and residential construction. Existing wiring systems are expensive to install, difficult to modify and revise, and generally have not progressed as rapidly as other areas of building construction. In 1971, industry (e.g., New York State Urban Development Corporation) visited MSFC through the NASA

Technology Utilization Program in quest of possible electrical wiring technology, and quickly identified MSFC's FCC technology as a possible solution to some of industry's building wiring problems. This solution is portrayed by both the baseboard and the under-carpet systems.

III. SURFACE-MOUNTED FCC BASEBOARD SYSTEM

A. State-of-the-Art

The surface-mounted FCC baseboard system has been primarily an MSFC in-house development effort. This technology has not been picked up by industry as has the under-carpet system. Program participants are noted in Table 1. This system has been exhibited at national building shows, conferences, expositions, etc., and a number of experimental installations have been made as verified by Table 2. To date, only prototype hardware has been fabricated and, therefore, a source has not been established for quality system hardware. Tables 3 and 4 illustrate hardware availability and design drawings. Figures 2, 3, and 4 portray the baseboard system installation procedure.

A fact finding reveiw was conducted by UL in the Melville, Long Island facility in 1975 with the preliminary findings very encouraging. However, in some of their torture tests (e.g., the nail penetration tests), it was found that the surface-routed flat cable offered a greater target than routed-round wire and created a greater fire and shock hazard in the baseboard. It was at this time UL recommended that the baseboard system and the under-carpet systems be identified as two separate systems. UL recommended that the baseboard system not be submitted to the NEC until a deterrent to nails and other penetrating objects is designed into the system.

Such a design has been incorporated into the system as noted in Table 4 and Figure 5. Hardware and installation costs increase when the hot conductor is shielded. With new and improved circuit protection devices, such a shield is not believed necessary and is included only as an option or addition to the baseboard system.

A further understanding of the MSFC development effort is depicted in the milestone chart of Figure 1. It is anticipated that industry will continue work in this area until a hardware source is established. Except for technical consultation the MSFC effort will be concluded at the end of the 1976 calendar year. All future inquiries regarding this system will be directed to NASA's Technology Utilization Offices.

B. Technical Reports

Report No.	Title	Author(s)	Date
NASA TM X-64887	Surface-Mounted Flat Conductor Cable for Home Wiring	James D. Hankins/ James Carden	Aug. 74
NASA TM X-64888	Testing of a Flat Conductor Cable Baseboard System for Residential & Commercial Wiring	James D. Hankins	Aug. 74
NASA TM X-64893	Testing of Flat Conductor Cable to Underwriters Laboratory Standards UL 719 and UL83	R. Loggins/ R. Herndon	Sept. 74
NASA TM X-64916	Installation Procedure for Surface-Mounted FCC	James R. Carden	Mar. 75

IV. FCC UNDER-CARPET SYSTEM

A. State-of-the-Art

MSFC's involvement in the development of this system has been limited since industry is actively pursuing its development. The principle industry participants are Amp, Inc., Western Electric Co., and Thomas & Betts, Inc.

These and other program participants are listed in Table 5. MSFC's role has been to develop an under-carpet cable, solicit industry participation, assist in NEC approval activities, and participate in exhibiting the system at national building shows, conferences, etc. Several experimental installations have been made in various areas of the U.S. Some of the more notable installations are listed in Table 6.

This under-carpet system was approved by the NEC Committee, panel No. 7, on December 6 and 7, 1976. Of the twelve voting members, there were ten "yes" votes and two abstentions, which is an approval vote. Although this was probably the most important meeting in the approval process, there will be other approval meetings before inclusion in the 1978 NEC Revision.

As for future systems hardware, please contact the following:

(Under-carpet telephone system)

Western Electric Co.
Engineering Research Center
Princeton, NJ 08540
Attn: Jack Balde

(Under-carpet electrical power system)

Amp, Inc.
Largo, FL
Attn: Mr. Jim Fleishhacker

B. Technical Reports

Report No.	Title	Author(s)	Date
NASA TM X-64883	Temperature Rise of Flat Conductor Cable Installed Under Carpet	James D. Hankins	Sept. 74

V. COST COMPARISON

Cost comparison estimates for the FCC versus round wire for commercial and residential wiring are presented in Table 7.

