NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report 32-1326

Documentation of Wiring Harnesses by Use of Punched-Card Techniques

W. G. Kloezeman
W. W. Hicks

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

October 15, 1968

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report 32-1326

Documentation of Wiring Harnesses by Use of Punched-Card Techniques

W. G. Kloezeman
W. W. Hicks

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

October 15, 1968

TECHNICAL REPORT 32-1326

Prepared Under Contract No. NAS 7-100
National Aeronautics & Space Administration

Preface

In developing the technique described in this report, the machines used included the IBM 82 card sorter and the IBM 407 card printer. Detailed instructions are not here included for their operation or for wiring the control panel of the printer. Manuals covering this material are readily available from the manufacturer of the equipment.

The work described in this report was performed by the Engineering Mechanics Division of the Jet Propulsion Laboratory.

Contents

Table

Figures

Abstract

This report discusses a technique for using a punched-card printer to produce wiring harness documentation. A format for punching the required information on the cards and a method for sorting the resulting cards in preparation for printing are covered. Also, the printing format and the wiring of the printer control panel are discussed.

Documentation of Wiring Harnesses by Use of Punched-Card Techniques

I. Introduction

In this investigation, a technique for documenting wire harnesses by use of punched IBM cards, in conjunction with a card sorter and a card printer, was applied. The technique was developed to save drafting time and to increase the flexibility of the wiring documentation method currently being used. In the existing method, a draftsman prepares a pictorial representation of each connector to show each pin of the connector, its wiring destination, the wire size, the function of the wire, and any pertinent twist or shield information. If a wiring change is made, it is required that the drawing be corrected and reissued. It is evident that this process is both time-consuming and costly. Other disadvantages are that the drawings fade over a period of time and they require hand lettering which can, at times, become illegible.

In the punched-card technique, each *pin* of each connector is represented by one of the cards. The original idea was to have each punched card represent each *wire* in a harness. However, with this method, each card would represent *two* connector pins and, in so doing, would present problems. For instance, sorting one particular connector out of a harness stack would remove cards representing pins of other connectors because each card represents two pins. The entire harness could not be printed in one operation. Further, the punched cards representing a harness could not be sorted into stacks representing complete connectors within a harness.

To obviate such difficulties as the above, it was determined that each connector pin would be represented by one card; and since, in this documentation method, a splice is treated as if it were a single pin connector, the total number of punched data cards for a harness equals the number of connector pins in the harness plus the number of wires in the harness that route to splices.

In the technique described herein, all of the cards representing a connector are punched, sorted on a card-sorting machine, then used to print out wiring documentation for that connector. If wiring changes are made, they are easily accommodated: All cards involved in the wiring change are separated from the other cards, new cards are punched, and the wiring documentation is reprinted to obtain the latest configuration. This feature is a prime advantage for harness fabrication in that the latest information is immediately available. There is no waiting for drawings to be updated, no fabricating to either engineering change orders or obsolete prints.

The following text covers the subjects of the card format, the card sorting, the printing format, the control panel wiring, and finally, the printing of the harness documentation.

II. Card Format

The typical 80-column computer card was used for punching the required wiring information for input. The format decided upon is described in the following paragraphs.

Columns 1–3 contain the harness number. For example, a typical harness might be denoted by the number 2009W109. The last three digits – in this case, 109 – are the harness number.

Columns 4–11 contain the alphameric designation representing the connector or the splice being considered.

Columns 12–14 contain the pin designation. The first two columns are the pin number or letter. If the letters in the pin designation are lower case, the third column contains a dash; otherwise, the column is left blank.

Columns 15–22 contain the alphameric designation representing the connector or splice to which the wire is routed from the connector being considered.

Columns 23–25 contain the designation representing the pin to which the wire routes. The format is identical to that considered above.

Columns 26–27 contain the wire size designation.

Columns 28–29 contain the twist reference number for the harness. For example, a "15" indicates that the wire is a member of the fifteenth twisted group in the harness.

Column 30 contains a number indicating the number of wires in the twisted group. For example, a "2" indicates that the wire is a member of a twisted doublet.

Columns 31–32 contain the shield number for the harness. For example, a "10" indicates that the wire is shielded by the tenth shield in the harness.

Column 33 contains the shield return letter for the connector. For example, an "A" indicates that the return is the first shield return for the connector.

Columns 34–35 contain the nominal wire length. The first column indicates the number of feet while the second column indicates tenths of a foot.

Column 36 contains a letter designating the wire type. It denotes whether the wire is excitation (x), return (R), or neither (blank).

Column 37 contains a letter designating the signal or power direction. If an R is used, the direction is from the connector pin being considered; an L designates the direction is to the connector pin being considered. For other cases – for example, for chassis grounds and some other miscellaneous wires – this column is left blank.

Columns 38–40 contain a number designation representing the impedance in ohms. The 3-column format includes the following: tens, units, and powers of ten. The negative power of 10^{-1} is denoted by an A; 10^{-2} is denoted by a B, and so forth.

