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USERS GUIDE FOR THE
SHUTTLE MASS PROPERTIES AUTOMATED SYSTEM

Job Order 88-069

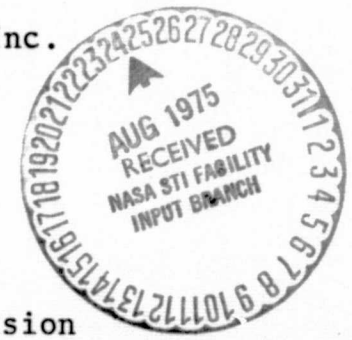
Prepared By

Lockheed Electronics Company, Inc.
Aerospace Systems Division
Houston, Texas

Contract NAS9-12200

For

Institutional Data Systems Division



National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

June 1975

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1.0 INTRODUCTION TO MAPSYS MASS PROPERTIES AUTOMATED SYSTEM

MAPSYS is a set of programs developed for use on the JSC Univac 1100 series computers and designed to automate the collection and processing of data into the mass properties section of the shuttle operational data book.

The primary program of this set is MPES which uses data processed by other programs in MAPSYS. This data as well as manually derived data is used to generate a set of output reports which describe the mass properties of the shuttle system. MPES also maintains data bases which are used to model mass properties of parts of the shuttle system.

Data tapes containing detailed mass properties for shuttle subsystems from three subcontractors will be processed on a regular basis. Tape pre-processors will reformat this data to a standard format and output the new format to other tapes for use by the tape compare program CMPARE. There are 3 basic capabilities built in this CMPARE program. Its main purpose is to generate reports showing the differences between two standard formatted tapes from the same subcontractor. This will automate the tracking of changes between one data tape and another generated at different times. CMPARE also calculates mass properties totals and subtotals for the various subsystems. These totals and subtotals will be used as card input data to MPES for these subsystems. The user may wish to change data on one of these tapes to reflect changes or to group subsystems differently. Thus, CMPARE has an edit feature which will create a new standard format tape reflecting these changes.

The mass properties of some fluids in the shuttle system are modeled in MPES by polynominal equations which give the values as a function of the weight of the fluid. The coefficients for these equations are calculated by a curve fit program. The input to this program may be manual or it may be calculated automatically by the program ONEGSM which models tank mass properties. ONEGSM calculates slosh inertias for these tanks and has descriptive data about the tanks as input as well as a criteria for point selection for feeding the curve fit program. ONEGSM also has the capability to translate and rotate a tank into a different coordinate system.

A tape from the SLAHTS system describing loose equipment for various shuttle missions will be periodically processed by the program UPTEL. This program will also maintain a location data base as directed by card input. It will use these data to calculate the total loose equipment mass properties for given missions and events and output this to a tape for input to MPES. UPTEL also generates reports of these mass properties and listings of the data base. Changes in the data may be made with an edit feature.

Other input to MPES is made manually according to the information received from other sources. The utility program MPSUM will do some mass properties calculation for adding the properties of a number of items together and for translating and rotating these items to a desired coordinate system. This program will be available on a DEMAND remote terminal.

2.0 INTRODUCTION TO TAPE PROCESSING PROGRAMS

The tape compare program (CMPARE) will process mass property detail data from magnetic tapes maintained by the various prime contractors after first being preprocessed to conform to a standard tape record format used by this program.

CMPARE will be a batch program, utilizing a magnetic tape data base, to list, compare, and/or edit mass property detail data records. The sums of mass properties will also be calculated and output to the printer. The CMPARE program and preprocessor will operate on the UNIVAC 1100 system.

2.1 CMPARE SYSTEM CAPABILITIES AND DATA STRUCTURE

The CMPARE program will operate under any of the control options listed below.

- List the contents of a data tape.
- Compare two data tapes from the same contractor and print their differences and Mass Properties.
- Edit a data tape by card updates.
- Any combination of the above.

The listing of the contents of any standard formatted data tape can be accomplished by placing a PRINT control card with the device code into the input data deck. The device code will indicate the device assigned to the tape by the control cards.

Two data tapes can be compared and the resulting differences output on the printer by inserting a COMPARE control card into the input data deck. This card requires two operational parameters. The first parameter being the device code for the CURRENT mass property data tape which will be compared to the MASTER mass property data tape specified by the second parameter device code. Also, the mass property sums of the CURRENT data tape are printed.

Data records are structured by function codes and then drawing numbers. Therefore, all preprocessed data tapes will be sorted with function codes and drawing numbers in ascending order. These two fields (detail ID) will uniquely identify each detail record. Similarly, the edit input cards must also be sorted in ascending order by function code then drawing number.

A data tape can be edited by first inserting an EDIT control card followed by the delete, add, and/or change cards. In this case, an output device code is also required. The card formats for deletions, additions, and changes are outlined later in this document.

The use of program control cards makes it possible to do any combination of processing with relative ease. For example, a tape could be updated, compared to MASTER, and then listed. Also, a tape could be listed, updated, compared to MASTER, and then updated again. It is possible to edit a tape with no updates being made, then compare the two units to obtain mass property sums with no differences printed.

The procedure necessary to list a data tape requires only one program control card. The list function is performed by first reading the selected tapes identification label and printing that information on the printer. Next, each data record is read and output to the printer until an end of file is encountered. Any tape or disk file in the standard data format can be listed.

Figure 2.1 gives detailed tape compare program control card formats.

PRINT CARD FORMAT

Column	Format	Data
1-5	A5	'PRINT' - INDICATES PRINT TAPE
6	1X	Blank
7	A1	DEVICE CODE

COMPARE CARD FORMAT

Column	Format	Data
1-7	A7	'COMPARE' - INDICATES COMPARE TAPES
8	1X	Blank
9	A1	DEVICE CODE FOR CURRENT TAPE
10	A1	',' - DEVICE CODE SEPARATOR
11	A1	DEVICE CODE FOR MASTER TAPE

EDIT CARD FORMAT

Column	Format	Data
1-4	A4	'EDIT' - INDICATES EDIT CURRENT TAPE
5	1X	Blank
6	A1	DEVICE CODE FOR CURRENT TAPE
7	A1	',' - DEVICE CODE SEPARATOR
8	A1	DEVICE CODE FOR NEW MASTER TAPE

SOURCE CARD FORMAT

Column	Format	Data
1-6	A6	'SOURCE' - INDICATES SOURCE OF VENDOR TAPE This must be the first card of the data deck.
7	1X	Blank
8-9	A2	VENDOR CODE, MM, RI, MC

Figure 2.1 Tape Compare Formats

The procedure necessary to compare two data tapes also requires one program control card. However, a "SOURCE" card must be read before a "COMPARE" card. The compare function is performed by reading data records from both tapes. The CURRENT data tape record is compared to the MASTER data tape record. Differences between the tapes are printed as well as the mass properties subtotals of the CURRENT tape.

The procedure necessary to edit a data tape requires one program control card followed by the data change cards. The format for these cards are shown in figure 2.2. To delete a single record from a data tape it is necessary to specify on a single delete card the function code and drawing number to be deleted. As previously mentioned the edit input cards must be sorted in ascending order by function code then drawing number. All edits other than deletes require two data change cards.

It is possible to delete all drawing numbers pertaining to a particular function code by leaving the drawing number field blank on the delete card. It is also possible to delete all records pertaining to a particular function code level and all levels below that level by placing blanks in the function code levels to be deleted on the delete card.

The addition of data records is accomplished by specifying the function code and drawing number plus all the detail items to be included on the add cards. If the specified function code is larger than any found on the data tape the record will be included at the end of new MASTER data tape.

DATA CHANGE CARD FORMATS

CARD NO 1

Column	Format	Data
1	A1	ADD, DELETE, OR CHANGE CODE='A', 'D', 'C'
2-13	A12	FUNCTION CODE
14-38	A25	ASSEMBLY DRAWING NUMBER
39-62	A24	ABBREVIATED DESCRIPTION
63-79	17X	Blank
80	I1	CARD NUMBER="1"

CARD NO 2

Column	Format	Data
1-7	F7.1	WEIGHT
8-14	F7.1	X - CENTER OF GRAVITY COORDINATE
15-21	F7.1	Y - CENTER OF GRAVITY COORDINATE
22-28	F7.1	Z - CENTER OF GRAVITY COORDINATE
29-39	F11.1	IXX INERTIAS
40-50	F11.1	IYY INERTIAS
51-61	F11.1	IZZ INERTIAS
62-68	F7.1	Ys - C.G. FOR SYMMETRIC PAIR (This is the positive side if this is a symmetric pair)
69-79	11X	Blank
80	I1	CARD NUMBER="2"

END OF DATA CARD

Column	Format	Data
1	A1	'*'=END OF DATA
80	I1	CARD NUMBER='1'

Figure 2.2 Data Change Formats

It is possible to make changes to records that already exist on tape by specifying the function code and drawing number plus only the detail items to be changed on the change cards. Blank fields will not be changed but two cards are still required.

The general deck setup is shown in figure 2.3.

DECK SETUP FOR PROGRAM CMPARE PAGE NO. 1 OF 1

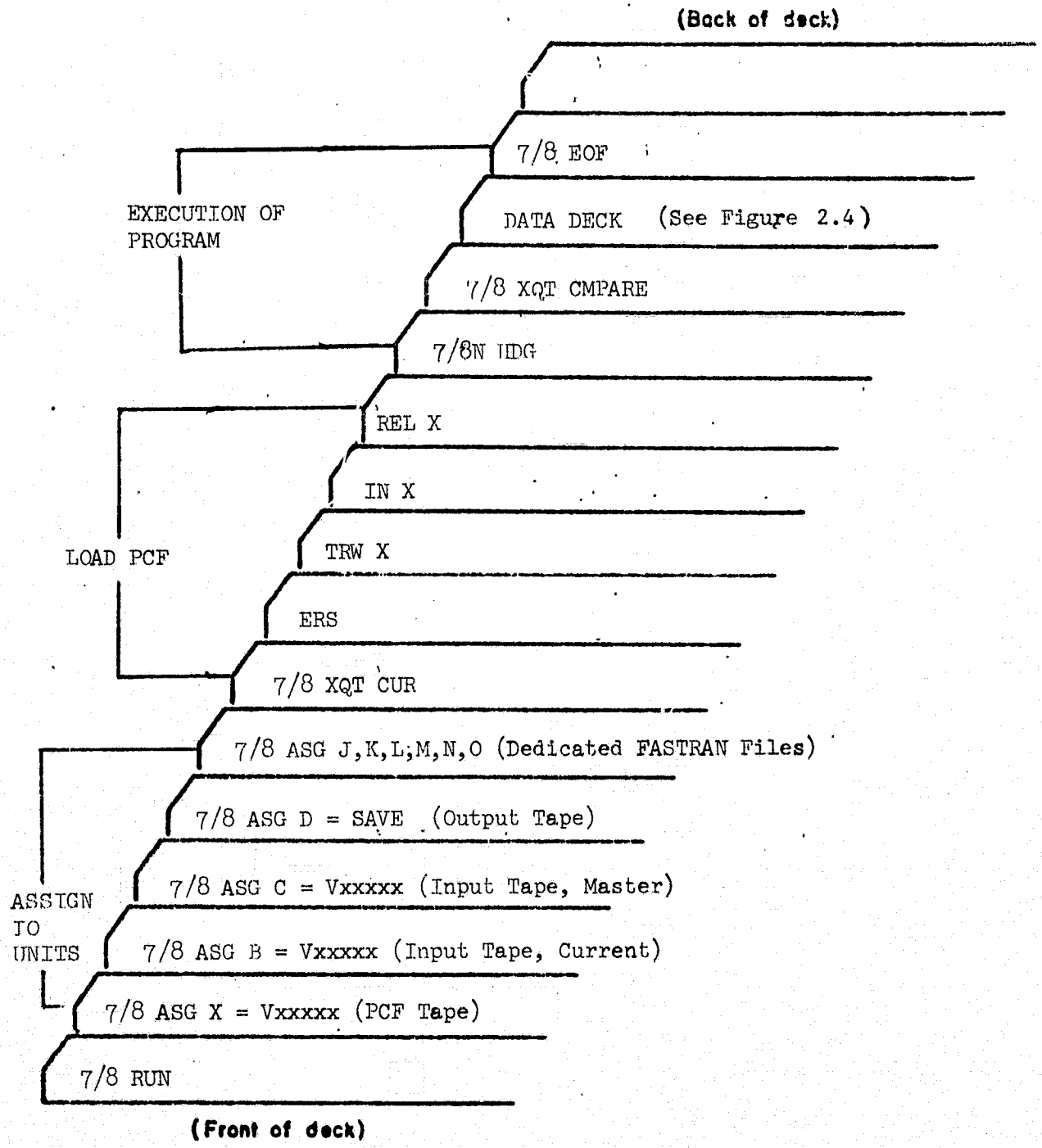

Figure 2.3 CMPARE Deck Setup

DECK SETUP FOR PROGRAM CMPARE DATA DECK PAGE NO. 1 OF 1

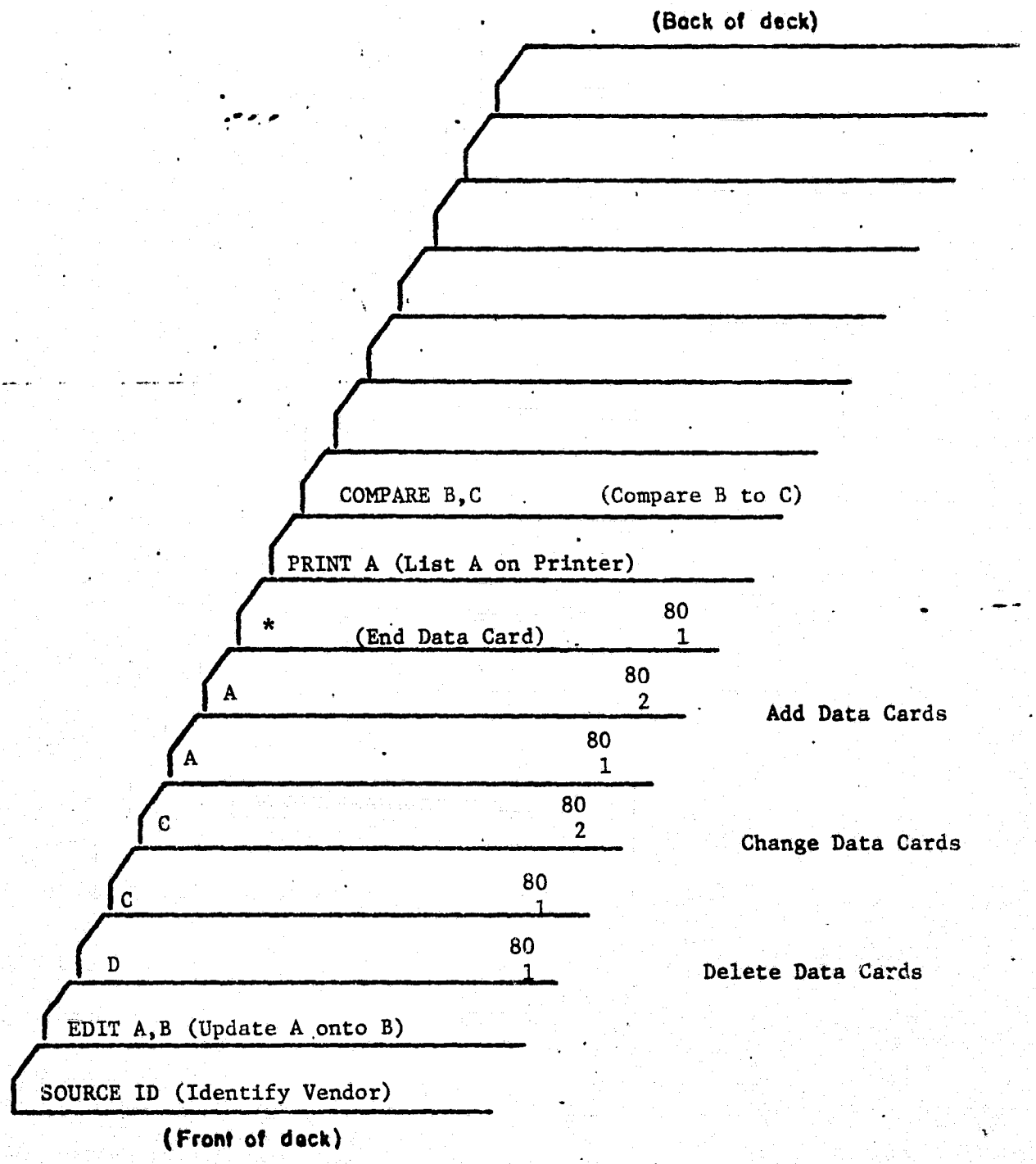

Figure 2.4 CMPARE Data Deck

FUNCTION	DRAWING NUMBER		FUNCTION DESCRIPTION	WEIGHT LB	CENTER OF GRAVITY INCHES X	Y	Z	MOMENT OF INERTIA SLUG/FT-SQ. IXX	IYY	IZZ
1.1.1	B 2	11	AAAA	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	B 2	12	BBBB	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	B 2	14	CCCC	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	B 3	16	DDDD	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	B 3	18	EEEE	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	C 1	20	FFFF	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	C 1	22	GGGG	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	C 2	24	HHHH	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.1	C 2	26	IIII	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.2	A 1	28	JJJJ	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.2	A 1	30	KKKK	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.2	A 3	32	LLLL	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1.2	A 3	34	MMMM	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.2.1	A 1	36	NNNN	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.2.1	A 1	37	OOOO	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.2.1	B 1	38	PPPP	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.2.1	B 1	39	QQQQ	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.1.1	A 1	44	TTTT	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.1.1	A 1	46	UUUU	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.1.1	B 2	46	VVVV	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.1.1	B 2	50	WWWW	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.1.1	B 2	55	XXXX	1.0	1.0	1.0	1.0	1.0	1.0	1.0

FIGURE 2.5 List Of Input Tape

OJSXMM 0 THIS IS A TEST TAPE MASTER RECORDS NOT FOUND ON CURRENT TAPE PAGE 1

FUNCTION	DRAWING NUMBER	FUNCTION DESCRIPTION	WEIGHT LB	CENTER OF GRAVITY INCHES X	Y	Z	MOMENT OF INERTIA SLUG/FT-SQ. IXX	IYY	IZZ	
2.1.1 A 1	40	RRRR	1.0	1.0	1.0		1.0	1.0	1.0	1.0
2.1.1 A 1	42	SSSS	1.0	1.0	1.0		1.0	1.0	1.0	1.0

FIGURE 2.6 List Of Current Records Not Found On Master Tape

DIAGRAM 1 THIS IS A TEST TAPE

FUNCTION	WEIGHT (LB)	CENTER OF GRAVITY (INCHES) X	Y	Z	MOMENT OF INERTIA (SLUG/FT-SQ.) IXX	IYY	IZZ	PRODUCT OF INERTIA (SLUG/FT-SQ.) PXY	PXZ	PYZ
1.1.1 B 2	3.	.0	1.0	1.0	3.0	3.0	3.0	.0	.0	.0
1.1.1 B 3	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.1.1 B	5.	.0	1.0	1.0	5.0	5.0	5.0	.0	.0	-.0
1.1.1 C 1	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.1.1 C 2	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.1.1 C	4.	.0	1.0	1.0	4.0	4.0	4.0	.0	.0	.0
1.1.1	9.	.0	1.0	1.0	9.0	9.0	9.0	.0	.0	-.0
1.1.2 A 1	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.1.2 A 3	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.1.2 A	4.	.0	1.0	1.0	4.0	4.0	4.0	.0	.0	.0
1.1.2	4.	.0	1.0	1.0	4.0	4.0	4.0	.0	.0	.0
1.1.	13.	.0	1.0	1.0	13.0	13.0	13.0	.0	.0	-.0
1.2.1 A 1	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.2.1 A	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.2.1 B 1	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.2.1 B	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
1.2.1	4.	.0	1.0	1.0	4.0	4.0	4.0	.0	.0	.0
1.2.	4.	.0	1.0	1.0	4.0	4.0	4.0	.0	.0	.0
1.	17.	.0	1.0	1.0	17.0	17.0	17.0	.0	.0	-.0
3.1.1 A 1	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
3.1.1 A	2.	.0	1.0	1.0	2.0	2.0	2.0	.0	.0	.0
3.1.1 B 2	3.	.0	1.0	1.0	3.0	3.0	3.0	.0	.0	.0
3.1.1 B	3.	.0	1.0	1.0	3.0	3.0	3.0	.0	.0	.0
3.1.1	5.	.0	1.0	1.0	5.0	5.0	5.0	.0	.0	-.0
3.1.	5.	.0	1.0	1.0	5.0	5.0	5.0	.0	.0	-.0
3.	5.	.0	1.0	1.0	5.0	5.0	5.0	.0	.0	-.0
TOTALS	22.	.0	1.0	1.0	22.0	22.0	22.0	.0	.0	-.0

FIGURE 2.7 List Of Mass Property Subtotals

	CENTER OF GRAVITY				MOMENT OF INERTIA			PRODUCT OF INERTIA		
	LB	INCHES			SLUG/FT-SQ.			SLUG/FT-SQ.		
FUNCTION	WEIGHT	X	Y	Z	IXX	IYY	IZZ	PXY	PXZ	PYZ
1.	17.	.3	1.0	1.0	17.0	17.0	17.0	.0	.0	.0
3.	5.	.0	1.0	1.0	5.0	5.0	5.0	.0	.0	.0
TOTALS	22.	.0	1.0	1.0	22.0	22.0	22.0	.0	.0	.0

FIGURE 2.8 List Of Total Summary

Examples of the output reports are given in the figures listed below:

Figure

2.3 CMPARE data deck
2.5 List of input tape
2.6 List of current records not found on Master Tape
2.7 List of mass properties subtotals
2.8 List of total summary

The error messages that are used are:

- Card error
- Vendor code error
- Please input source control card
- Source does not match
- Card not found
- Card already exists

The logical units 12 through 18 (J through O) are internally dedicated units assigned to fastran files which should not be used as input or output logical devices in your job stream.