TABLE 1. INDUSTRY AND GOVERNMENT ORGANIZATIONS INVOLVED IN FCC BASEBOARD HARDWARE DEVELOPMENT, MANUFACTURE, TEST OR USE

Nongovernment	Government
Parlex Corp. 145 Milk Street Methuen, MA 01844 Attn: Chuck Surat	General Services Administration (GSA)
Port Chester Electrical Co., Inc. 354 N. Main Street Port Chester, NY 10573 Attn: Kenneth M. Menz	Housing and Urban Development (HUD)
Technology+Economics, Inc. 129 Mount Auburn Street Cambridge, MA 02138 Attn: David J. MacFadyen	National Aeronautics and Space Administration (NASA)
Underwriters' Laboratories 1285 Walt Whitman Road Melville, Long Island, NY 11746 Attn: Ed Coffee Ed Krawiec	National Bureau of Standards (NBS)
Halpern Building Corp. 1101 Midland Avenue Bronxville, NY 10708 Attn: Irvin Appledorff Hyman Rostoker Robert A. Spies	New York City Housing Authority 250 Broadway New York, NY 10007 Attn: Eric Nadel
Leviton Mfg. Co., Inc. 59-25 Little Neck Pkway. Little Neck, NY 11362 Attn: Bill Drapkin	New York State Urban Development Corp. 1345 Avenue of the Americas New York, NY 10019 Attn: Harvey Walcoff

TABLE 2. EXPERIMENTAL INSTALLATIONS

MSFC Conference Room[a]	MSFC, Huntsville, AL	May 74
N.Y. State Urban Development Corp. Apartments[a]	Yonkers, NY	December 74
MSFC Solar House[a]	MSFC, Huntsville, AL	July 75
UL Fact Finding[a]	Melville, Long Island, NY	August 75
LARC Technology House[a]	Langley Research Center, Hampton, VA	June 76

a. Installed by MSFC personnel.

TABLE 3. BASEBOARD SYSTEM HARDWARE AVAILABILITY

Type Hardware	Manufacturer's Part No.	Manufacturer's Name and Address	Crimp Tool
Termi-foil, Crimp	H143898	Amp, Inc. Harrisburg, PA	69288-1
Disconnect, Female Wire 16-14	DV14-250F1-C	Panduit Corp. Tinley Park, IL	CT-100
Disconnect, Female	DV10-250-L	Panduit Corp. Tinley Park, IL	CT-100
Terminal, Fork Wire 16-14, Stud 8	PV14-8F-C	Panduit Corp. Tinely Park, IL	CT-100
Terminal, Fork Wire 12-10, Stud 10	PV10-10F-L	Panduit Corp. Tinley Park, IL	CT-100
Flat Conductor Cable	MM-5000-26X	Parlex Corp. 145 Milk St.	N/A
Extruded 2-piece Baseboard	N/A	Quick Plastics, Inc. Jackson, MI	N/A
Receptacle	Duplex Thin Line	Leviton Mfg. Co., Inc. Little Neck, NY	N/A
Inside and outside corner brackets and covers, splices, receptacle brackets and covers	Unavailable, only prototypes fabricated to date. MSFC has prototype drawings.	Source Not Established	N/A

TABLE 4. BASEBOARD SYSTEM HARDWARE

Hardware Item	Drawing No.
Baseboard Back Channel	50M27865
Baseboard Front Cover	50M27867
Inside Corner Cover	50M25629
Outside Corner Cover	50M27868
Baseboard End Cap	50M27863
Receptacle Cover	50M27862
Baseboard Splice	50M25630
Inside Corner Mounting Bracket	50M25623
Outside Corner Mounting Bracket	50M25627
Receptacle Mounting Bracket	50M25625
Receptacle Cable Clamp	50M24560
Shield Clip	50M24563
Shield	50M24564

Note: Hardware for 2 in. wide FCC.

