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AN AUTOMATED SYSTEM FOR GENERATING PROGRAM DOCUMENTATION

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There are several proprietary software packages available that provide the user with documentation aids. IBM's AUTOCHART and Applied Data Research's AUTOFLOW are examples of flowchart generators. For many years, it has been the flowchart that provides the key to good program documentation. Flowcharts are invaluable for documenting machine language programs; they are only slightly less helpful with large FORTRAN and COBOL programs. However, flowcharts are not necessarily the most important pieces of documentation for medium-size, compiler-level programs.

With this in mind, a documentation program was developed in which the emphasis is placed on text content rather than flowcharting. Grumman Data Systems has been using this program for 1 year to document most of its production-type programs. There are personnel whose sole responsibility is to prepare these production jobs for computer runs. Each of these individuals must know how to prepare several different jobs for runs on the computer. This arrangement permits the programmer to write, debug, and then turn over his program along with a copy of his documentation to deck assembly personnel for production use.

The documentation that accompanies the debugged program is often called operational documentation. Such documentation usually includes all parts of the complete document except the source listings. A typical document would include the following:

- (1) Accounting information (deck number, job charge numbers, etc.)
- (2) General description (an abstract of the program explaining how it fits into the overall data flow and subroutine descriptions)
- (3) Functional flowcharts (Detailed flowcharts are not considered necessary because of the type of work done by batch programmers. Few programs of any size are reused once their primary job requirement has ended. In most cases, if a future task has need for a similar program, a new program is written, rather than rework an old program.)
- (4) Data card formats, deck setups, and options

These four sections appear in all operational documentation. The programming department retains a copy of the document with the source listings added.

USE OF THE DOCUMENTATION PROGRAM

The documentation program is used to generate the entire document. It is keyword oriented, with 26 keywords that control the program. Seventeen of those keywords are

recognized by the flowchart generator, three are related to text generation, and three have to do with control card and deck displays. The programmer who uses the documentation program prepares his document on data cards. This is the major drawback of the documentation program because all input is contained on 80-column card images that must be prepared by the programmer. The program cannot yet generate text narratives by inspecting source decks.

Repetitive use of the documentation program helps each programmer become more familiar with both this particular program and program documentation in general. The keyword cards are very easy to understand and prepare, and most programmers become adept at using the program after their first try. The strongest advantage offered by the documentation program is that it produces the entire document. The document is prepared on 35-mm microfilm, which is easy to store, and letter-size reproductions can be made inexpensively on bond paper. The following is a list of features of the documentation program:

- (1) *Text generator*—the program can delimit sections of a document at three levels: topics, subtopics, and paragraphs.
- (2) *Flowchart generator*—the flowchart generator is activated when the program reads a flow card (one of the 17 flowchart keywords). Subsequent cards are inspected for special keywords that pertain to flowcharting. Flowcharting terminates when an exit card is read. The flowchart generator can be called as many times as desired.
- (3) *Coding form displays*—cards can be displayed singly or in groups on a coding form display which numbers each column.
- (4) *Deck displays*—the deck option operates exactly like the card option, with one added feature: After the coding form display has been completed, the deck option will cause all displayed cards to be shown in a fanned-deck pictorial representation. This type of display gives quick information about card orders to personnel responsible for job preparation.
- (5) *Underlining*—any line of text can be underlined for particular emphasis of important words or phrases.
- (6) *Sample output display*—the programmer can include a binary coded decimal file containing sample tab outputs of his program. The documentation program will automatically include the samples in the document when it reads an output card.
- (7) *Auxiliary tape input*—a keyword card will cause the program to switch from the standard input file (usually the card reader) to any other sequential file for primary input card images.
- (8) *Index*—an index of all topics, subtopics, and paragraphs is provided at the end of the document that gives page numbers of all sections of the document.

To aid the programmer in checking the output of the documentation program, a tab listing is provided that gives the results of the run. Usually, the microfilm output file is stored on tape; the programmer can direct this file to the microfilm unit after he has checked the tap output and is satisfied that his document is correct. The tab listing shows the contents of each frame of output generated by the documentation program. Flowcharts are also

printed to show exactly how they will appear on the film. Figure 1 contains a sample program output.