2.2 MARTIN MARIETTA TAPE PREPROCESSORS

The Martin Marietta Tape cannot be prepared for the CMPARE program with a single pass through the preprocessor program. Hardware limitations of the computer complex require two passes in order to properly reformat the tape. The first preprocessor Martin Marietta 1 is run on the UNIVAC 1110 system. This program does all of the

reformatting of the original data and gets it in the correct format for later use in the programs. The second phase of the preprocessor ETFIX, is required to prepare the output from the first phase preprocessing to go from the UNIVAC 1100 to the UNIVAC 1108 computer.

2.2.1 Martin-Marietta Pre-Processor

This program will read a tape produced by Martin Marietta and write the data in a standard format. This output tape will be used by the tape compare program of the Mass Properties Automated System.

The radii of gyration will be converted to moments of inertia using the classical equation and added to the moments for final output. All other detail data will be simply reformatted into the standard data format.

One input data card is required to show the device code for input, device code for output, function level code, and the tape title as indicated in figure 2.9. The device code refers to an alpha character indicating a tape unit or fastran logical number. The function code is subdivided into 3 levels. The function level code indicates the level desired. The program is run on the UNIVAC 1110 EXEC 8. The output is binary and is used for input to the ETFIX subroutine run on the UNIVAC 1108 EXEC 2 system. The deck setup is shown in figure 2.10.

*INPUT DATA CARD

Column	Format	Data
1	A1	Device code for input tape
2	A1	',' - device code separator
3	A1	Device code for output tape
4-5	I2	Function level code
6-29	A24	Tape Title
30-80		blank

Figure 2.9 Input Data Card Format for Martin Marietta Preprocessor

DECK SETUP FOR PROGRAM Martin Marietta Preprocessor PAGE NO. 1 OF 1

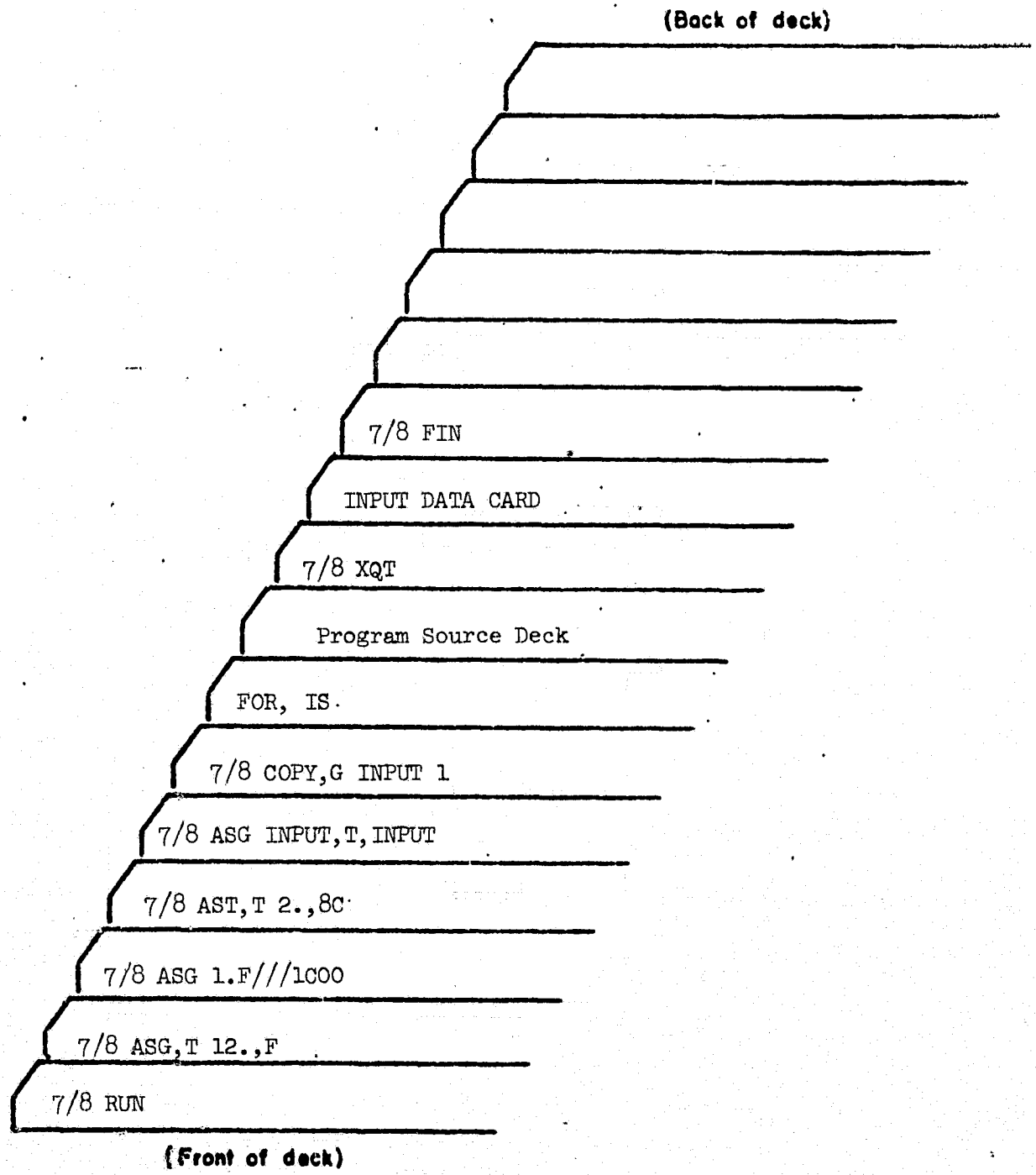

FIGURE 2.10 Deck Set Up for Martin Marietta Preprocessor 1

2.2.2 ETFIX

This program is a conversion routine to allow the user to go from the UNIVAC 1110 to the UNIVAC 1108. This program is used directly as an input to the CMPARE program. The input data card format is shown in figure 2.11. The deck setup is shown in figures 2.12, 13.

ETFIX - INPUT DATA CARD FORMAT

Column	Format	Data
1	A1	Device code for input tape
2	1X	',' - device code separator
3	A1	Device code for output tape
4	77X	blank

Figure 2.11 ETFIX Input Data Card Format

DECK SETUP FOR PROGRAM MARTIN CMPARE PAGE NO. 1 OF 2

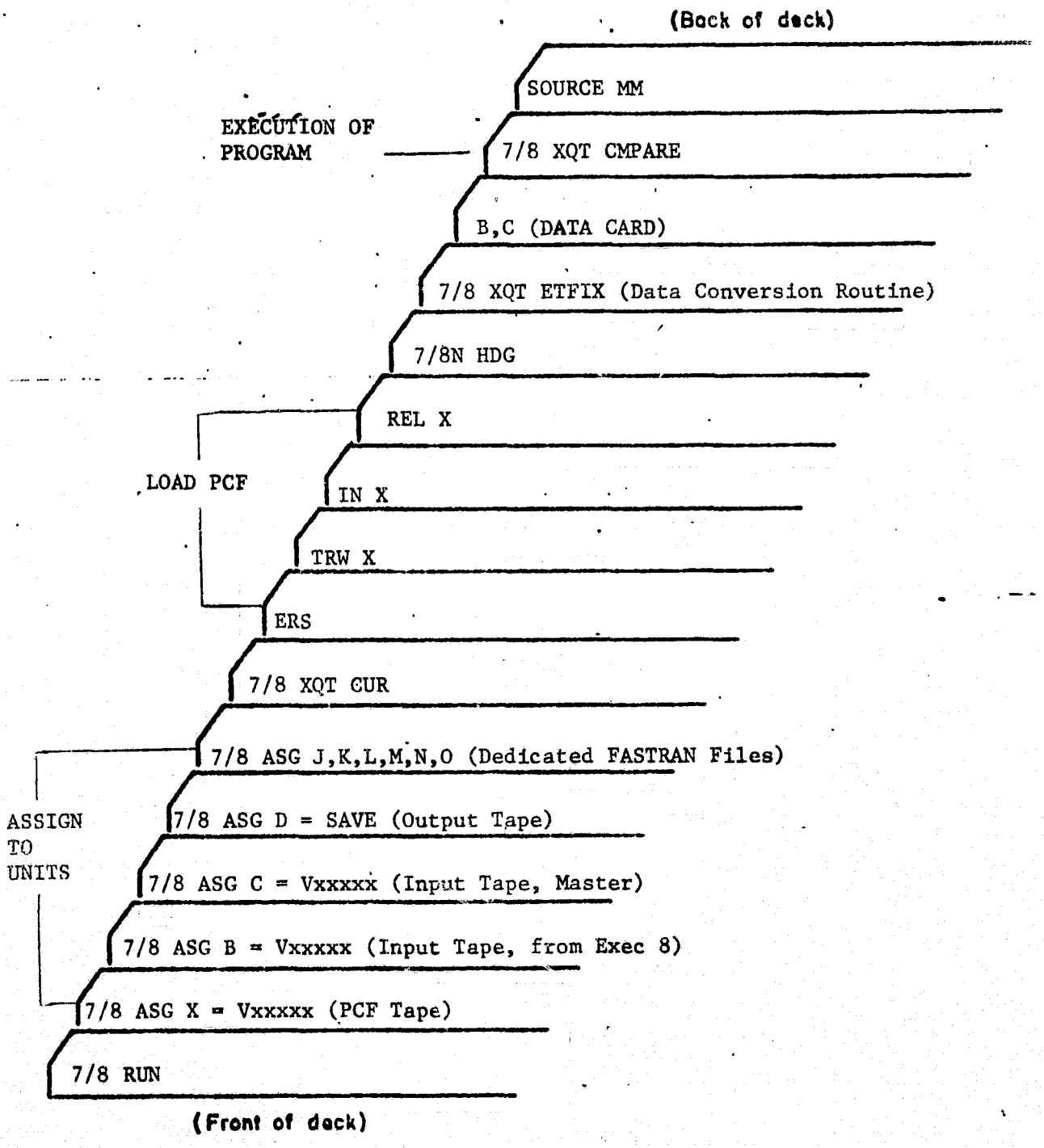

Figure 2.12 Martin CMPARE Deck Setup

DECK SETUP FOR PROGRAM MARTIN CMPARE PAGE NO. 2 OF 2

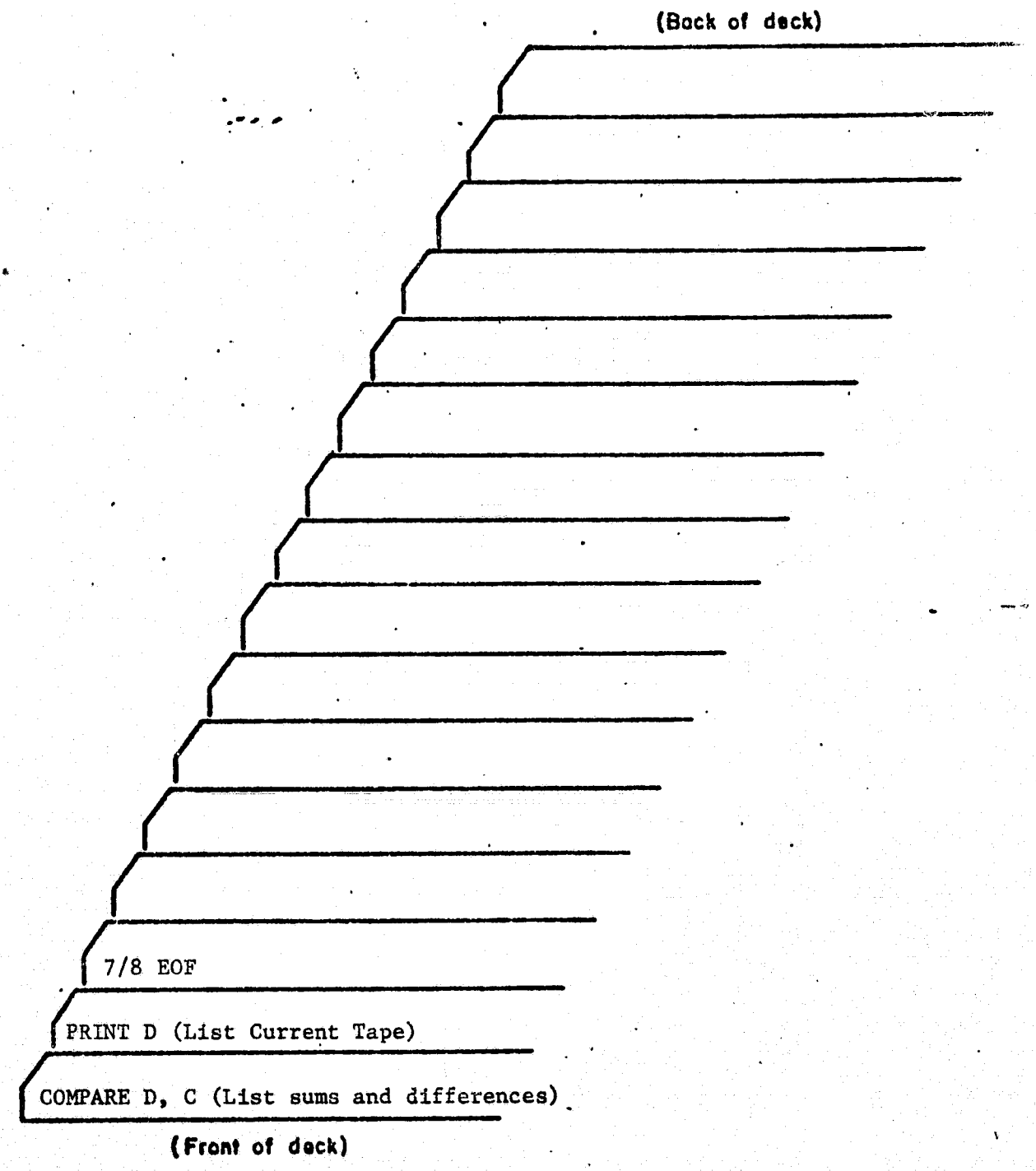

Figure 2.13 Martin CMPARE Deck Setup (Continued)

2.3 MARSHALL SPACEFLIGHT CENTER PREPROCESSOR

This preprocessor accepts the tape furnished by Marshall Spaceflight Center and reformats it to the standard format required by the CMPARE Program.

Two basic reports are generated by the program. The first report is a listing of all of the accepted records which have been put in the standard format. These records are sorted and are not necessarily in the same order as is on the input tape. The second report consists of those records that were rejected by the program for any reason.

An item can be rejected for one of two reasons: (1) it has the same function code and drawing number as another record (these must be unique in every detail) and (2) the weight of an item is too large to be in the standard F7.1 format of the standard tape format.

The card format is shown in figure 2.14. The deck setup to run the program is shown in figure 2.15.