TABLE 5. INDUSTRY AND GOVERNMENT ORGANIZATIONS INVOLVED IN FCC UNDER-CARPET HARDWARE DEVELOPMENT, MANUFACTURE, TEST OR USE

Nongovernment	Government
Parlex Corporation 145 Milk Street Methuen, MA 01844 Attn: Chuck Surat Technology+Electronics, Inc. 129 Mount Auburn Street Cambridge, MA 02138 Attn: David J. MacFadyen The Thomas & Betts Co. 36 Butler Street Elizabeth, NJ 07207 Attn: Manny Bromberg Underwriters' s Laboratories 1285 Walt Whitman Road Melville, Long Island, NY 11746 Attn: Ed Coffee Ed Krawiec Western Electric P. O. Box 900 Princeton, NH 08540 Attn: John W. Balde Amp, Inc. 230 Commerce Dr. Largo, FL 33540 Attn: James Fleischhacker Chuck Schaal	General Services Administration (GSA) Housing and Urban Development (HUD) National Aeronautics and Space Administration (NASA) National Bureau of Standards (NBS)

TABLE 5. (Concluded)

Nongovernment	Government
Collins and Aikman, Inc. 210 Madison Avenue New York, NY 10016 Attn: Lester Votava Lamotite Products 2909 East 79th Street Cleveland, OH 44104 Attn: Bob Jackson Bob Underhill	

TABLE 6. EXPERIMENTAL INSTALLATIONS

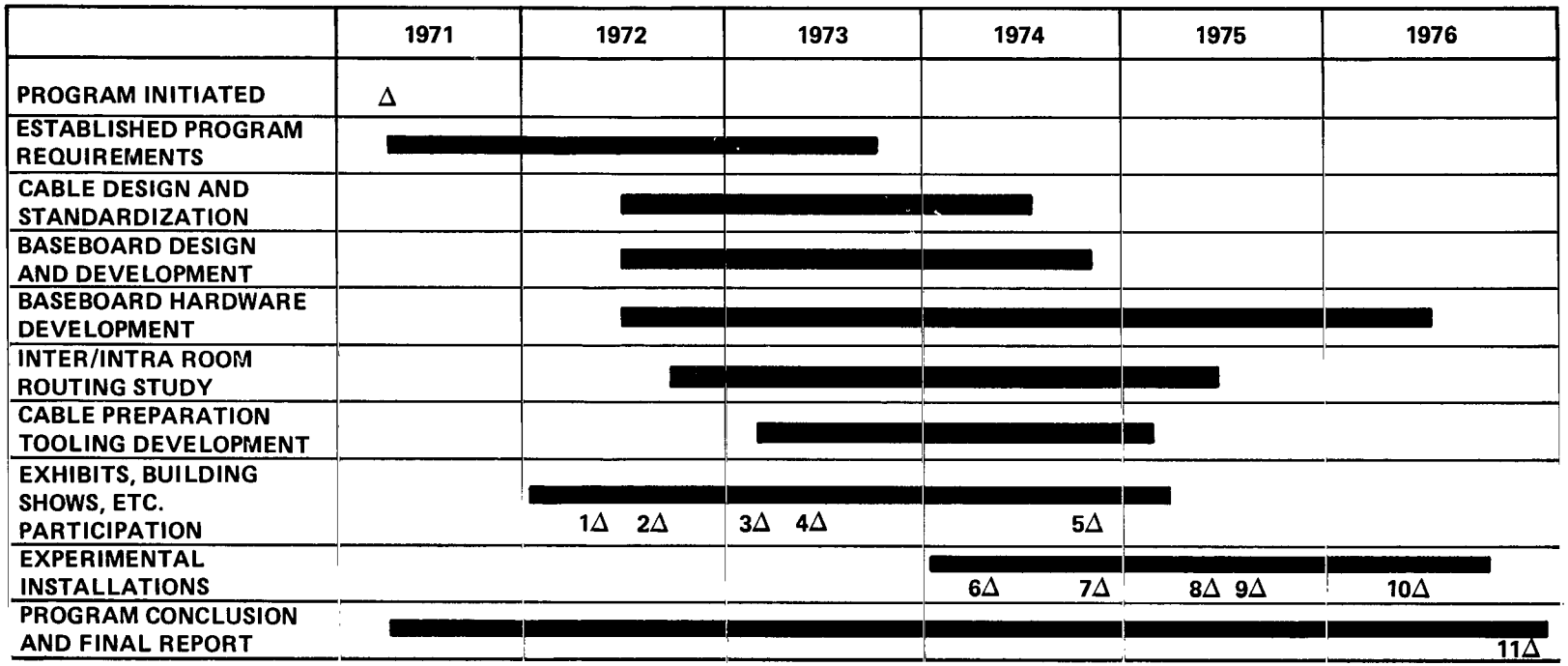
Western Electric	Sunnyvale, CA	Feb. 74
Western Electric	Indianapolis, IN	Oct. 74
Southern Bell Office	Greensboro, NC	Mar. 75
MSFC Solar House[a]	Huntsville, AL	July 75
UL Fact Finding	Melville, Long Island, NY	Aug. 75

a. Installed by MSFC Personnel.