FUTURE DEVELOPMENTS

The features of the described documentation program are options; for example, the user does not have to use the flowchart generator. Thus, program documentation is still controlled by the programmer. To prevent too many stylized documents from being generated, the documentation program is supplemented by a set of documentation standards to which all programmers must adhere. Because the documentation program itself is in total control of the various formats of its options, program documentation has become fairly standardized; at least the formats are similar, although content and quality are still the responsibility of the programmer.

It is clear that this system uses a traditional rather than a new or radical approach to the problem of documentation. However, these methods suit Grumman's internal needs.

GRUMMAN DATA SYSTEMS

1.0 GENERAL INFORMATION

PROGRAM NAME	PRIN4PI		
WRITTEN BY	R. HANNEY		
DECK NO.	D047B	CSRA	14022
SOURCE LANGUAGE	FORTRAN EXTENDED		
COMPUTER	CDC-6400 (ATS, PLT. 7)		

Figure 1.—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

2.0 GENERAL DESCRIPTION

PRIN4PI WILL PROVIDE LISTINGS OF SELECTED PARAMETERS (FROM THE 4PI E.U. TAPE) AT VARIABLE PRINT RATES (SAMPLES/SEC.). THE LISTINGS ARE CONTROLLED BY START-STOP TIMES (IRIG B). SELECTED PARAMETERS ARE DEFINED BY DATA CARDS, UP TO 50 PARAMETERS CAN BE HANDLED AT ANY ONE TIME. IF MORE ARE TO BE PRINTED, A REWIND CARD WILL ALLOW THE USER TO RE-START WITH A NEW SET OF SELECTED PARAMETERS.

2.1 SUBPROGRAM DESCRIPTIONS**2.1.1 EUPROC**

EUPROC IS THE MAIN PROGRAM. IT READS ALL DATA CARDS AND CONTROLS THE FLOW OF DATA. IT ISSUES CALLS TO OTHER SUBROUTINES TO PERFORM SPECIFIC FUNCTIONS SUCH AS - DATA CARD DIAGNOSTICS, DATA INPUT, PRINT OUTPUT, MATH SUMMARIES.

2.1.2 EUPROD

EUPROD INSPECTS THE DATA CARDS FOR NON-EXISTENT PARAMETERS. WHEN ILLEGAL PARAMETERS (THOSE NOT ON TAPE) ARE FOUND, THEY ARE SIMPLY DELETED AND AN APPROPRIATE MESSAGE IS PRINTED.

2.1.3 DATAIN

DATAIN READS THE 4PI E.U. TAPE AND PASSES THE SELECTED PARAMETERS TO EUPROC FOR FURTHER PROCESSING. IT ALSO RETURNS A FLAG SIGNIFYING THE END OF A RUN.

2.1.4 PCMA

PCMA PERFORMS MATHEMATICAL SUMMARY OPERATIONS AND LIMIT CHECKING (WHERE REQUESTED) DURING EACH RUN.

2.1.5 MATHI

MATHI IS CALLED BY PCMA DURING A RUN (TIME SLICE), ONCE FOR EACH SAMPLE OF EACH PARAMETER.

2.1.6 MATHO

MATHO IS CALLED BY PCMA AT THE END OF A RUN. IT LISTS THE RESULTS OF THE MATHEMATIC SUMMARY TAKEN ON EACH PARAMETER DURING THE RUN. AMONG THE VALUES LISTED FOR EACH PARAMETER ARE -

- A. MINIMUM VALUE AND TIME OF OCCURRENCE
- B. MAXIMUM VALUE AND TIME OF OCCURRENCE
- C. STANDARD DEVIATION
- D. MEAN VALUE
- E. ROOT-MEAN-SQUARE VALUE
- F. NO. SAMPLES OVER LIMIT (IF APPLICABLE)
- G. NO. SAMPLES UNDER LIMIT (IF APPLICABLE)
- H. TOTAL NO. SAMPLES OUTSIDE LIMITS
- I. PERCENT OVER LIMIT

Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

2.0 GENERAL DESCRIPTION (CONTD.)

J. PERCENT UNDER LIMIT

2. 1. 7 PCMPR

PCMPR SAVES PRINT VALUES AT THE RATE(S) SPECIFIED. WHEN 40 SAVED VALUES ARE ACCUMULATED, PCMPR ISSUES A CALL TO OUTPUT TO EMPTY THE BUFFER(S).