Column	Format	Description
1-6	A6	MMYJMC This identities the tape as being generated at Johnson Space Center "J" and as a Marshall supplied tape "MC". The MMY is the date where MM = Month and Y = Last digit of the year
7	I1	The tape edit indicator. (Blank if this is the first version.)
8-31	A24	Tape Title

Figure 2.14 Marshall Data Card Format

DECK SETUP FOR PROGRAM Marshall Preprocessor PAGE NO. 1 OF 1

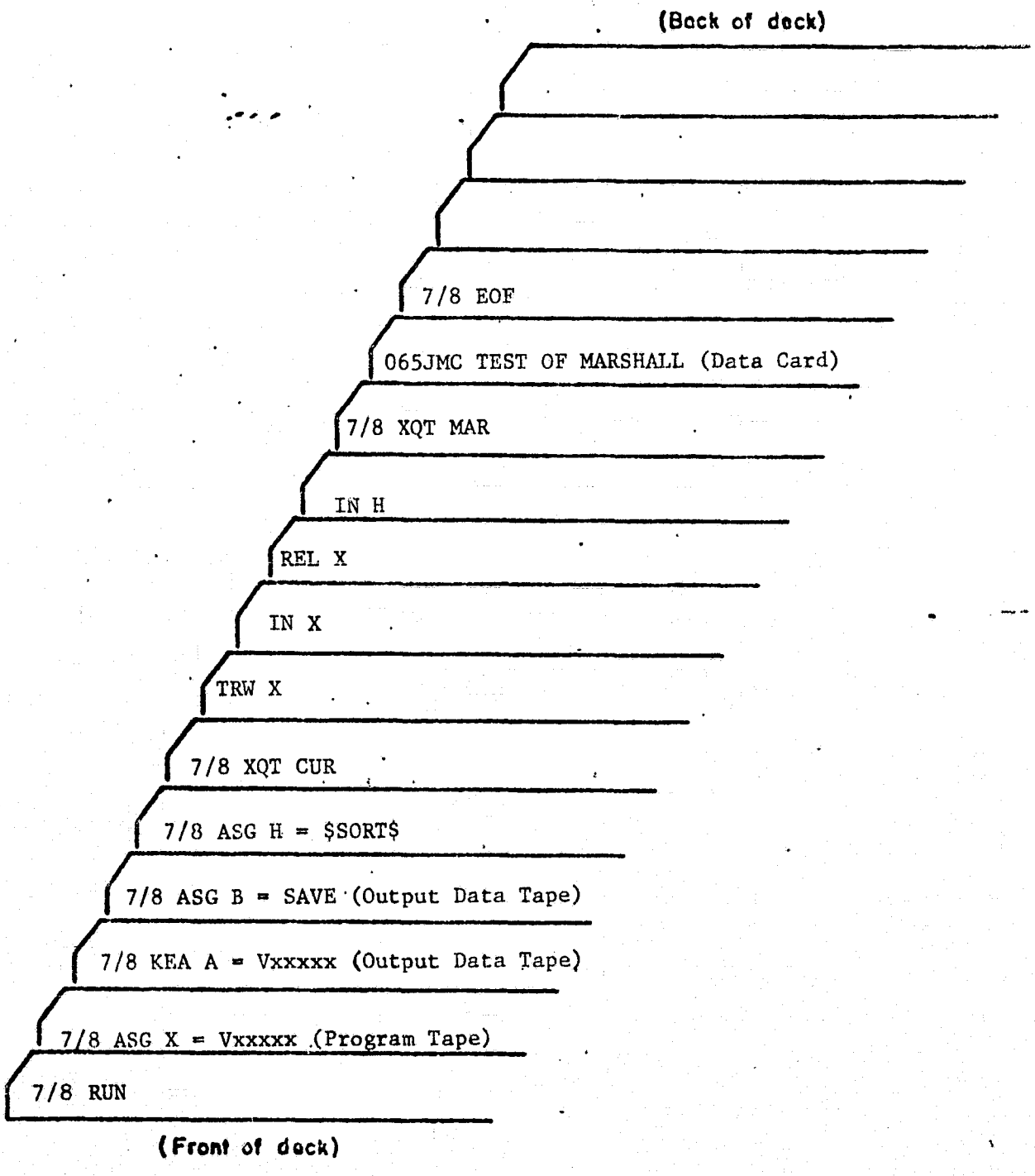

Figure 2.15 Marhsall Preprocessor Deck Set UP

2.4 ROCKWELL PREPROCESSOR

This program accepts a print tape from North American Rockwell with data on the orbiter vehicle. The data is reformatted to the standard tape format required for use in the Tape Compare program.

The program is designed to run on the UNIVAC 1108 EXEC 2 system. The deck setup is shown in figure 2.16. One input data card is required to indicate I/O devices for each of the devices. The title of the tape is input on one data card. Figure 2.17 describes the formats for these data cards.

DECK SETUP FOR PROGRAM Rockwell Preprocessor PAGE NO. 1 OF 1

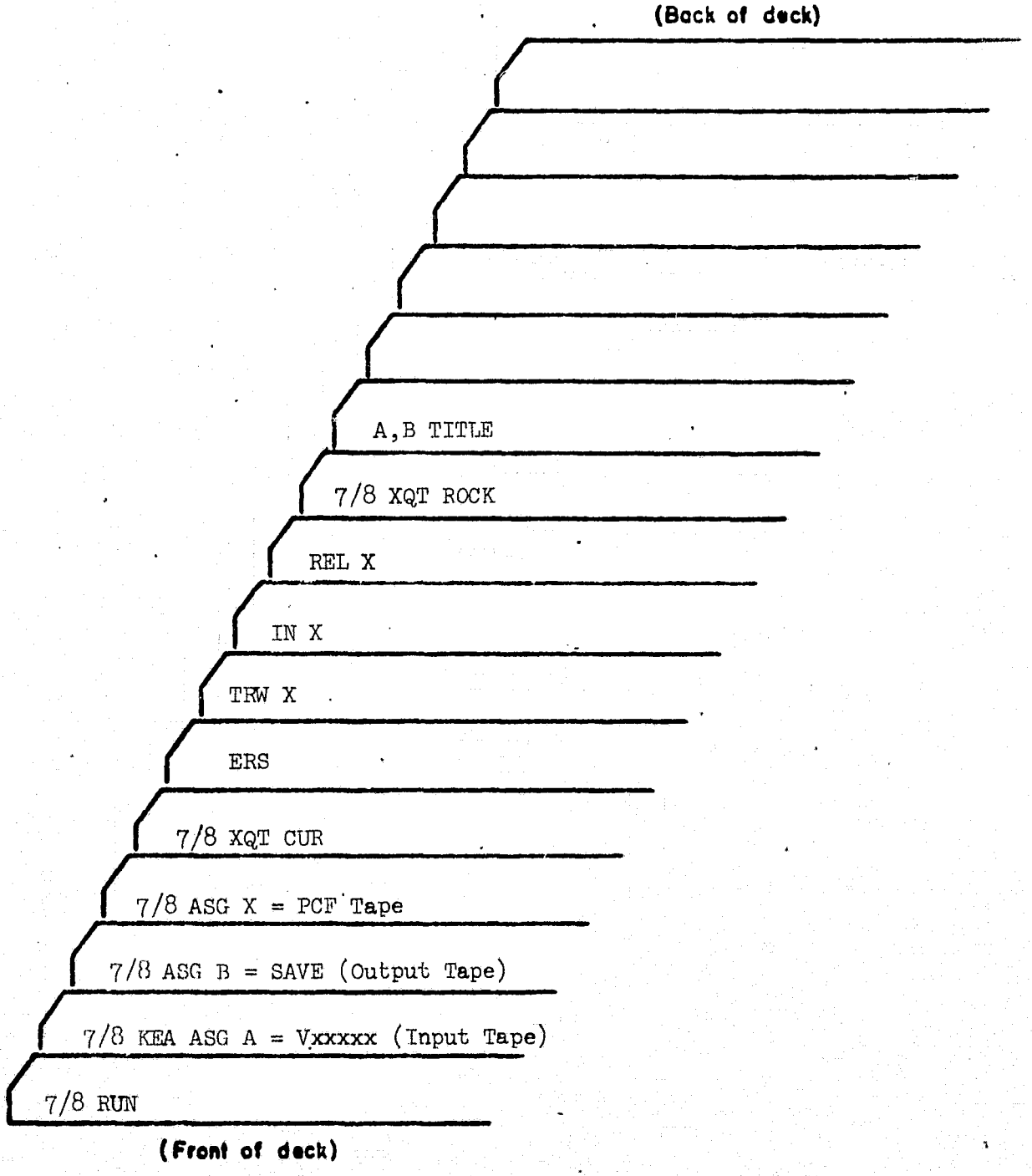

FIGURE 2.16 Deck Set Up for Rockwell preprocessor

Column	Format	Description
1	A1	Device code for input tape
2	A1	',' - Device code separator
3	A1	Device code for output tape
4-27	4A6	Tape title
28-80		blank

Figure 2.17 Input Data Card Format for Rockwell Preprocessor

3.0 CURVE FIT PROGRAM

The Curve Fit Program accepts the x and y Cartisian coordinate values of points on a curve and calculates the coefficients for an equation that represents that curve. This program is designed to run on a UNIVAC 1108 EXEC 2 operating system. All of the calculations are done in double precision arithmetic. The input is limited to 200 pairs of points.

The program will calculate and output to the line printer and by option to the card punch, the coefficients for the polynomial that best represents the input data. The calculation is made for all degrees of polynomials from m to n. If m = n, then only one degree of polynomial will be calculated, namely m.

The option to have the coefficients output on cards allows the user to directly input the coefficient cards into the MAPSYS program after changing only one card per equation (the name of the polynomial).

In order to execute the program the following cards are needed.

Card No. 1

COLS	FORMAT	DEFINITION
1		C - Comment
2-80		Identification

Card #2

COLS	FORMAT	DEFINITION
1-3	I3	Maximum degree of polynomial to be calculated (must not exceed 19).
4	I1	Punch option. Blank = No punch P = Coefficients will be output to card punch. Default = Blank
5-6		Blank
7-9	I3	Number of pairs of points that will be input
10-12		Blank
13-15	I3	Minimum degree of polynomial to be calculated. If Min = Max, only one value will be calculated. If blank default is Min = 2.

Card No. 3 and Above

COLS	FORMAT	DEFINITION
1-12	F12.4	Value of the independent variable.
13-24	F12.4	Value of the dependent variable.

Multiple executions are possible with this program by repeating the data cards. The deck set up shown for two executions is shown in figure 3.1.

DECK SETUP FOR PROGRAM FIT- Multiple Executions PAGE NO. 1 OF 1

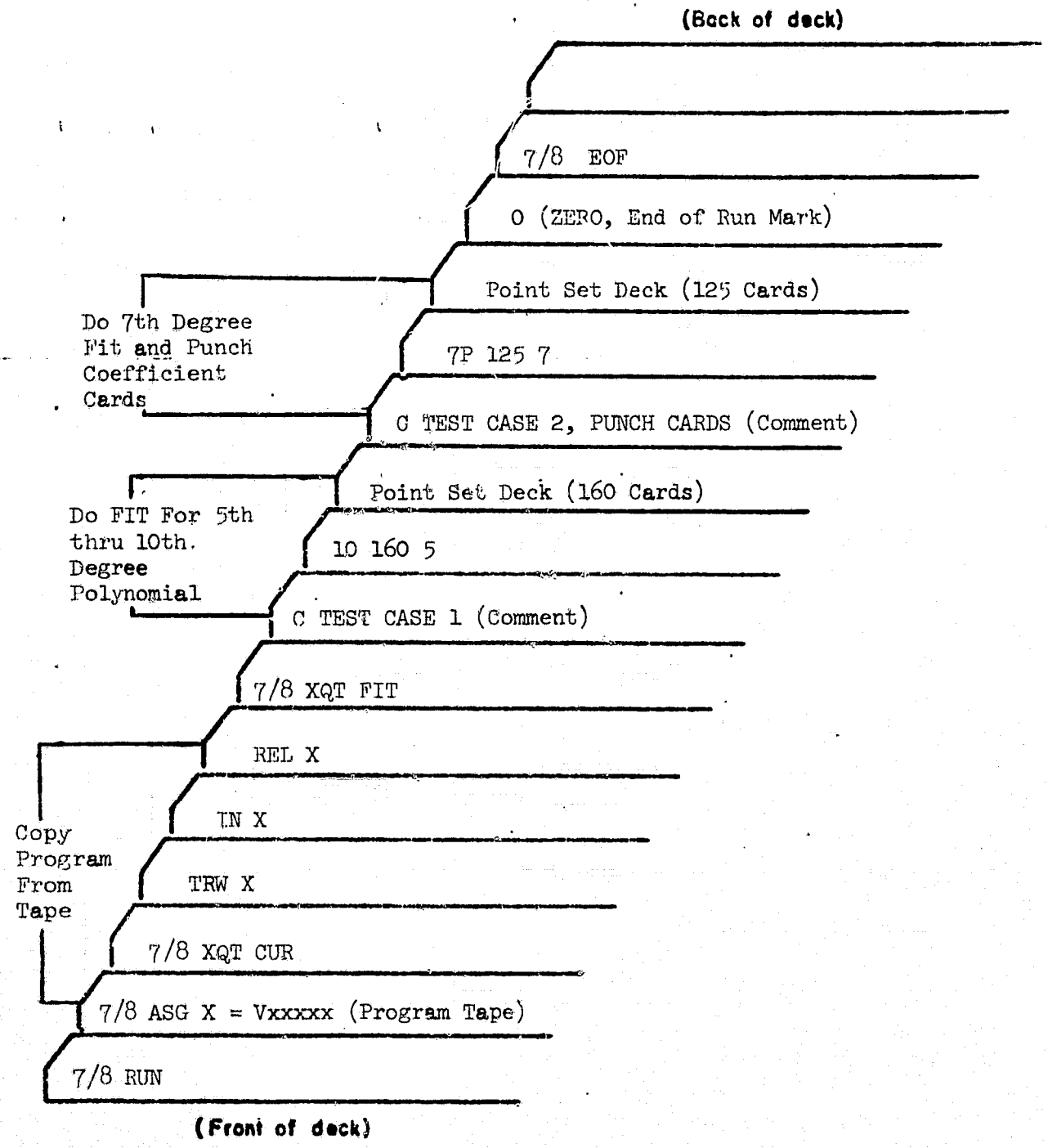

Figure 3.1 Deck Set Up For Multiple Executions of FIT.

4.0 MPSUM

MPSUM is a utility program which adds the mass properties of separate items into a single line of mass properties. It also will translate and rotate each item to a common coordinate system. It is designed for use on a DEMAND remote terminal but a batch version also exists. The terminal version uses prompts stating what data is to be entered. One prompt will ask for an index which will indicate if translation/rotations are to be read or if the previous data is to be reentered because of errors. All data input is free form with fields separated by commas and of variable length. Table 4.1 has a list of prompts and the order of entering data.

Table 4.2 has the card formats for the batch version. A deck setup will be shown in figure 4.1.

TABLE 4.1 - MPSUM PROMPTS

ENTER THE NUMBER OF ITEMS

- Enter an integer from 1 to 99.
- Enter a 0 to terminate execution.

ENTER MASS PROPERTIES FOR ITEM 1

- Enter 10 numbers separated by commas.
- Weight, X C.G., Y C.G., Z C.G., IXX, IYY, IZZ, PYX, PXZ, PYZ.

ENTER 1 TO TRANSLATE/ROTATE, 2 TO DELETE LAST LINE

- Enter a carriage return to skip the next prompt.
- Enter a 1 to get next prompt.
- Enter a 2 to get the previous prompt in case of an error.

ENTER X, Y, Z TRANSLATIONS AND ROTATIONS

- Enter 6 numbers separated by commas.
  X translation, Y translation, Z translation,
  X rotation, Y rotation, Z rotation.

All prompts except the first will be repeated until the number of items in the first one are entered. Then the totals will be printed and the first prompt repeated.

TABLE 4.2 - MPSUM CARD FORMAT

Column	Format	Contents
		CARD 1
1-2	I2	Number of items to be summed 1-99 0 to terminate program
		CARD 2
1-10	F10.1	Weight
11-20		X C.G.
21-30		Y C.G.
31-40		Z C.G.
41-50		IXX
51-60		IYY
61-70		IZZ
71-80		PXY
		CARD 3
1-10		PXZ
11-20		PYZ
21-30		X translation (in)
31-40		Y translation
41-50		Z translation
51-60		X rotation (deg.)
61-70		Y rotation
71-80		Z rotation

CARD 4 AND ABOVE

Like cards 2 and 3 for all items, then repeat card 1.

DECK SETUP FOR PROGRAM MPSUM PAGE NO. 1 OF 1

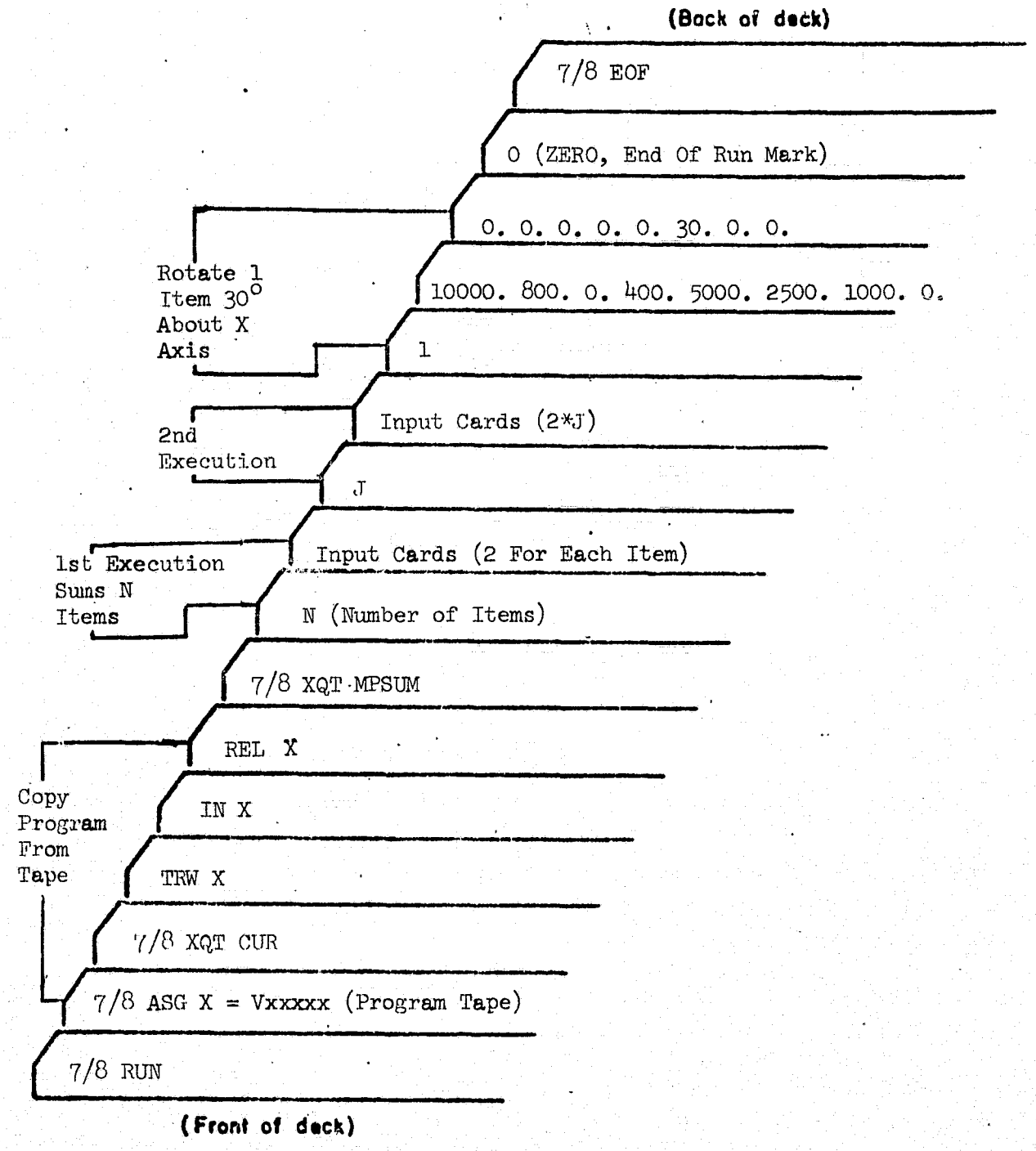

Figure 4.1 Deck Set Up for MPSUM Multiple Execution

5.0 ONE-G SLOSH

The One-G Slosh Model is divided into two sections, the cylindrical tank, and the oxygen tank. Each of these tanks will have a separate program deck to produce the required data from the tank.

The decks are set up to be run on a Univac 1108 EXEC 2 system. Each of the decks will generate a line printer output and (optionally) a punched card output. The punched cards will be the coefficients that go into the MAPSYS coefficient program.