TABLE 7. COST COMPARISON ESTIMATES

Type of Installation	Flat Cable		Round Wire
	Present Prototype Hardware	Future Production Hardware	Present or Production Hardware
Single Unit Residence	$ 3.00	$ 0.60	$ 0.70
Multiunit Apartment Complex	3.00	0.60	1.60
Office Complex	1.80	0.45	3.40
Single Unit Residence Rehab Wiring	3.00	0.60	0.70+
Office Complex Rehab Wiring	1.80	0.45	3.40+

Note: Costs noted are per square foot of floor space.



1. URBAN TECH. CONFERENCE, SAN FRANCISCO, CA – JULY 24-26
2. INTERNATIONAL BLDG. EXPOS, LOUISVILLE, KY – OCT. 30-NOV. 2
3. NATIONAL ASSOC. OF HOME BUILDERS, HOUSTON, TX – JAN. 7-9
4. ASSOC. PRESERVATION TENNESSEE HISTORICAL HOMES, COLUMBIA, TN – MAY 9
5. NATIONAL ASSOCIATION OF HOME BUILDERS, CHICAGO, IL – DEC. 9-12
6. MSFC CONFERENCE ROOM, MAY 1974
7. UDC APARTMENTS, YONKERS, NY, DEC. 1974
8. MSFC SOLAR HOUSE, JULY 1975
9. UL, MELVILLE, LONG ISLAND NY, AUGUST 1975
10. LANGLEY TECHNOLOGY HOUSE, LANGLEY, VA – JUNE 1976
11. FINAL REPORT

Figure 1. Program development schedule and milestones (baseboard system).