2. 1. 8 OUTPUT

OUTPUT LISTS THE SAMPLES SUPPLIED BY PCMPR ON THE OUTPUT FILE, 40 LINES OF DATA MAXIMUM.

2- 2

Figure 1 (continued).—Illustration of documentation program.

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3.0 4 PI PRINT - FUNCTIONAL FLOWCHART (CONTD.)

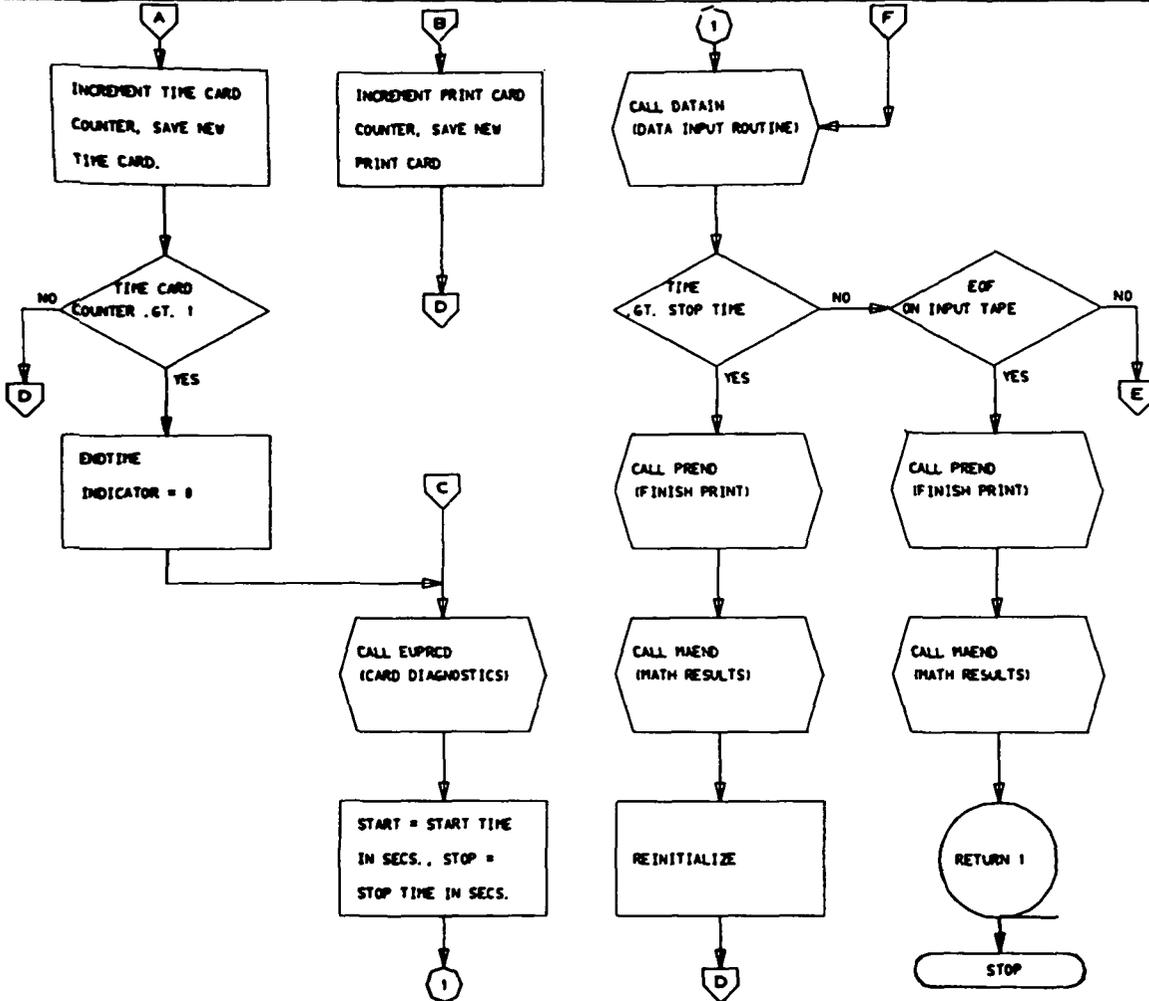
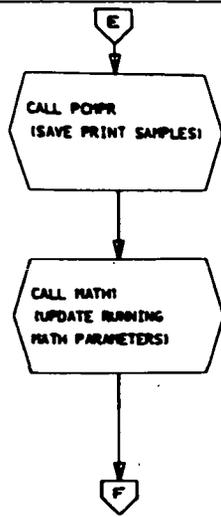


Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

3.0 4 PI PRINT - FUNCTIONAL FLOWCHART (CONTD.)



3- 3

Figure 1 (continued).--Illustration of documentation program.

GRUMMAN DATA SYSTEMS

4.0 CARD FORMATS

THE CARDS DISPLAYED IN THIS SECTION ARE RECOGNIZED BY THE PROGRAM. ALL OTHER CARDS WILL BE REJECTED.

4.1 TITLE CARD

THE TITLE CARD SHOULD BE THE FIRST CARD IN THE DECK. IT CONTAINS A TITLE WHICH WILL APPEAR AT THE TOP OF EACH PAGE OF OUTPUT.

SAMPLE TITLE CARD

1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
TITLE	TITLE GOES HERE	---	---	---	---	---	---

COLS.	CONTENTS
1-5	TITLE
11-72	TITLE TO APPEAR AT TOP OF EACH PAGE OF OUTPUT

4.2 TIME SLICE CARD

THE TIME CARD DEFINES THE IRIG START-STOP TIMES FOR A RUN. IT ALSO ALLOWS THE USER TO INHIBIT THE MATH SUMMARY WHICH IS COMPILED DURING THE RUN, AND (IF DESIRED) TO SPECIFY ONE PRINT RATE FOR ALL PRINT PARAMETERS.

SAMPLE TIME CARD

1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
TIME	XX XX XX.XXX	YY YY YY.YYY	Z	AAAA.A			

COLS.	CONTENTS
1-4	TIME
11-12 ---	
14-15 ----	START TIME IN HOURS (11-12), MIN (14-15), SECS (17-22)
17-22 ---	
25-26 ---	
28-29 ----	STOP TIME IN HOURS (25-26), MIN (28-29), SECS (31-36)
31-36 ---	
41	MATH INHIBIT FLAG
	= 1, NO MATH OUTPUT AT END OF SLICE
46-51	OVERALL PRINT RATE (MUST INCLUDE DEC. PT.) IN SAMPLES/SECOND

Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

4.0 CARD FORMATS (CONTD.)

4.3 PRINT CARD SETS

A PRINT CARD SET SPECIFIES UP TO FIVE PARAMETERS TO BE PRINTED ON A SINGLE PAGE OF OUTPUT. IT ALSO SPECIFIES THE PRINT RATE (S/S) FOR THAT PAGE. UP TO 10 PRINT SETS CAN BE ACTIVE DURING A GIVEN TIME SLICE.

SAMPLE PRINT SET (EACH SET MUST HAVE TWO CARDS)

1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
PRINT	15.	PARAMETER1			PARAMETER2		
PARAMETERS			PARAMETER4			PARAMETERS	

FORMAT OF FIRST CARD

COLS.	CONTENTS
1-5	PRINT
11-14	RATE (MUST INCLUDE DECIMAL PT.) IN SAMPLES/SECOND THIS FIELD IS OPTIONAL (IF OVERALL PRINT OPTION ON TIME CARD WAS USED FOR CURRENT TIME SLICE)
21-30	MNEMONIC FOR FIRST PARAMETER
51-60	MNEMONIC FOR SECOND PARAMETER

FORMAT OF SECOND CARD

COLS.	CONTENTS
1-10	THIRD PRINT PARAMETER MNEMONIC
31-40	FOURTH PRINT PARAMETER MNEMONIC
61-70	FIFTH PRINT PARAMETER MNEMONIC

4.4 LIMIT CHECKING

ANY PARAMETER ON THE TAPE (INDEPENDENT OF THOSE PRINTED) CAN BE LIMIT CHECKED. THE RESULTS WILL BE ADDED TO THE MATH SUMMARY AT THE END OF THE RUN.