5.1 CYLINDRICAL TANK

The cylindrical tank program will calculate and output to the line printer and the card punch the following variables in the format listed.

The line printer output is:

- 'Total Weight in Tank in Pounds' F10.2. This value is the weight of the liquid and gas in the tank.
- 'Liquid Height in Tank in Inches' F9.3. This value is the height of the liquid from the bottom of the tank.
- 'Liquid Weight in Tank in Pounds' F10.2. This value is the weight of the liquid in the tank.

- 'Gas Weight in Tank in Pounds' F10.2. This value is the weight of the gas in the tank.

- 'Volume Liquid in Tank in Cubic Feet' F10.2. This value is the volume of the liquid in the tank.

- 'Volume Gas in Tank in Cubic Feet' F10.2. This value is the volume of the gas in the tank.

- 'Centroid Liquid Reference System in Inches' F10.3. This value is the centroid of the liquid portion of the tank with respect to the reference system.

- 'Centroid Gas Reference System in Inches' F10.3. This value is the centorid of the gas portion of the tank with respect to the reference system.

- 'Liquid Slosh Inertia in Slug-Feet^2' F12.3. This value is the slosh inertia of the liquid portion of the tank.

The punched card output is:

- Card 1
  ID identifies the coefficients

- Card 2
  $COS. This card will be discarded.

- Card 3 and up
  These cards contain the coefficients for the curves for each of the mass properties which will be input

to MAPSYS from the One G Slosh model. These can be up to 20 coefficients for each mass property.

- Card 14
  $END. This card will be discarded.

- Cards 15 up are repeats of Cards 1-14.

In order to get the outputs just listed, the following inputs must be made by card. A sample deck set-up is presented to show where these input cards fit in the program deck.

Card No. 1

COLS	FORMAT	VARIABLE	DEFINITIONS
1-10	F10.3	A1	Radius of cylindrical section in inches
1-20	F10.3	A2	Length in cylindrical section in inches
21-30	F10.3	A3	Depth of head in inches
31-40	F10.3	A4	Do Not Use
41-50	F10.3	A5	Reference system x coordinate
51-60	F10.3	A6	Not Used

61-70	F10.3	A7	Density of Liquid hydrogen in lb-Ft^3
71-80	F10.6	A8	Density of Gaseous hydrogen in lb-Ft^3

Card No. 2

COLS	FORMAT	VARIABLE	DEFINITION
1-10	F10.3	A9	Not Used
11-20	F10.3	A10	Not Used
21-30	F10.3	A11	Increment to be added to previous liquid height
31-40	F10.3	A12	Degrees to be rotated about x axis
41-50	F10.3	A13	Degrees to be rotated about y axis
51-60	F10.3	A14	Degrees to be rotated about z axis
61-70	F10.3	A15	Translation on x axis in inches
71-80	F10.3	A16	Translation on y axis

in inches

Card No. 3

COLS	FORMAT	VARIABLE	DEFINITION
1-10	F10.3	A17	Translation on z axis in inches
11-20	F10.3	A18	Not Used
21-30	F10.3	A19	Not Used
31-40	F10.3	A20	Not Used
41-50	F10.3	A21	Not Used
51-60	F10.3	A22	Not Used
61-70	F10.3	A23	Not Used
71-80	F10.3	A24	Height of tank in inches

Card No. 4

COLS	FORMAT	DEFINITION
1-3		FIT This card is an indication that the point selection/curve fit routine

is to be called. If omitted, the program will terminate after generating the normal line printer output.

Card No. 5 and Above

COLS	FORMAT	DEFINITION
1-2	I2	Index of variable to be curve fit. The liquid properties are: 1 = x c.g. 2 = y c.g. 3 = z c.g. 4 = Ixx 5 = Iyy 6 = Izz 7 = Pxy 8 = Pxz 9 = Pyz The gas properties are: 21 = x c.g. 22 = y c.g. 23 = z c.g. 24 = Ixx 25 = Iyy 26 = Izz 27 = Pxy 28 = Pxz 29 = Pyz 0 = Termination of program
3	A1	C or blank. C means this is a continuation of the same segment of curve fit but with a different point density.
4-6	I3	Point density. Every nth point will be used until maximum weight for this density is reached. (The One G Slosh program calculates values every one inch of liquid height.

		All of these values are not needed for the curve fit routine and this point density will allow a selective reduction of points.)
7-9	I3	Degree of polynomial to be calculated. This is necessary only on the last card in a data set.
10-21	F12.1	Maximum weight for this density.
22-76	9A6	Comment which will appear in the curve fit program if this is the last card in a data set.

The curve fit routine has the capability of breaking a curve into several sections. This may be necessary if the curve has some irregular smooth shape. The curve fit routine is limited to 200 pairs of points, therefore, since the One G Slosh model calculates values for every one inch change in liquid height some point reduction is necessary. A segment of a curve may be further subdivided by choosing different point densities depending on the curves behavior. If a curve is relatively smooth, fewer points will be needed for the curve fit. The weights for the beginning and ending points for the different densities are input on card No. 5.

The punched output from this program will be used in the MAPSYS coefficient program.

5.2 OXYGEN TANK

The oxygen tank program will calculate and output to the line printer and the card punch the following variables in the format listed.

The line printer output is:

- 'Total Weight in Tank in Pounds' F10.2. This value is the weight of the liquid and gas in the tank.
- 'Liquid Height in Tank in Inches' F9.3. This value is the height of the liquid from the bottom of the tank.
- 'Liquid Weight in Tank in Pounds' F10.2. This value is the weight of the liquid in the tank.
- 'Gas Weight in Tank in Pounds' F10.2. This value is the weight of the gas in the tank.
- 'Volume Liquid in Tank in Cubic Feet' F10.2. This value is the volume of the liquid in the tank.
- 'Volume Gas in Tank in Cubic Feet' F10.2. This value is the volume of the gas in the tank.
- 'Centroid Liquid Reference System in Inches' F10.3. This value is the centroid of the liquid portion of the tank with respect to the reference system.

- 'Centroid Gas Reference System in Inches' F10.3. This value is the centorid of the gas portion of the tank with respect to the reference system.

- 'Liquid Slosh Inertia in Slug-Feet^2' F12.3. This value is the slosh inertia of the liquid portion of the tank.

- 'Fineness Ratio'. This value is the fineness ratio as derived from the hand calculations.

The punched card output is:

- Card 1
  ID identifies the coefficients

- Card 2
  $COS. This card will be discarded.

- Card 3 and up
  These cards contain the coefficients for the curves for each of the mass properties which will be input to MAPSYS from the One G Slosh model. There can be up to 20 coefficients for each mass property.

- Card 14
  $END. This card will be discarded.

- Cards 15 up are repeats of Cards 1-14.

In order to get the outputs just listed, the following inputs must be made by card. A deck set-up will be

presented to show where these input cards fit in the program deck.

Card No. 1

COLS	FORMAT	VARIABLE	DEFINITIONS
1-10	F10.3	A1	Radius of cylindrical section in inches
1-20	F10.3	A2	Length in cylindrical section in inches
21-30	F10.3	A3	Depth of head in inches
31-40	F10.3	A4	Not Used
41-50	F10.3	A5	Reference system x coordinate
51-60	F10.3	A6	Not Used
61-70	F10.3	A7	Density of Liquid oxygen in lb-Ft^3
71-80	F10.6	A8	Density of Gaseous oxygen in lb-Ft^3

Card No. 2

COLS	FORMAT	VARIABLE	DEFINITION
1-10	F10.3	A9	.1 height of the disc used in the disc inertia calculation in the middle section
11-20	F10.3	A10	Not Used
21-30	F10.3	A11	Increment to be added to previous liquid height
31-40	F10.3	A12	Degrees to be rotated about x axis
41-50	F10.3	A13	Degrees to be rotated about y axis
51-60	F10.3	A14	Degrees to be rotated about z axis
61-70	F10.3	A15	Translation on x axis in inches
71-80	F10.3	A16	Translation on y axis in inches

Card No. 3

COLS	FORMAT	VARIABLE	DEFINITION
1-10	F10.3	A17	Translation on z axis in inches
11-20	F10.3	A18	Not Used
21-30	F10.3	A19	Not Used
31-40	F10.3	A20	Not Used
41-50	F10.3	A21	Not Used
51-60	F10.3	A22	Not Used
61-70	F10.3	A23	Not Used
71-80	F10.3	A24	Height of tank in inches

Card No. 4

COLS	FORMAT	DEFINITION
1-3		FIT This card is an indication that the point selection/curve fit routine is to be called. If omitted, the program will terminate after generating the normal line printer output.

Card No. 5 and Above

COLS	FORMAT	DEFINITION
1-2	I2	Index of variable to be curve fit. The liquid properties are: 1 = x c.g. 2 = y c.g. 3 = z c.g. 4 = Ixx 5 = Iyy 6 = Izz 7 = Pxy 8 = Pxz 9 = Pyz The gas properties are: 21 = x c.g. 22 = y c.g. 23 = z c.g. 24 = Ixx 25 = Iyy 26 = Izz 27 = Pxy 28 = Pxz 29 = Pyz 0 = Termination of program
3	A1	C or blank. C means this is a continuation of the same segment of curve fit but with a different point density.
4-6	I3	Point density. Every nth point will be used until maximum weight for this density is reached. (The One G Slosh program calculates values every one inch of liquid height. All of these values are not needed for the curve fit routine and this point density will allow a selective reduction of points.)

7-9	I3	Degree of polynomial to be calculated. This is necessary only on the last card in a data set.
10-21	F12.1	Maximum weight for this density.
22-76	9A6	Comment which will appear in the curve fit program if this is the last card in a data set.

The curve fit routine has the capability of breaking a curve into several sections. This may be necessary if the curve has some irregular smooth shape. The curve fit routine is limited to 200 pairs of points, therefore, since the One G Slosh model calculates values every one inch change in liquid height some point reduction is necessary. A segment of a curve may be further subdivided by choosing different point densities depending on the curves behavior. If a curve is relatively smooth, fewer points will be needed for the curve fit. The weights for the beginning and ending points for the different densities are input on card No. 5.

The punched output from this program will be used in the MAPSYS coefficient program.

DECK SETUP FOR PROGRAM ONEGSM PAGE NO. 1 OF 1

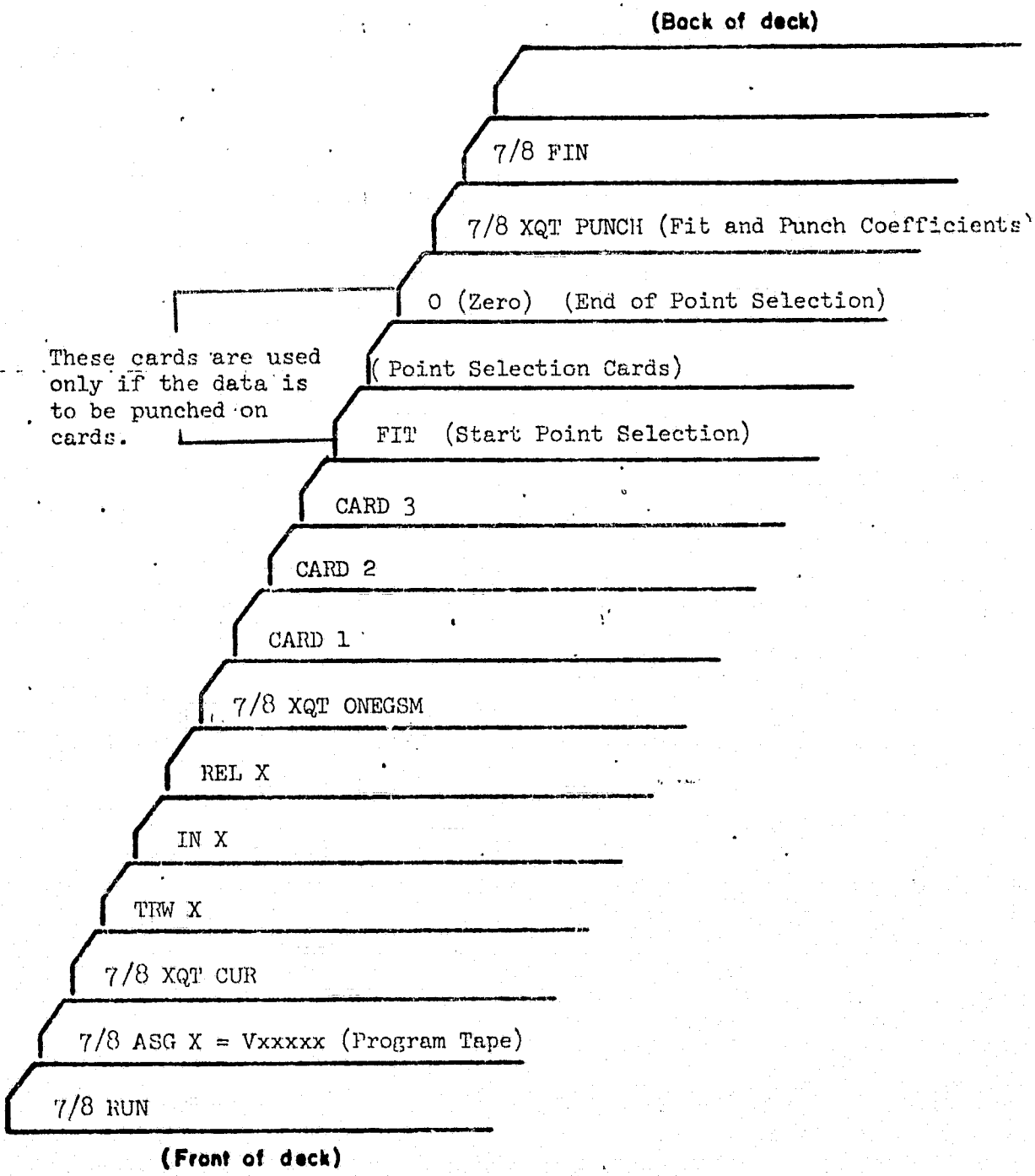

Figure No. 5.1 Deck Setup for the One G slosh Model

6.0 MPES - MAIN MASS PROPERTIES PROGRAM

MPES is the main program in the Shuttle Mass Properties Automated System. This program uses data from different sources to produce a number of reports on the mass properties of a given Shuttle configuration at a given time. These reports are listed in Table 6.7.

The following sections describe in detail the input data to MPES. There are four basic input data sets, three of which are normally stored on tapes and the fourth is stored on cards and updated as necessary.

6.1 COEFFICIENTS DATA BASE

The coefficients data base is used to model OMS, ET, and SRB consumables by the use of polynominal equations. The coefficients for these polynominals are generated by curve fit programs and are input to MPES on cards. The coefficients are output by MPES and saved on a tape which can be updated by cards when the key card "COEFFICIENTS" follows the RUNID card. When it is necessary to change the values of the coefficients, it is done by the use of a NAMELIST input. The format for these cards is shown in Table 6.1. A sample deck setup is shown in figure 6.1. The name of the polynominal or the variable to be changed must be on the update cards. A list of all names and their descriptions is shown in Table 6.2.

Other types of MPES runs may follow a coefficient update. All MPES executions will list the current values of

all coefficients. If an update run is made, both the old and new coefficient values will be listed.

TABLE 6.1 COEFFICIENTS CARD FORMAT

Column	Format	Description
		Card No. 1
1-12	A12	"COEFFICIENTS" Key card. This indicates coefficients cards are to follow.
		Card No. 2
2-7	A6	$COEFS - signals start of NAMELIST input. Note that all NAMELIST cards must have a blank in column 1.
		Card No. 3 and Above
2-7	A6	Name of coefficent variable to be changed.
7	A1	"=".

Column	Format	Contents
8-60	2(D22.18)	Double precision numbers in E format with up to 18 digits after decimal point. Followed by "DIXXX,".XXX is the exponent of 10 for that number. Caution - If more coefficents were present in the previous set of coefficients than the new set, the old values must be zeroed out. The change program affects only those coefficents that it has new values for. An array name need appear only once followed by up to 20 numbers in the above format (separated by commas). A new "NAME=" will signal that other array elements will not be updated.
		Last Card
2-5	A4	"$END" marks the end of a NAMELIST coefficient update.

TABLE 6.2 COEFFICIENTS NAMES

All SRB's have the following formats:

"SXXXKN"

where "S" denotes SRB

XXX is X, Y, Z, IX, IY, IZ, PXY, PXZ, or PYZ
(The mass property concerned)

K is "C" if this is the actual coefficient array.

K is "W" if this is the minimum weight that this polynomial will be used for.

N is an index from 1 to 5.

45 polynomials and their 45 minimum weights are thus defined. Note that the minimum weights for polynomial "N" must be in decending order, i.e.,

SXW1>SXW2>SXW3...>SXW5

These polynomials must describe the Right SRB. The Left SRB is identical except for some of the signs.

ET Polynomials

ELH2X1 - X C.G. for weight < breaking weight (BW).

ELH2X2 - X C.G. for weight > BW.

ELH2Y1 - Iyy, Izz for weight < BW.

ELH2Y2 - Iyy and Izz when weight > BW.

ELO2X1 - X when weight ≤ line weight in pounds.

ELO2X2 - Oxygen tank X when weight ≤ BW.

ELO2X3 - Oxygen tank X when weight > BW.

ELO2Y1 - Oxygen tank Iyy and Izz when weight ≤ BW pounds (line weight).

ELO2Y2 - Oxygen tank Iyy and Izz when weight ≤ BW.

ELO2Y3 - Oxygen tank Iyy and Izz when weight > BW.

XGAS - O2 gas X C.G.

FXGAS - H2 gas X C.G.

OMS Polynomials

These polynomials describe the right tank. The left tank is identical except for some signs.

OMSFX - X.

OMSFY - Y.

OMSFZ - Z.

OMSFIX - Ixx.

OMSFIY - Iyy.

OMSFIZ - Izz.

OMSFXY - Pxy.

OMSFXZ - Pxz.

OMSFYZ - Pyz.

OMSOOX - X

OMSOOY - Y.

OMSOOZ - Z.

OMSOIX - Ixx.

OMSOIY - Iyy.

OMSOIZ - Izz.

OMSOXY - Pxy.

OMSOXZ - Pxz.

OMSOYZ - Pyz.