Columns 41–43 contain a number designation representing the maximum signal voltage in millivolts. Again, the 3-column format of tens, units, and powers of ten is used; the letter system denotes negative powers of ten.

Columns 44–46 contain a number designation representing the noise index number in microvolts of noise per volt of signal. The 3-column format of tens, units, and powers of ten is used and, also, the letter system to denote negative powers of ten.

Columns 47–55 contain a 9-character designation representing the circuit data sheet (CDS) number.

Columns 56–76 contain an alphameric description of the wire function as taken from the CDS.

Column 77 can be used to reference the card to a general note.

Columns 78–80 contain the date of the last card change. The first two columns indicate the month, while the third column contains the last digit of the year.

Figure 1 shows the punched cards required for a hypothetical 5-pin connector. Figure 2 shows the cards required for a hypothetical splice.

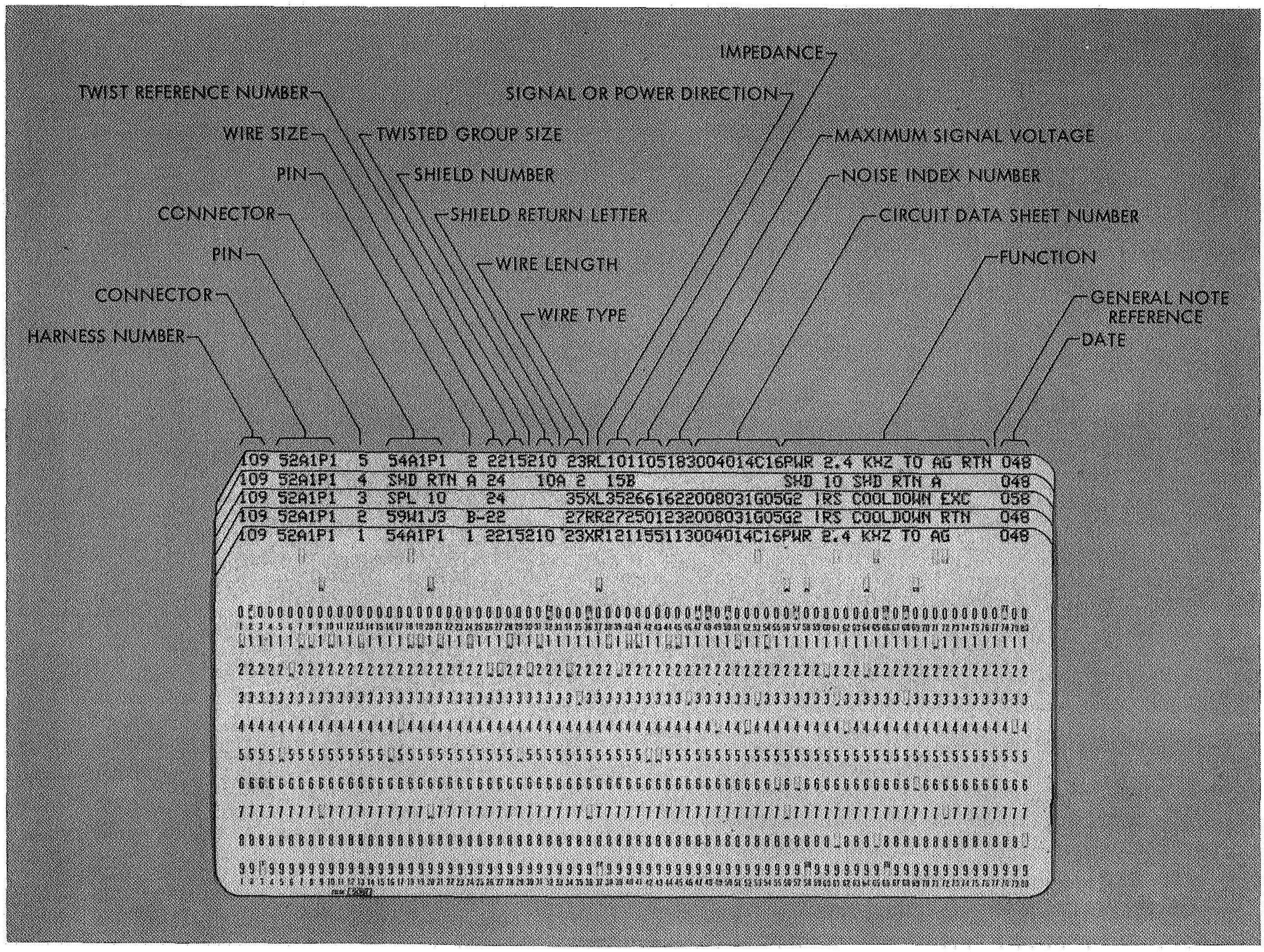

Fig. 1. Data cards for a 5-pin connector

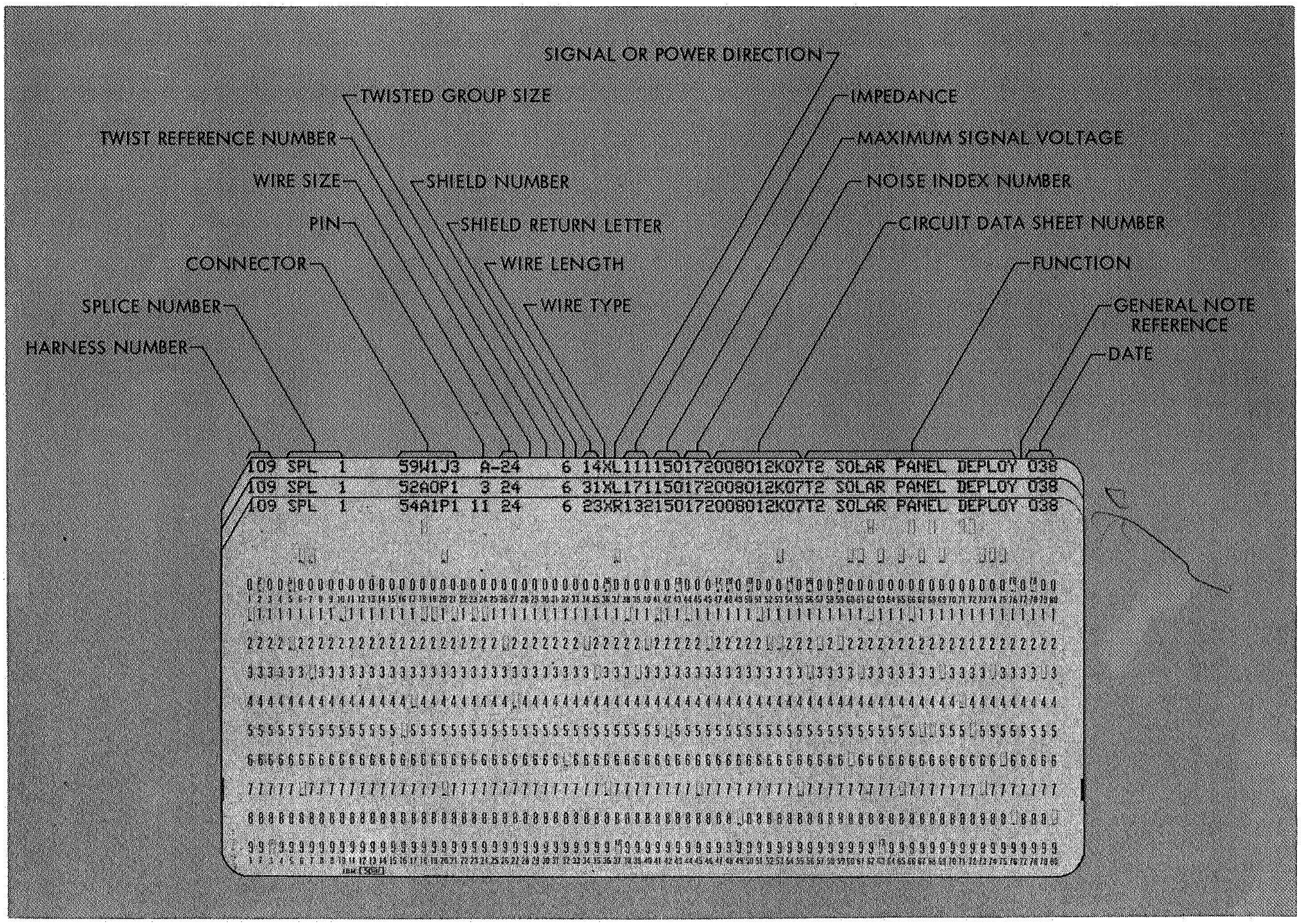

Fig. 2. Data cards for a splice

III. Card Sorting

After the cards are punched and sorted according to harness, they are then sorted according to connectors or splices within each harness. The total number of cards for each harness should equal the number of connector pins in the harness plus an additional number equal to all the wires in the harness that route to splices.

The goal of the first sorting operation is to obtain a stack of cards representing all connector pins and splices within a particular harness. This harness stack is then sorted to obtain stacks of cards representing each connector and each splice within that harness. Each of the connector stacks is next arranged in consecutive order according to pin. These sorting operations can be done easily on typical card-sorting machines. In this case, an IBM 82 card sorter was used.

The use of punched cards and a sorting machine make it possible to print out lists based on characteristics other than harnesses, connectors, or splices. For example, the cards could be sorted to obtain a stack of cards representing all twisted doublets in a particular harness by sorting for all cards with a "2" punched in column 30.