SAMPLE LIMIT CARD

1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
LIMIT	MNEMONIC		XXXXX,XXX	YYYYY,YYY			

COLS.	CONTENTS
1-5	LIMIT
11-20	PARAMETER MNEMONIC
31-40	LOWER LIMIT (IN ENGINEERING UNITS)
41-50	UPPER LIMIT (IN ENGINEERING UNITS)

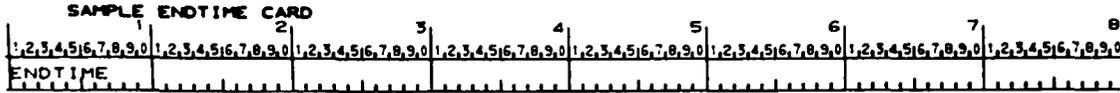
Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

4.0 CARD FORMATS (CONTD.)

4.5 ENDTIME CARD

THE ENDTIME CARD IS USED BETWEEN TIME SLICES WHEN AN ENTIRELY NEW SET OF PRINT AND/OR LIMIT PARAMETERS IS TO BE OUTPUT.



COLS. 1-7 CONTAIN THE CHARACTERS ENDTIME .

4.6 THE REWIND CARD

THE REWIND CARD WILL CAUSE THE PROGRAM TO REWIND THE INPUT TAPE(S) TO LOAD POINT AND REINITIALIZE ALL ARRAYS. THEN THE PROGRAM WILL BEGIN READING CARDS AGAIN. THE REWIND SHOULD APPEAR AFTER AN ENDTIME CARD TO ALLOW THE PREVIOUS TIME SLICE TO GO TO COMPLETION.

4.7 STOP CARD

THE STOP CARD TERMINATES THE RUN. IT CONTAINS THE LETTERS STOP IN COLS 1-4

4- 3

Figure 1 (continued).--Illustration of documentation program.

GRUMMAN DATA SYSTEMS

5.0 DECK SET-UPS

5.1 DATA DECK SAMPLE

THE SAMPLE SHOWN BELOW INDICATES A TYPICAL DECK SET-UP. NOTE THE FIRST ENDTIME CARD AND THE NEW SET OF PRINT/LIMIT CARDS WHICH FOLLOW IT.

EXPLANATION OF SAMPLE DATA DECK

TIME SLICE 1 (4/15/11.6 TO 4/16/22.3) WILL OUTPUT AS FOLLOWS -

PAGE 1 PARAM NOS. 1, 2, AND 3

PAGE 2 PARAM NOS. 4 AND 5

LIMIT CHECKING TO BE DONE ON PARAMS 2 AND 5

THE ABOVE OUTPUT GROUPS WILL BE RETAINED FOR TIME SLICES 2 AND 3 WITH TIME SLICE 3 DOING, ADDITIONALLY, LIMIT CHECKING ON PARAMS 1 AND 3

TIME SLICE 4 (6/13/12. TO 6/13/30.) WILL OUTPUT AS FOLLOWS -

PAGE 1 PARAM NOS. 3, 7, 9, AND 2

PAGE 2 PARAM NOS. 5 AND 6

LIMIT CHECKING ON PARAM NO 4

SAMPLE DATA CARDS							
1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
TITLE			PAGE HEADING				
TIME	04 15 11.6	04 16	22.3				
PRINT	10.	PARAM NO 1		PARAM NO 2			
PARAM NO 3							
LIMIT	PARAM NO 2		-133.64	4096.873			
PRINT	20.	PARAM NO 4		PARAM NO 5			
LIMIT	PARAM NO 5		-3.6	44.8			
TIME	05 01 03.6	05 01	25.4				
TIME	05 02 01.0	05 05	0.0				
LIMIT	PARAM NO 1		432.6	1230.5			
LIMIT	PARAM NO 3		-123.5	-23.6			
ENDTIME							
TIME	06 13 12.	06 13	30.0				
PRINT	20.	PARAM NO 3		PARAM NO 7			
PARAM NO 9			PARAM NO 2				
PRINT	5.	PARAM NO 5		PARAM NO 6			

Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

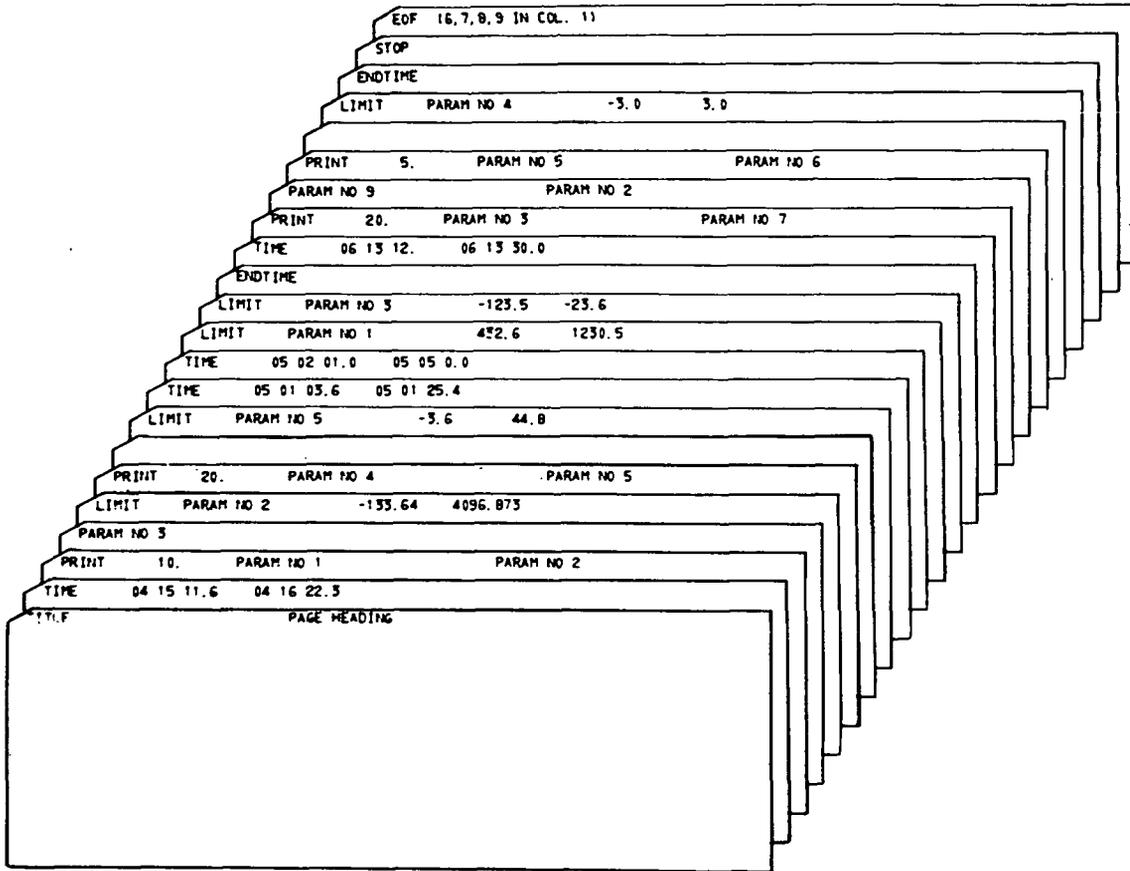
5.0 DECK SET-UPS (CONTD.)