Payload Bay OMS Coefficients

Fuel	Oxidizer
FPLX	OPLX
FPLY	OPLY
FPLZ	OPLZ
FPLIX	OPLIZ
FPLIY	OPLIY
FPLIZ	OPLIZ
FPLPXY	OPLPXY
FPLPXZ	OPLPXZ
FPLPYZ	OPLPYZ

DECK SETUP FOR PROGRAM Coefficients Update PAGE NO. 1 OF 1

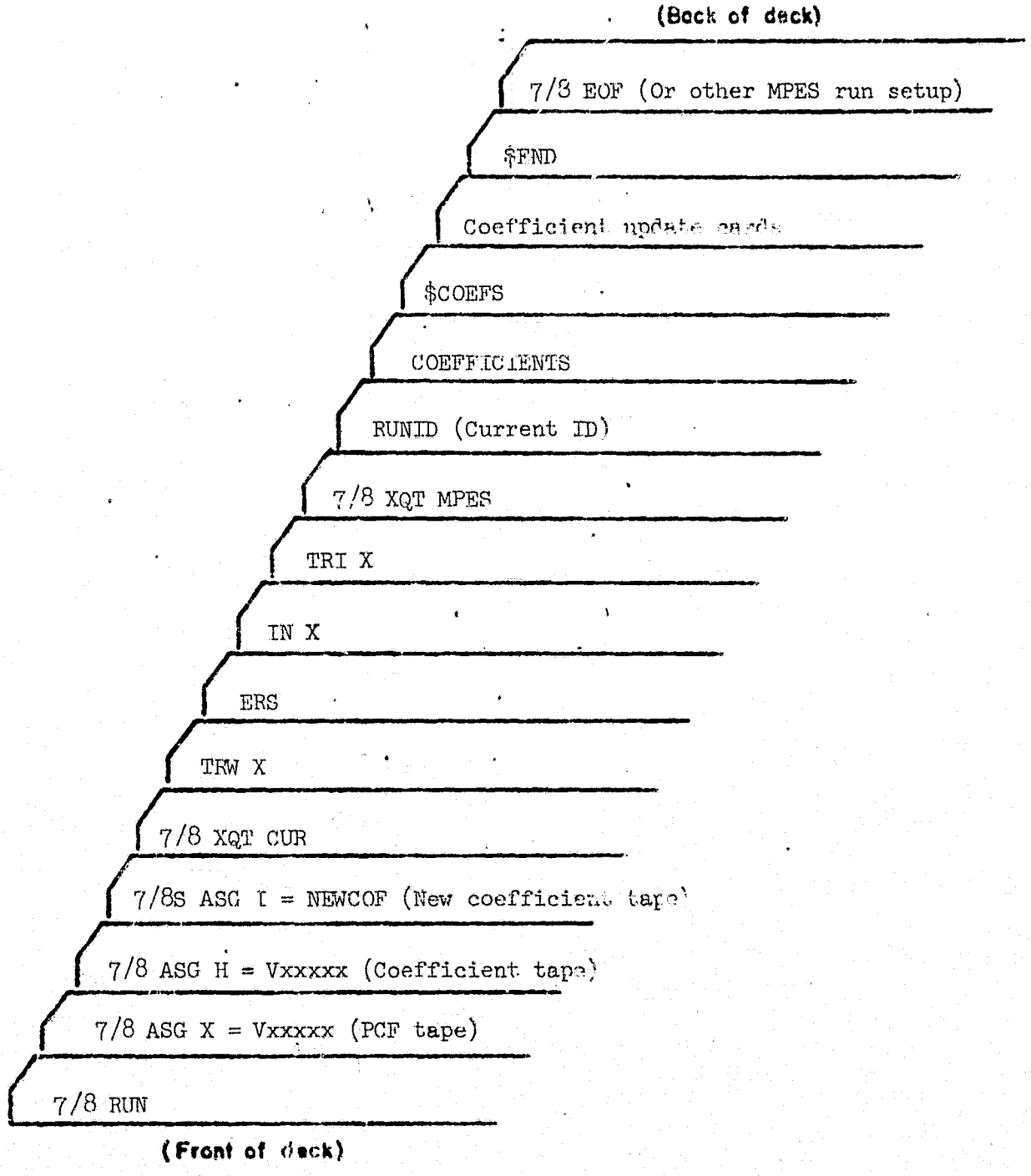

Figure 6.1 Coefficient Update deck setup.

6.2 BASIC DATA SET

The basic data set is the main set of mass properties for all of the items which comprise the basic Shuttle system configureation. Each of the items is identified with a unique item number.

Item numbers 1, 11, 21, ..., 91 are reserved for basic "modules". If, for example, item 1 was external tanks, items 2 through 9 would be items that are associated with the ET's. MPES will calculate subtotals for these 10 modules which will include the nine (if nine are used) items associated with it. All items assigned to a module must be in that modules coordinate system.

Items 1 - 99 have fixed assignments and all others have default assignments that may be changed when the item cards are read. Items 100 - 199 are reserved for consumables and MPES will not include these in the "DRY" subtotals. The item assignments and the module coordinate systems are:

Item numbers	1-10 are in module 1	Orbiter (0)
	11-20 are in module 2	External Tank (ET)
	21-30 are in module 3	ET
	31-40 are in module 4	ET
	41-50 are in module 5	0
	51-60 are in module 6	0
	61-70 are in module 7	0
	71-80 are in module 8	0
	81-90 are in module 9	0
	91-99 are in module 10	0

The lowest item number in each partition (1, 11, 21, etc., hereafter called the head entry) is always the entry for the basic mass properties module. The remaining entries in the partition can be used for different items in the basic module.

Shuttle Consumable Assignment
Item Numbers 100 through 199

Item Number	Shuttle Consumable
101	Orbiter Ammonia Tank 1
102	Orbiter Ammonia Tank 2
108	Orbiter Waste Water 1
109	Orbiter Waste Water 2
110	Orbiter Waste Water 3
111	Orbiter Potable Water 1
112	Orbiter Potable Water 2
113-118	"Misc" items - Helium Tanks
132	Orbiter OMS Fuel Right
133	Orbiter OMS Oxidizer Right
134	Orbiter OMS Fuel Left
135	Orbiter OMS Oxidizer Left
144	Orbiter OMS Fuel Payload Bay
145	Orbiter OMS Oxidizer Payload Bay
146	Orbiter RCS Fuel Forward
147	Orbiter RCS Oxidizer Forward
148	Orbiter RCS Fuel Right Pod
149	Orbiter RCS Oxidizer Right Pod
150	Orbiter RCS Fuel Left Pod
151	Orbiter RCS Oxidizer Left Pod
152	Orbiter Main Fuel

Item Number	Shuttle Consumable
153	Orbiter Main Oxidizer
154	Orbiter Main Helium - also a "Misc" item
155	Gaseous Nitrogen (GN2)
156	Gaseous Oxygen (GO2)
157	APU Hydrozine Tank 1
158	APU Hydrozine Tank 2
159	APU Hydrozine Tank 3
160	Liquid Oxygen Tank 1
161	Liquid Oxygen Tank 2
162	Liquid Hydrogen Tank 1
163	Liquid Hydrogen Tank 2
164	Hydraulic Water Pot 1
165	External Tank LH2
166	External Tank LOX
167	Hydraulic Water Pot 2
168	Hydraulic Water Pot 3
169	SRB Left
170	SRB Right
171	Orbiter OMS Fuel Right Trapped Outside Tank
172	Orbiter OMS Oxidizer Right Trapped Outside Tank
173	Orbiter OMS Fuel Left Trapped Outside Tank
174	Orbiter OMS Oxidizer Left Trapped Outside Tank
175	Orbiter OMS Fuel Payload Bay Trapped Outside Tank
176	Orbiter Oxidizer Payload Bay

Item Number	Shuttle Consumable
	Trapped Outside Tank
177	Orbiter RCS Fuel Fwd Trapped Outside Tank
178	Orbiter FCS Oxidizer Fwd Trapped Outside Tank
179	Orbiter RCS Fuel Right Pod Trapped Outside Tank
180	Orbiter RCS Oxidizer Right Pod Trapped Outside Tank
181	Orbiter RCS Fuel Left Pod Trapped Outside Tank
182	Orbiter RCS Oxidizer Left Pod Trapped Outside Tank
All Others	Not used

The fluids fall into two categories:

- Those whose c.g.'s do not move as they are consumed, which are point masses. The c.g.'s and associated dispersions in the basic input are used throughout the run and local inertias are set to zero.
- Those whose c.g.'s move as they are consumed. These use the current weight to determine the c.g.'s and inertias by using polynominals to calculate the appropriate values. Initial dispersions are used throughout the run.

The following fluid items use curves:

132	OMS	Fuel R

133	OMS	Oxidizer R
134	OMS	Fuel L
135	OMS	Oxidizer L
144	OMS	Fuel Payload Bay
145	OMS	Oxidizer Payload Bay
165	ET	Fuel
166	ET	Oxidizer
169		SRBL
170		SRBR

- Sequence numbers 200-300 can be used for entries which are not basic module and not fluids. Sequence number assignment in this grouping is unrestricted with one exception: sequence numbers 253-254 are reserved for TEL summaries.
- All inputs assigned to a module must be in the same coordinate system.
- The names of the modules used in the report are taken from Columns 4 through 8 of the Card 1 for the head entry for each module.
- Sequence numbers 100 to 300 must be linked to the module in which they are summed. Many sequence numbers default to particular modules or the user can do his linking by putting a module number in Column 4-9 (right justified) of the Card 2 for entries.
- Sequence numbers 100-199 are assumed to be fluids and are included in the wet module total. Sequence numbers 1-99 and 200-300 are included in the dry total.

6.2.1 Basic Data Set Maintenance

Normally the basic data sets are stored on a tape. This tape is originally created with an initialization run. The deck setup for this type of run is shown in figures 6.2 and 6.3. This particular example has three sets being copied to tape at once. Each set will exist as a separate file which must be uniquely identified by the RUNID card with that set.

When MPES reads this tape on subsequent runs it must match the RUNID card with an identified file ID on the tape in order to use it.

After a tape has been created new data sets may be appended to it (and a new tape written) by using the deck setup in figures 6.4 and 6.5. This example will append two sets to the original tape and output a new tape with all the sets.

The input card formats for initialization and appending data sets is shown in Table 6.3.

Once a data set is saved on a tape, it may be updated (and a new tape created) by the use of a deck setup as in figures 6.5, 6. The cards which update this data must be in the format shown in Table 6.4. The set to be updated must be identified by the correct RUNID.

Once all basic data sets needed for a calculating execution have been created on a tape and uniquely identified, they may be read by using the correct RUNID with

a set of EVENT cards. MPES will search the tape until it finds a data set with the same ID and print this entire data set before processing any events. This allows the user to verify that the data is correct.

When updating, a data set edits must be made in the following order:

Deletes, Adds, and Changes. A delete is accomplished by inputting a word with nothing but the item number and card number. Adds are items in the normal format shown in Table 6.3. Update cards are in the format shown in Table 6.4. Each of these cards has the word "UP" on them and a flag in columns 10-15 indicating which fields are to be updated.

DECK SETUP FOR PROGRAM MPES Initilization Run PAGE NO. 1 OF 2

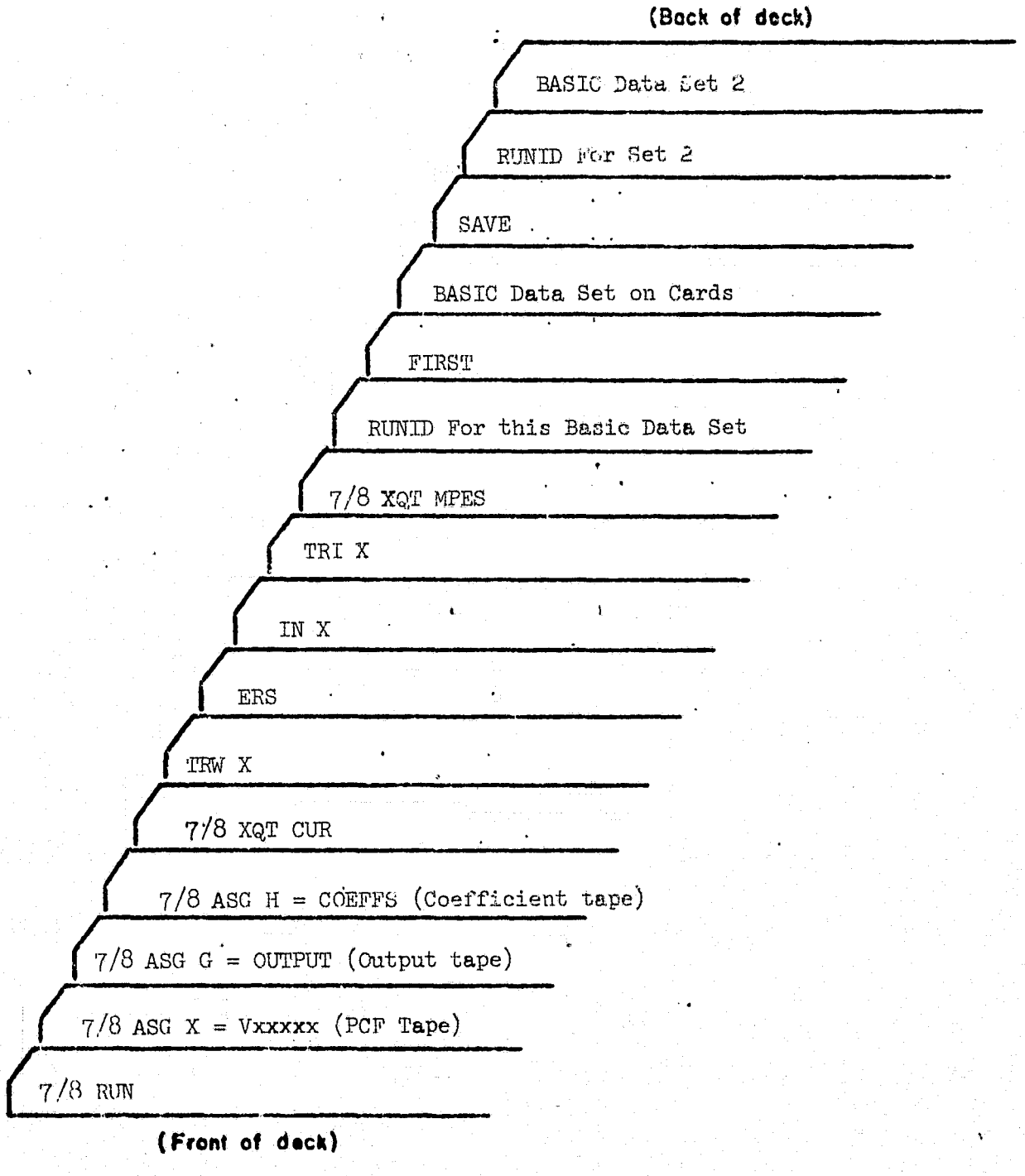

Figure 6.2 Initilization Run Deck Setup

DECK SETUP FOR PROGRAM MPES Initilization Run PAGE NO. 2 OF 2

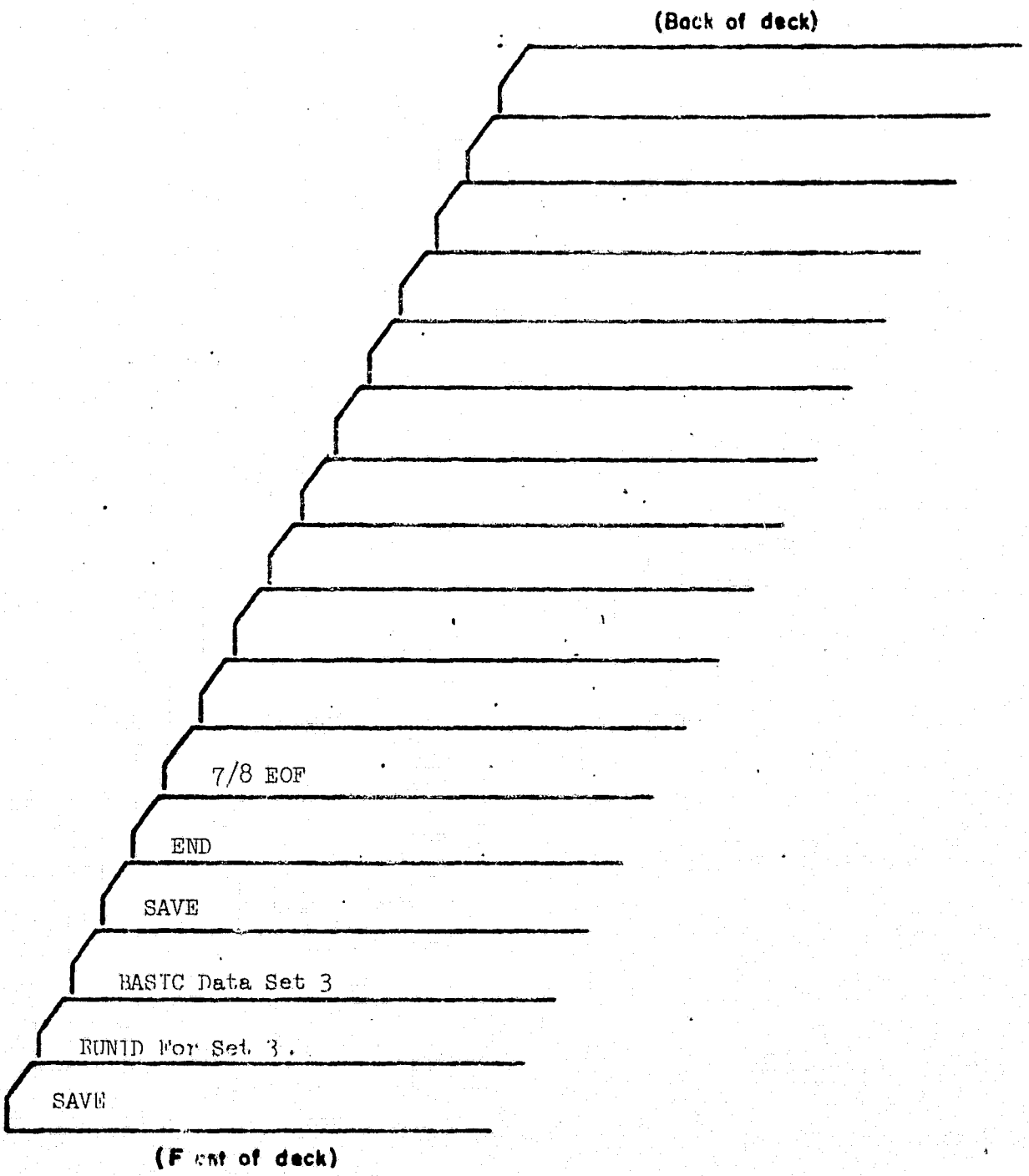

Figure 6.3 Initilization Run Deck Setup (Continued)