IV. Printing Format

When the cards are arranged by harness and connector and are in consecutive pin order, they are ready to be run through a card printer to obtain wiring harness documentation. An IBM 407 card printer was used during this study. The printing format was basically the same as the card format discussed previously; however, the printing format has 120 spaces available, in comparison with the 80 columns on the punched cards. Thus, the information on the cards can be made to print out with blanks inserted in appropriate locations. The following is the format developed for the printout:

Spaces 1–2 are used to print out information pertaining to the harness. For example, "9W," which indicates that the harness is part of the cabling subsystem, could be printed out in these two spaces. The characteristics would be identical for all harnesses and, thus, they would come from the character emitter of the printer.

Spaces 3–5 are used to print out the harness number.

Spaces 8–15 are used to print out the alphameric designation representing the connector or splice being considered.

Spaces 17–19 are used to print out the pin designation for this connector.

Spaces 22–29 are used to print out the alphameric designation representing the connector or splice to which the wire is routed from the connector being considered.

Spaces 31–33 are used to print out the designation representing the pin to which the wire routes.

Spaces 36–37 are used to print out the wire size designation.

Spaces 40–41 are used to print out the twist reference number for the harness.

Space 43 is used to print out the number indicating the number of wires in the twisted group.

Spaces 45–46 are used to print out the shield number for the harness.

Space 48 is used to print out the shield return letter for the connector.

Spaces 51–52 are used to print out the wire length.

Space 55 is used to print out the letter designating the wire type.

Space 57 is used to print out the letter designating the signal or power direction.

Spaces 60–62 are used to print out the number designation representing the impedance.

Spaces 64–66 are used to print out the number designation representing the maximum signal voltage.

Spaces 68–70 are used to print out the number designation representing the noise index number.

Space 72 is used to print out the circuit class, which is the power of ten of the noise index number.

Spaces 75–77, 79–81, and *83–85* are used to print out the 9-character designation representing the circuit data sheet number.

Spaces 88–108 are used to print out the alphameric description of the wire function.

Space 111 is used to print out the number referencing the card to a general note.

Spaces 114–115 are used to print out the month of the last card change.

Spaces 116–117 are used to print out "/6" from the character emitter of the printer. This prints between the columns for the month and the last digit of the year and, thus, is used to complete the date of the last card change.

Space 118 is used to print out the number representing the last digit of the year of the last card change.

Space 120 is used to print out a revision letter from the character emitter. This letter corresponds to an entire harness printout.

The IBM 407 card printer has a control panel that must be wired to accomplish this print format.

V. Control Panel Wiring

The procedure for wiring the IBM 407 printer to accomplish the printing of the wiring harness documentation consists of three steps.

First, the 80-second-reading hubs that represent the 80 columns on the data card are wired to their required normal print-entry hubs which represent the 120 print spaces. Blank spaces result on the printout when no wire is routed to a normal print-entry hub. It is also required that any characters printing from the character emitter must be wired to their required normal print-entry hubs.

For example, spaces 1, 2, 116, 117, and 120 require character-emitter wiring. Table 1 summarizes this step 1 wiring.

Second, the printer is wired to single-space the print-out by wiring the single-space hubs together (Fig. 3).

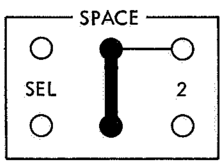

Fig. 3. Step 2 control panel wiring

Third, the printer is wired for zero print control. This is done by wiring the pair of diagonally arranged zero print-control hubs that corresponds to each print-entry hub that prints numbers or combinations of numbers and letters. For example, print-entry hubs 8–15 are used to print out the number and letter designation representing the connector or splice being considered; thus, hubs 8–15 of the zero print control are required to be wired. Figure 4 shows the zero print-control wiring required for the print format used.

VI. Printing the Harness Documentation

The data cards that are grouped by harness, sub-grouped by connector or splice within that harness, and arranged in consecutive pin order are now used in conjunction with the punched-card printer to print wiring harness documentation. A heading card is placed at the front of each connector or splice stack before printing. An example of a heading card is shown in Fig. 5. The punched cards are then run through the printer by connector or splice. The vertical position of the paper in the carriage of the printer can be varied to obtain any desired spacing between connector printings. One method is to use a sheet of paper for each connector. All of the connector and splice sheets representing each harness can then be stapled together. A wiring change is easily accommodated. The cards involved in the wiring change are removed and new cards punched. New wiring documentation for each affected connector is then printed and stapled with its respective harness. A printout for a hypothetical 5-pin connector is shown in Fig. 6.

An entire harness printout consists of a printed sheet for each connector and for each splice in the harness. Many wiring changes within a harness might require that the entire harness be reprinted. In this case, the revision letter that is wired from the character emitter to normal print-entry hub 120 would be changed. For example, it might be changed from revision A to revision B.

After printing, the data cards can be stored in a card file, filed according to harness and connector or splice, and arranged in consecutive pin order. This card file can be used to print out wiring harness information that is tailored to the requester's needs. For example, actual harness fabrication might require only the information in print spaces 1–52 and 88–120. This can be controlled easily, either by using a second control panel or by disconnecting the control panel wires to normal print-entry hubs 55–85. This system of using punched cards to record the wiring data and a card printer to produce wiring harness documentation is faster and more flexible than the current wiring documentation method being used.