SAMPLE DATA CARDS							
1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
LIMIT	PARAM NO 4		-3.0	3.0			
ENDTIME							
STOP							
EOF (6,7,8,9 IN COL. 1)							

5- 2

Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS



SAMPLE DATA CARDS

Figure 1 (continued).—Illustration of documentation program.

GRUMMAN DATA SYSTEMS

5.0 DECK SET-UPS (CONTD.)

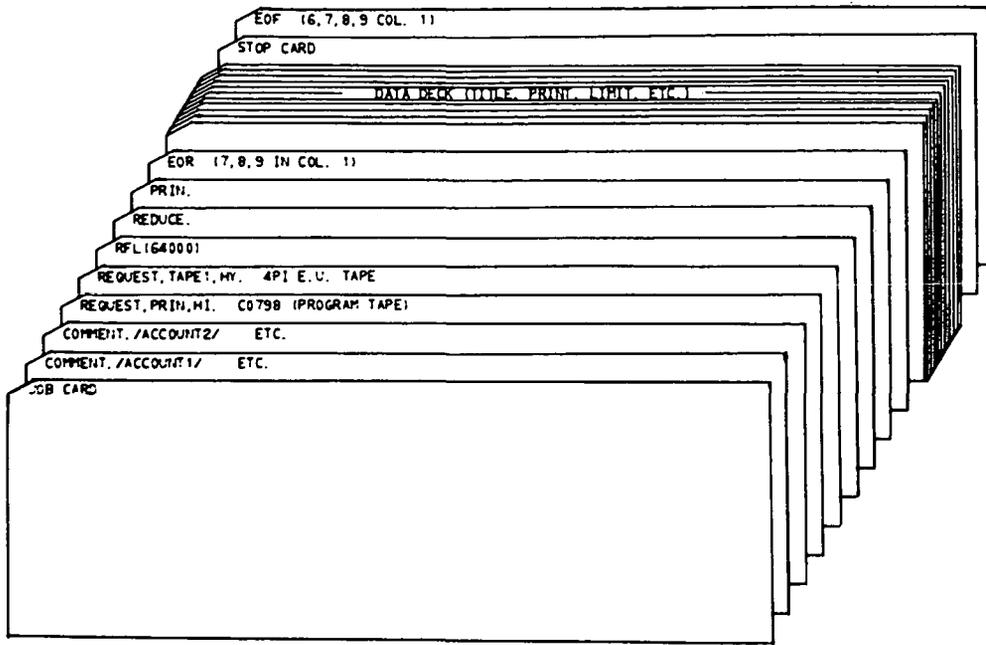
5.2 JOB DECK SAMPLE

SAMPLE 4PI PRINT JOB DECK							
1	2	3	4	5	6	7	8
1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0	1,2,3,4,5,6,7,8,9,0
JOB CARD							
COMMENT./ACCOUNT1/	ETC						
COMMENT./ACCOUNT2/	ETC						
REQUEST.PRIN.HI.	C0798 (PROGRAM TAPE)						
REQUEST.TAPE1.HV.	4PI E.U. TAPE						
RFL(64000)							
REDUCE.							
PRIN.							
FOR (7,8,9 IN COL. 1)							
BLOC DATA DECK (TITLE, PRINT, LIMIT, ETC.)							
STOP CARD							
EOF (6,7,8,9 COL. 1)							

5- 4

Figure 1 (continued).--Illustration of documentation program.

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SAMPLE 4PI PRINT JOB DECK

Figure 1 (continued).—Illustration of documentation program.

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Figure 1 (concluded).—Illustration of documentation program.

DISCUSSION

MEMBER OF THE AUDIENCE: Would you comment further on the 26 keywords?

HANNEY: The topic, subtopic, and paragraph keywords are in the text generator. There is a card keyword for the coding form and a deck keyword for the deck display. The flowchart generator has 17 keywords, one for each symbol.

MEMBER OF THE AUDIENCE: Are the numerical displays used for text generation or simply stored on cards?

HANNEY: There are cathode ray tube (CRT) displays at the automated telemetry station, and we have a command program that interacts with the CRT unit. The user at this station can create a display code file and send it to the documentation programmer. It would then be stored on a disk file and inserted in the program later.