DECK SETUP FOR PROGRAM MPES- Appending Data Sets PAGE NO. 1 OF 2

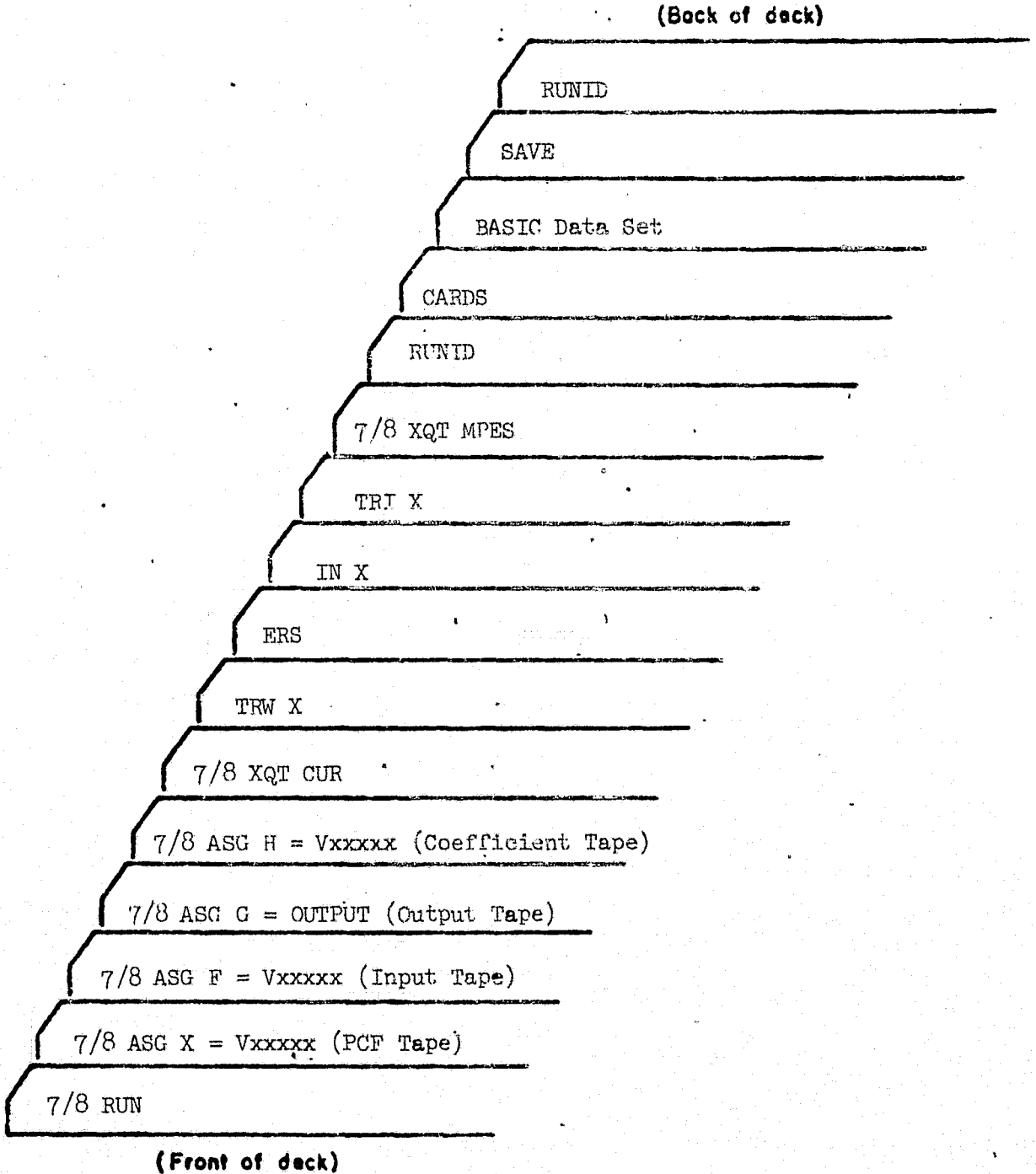

Figure 6.4 Appending Data Sets Deck Setup

DECK SETUP FOR PROGRAM MPES- Appending Data Sets PAGE NO. 2 OF 2

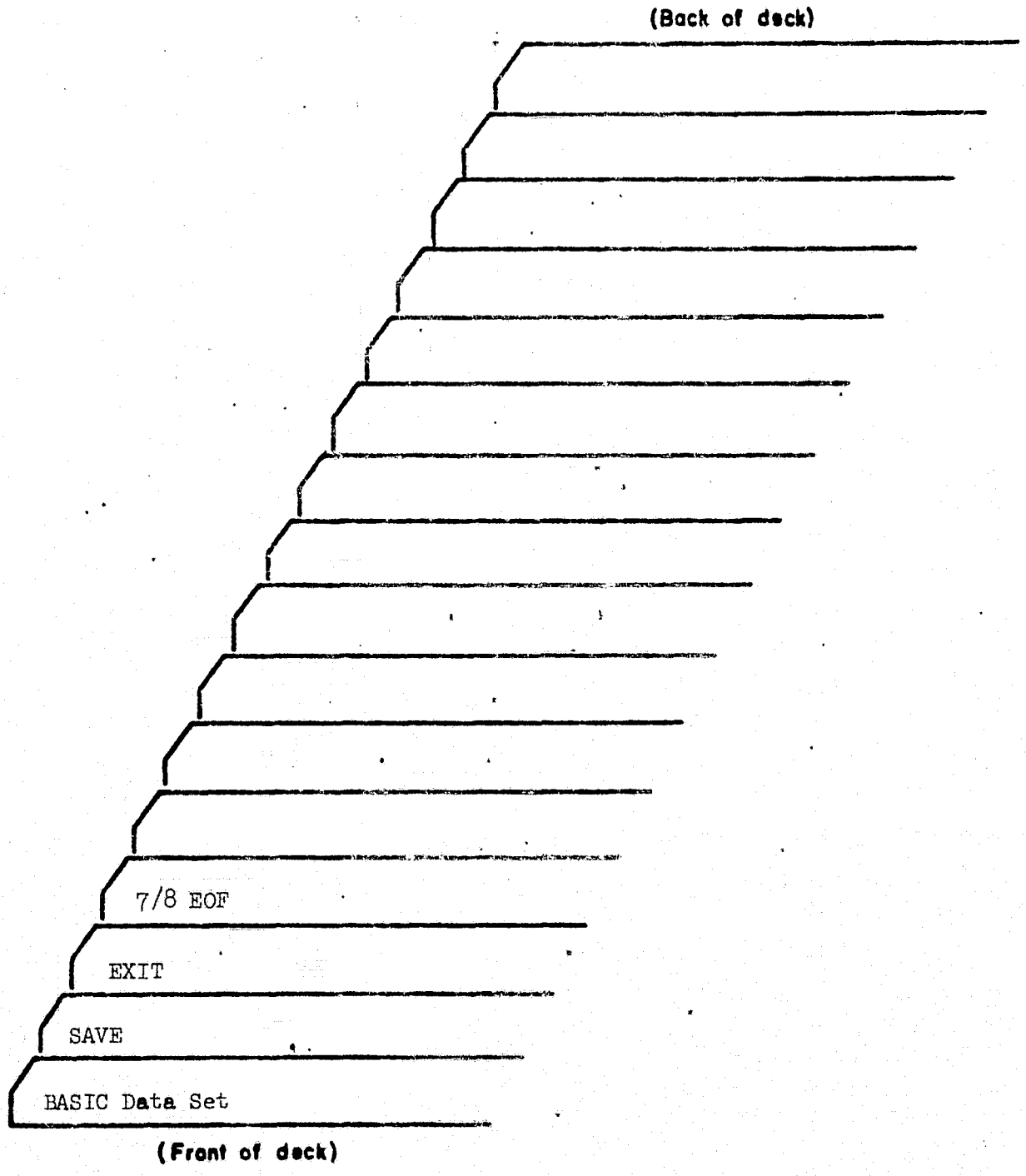

Figure 6.5 Appending Data Sets Deck Setup (Continued)

DECK SETUP FOR PROGRAM MPES - Data Updates PAGE NO. 1 OF 2

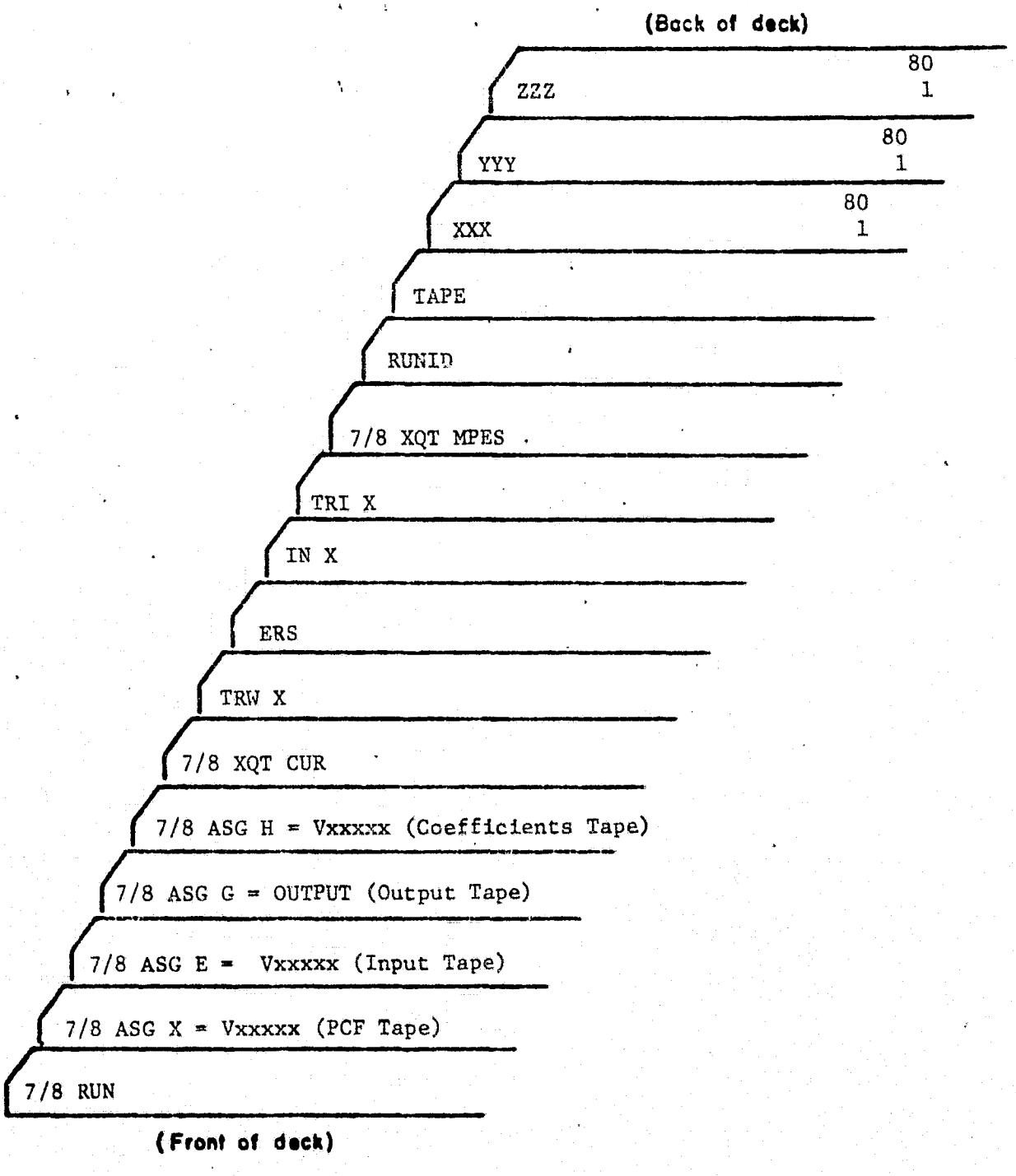

Figure 6.6 Data Updates Deck Setup

DECK SETUP FOR PROGRAM MPES - Data Updates PAGE NO. 2 OF 2

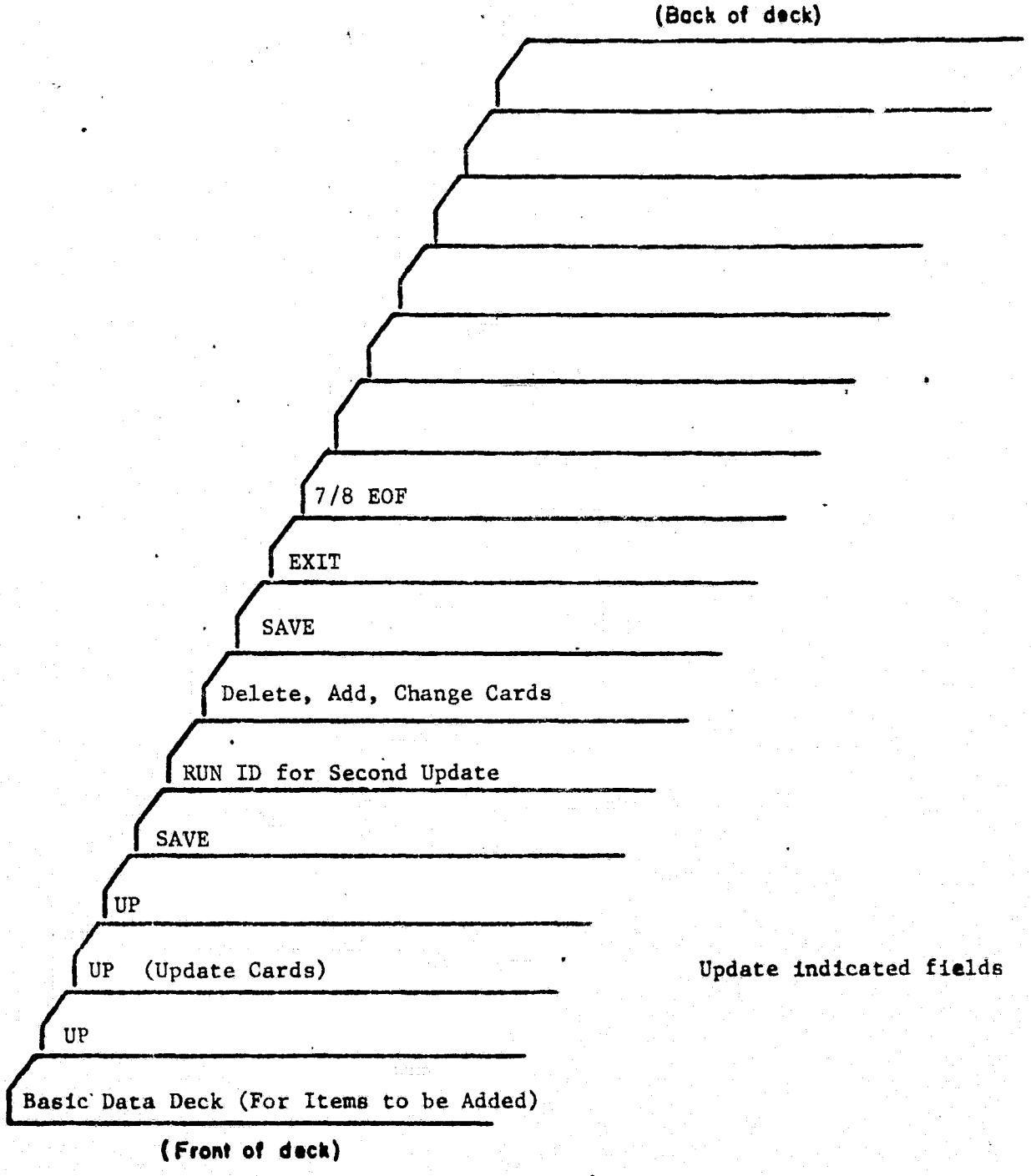

Figure 6.7 Data Updates Deck Setup (Continued)

TABLE 6.3 - BASIC DATA SET CARD FORMATS

The basic mass property data for each item required in the data base is entered initially on one to four cards. The format for each of these cards and a description of the data elements are described below.

CARD 1

Columns	Format	Description
1-3		Sequence Number
4-15		Alpha/numeric characters describing the item.
16-25	F10.0	Weight. If the weight is in kilograms, then column 76 must contain an M.
26-35	F10.0	X relative to module coordinate system.
36-45	F10.0	Y relative to module coordinate system.
46-55	F10.0	Z relative to module coordinate system.
56-65	F10.0	Ixx moment of inertia about x axis.
66-75	F10.0	Iyy moment of inertia about y axis.
76		Blank or M. If M the input data is assumed to be metric and is converted to English units.
80		1 indicates card no. 1.

CARD_2

Columns	Format	Description
1-3		Sequence Number.
9		Module Number.
16-25	F10.0	Izz moment of inertia about z axis.
26-35	F10.0	Pxy product of inertia about xy plane.
36-45	F10.0	Pxz product of inertia about xz plane.
46-55	F10.0	Pyz product of inertia about yz plane.
56-65	F10.0	Dispersion of weight.
66-75	F10.0	Dispersion of X.
76		Blank or M.
80		2 indicates card no. 2.

CARD_3

Columns	Format	Description
1-3		Sequence Number.
16-25	F10.0	Dispersion of Y.
26-35	F10.0	Dispersion of Z.
36-45	F10.0	Dispersion of Ixx.
46-55	F10.0	Dispersion of Iyy.
56-65	F10.0	Dispersion of Izz.
66-75	F10.0	Dispersion of Pxy.
76		Blank or M.
80		3 indicates card no. 3.

CARD 4

Columns	Format	Description
1-3		Sequence Number.
16-25	F10.0	Dispersion of Pxz.
26-35	F10.0	Dispersion of Pyz.
76		Blank or M.
80		4 indicates card no. 4.

TABLE 6.4 - UPDATE CARD NO. 1

Column	Format	Description
1-2		UP.
4-6		Sequence Number.
10		Update columns 16-25 if column 10=1 - weight.
11		Update columns 26-35 if column 11=1 - X bar.
12		Update columns 36-45 if column 12=1 - Y bar.
13		Update columns 46-55 if column 13=1 - Z bar
14		Update columns 56-65 if column 14=1 - Ixy.
15		Update columns 66-75 if column 15=1 - Iyy.
16-25	F10.0	Updated weight.
26-35	F10.0	Updated X.
36-45	F10.0	Updated Y.
46-55	F10.0	Updated Z.
56-65	F10.0	Updated Ixx.
66-75	F10.0	Updated Iyy.
76		Blank or M.
80		1.

UPDATE CARD NO. 2

Column	Format	Description
1-2		UP.
4-6		Sequence Number.
9		Updated module number (if required).
10		Update columns 16-25 if column 10=1 - Izz
11		Update columns 26-35 if column 11=1 - Pxy
12		Update columns 36-45 if column 12=1 - Pyy
13		Update columns 46-55 if column 13=1 - Pyz
14		Update columns 56-65 if column 14=1.
15		Update columns 66-75 if column 15=1.
16-25	F10.0	Updated Izz.
26-35	F10.0	Updated Pxy.
36-45	F10.0	Updated Pxz.
46-55	F10.0	Updated Pyz.
56-65	F10.0	Updated dispersion for weight.
66-75	F10.0	Updated dispersion for X.
76		Blank or M.
80		2.

UPDATE CARD NO. 3

Column	Format	Description
1-2		UP.
4-6		Sequence Number.
10		Update columns 16-25 if column 10=1.
11		Update columns 26-35 if column 11=1.
12		Update columns 36-45 if column 12=1.
13		Update columns 46-55 if column 13=1.
14		Update columns 56-65 if column 14=1.
15		Update columns 66-75 if column 15=1.
16-25		Updated dispersion for Y.
26-35		Updated dispersion for Z.
36-45		Updated dispersion for Ixx.
46-55		Updated dispersion for Iyy.
56-65		Updated dispersion for Izz.
66-75		Updated dispersion for Pxy.
76		Blank.
80		3.

UPDATE CARD NO. 4

Column	Format	Description
1-2		UP.
4-6		Sequence Number.
10		Update columns 16-25 if column 10=1.
11		Update columns 26-35 if column 11=1.
16-25	F10.0	Updated dispersion for Pxz.
26-35	F10.0	Updated dispersion for Pyz.
76		Blank or M.
80		4.

6.3 THE TEL DATA BASE

The TEL data base tape contains mass properties information on loose equipment. The data base is generated and maintained by the program UPTEL. The data will originate from the SLAHTS system.