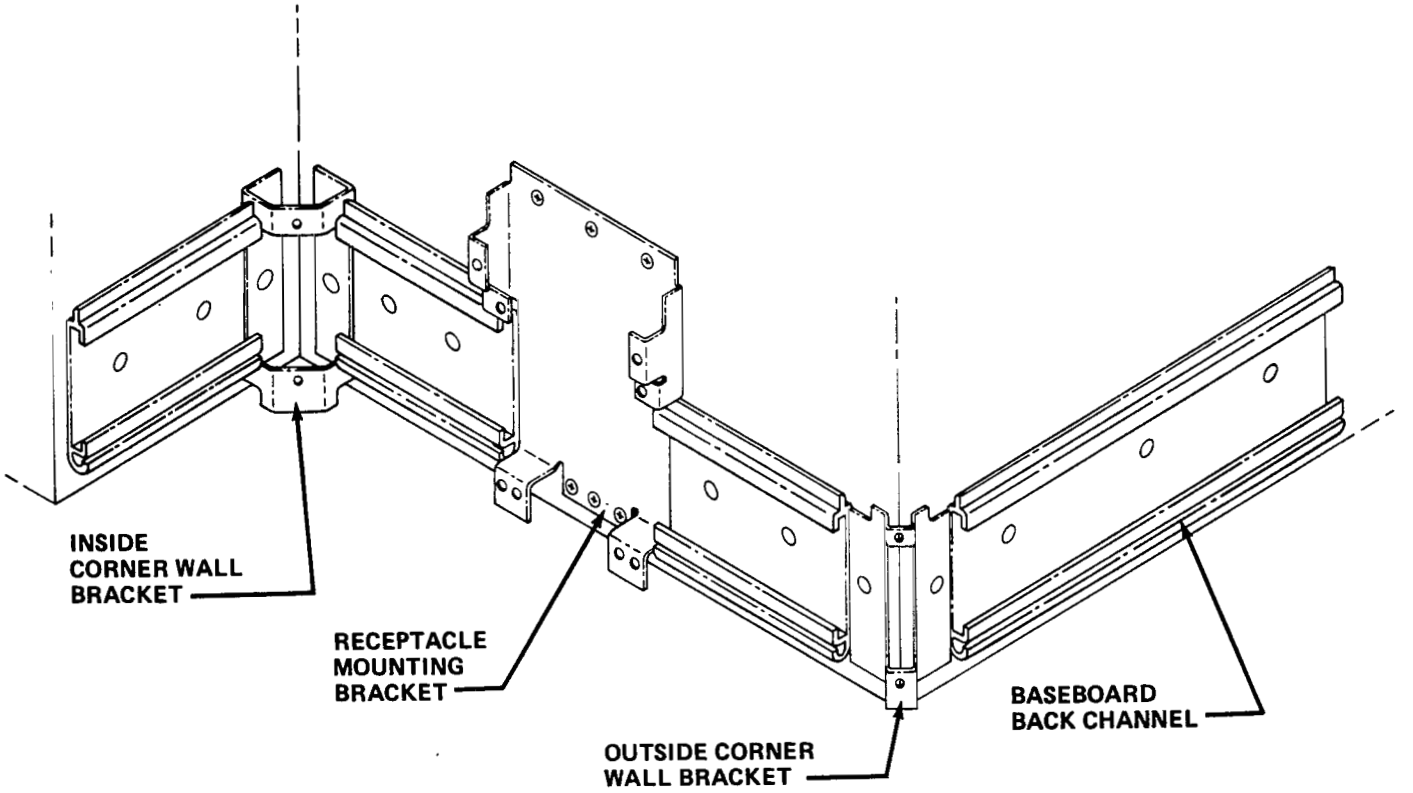


Figure 2. Baseboard assembly wall mountings.