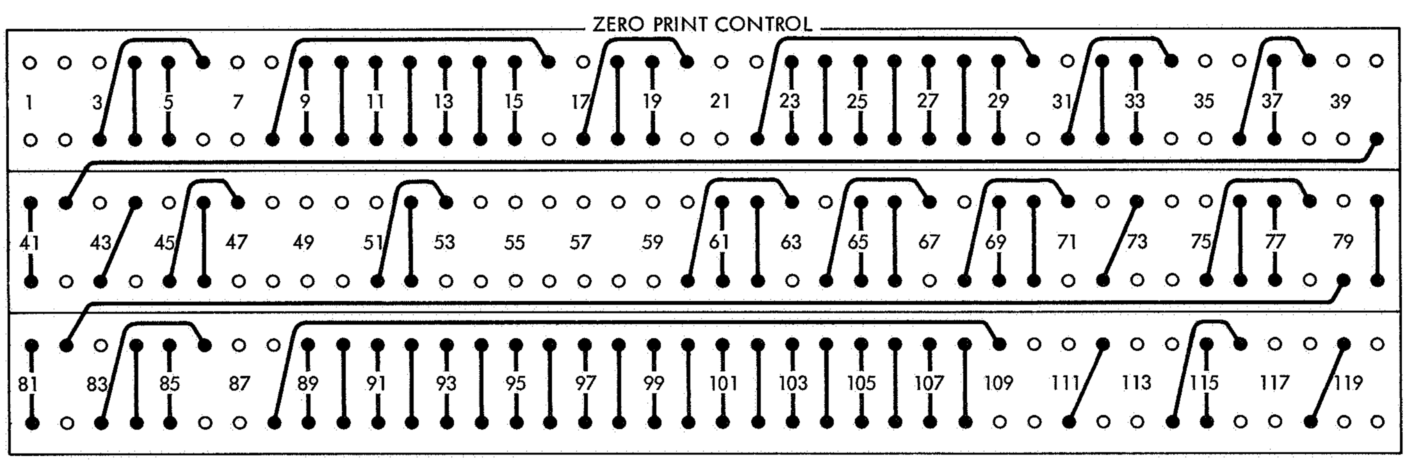

Fig. 4. Step 3 control panel wiring

Table 1. Step 1 control panel wiring

Normal print-entry hub	Second reading or character-emitter hub	Normal print-entry hub	Second reading or character-emitter hub	Normal print-entry hub	Second reading or character-emitter hub
1	Character emitter	41	29	81	52
2	Character emitter	42	Not wired	82	Not wired
3	1	43	30	83	53
4	2	44	Not wired	84	54
5	3	45	31	85	55
6	Not wired	46	32	86	Not wired
7	Not wired	47	Not wired	87	Not wired
8	4	48	33	88	56
9	5	49	Not wired	89	57
10	6	50	Not wired	90	58
11	7	51	34	91	59
12	8	52	35	92	60
13	9	53	Not wired	93	61
14	10	54	Not wired	94	62
15	11	55	36	95	63
16	Not wired	56	Not wired	96	64
17	12	57	37	97	65
18	13	58	Not wired	98	66
19	14	59	Not wired	99	67
20	Not wired	60	38	100	68
21	Not wired	61	39	101	69
22	15	62	40	102	70
23	16	63	Not wired	103	71
24	17	64	41	104	72
25	18	65	42	105	73
26	19	66	43	106	74
27	20	67	Not wired	107	75
28	21	68	44	108	76
29	22	69	45	109	Not wired
30	Not wired	70	46	110	Not wired
31	23	71	Not wired	111	77
32	24	72	46	112	Not wired
33	25	73	Not wired	113	Not wired
34	Not wired	74	Not wired	114	78
35	Not wired	75	47	115	79
36	26	76	48	116	Character emitter
37	27	77	49	117	Character emitter
38	Not wired	78	Not wired	118	80
39	Not wired	79	50	119	Not wired
40	28	80	51	120	Character emitter