To read a new Loose Equipment item from the tape, a "T" is put in column five of the Event Option Card, which is discussed below. MPES will read data from the tape into item numbers 153 and 154. One item will be payload attributable and the other operational equipment. When included on summary event cards, (discussed below), these items will be included in the summary for that particular event.

6.4 EVENT DESCRIPTION CARDS

Mass properties data for items comprising a given Shuttle configuration will exist on the data bases already discussed. The actual calculations by MPES of the total and subtotal mass properties as well as other optional calculations are made as dictated by a sequence of event description card sets. The types of cards and their formats are described in Table 6.5. A description card set consists of an event option card, an event title card, consumable cards (maximum of 5) and sum cards (maximum of 5).

Three cards are required for every event, the remaining cards are optional. These are: the Event Option card, the Event Title card, and at least one Sum card. There are two types of sum cards; i.e., "S" cards and "A" cards. Both

cards result in the same program calculations. The difference being, an item entered on an "A" card causes an asterisk to be printed with the name of the item on the Transferable Equipment Report. This is used to indicate when an item is entered for the first time. The "S" card will not print the asterisk. "C", consumable, cards can be used to change the weights of consumables. This is necessary to model engine burns where propellent is used, or to model fluid transfers from one tank to another.

If a "P" or "L" is in column three of the Event Option card then "XX" cards, described below, may be included in an event. These "XX" cards cause a depletion table to be generated containing the Shuttle's mass properties for various weights of propellants. The possible combinations of propellant depletions are:

- Any combination of OMS and RCS.
- Any combination of SRB's and ET's.

This table will also be copied to tape unit "M" if there is a "L" in column three of the Event Option card.

A print option card is used immediately before the first event of a series of events. Its format is below.

The Print Option Card

Column	Description
1-6	OPTION. Signals that this card is an option card controlling the print output.
12	1 or 2. A 1 causes the mass properties by module to be printed in the output coordinate system requested on the header card. A 2 causes the mass property report described for 1 to be printed in addition to the mass properties report containing modules in the input coordinate system (instead of in place of the regular report).
18	Blank or 1. 1 causes the dispersions by modules to be included in the report.

Using multiple executions MPES can create and/or update any number of Basic Data Sets and then execute calculations for events using the updated tape. A "CHANGE" card before the Event cards indicates that the new tape is to be used for basic data. The RUNID card is the key for linking a set of Event cards to the correct Basic Data Set. Examples of multiple executions are in figures 6-8 through 12. Control card formats are in Table 6.6.

DECK SETUP FOR PROGRAM MPES Multiple Execution PAGE NO. 1 OF 5

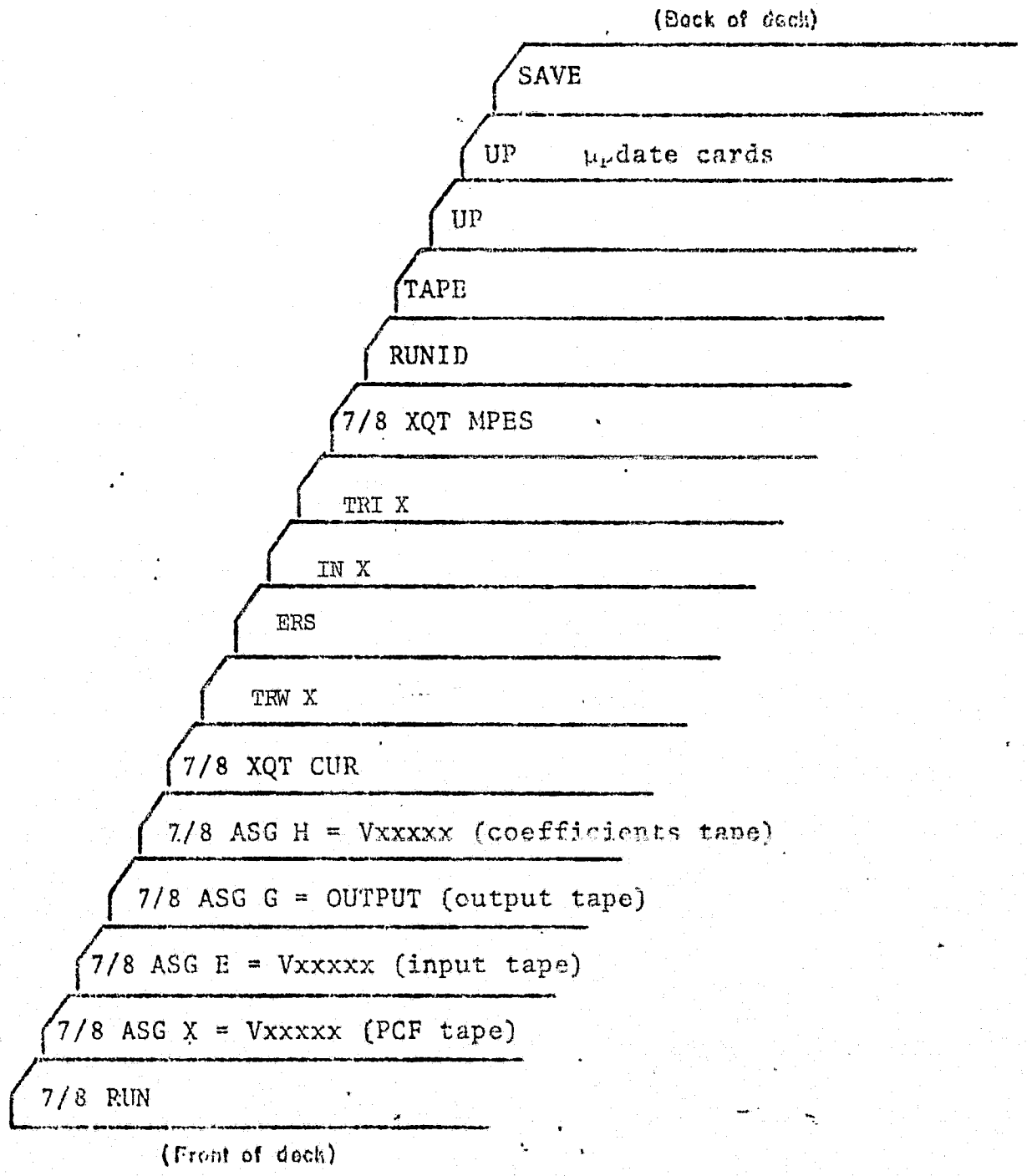

FIGURE 6.8 MPES Multiple Execution Deck Set Up

DECK SETUP FOR PROGRAM MPES Multiple Execution PAGE NO. 2 OF 5

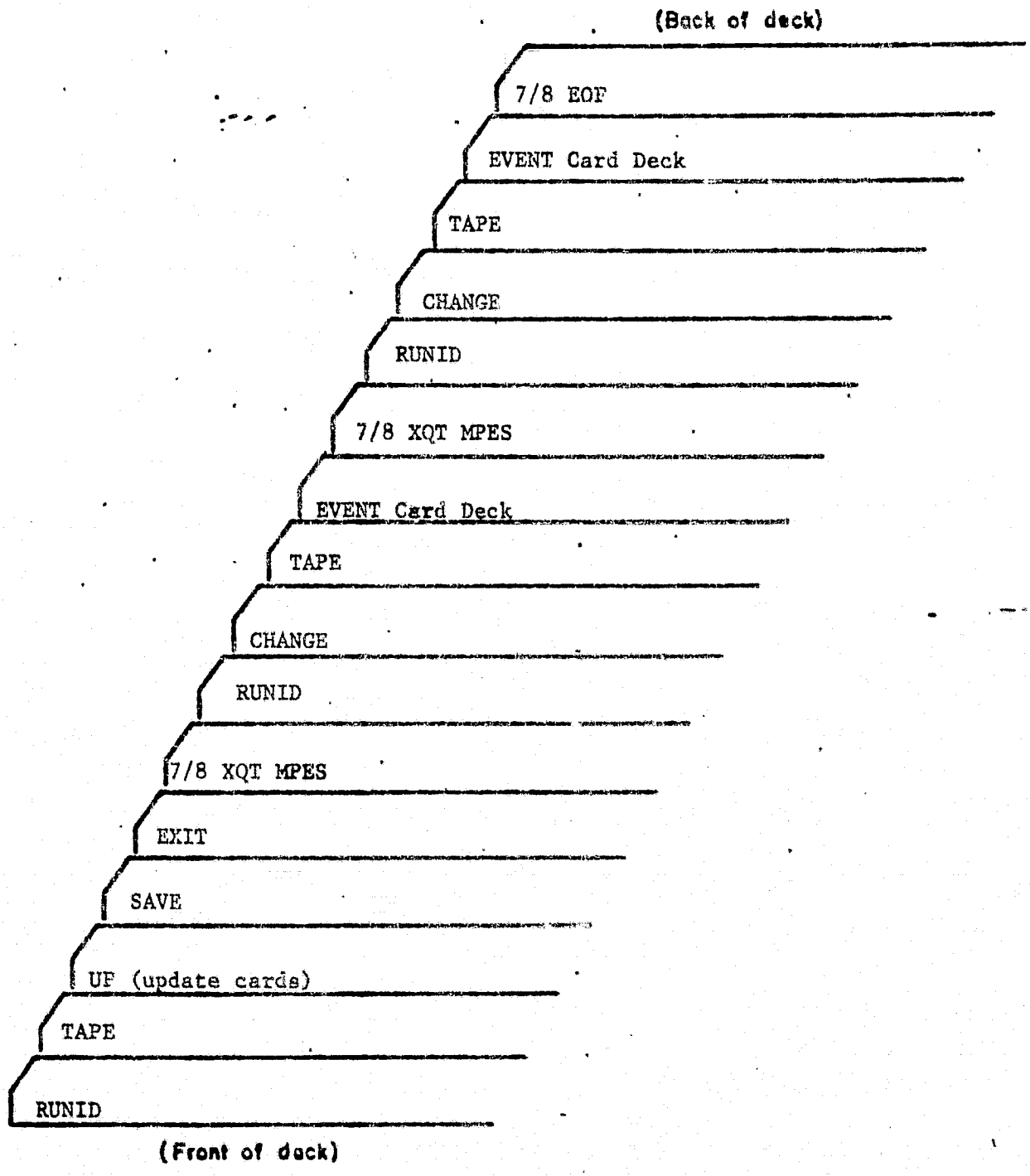

Figure 6.9 MPES Multiple Execution Deck Set Up (Continued)

DECK SETUP FOR PROGRAM MPES Multiple Execution" PAGE NO. 3 OF 5

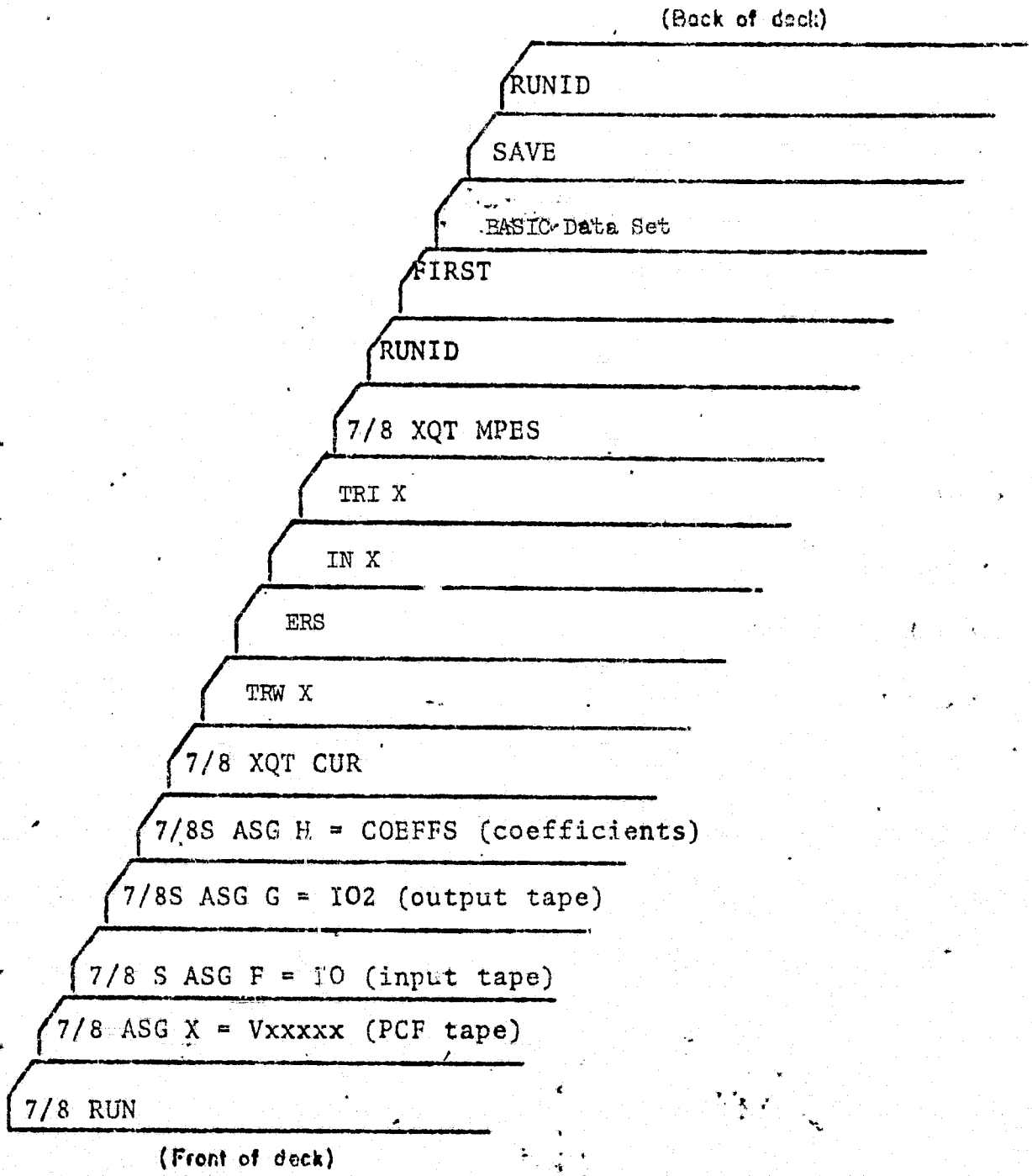

FIGURE 6.10 MPES Multiple Execution Deck Set Up (Continued)

DECK SETUP FOR PROGRAM MPES Multiple Execution PAGE NO. 4 OF 5

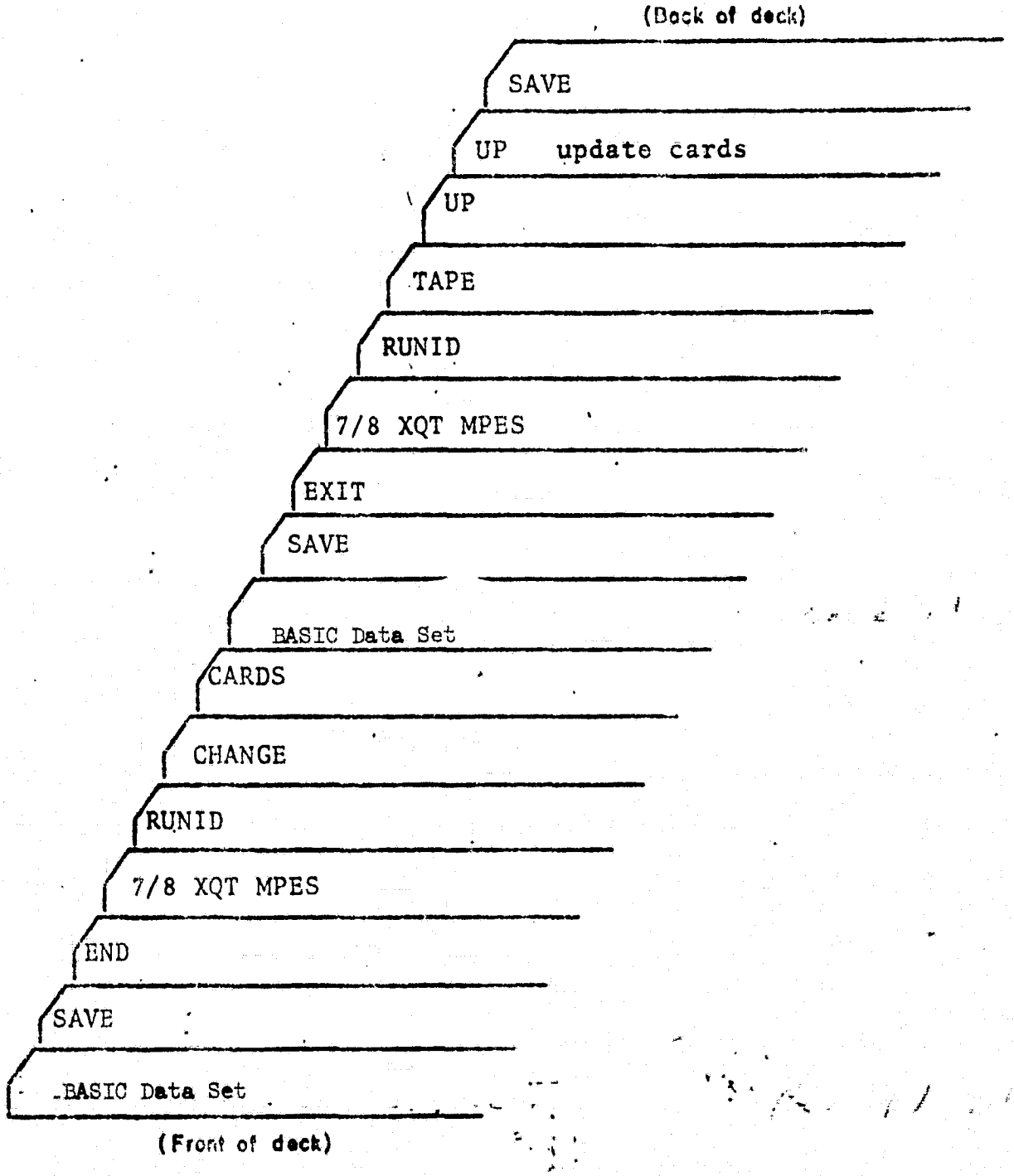

FIGURE 6.11 MPES Multiple Execution Deck Set up (Continued)