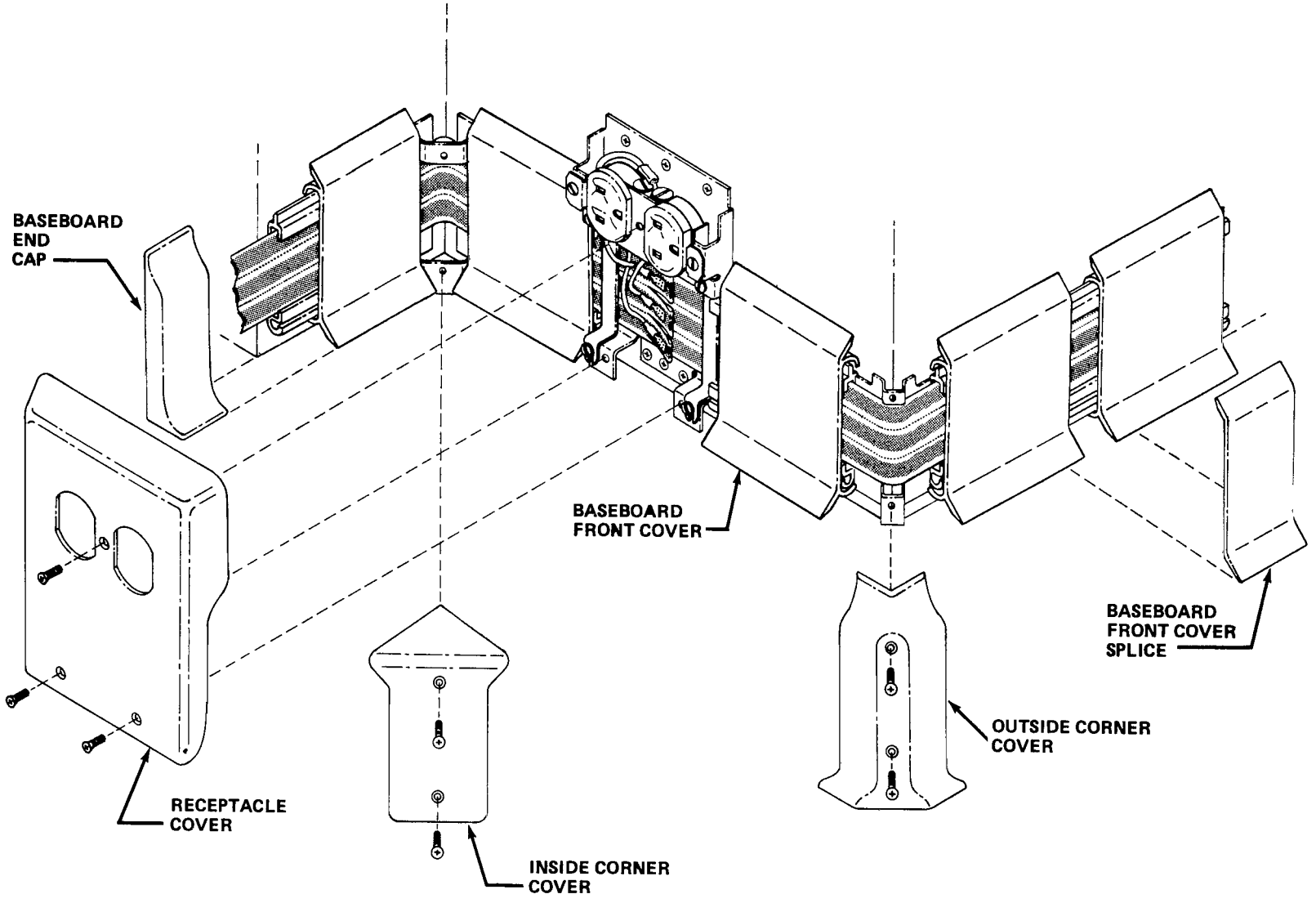


Figure 3. Baseboard assembly with cable, receptacle, and front cover mounted and assembled.

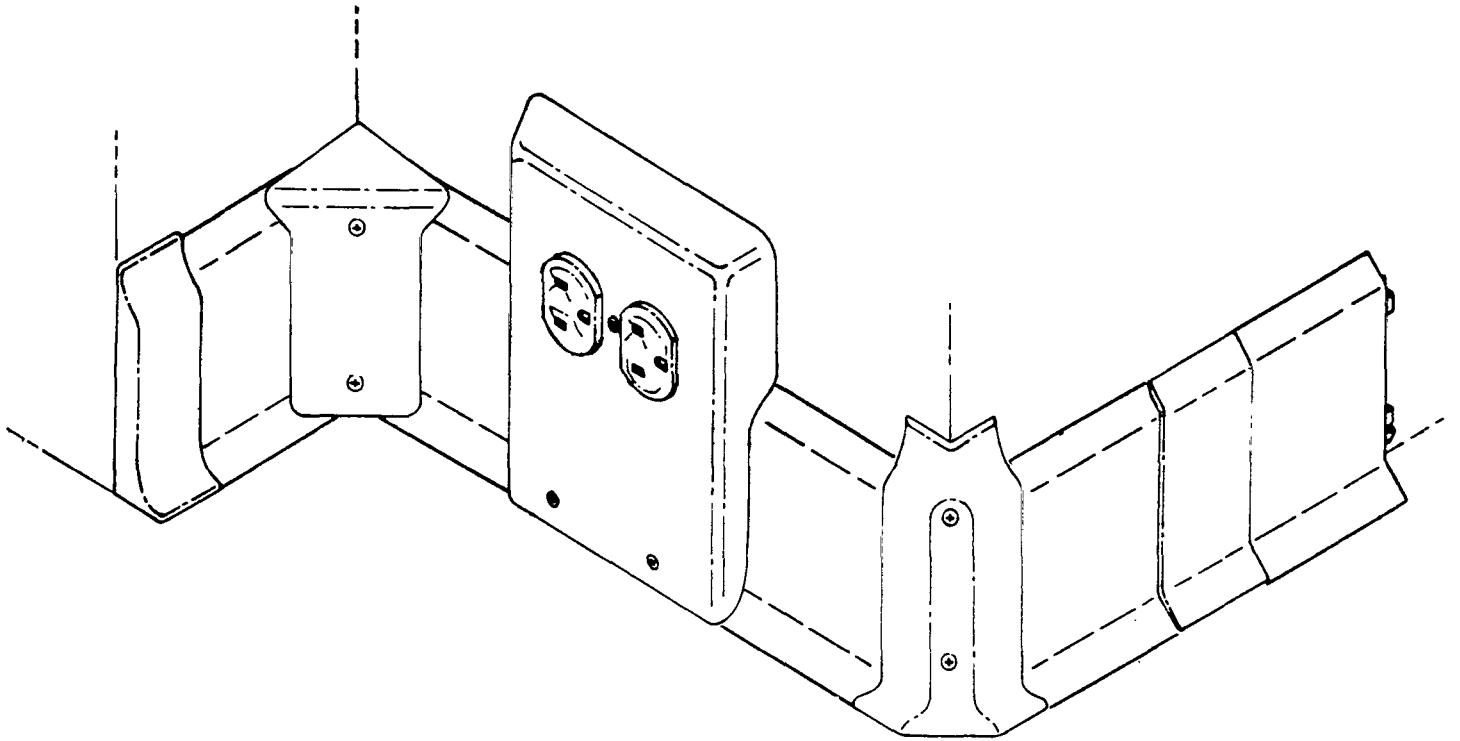


Figure 4. Baseboard system totally assembled.