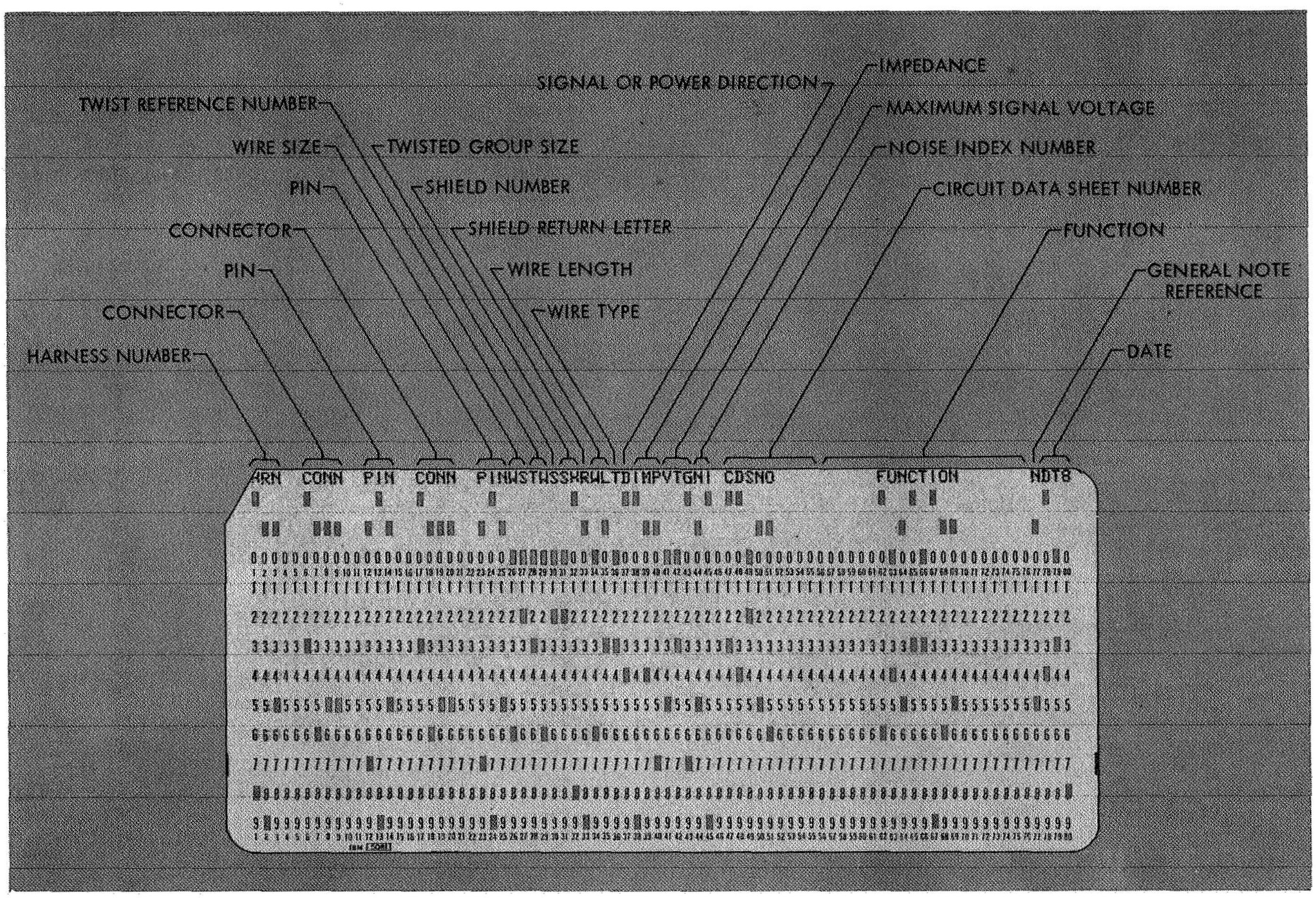

Fig. 5. Heading card

HARNESS NUMBER — CONNECTOR — PIN — CONNECTOR — PIN — WIRE SIZE — TWISTED GROUP SIZE — TWIST REFERENCE NUMBER — SHIELD NUMBER — SHIELD RETURN LETTER — WIRE LENGTH — WIRE TYPE — SIGNAL OR POWER DIRECTION — IMPEDANCE — MAXIMUM SIGNAL VOLTAGE — NOISE INDEX NUMBER — CIRCUIT CLASS — CIRCUIT DATA SHEET NUMBER — FUNCTION — GENERAL NOTE REFERENCE — DATE — REVISION LETTER

9WHRN	CONN	PIN	CONN	PIN	WS	TW	S	SH	R	WL	T	D	IMP	VTG	NI		CDS NO	FUNCTION	N	DT/68	A
9W109	52A1P1	1	54A1P1	1	22	15	2	10		23	X	R	121	155	113	3	004 014 C16	PWR 2.4 KHZ TO AG		04/68	A
9W109	52A1P1	2	59W1J3	B-	22					27	R	R	272	501	232	2	008 031 G05	G2 IRS COOLDOWN RTN		04/68	A
9W109	52A1P1	3	SPL 10		24					35	X	L	352	661	622	2	008 031 G05	G2 IRS COOLDOWN EXC		05/68	A
9W109	52A1P1	4	SHD RTN	A	24			10	A	2			15B					SHD 10 SHD RTN A		04/68	A
9W109	52A1P1	5	54A1P1	2	22	15	2	10		23	R	L	101	105	83	3	004 014 C16	PWR 2.4 KHZ TO AG RTN		04/68	A