DECK SETUP FOR PROGRAM MPES Multiple Execution PAGE NO. 5 OF 5

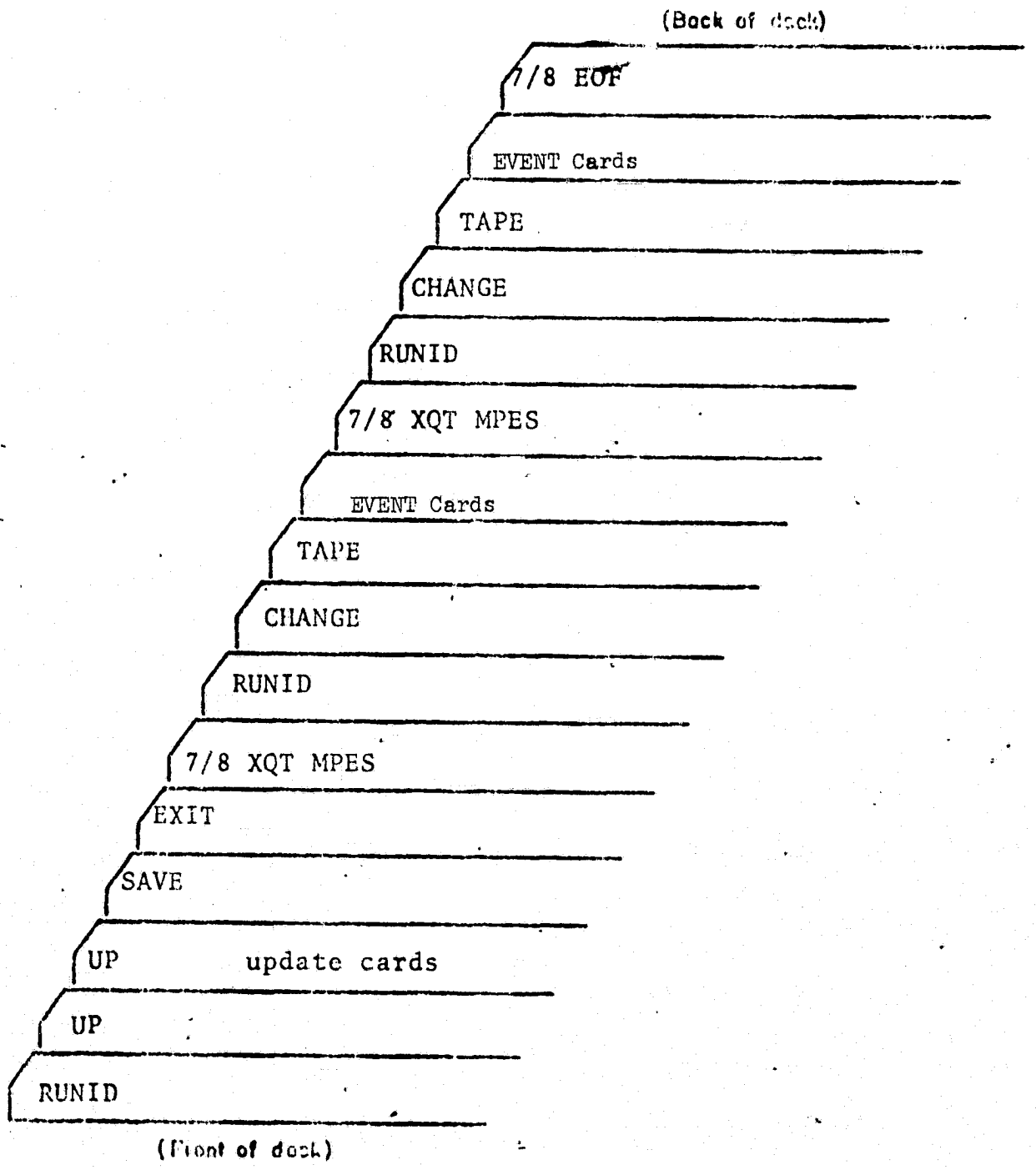

FIGURE 6.12 MPES Multiple Execution Deck Set Up (Continued)

TABLE 6.5 - EVENT DESCRIPTION SETS

CARD 1 - Event Option Card

Column	Format	Description
1-2		Output coordinate system. T is the tank coordinate system. O is the orbiter coordinate system.
3		Blank or "P" or "L". A "P" or "L" causes depletion tables to be printed for the OMS, ET's, and SRB propellants if the proper XX cards are input. (See section 3.2.4.) "L" causes the depletion table generated above to be written to tape unit M.
4		Not used.
5		Blank or "T". A "T" causes the next loose equipment entry to be read from the TEL tape into items 153 and 154.
6		Blank or "A". "A" causes this event to be included in The Abbreviated Report.
7-72		Mission Title. This title need not not be given on each set of cards. The last title given will be used until a new title is read.

CARD 2 - Event Title

Column	Format	Description
1-12		Event Title. Printed left justified beneath mission title. The first 12 characters are used for event names on TEL and Fluid Budget Report.

Consumable Cards (C)

Column	Format	Description
1		"C." Identifies the card as a consumable card. (Maximum of 5 per event)
2-72	Free field	Consumable sequence number, either 200 or 300 series items, followed by the delta weight.

Sum Cards (S or A)
(Maximum of 5 per event)

Column	Format	Description
1		"S or A." Identifies this card as a sum card.
2-4	I3	Sequence numbers which are to be summed. Three digit, right justified.
5-8	I4	Ranges are designated in the following manner: b003-010. b017-021-025 is not allowed. b017-014 is not allowed.

9-12	I4	Same as 5-8
etc.		

Propellant Depletion Cards (XX)

Column	Format	Description
1-2		"XX." Identifies this card as a depletion card.
6-8	I3	Sequence number of propellant to be depleted.
11-20	F10.0	Consumable starting weight.
21-30	F10.0	Consumable decrement weight.
31-40	F10.0	Stop weight.

TABLE 6.6 - CONTROL CARDS FOR CREATING/UPDATING BASIC DATA SETS

Columns	Identification
1-4	EXIT. This card is used to end the updating of addition of a new basic data to a tape.
1-5	FIRST. This card is used to initially create a MAPSYS input data tape and a coefficients data tape. Used on an Initialization run only.
1-4	SAVE. This card is used to save a file of basic data on the output.
1-5	RUNID.
7-24	Identification of Run. This card identifies the mission number associated with the Basic Data Set or event cards that follow the RUNID card. Used in all types of jobs as the first card in a data set.
1-4	TAPE. This card is used to signal that data is to be read from an input tape for updating or calculations.
2-7	
1-3	END. This card signals the end of initially creating an update data tape. Used with Initialization run only.

Columns	Identification
1-6	CHANGE. This card will switch the output unit for a multiple execution job so that the newly created output tape. Used on multiple execution Types 2 and 4 and Types 3 and 4. The change card is an optional card. The change card is read only in as standard run job; i.e., if either Type 1 or Type 2 was executed first and Type 3 followed, the change card is used. If Type 3 is a one-time execution, no change is required.
1-5	CARDS. This card is used to append new files to an output tape. Previous files will be copied first, and then the new files will be added.

TABLE 6.7 - MPES REPORTS

Sequential Mass Property Report (For each event)

This report lists the mass properties totals and subtotals by module for both the complete vehicle (WET) and for the vehicle without fluids (DRY). It also lists the principal axis and principal moments for the complete vehicle as well as the wet and dry uncertainties. This report is printed in English and metric units.

Consumable Report (For each event)

Fluids item numbers 100-199 which are included in an event have their current weights listed along with their names. Trapped fluids (items 171-182) are added to their associated tanks. This report is printed in English and metric units. A maximum of 45 consumables are allowed in this report (57 items total).

Consumed Fluids Report (optional each event)

All fluids changed by "C" cards are listed with the change to their weight. The previous, present and next event weights for the total vehicle are also listed.

Basic Data Items in Sum (each event)

All items included in an event along with their mass properties and dispersions are listed. This is a useful debugging aid to see which items are included and whether their properties are correct.

C - 2

Depletion Sequence (Optional, each event)

The mass properties of the vehicle are listed as propellents are depleted as dictated by "XX" cards. This is useful when relatively large burns will effect the mass properties significantly between events. This report may by option be written to tape. English and metric versions of the report are generated. Up to 50 lines can be generated in this report.

Equipment Transfer Summaries (At end of run)

If any items with item numbers 200-299 are included in an event, their names and mass properties along with the event title will be included in this report. This is a summary of all these items as they are added or dropped between events for ease of tracking. This report is also printed in English and metric units.

Fluid Budget Report (At end of run)

This report gives the remaining weights of 20 different fluid types for each event. A list of the 20 types with the item numbers included in each follows:

Type Fluid	Item Number Included
MTSC	113-131, 154
OMS FU.	132, 134, 144, 171, 173, 175
OMS OX.	133, 135, 145, 172, 174, 176
RCS FWD	146, 147, 177, 178
RCS AFT	148-151, 179-182

WATER POT	111, 112
WATER WASTE	108-112
WATER HYD	164, 167, 168
GN2	155
GO2	156
LO2	160, 161
LH2	162, 163
NH3	101, 102
APU N2H4	157-159
Orbiter Fuel	152
Orbiter OX	153
ET LH2	165
ET LO2	166
SRB LEFT	169
SRB RIGHT	170

This report is printed in English and metric units.

Abreviated Report (At end of run)

This report contains the event description and a line of total mass properties for all events that have an "A" in the 6th column of the Event Option card. This allows the user to obtain a single report with the totals of significant events without the bulk of the detailed reports.

7.0 UPTEL USERS GUIDE

The UPTEL program is used to process data tapes from SLAHTS describing the distribution of loose equipment into a data tape for input into MPES with loose equipment mass properties for different times in a mission. To do this in an orderly manner UPTEL will maintain three data bases on two magnetic tapes.

The original SLAHTS data tape will contain distribution information for the launch, orbit and return phases of a mission. It will also have 100 blank records for keeping the LOCATION data base. This information is not available from SLAHTS and must be added initially from cards. The original SLAHTS tape will have only one "orbit" phase. UPTEL will have the capability to add additional on-orbit phases with cards as well as editing existing SLAHTS data. An execution of UPTEL will create new edited data tapes which may be used for subsequent executions of UPTEL.

The MPES tape will not exist on an initial execution. An option on the "TEL" card will indicate that there is no MPES tape. Otherwise, all Files on the MPES tape will be copied to the new MPES tape except for the one with the same RUNID which will be written as it is calculated by UPTEL. The RUNID on the "UPTEL" card must match exactly the RUNID used in MPES.

The Control Card Deck Setup is shown in figure 7.1 and the UPTEL deck setup is shown in figure 7.2. Figures 7.3, 4 are the card formats.

DECK SETUP FOR PROGRAM UPTEL Control Cards PAGE NO. 1 OF 1

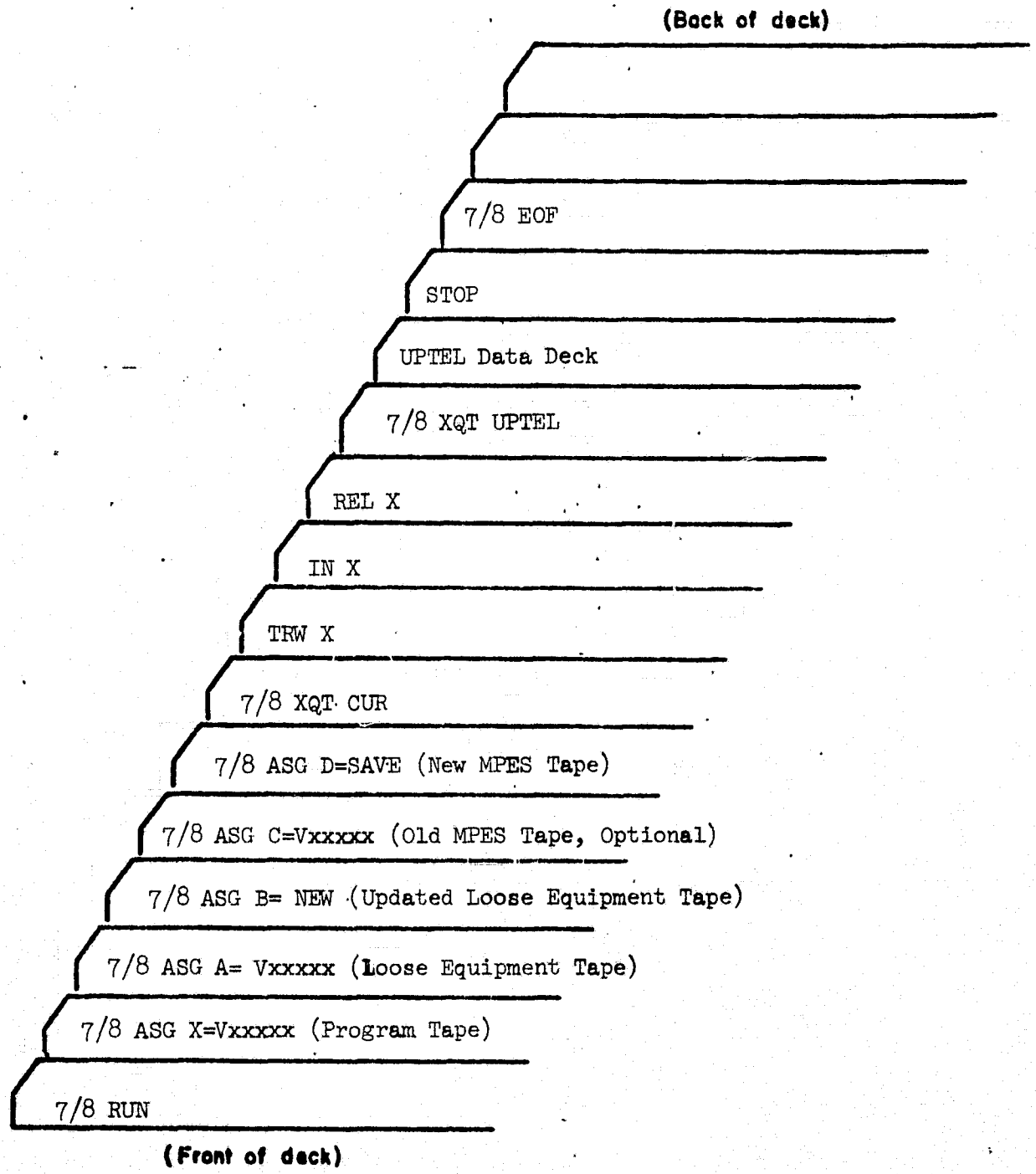

FIGURE 7.1 UPTEL Control Card Deck Set Up

DECK SETUP FOR PROGRAM UPTEL PAGE NO. 1 OF 1

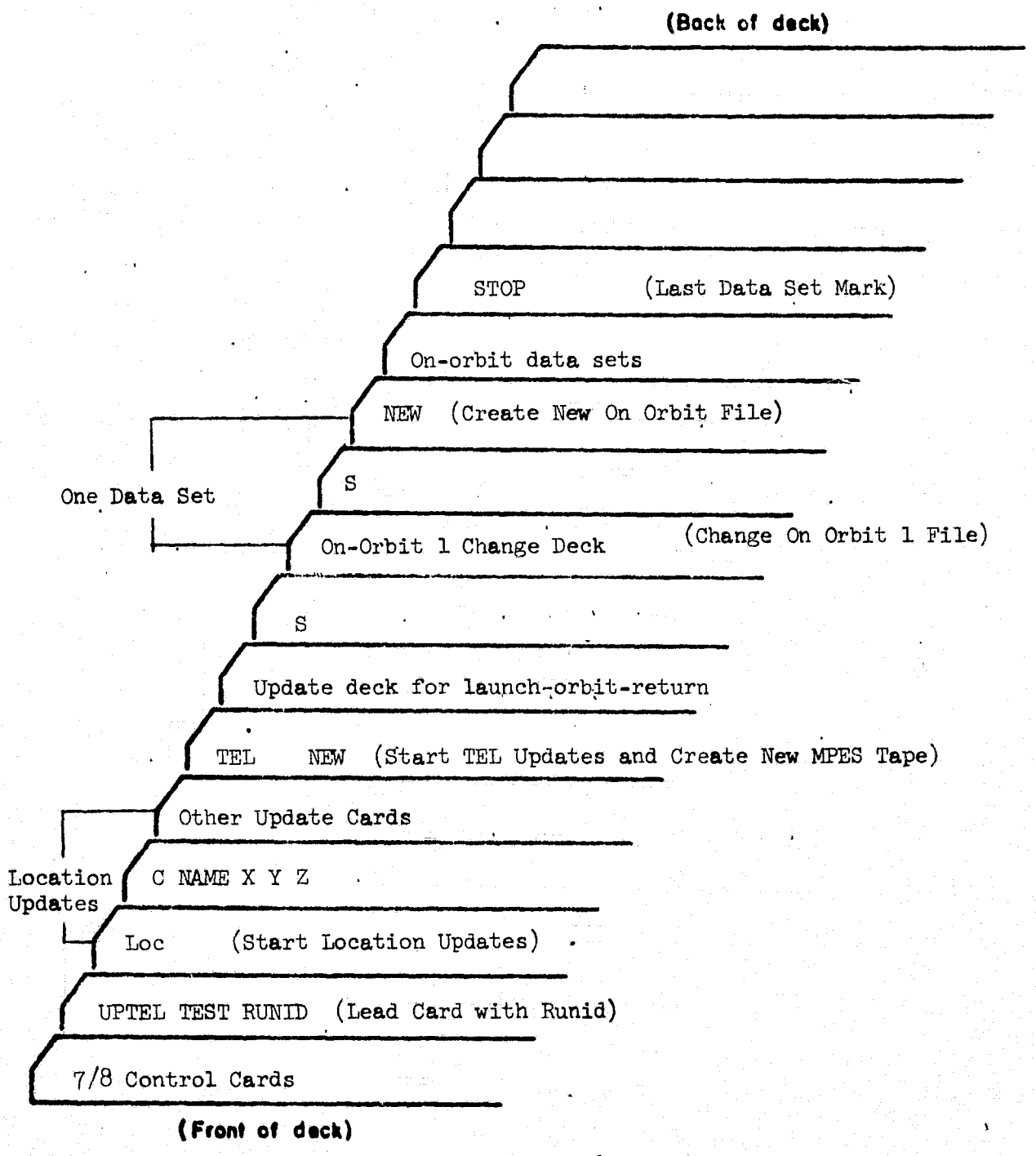

FIGURE 7.2 UPTEL Deck Set-Up

Column	Format	Contents
		Single Card Switches
1-5	A5	"UPTEL" marks start of deck
7-26	A18	Run ID for MAPSYS
1-3	A3	"LOC" marks location update deck
1-3	A3	"TEL" marks start of TEL updates
7-9	A3	"NEW" indicates that there is no MPES tape input
1-4	A4	"S" marks end of data set updates
1-4	A4	"STOP" marks end of run
1-3	A3	"NEW" indicates that all following additional on-orbit changes are to be applied to the old Launch-Orbit-Return data set rather than to the old edited on-orbit data sets. This option must be used to create additional on-orbit changes to an original SPIMS data tape
		Location Update Card
1	A1	"A", "C", or "D" for add, change or delete
2-7	A6	Stowage location
8-10	3X	Filler
11-20	F10.2	X c. g. coordinate
21-30	F10.2	Y c. g. coordinate
31-40	F10.2	Z c. g. coordinate

Figure 7.3 UPTEL Card Formats

Column	Format	Contents
		Header Update Cards
1	A1	"A", "C", or "D" add, change or delete
2	A1	"2" for header
3-14	A11	Item number
15-44	A30	Drawing number
45-64	A20	Part number
65-70	F6.2	Current weight
71-72	I2	Operational quantity
73-74	I2	Payload quantity
		Detail Update Cards
1	A1	"A", "C", or "D" add, change or delete
2	A1	"3" = Launch-Orbit-Return update "4" = Additional On-Orbit update
3-14	A11	Item number
15-16	I2	Sequential detail record number
17-22	A6	Stowage location
23-24	I2	Quantity stowed here
25	A1	Time Code: L = Launch O = Orbit R = Return

NOTE: Unneeded fields are ignored. Blank Fields for change cards are not changed.

Figure 7.4 UPTEL Card Formats