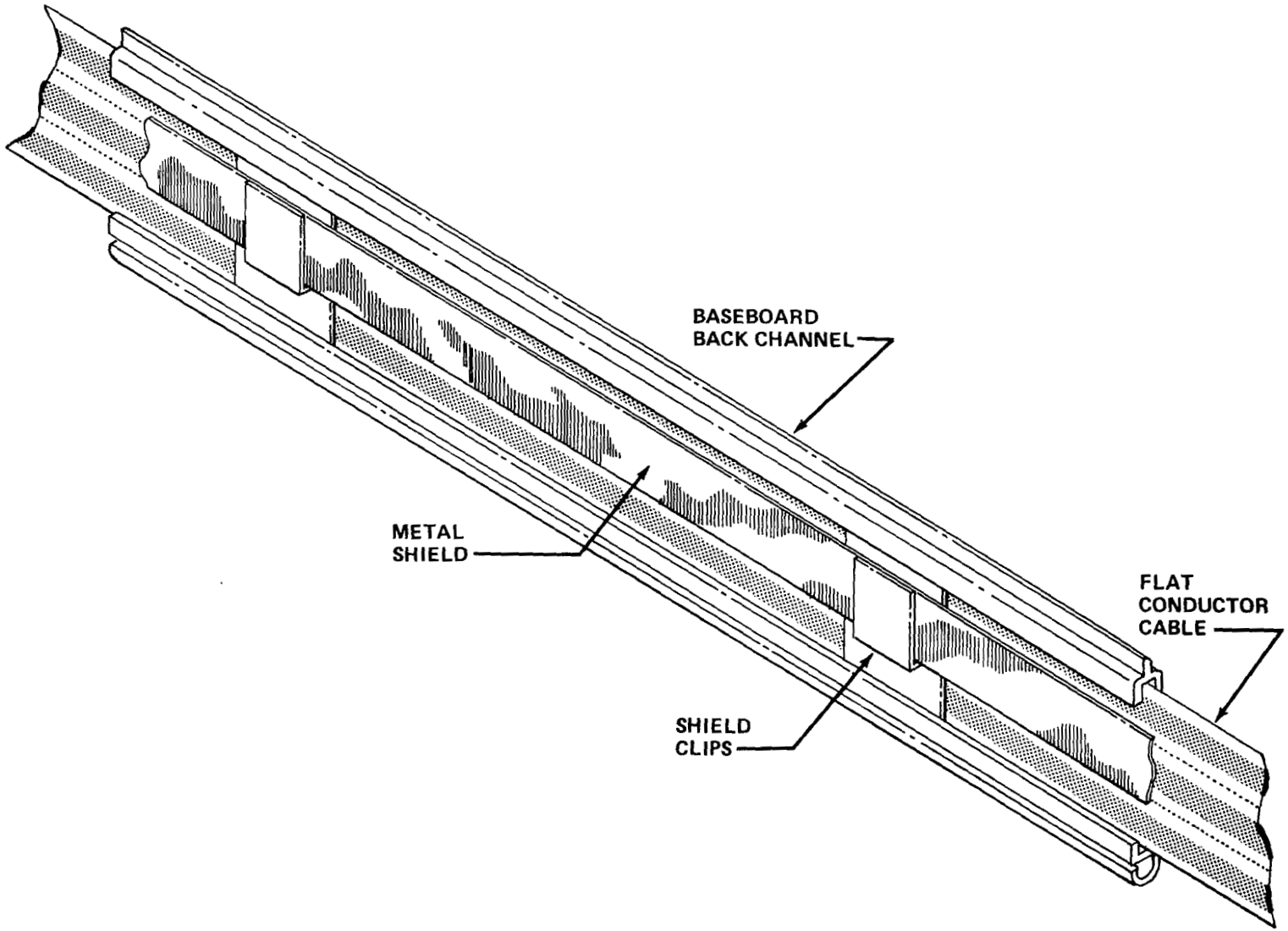


Figure 5. Flat conductor cable baseboard system with center conductor metal shield.

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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