Fig. 6. Printout for a hypothetical connector

Appendix

Improving Connector Designations for Use with Punched Cards

A corollary effort during this study was the reviewing of the presently used connector numbering format to find a format for designating connectors compatible with the 8-character card and print spacing. Because the format currently being used does not result in designations having the same number of characters for all connectors, it is difficult to transfer the connector designations onto the punched cards and still keep the subdivisions of the designation representing different characteristics in the same card columns. For example, four different connector designations might be 2009W100P71, 2009W105P2, 2020A2P1, and 2008PP7P2. The difference in designations results when allotted character spaces are not used. Currently, the number of character spaces allotted for a complete connector designation is fourteen. An 8-character format that contains all of the required information is possible; this connector designation format is illustrated in Fig. A-1. For example, 2009W01P02 would indicate that the connector was in the 09 subsystem, in the first harness in that subsystem (W01), and was the second connector in that harness (P02). This format can accommodate up to a hundred connectors in each harness and a hundred harnesses in each subsystem. The harness format should change to conform. Now, typical harness designations might be 2009W109 or 2009W107. These, in the new format, would be 2009W01 and 2007W01. The first four characters are the subsystem numbers while the last three characters are the harness number for that subsystem. The first two digits (20) for both the connector and the harness are not punched on the cards and, thus, do not print. Thus, the connector designation requires eight characters and the harness designation requires five characters.

The proposed 8-character connector designation discussed above is compatible with both the card and print format discussed in the body of this report. The 5-character harness designation, however, is not. Currently, harness designations consist of two constant characters (9W), which print from the character emitter, and three variable digits, which print from the first three columns

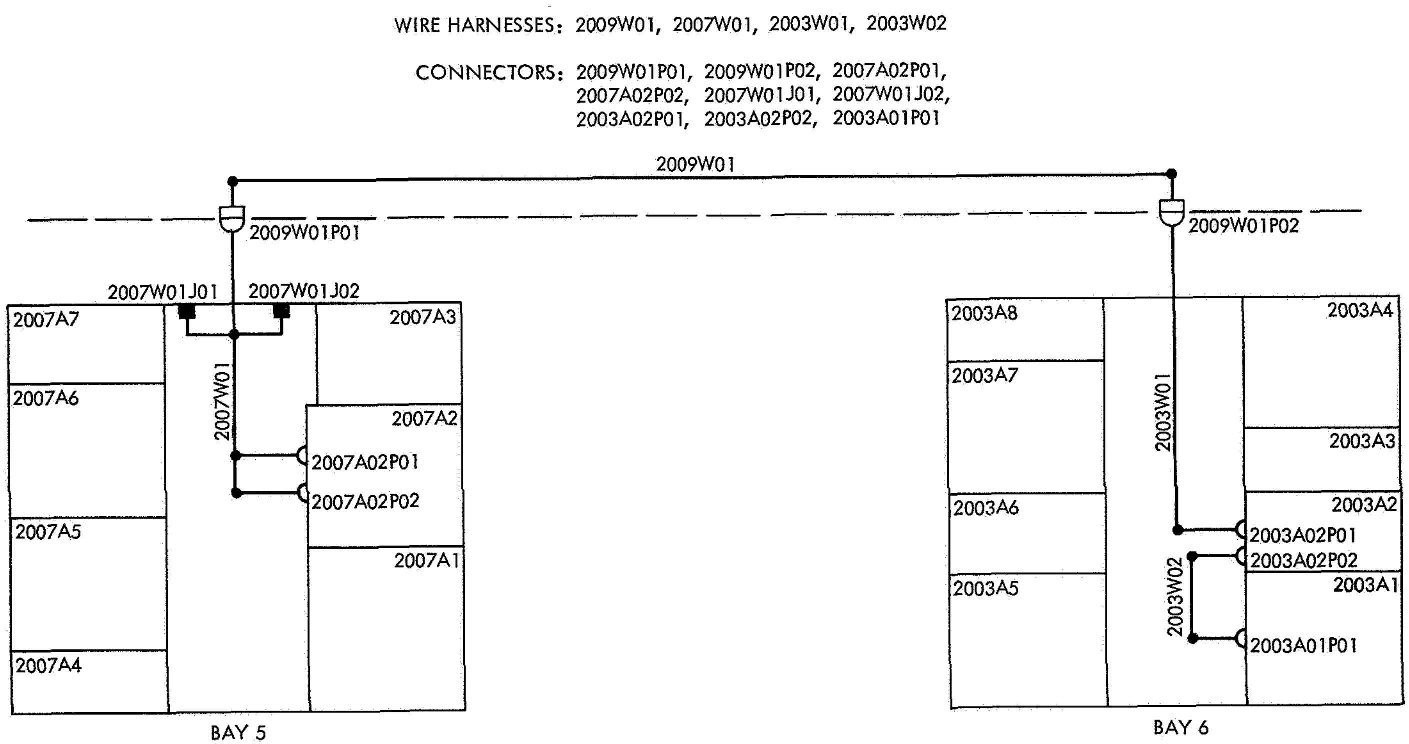

Fig. A-1. Connector designation format

of the punched card. The proposed designation consists of one constant character (W), which would print from the character emitter, and four variable digits. These four variable digits would require the first four card columns instead of just the first three, which would necessitate changing the card and print format. The harness designation would be increased by one character and the wire function designation would be decreased by one character. All of the information located between these two designations would be shifted one column to the right. The constant W would then print between card columns 2 and 3. Changing the format for designating harnesses and connectors would enable the punched cards to be easily sorted by subdivision within the harness or connector designation, because the different subdivisions would always be located in the same card columns. For example, it would be easy to obtain all the connectors located on a particular subassembly by sorting for its subsystem and then sorting for the subassembly number.

A card punched with connector information and inserted in front of the heading card for each connector would be useful. This card would give such information as the manufacturer's number for the connector, the JPL code number for the connector, the bay or location of the connector, and any other useful information regarding the connector. Such a card is shown in Fig. A-2. The spacing of the information on this card should take into account the spacing of the blanks on the printout. This example is based on the card and print format described in the body of the report, not on the format just discussed. The connector information cards could be used in conjunction with the sorter and printer to print, for example, a list containing all of the connectors in a certain bay. The wiring characteristics that can be isolated by the card sorter and printed are limited only by the information punched on the cards. This fact enables the wiring documentation produced by this punched card method to be easily changed in response to varying documentation requirements.

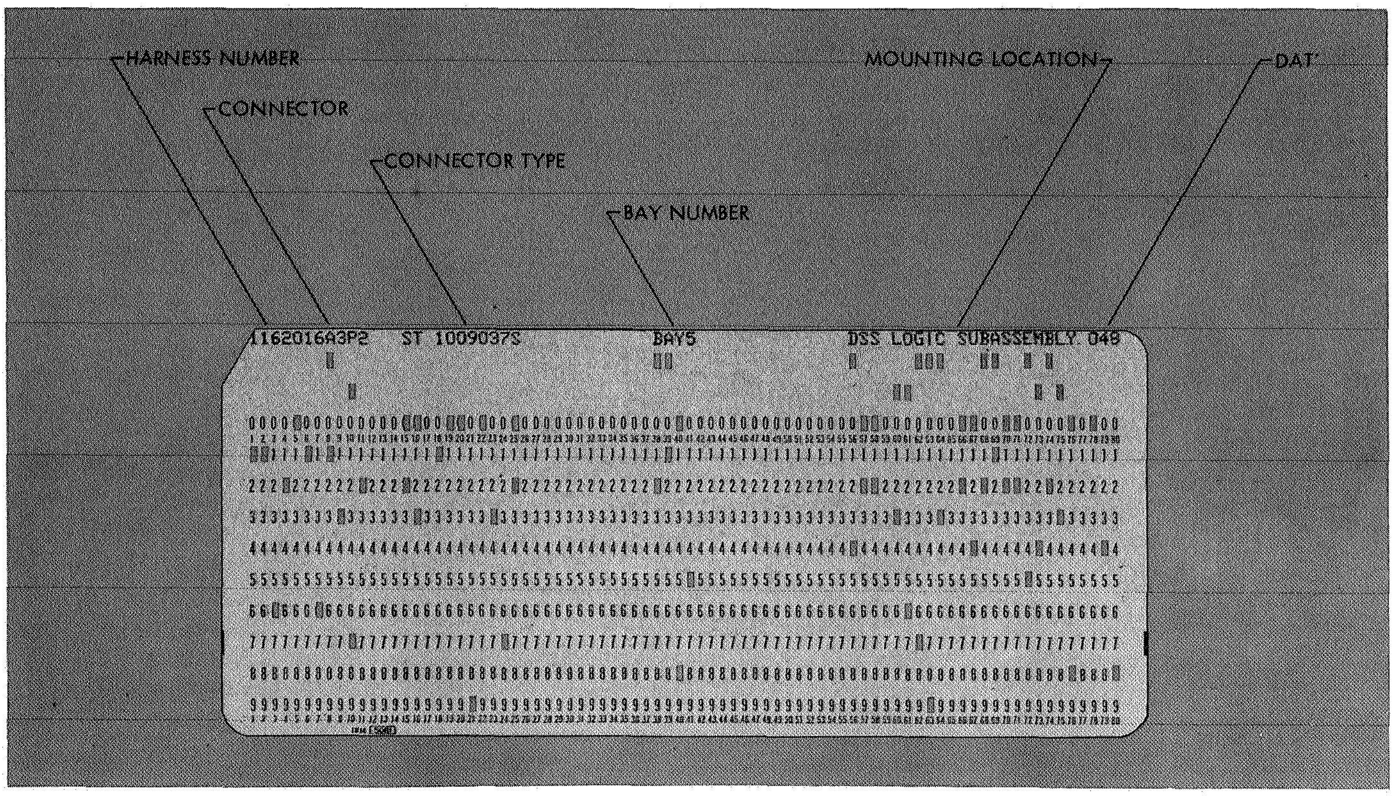

Fig. A-2. Connector information card